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Ethical Dilemmas of Autonomous Driving
How are the ethical dilemmas characterized by AI?

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MASTER'S THESIS

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Abstract

If we want vehicles that will operate autonomously in a responsible manner on the roads, it will be necessary to replicate at least, or organize better, the decision-making process done by humans now. In some scenarios it's more than just a mechanical application of traffic laws and offering a safe path. To make this possible a sense of ethics is needed, and to translate this capability into algorithms that can processed by a computer seems quite complex.

Before we can use self-driving vehicles, several questions need to be answered where investigation is still needed. Questions around the use of artificial intelligence technology and acceptance by society. Beside that there is current investigation ongoing about complex subjects, such as how decision making will take place during accidents, who will be liable in the event of an accident? Will that be the driver, the manufacturer, or a combination?

In this thesis the implications of self-driving vehicles will be addressed. The relation and the importance of autonomous driving for this research is that autonomous driving is one of the key application areas of artificial intelligence. This makes that this area is interesting to investigate, for topics that will be significant in the field of ethical dilemmas of autonomous driving. The research areas that will be investigated are:

- Dilemmas that will arise, data collection, insurance, acceptance, and responsibilities by the introduction of autonomous vehicles.
- The social acceptance of artificial intelligence techniques of autonomous driving, and the responsibility during traffic accidents.
- Which contribution will deliver the technology to allow decision-making in a moral way?

For the thesis the following research question is defined:

How will AI technology influence social acceptance and decision-making by accidents during autonomous driving, and which ethical dilemmas will this cause?

The used method for this research is, that a literature study will be performed regarding autonomous driving, to gather basic knowledge, to understand what has already done, and what can be expected in the future. Further during the literature study investigation, in reference to autonomous driving; which technologies will be used, by what means the data is used by the consumers, will insurance companies offer other products, what will change for society and who is held responsible during accidents?

In addition, to answer the research question, interviews were held to gather broader input from the community. By interviewing participants with open questions an extra table of interest was completed in order to verify their answers, with the focus on human acceptance for autonomous vehicles during decision making in case of accidents and the thoughts of consumers about this.

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List of Abbreviations

Abbreviation	Definition
2D	Two-dimensional
3D	Three dimensional
ADAS	Advanced Driver Assistance System
AI	Artificial intelligence
ATV	All-Terrain-Vehicle
AV(s)	Autonomous-vehicle(s)
CTAM	Car Technology Acceptance Model
DARPA	Defense Advanced Research Projects Agency
DOS	Denial of Service
EVs	Electric Vehicle
GPS	Global Positioning System
HD	High definition
IMU	Inertial Measurement Units
IoT	Internet of Things
LIDAR	Light Detection And Ranging of Laser Imaging Detection And Ranging
mIoU	Mean Intersection over Union
MVs	Manually Driven Vehicles
OBD	On-Board Diagnostics
OGs	Occupancy grids
PX	Pixel
RADAR	Radio Detection and Ranging
RF	Radio Frequency
SAE	The Society of Automotive Engineers
SLAM	Simultaneous Localization And Mapping
TAM	Technology Acceptance Model
TDO	Transit Oriented Development
TRA	Theory Reasoned Action
UTAUT	Unified Theory Of Acceptance And Use Of Technology
VO	Visual Odometry
VRU	Vulnerable Road Users

1 Introduction

New technologies are part of our daily life, and often we are confronted with new features that must make our lives easier. This is the same for the development of vehicles, in recent years major adjustments were implemented in vehicles. The adjustments are mostly to make driving of vehicles easier or more comfortable by automating activities. The speed that vehicles are equipped with automatic features takes place quickly. Also known as driving assistance, such as adaptive cruise control, automatic stop and parking systems. Development of vehicles will only increase over the coming years, and it is expected that in few years vehicles will be able to drive autonomously. Whereby the levels of autonomy will be introduced in phases.

With integration of artificial intelligence (AI) in autonomous vehicles (AVs), the aim is that vehicles will be safer and activities of driving able to automate, with methods of AI, as deep learning and neural networks. AI will be important to achieve autonomous driving, as AI is able to perform the same functions as a human driver. With AI it's possible to recognize objects and possible to make decisions. Through use of sensors, and modelling data with deep learning algorithms AI will be able to drive vehicles autonomously.

Driving autonomously will bring changes in several areas, some of them will be major and there will be an evolution of vehicles if they will drive autonomously. There will be adjustments needed in terms of legalization if decision-making will take place by a vehicle or more correctly by a system or machine.

One of the aspects that will arise with the implementation of autonomous driving is the acceptance by society. When decision making will happen by a system what can we expect and what is acceptable? Autonomous driving with AVs will require a transition in behavior of the consumer, instead of controlling the vehicle by driving it, they need to hand over control to a machine and to trust it. Beside that there are also more moral questions, as what will be ethical if decision making will be takes place by a system? Therefore, the acceptance of the consumer, society is an important factor for the introduction of AVs.

With new aspects as, AI and autonomous driving , and the acceptance by society of it, new dilemmas will exist. The more complex dilemmas will arise in the area of acceptance is the expectation for self-driving vehicles. Where topics needs to be discussed about ethics and decision-making. In this thesis there will be an investigation on what will be impacted by the introduction of AVs, and which factors this will influence.

1.1 Problem Statement

Autonomous vehicles (AVs) are vehicles that can drive without input from a human driver. These types of vehicles are known as self-driving vehicles, driverless vehicles, or robotic vehicles.

The self-driving vehicle is equipped with several technologies to observe the environment, with technologies such as cameras and sensor technology, LIDAR, RADAR, GPS, and wheel odometry sensors. Due to the technology the vehicle knows the way to drive, by navigating the vehicle through the traffic, and can react without the influence of human interaction.

The self-driving vehicle needs a control system to understand and process the data from the sensors, so that the vehicle can distinguish between road signs, obstacles, pedestrians and other related traffic facilities and unpredictable things on the road. For a vehicle to drive autonomously, it’s necessary that several real-time systems can work together. As described in Levinson et al. (2011), real-time systems must have knowledge and perception of the environment including localization, planning, and control. To make this possible the real-time systems need a robust vehicle platform, the self-driving vehicle must be included with appropriate sensors, computational hardware, networking, and software infrastructure.

In Zakharenko (2016) it is indicated that the advent of autonomous driving will bring many benefits, travel costs will be reduced, people will be able to travel more freely without any guidance, as older people, and children. People don’t have to worry about driving themselves, which will ultimately lead a lot of people to a better travel experience.

In Rosenzweig & Bartl (2015) it is mentioned that there is less attention in publications for autonomous driving and the user acceptance of autonomous driving. Whereby data and privacy topics are that important are for AVs, in particular the recording of driving data and the several questions about data property and privacy (Probst & Werro, 2016). AVs are included with artificial intelligence technology; therefore, this will require a different way how we need to see related liability, security, mobility, insurance, or ownership (European Commission., 2018). The current available (worldwide) liability will not cover all changes and risks that will be come with the introduction of AVs. With questions and challenges in the area of rights and duties, in particular about liability in case of damages to others.

According to O’Toole (2014) AVs cannot be defined as extensions of vehicles and should be seen as a completely new product. This leads to a central legal question surrounding the use of fully autonomous vehicles, who should be held responsible if an accident occurs?

1.2 Research Objective

A lot of research has already been taken place in the field of autonomous driving, many studies are performed, in some countries governments are involved in creating policies and manufactures are making progress with the development of AVs. Limited research is performed in the field of autonomous driving, in relation how decision making is taking place during accidents, and the possible influence of AI (Maurer, Gerdes, Lenz, & Winner, 2016).

The purpose of the study is to gather information to understand the influence that autonomous driving will bring, which technologies will be used and how this will influence moral questions around liability. During the research focus is on issues that are found during continuous development of the last years of autonomous driving to have insight which challenges there are to use AVs in daily life. To create insight what is needed for the onset of AVs a literature study will be carried out, additional interviews have occurred to collect broader input from the community by interviewing participants.

In this study the overall research objective is to recognize dilemmas and what is needed to use autonomous driving vehicles in public, with the focus on data collection, insurance, acceptance, and responsibilities. With the arrival of autonomous vehicles, a lot will change in the way people will move in daily life. Infrastructure maybe need to be adapted, it will be examined whether cities will have to be adapted. Beside that there are necessary changes in the field of policies required. This requires acceptance of the necessary changes, to be able to drive autonomously.

1.3 Research Question

The research question is defined as follow:

How will AI technology influence social acceptance and decision-making by accidents during autonomous driving, and which ethical dilemmas will this cause?

The related sub-questions are:

1. What are the characteristics of autonomous driving?
2. Which different ethical dilemmas are already under attention?
3. How are ethical aspects and user acceptance correlated?
4. How will the user acceptance be influenced?

For this research I will use a qualitative research method that is descriptive from nature. The results of this research will be based on words that will answer the main and sub questions. Answers will be searched for the defined research questions, which are substantiated by interpretations, experiences and meaning.

1.4 Significance

By interest from the community, autonomous driving has not only the attention of the sales companies, but also of the consumers, that gives the topic the ambition to research specific areas further that are important for the decisiveness of autonomous driving.

In the book: "Autonomous driving: technical, legal and social aspects", (Maurer et al., 2016) it is mentioned that vehicles will change with the onset of AVs, the environment, such as infrastructure and the use of the vehicles themselves will change as well. This will require adjustments in several areas for the introduction of self-driving vehicles. Whereby research of social acceptance and decision-making in case of accidents is still required. The goal is to gather knowledge of self-driving vehicles of, dilemmas that will arise, data collection, insurance, acceptance, and responsibilities.

This study will contribute to science in the field of social acceptance of artificial intelligence techniques of autonomous driving. The research can be used as a basis for further research of the acceptance of autonomous driving, and the use of artificial intelligence in case of accidents. In this research, various scenarios will be discussed where the feasibility, technology and acceptance will be examined. Autonomous driving is broad and has complex areas, in this research the aim will be to make predictions about human acceptance of autonomous driving, and decision-making in case of accidents with the use of artificial intelligence.

1.5 Report Structure

The thesis is structured as follows:

Chapter 1
Introduction: provides the starting point of this thesis, which includes the chapters, problem statement, research objective, research questions, significance, and report structure.

Chapter 2
Theoretical framework: describes the literature review in relation to autonomous driving and the ethical dilemmas, and the influence of AI. Literature will be gathered for autonomous driving, of the characteristics, dilemmas, technology, data, ethical aspects, insurance, and the user acceptance.

Chapter 3
Methodology: provides the research methodology, applied is a quantitative research method that exists of the literature review, open questions during the community interviews and expert interviews.

Chapter 4
Results: consists of the results of the interviews and the presentation of the outcome of the focus areas that are indicated about autonomous driving and ethical dilemmas. The results will be shown divided, from the participants and technological perspective. With an addition table during the interviews (see Table 51), the interests of the participants

were verified and as last part of this chapter the results of the interviews will be validated.

Chapter 5
Discussion: there will be discussion around the outcome of the interviews that were held. The answers of the participants will be discussed, and which dilemmas will arise by using AVs, the impact of it and the most important gaps that needs attention, in reference to decision making with AI and traffic accidents.

Chapter 6
Conclusions: as final, the conclusions are mentioned in this chapter, that can be done after the research. Whereby the research and sub questions will be answered and further topics suggested for further research and recommendations for the future will be made.

2 Theoretical framework

2.1 Characteristics

To gather knowledge of autonomous driving and autonomous vehicles (AVs), first will be clarified what an AV is. In this research an AV is defined as follow:

An Autonomous Vehicle (AV) is a vehicle that is able to sense it's environment and operating without human involvement. It's not required that a human passenger needs to control the vehicle at any time. In practice it must be possible that the vehicle can operate without a human passenger being available during driving in the vehicle.

To collect knowledge of autonomous driving and AVs, the history and future of vehicles related to autonomous driving will be presented. In this section the characteristics of vehicles will be provided, by starting with the evolution of the last 28 years of vehicles and what we can expect the next coming 5 – 10 years of vehicles.

2.1.1 Evolution of autonomous driving last 28 years

In this subsection the focus will be on the development of the last twenty-eight years of vehicles in relation to autonomous driving. The first step in the development of autonomous driving, was to add driving assistance. This had some commercial success.

1995
In 1995, Mitsubishi introduced at first the distance control that was LiDAR-based ("New Driver Support System," 1995).

1999
Short after the first distance control was introduced, Mercedes-Benz in 1999 introduced adaptive cruise control also known as radar-assisted driving (Janai, Güney, Behl, & Geiger, 2020).

2000
Digital road maps and navigation systems were introduced in 2000. Nowadays vehicles are using GPS in relation with inertial measurement units (IMU), this makes localization possible at an accuracy of 5cm in good circumstances, with the possibility of a detailed lane-level road maps (HD maps).

2004
In 2004 the Defense Advanced Research Projects Agency (DARPA) US Department of Defense started 3 races to stimulate the development of autonomous driving technology ("The DARPA Grand Challenge: Ten Years Later," 2014).

The first organized race of the DARPA Grand Challenge was only available for US attendees. There was a prize of $1 million to win for the team that was able to complete the 240 km route autonomously from California to Nevada cross through the Mojave desert. The track was based on GPS waypoints. Unfortunately, not a single vehicle was able to finish the course. The long term goal was to speed up the development of the technological foundations for autonomous vehicles to support supply convoys for military operations ("The DARPA Grand Challenge: Ten Years Later," 2014). The Grand Challenge was to take steps in the traditional defense, to trigger the ingenuity of the wider research community. "That first competition created a community of innovators, engineers, students, programmers, off-road racers, backyard mechanics, inventors and dreamers who came together to make history by trying to solve a tough technical problem," said Lt. Col. Scott Wadle, DARPA's liaison to the U.S. Marine Corps.

To have deeper understanding how the AVs were development during the challenge, the vehicle of team SciAutonics which participated in the DARPA Grand Challenge, had a combination of Lidar and Radar sensors for being able to look far ahead and a few ultrasonic and optical sensors for the detection of obstacles. With the use of pinhole cameras for detection of visual path boundaries. The vehicle used by the team was a 4-wheel drive ruggedized All-Terrain-Vehicle (ATV). A differential GPS in combination with inertial sensors was providing input to the low-level vehicle control to keep the vehicle on the track between a number of closed intermediate waypoints (Behringer et al., 2004). In figure 1 the system architecture of the control system of one of the participating cars during the DARPA challenge is shown.

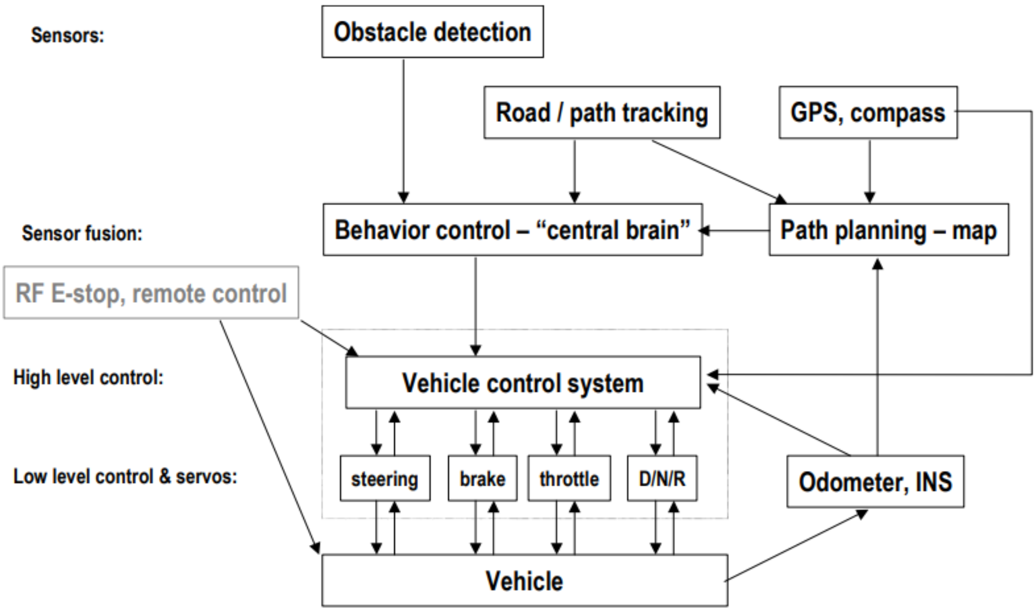

Figure 1 System architecture of control system of AV that participated during the DARPA (Behringer et al., 2004)

2005

During a second edition of DARPA in 2005, five vehicles completed the route successfully (Buehler, Iagnemma, & Singh, 2007). For the second challenge the price for the winning team was increased to 2 million dollars. A lot of technical innovations were demonstrated during this edition of the Grand Challenge. As a novel 64-sensor configuration was developed and demonstrated. Also, a rotating LIDAR system was designed to create a low-cost system capable of full azimuthal coverage operating at an update rate needed by a vehicle in motion. Further a system was demonstrated that had plug-and-play sensors for the use within a network protocol for AVs. This challenge contributed greatly to the advancement of autonomous systems and their growth. Beside advancing militarily relevant technologies, the competition format stimulated interest and excitement in a complex problem area of the usage of applicable technologies for AVs in general (Authority, 2004).

2007

The last of the three DARPA races was organized in 2007, the DARPA Urban Challenge (Buehler, Iagnemma, & Singh, 2009). This race was also open for international attendees.

Figure 2 AnnieWAY. Participant in the DARPA Urban Challenge (Janai et al., 2020)

In this challenge the course of the vehicles was a 96 km route through a mock-up town at George Air Force Base created. Where the vehicles had to deal with traffic laws, avoiding obstacles, negotiating with other vehicles and other road traffic. The best teams were using the multi-beam LiDAR technology developed by Velodyne (Péntek, Allouis, Strauss, & Fiorio, 2018). This rotating multi-beam LiDAR scanner is accurate in depth readings with a 360 degree field of view around the vehicle, which is crucial for navigating in urban environments.

2010

Alberto Broggi from the University of Parma introduced the VisLab Intercontinental Autonomous Challenge (VIAC) in 2010 (Broggi et al., 2010). The VIAC (Bertozzi et al., 2011) target was to drive semi-autonomously from Parma to Shanghai. The basis was the already collected knowledge of several prototype vehicles (Broggi, 1999), (Braid, Broggi, & Schmiedel, 2006), (Grisleri & Fedriga, 2010). During the race challenge, a second autonomous vehicle was following the way that was coordinated by a human driven vehicle, that was sending GPS waypoints to the AV, whereby the onboard system was crucial for observing obstacles to determine the presence and position of the vehicle in front.

In 2010 Audi demonstrated an AV to drive to the summit of Pikes Peak at 4300 meters above sea level.

Also in the year 2010 the Technical University of Braunschweig introduced the Stadtpilot ("Stadtpilot," 2010). That had the possibility to navigate in a narrow inner-city area with LiDAR, cameras and HD maps.

2011

In 2011, TNO (the Netherlands Organisation for applied scientific research) had organized the Grand Cooperative Driving Challenge (Lauer, 2011). This was a challenge with the attention of the behavior of cooperative autonomous driving. The first challenge was in 2011 and organized in Helmond in the Netherlands. The challenge was based on semi-autonomous vehicles that had to deal, with joining and leading convoys of vehicles. The longitudinal control was autonomous, and there was a human safety driver for lateral control. The winner of the first challenge in 2011 was team KIT (Geiger et al., 2012).

2013

In 2013, Mercedes Benz presented the S500 Intelligent Drive, this was a 103 km autonomous drive through the historic Bertha Benz route in Germany from Mannheim to Pforzheim. Funded by Daimler and researched together with the Karlsruhe Institute of Technology (KIT) (Ziegler et al., 2014). The Mercedes S500 vehicle was equipped with sensor hardware that was almost production ready, such as radar and stereo vision for object detection and free-space analysis. Traffic light detection and object classification was possible with monocular vision. The vehicle was further equipped for centimeter-accurate localization in HD maps with two complementary vision algorithms, point-feature-based and lane-marking-based. While the effort focused on a single route, the results were showing that autonomous driving in complex inner-city environments based on almost production ready hardware and HD maps was possible.

Further in 2013 there was Project V-Charge funded by the EU (Furgale et al., 2013). The participating companies were VW, Bosch and a few other academic partners (ETHZ, Oxford, Parma, Braunschweig). With the focus on electric vehicles in the area of fully autonomous charging. During the project, a complete operational system was presented with vision-only localization, mapping, navigation and control, and a lot of publications for several problems as calibration (Heng, Li, & Pollefeys, 2013), (Heng, Furgale, & Pollefeys, 2015), stereo (Häne, Heng, Lee, Sizov, & Pollefeys, 2014), reconstruction (Häne, Zach, Zeisl, & Pollefeys, 2012), (Hane, Zach, Cohen, Angst, & Pollefeys, 2013) (Hane, Savinov, & Pollefeys, 2014) SLAM (Grimmett et al., 2015) and free space detection (Häne, Sattler, & Pollefeys, 2015).

2014

The Society of Automotive Engineers (SAE) introduced in 2014 a classification for autonomous driving systems with 6 SAE levels of autonomy, with a category starting with level 0, no autonomy to level 5, full autonomy (Janai et al., 2020).

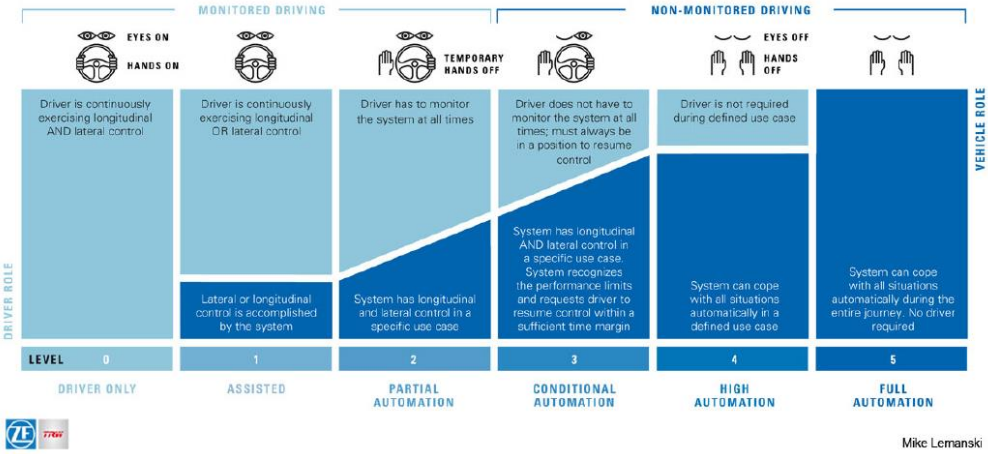

Figure 3 SAE Levels of Autonomy. From Mike Lemanski (Janai et al., 2020)

In 2014 also the Mercedes S Class and Tesla introduced the Autopilot (Tsai et al., 2003). With autonomy level 2, included with autonomous steering, lane keeping, acceleration, and automated braking.

2015

In 2015 Uber introduced his self-driving effort ("The Aurora Driver, delivering the benefits of self-driving to the world," 2015). This was done by hiring (Argo AI Center for Autonomous Vehicle Research) a few robotics researchers from CMU.

Also in 2015 also the team of VisLab of Alberto Broggi presented a project PROUD, regarding in Parma driving on the freeway and inner-city (Broggi et al., 2015).

2016

In Janai et al. (2020) is mentioned that from 2016 all Tesla vehicles had eight cameras, twelve ultrasonic sensors, and a forward-facing radar to make (full) autonomous driving possible in the near future. Uber and Tesla were both involved in fatal accidents were the driver was neither attentive, nor the self-driving system worked properly (Janai et al., 2020).

Also in 2016 the project for the self-driving vehicle of Google was changed into project Waymo, part of Alphabet Inc. Waymo gave 400 citizens of Phoenix access to their rider program ("Be an early rider," 2019). This program aimed performing full self-driving, with on the back seat a safety driver, in several areas of Phoenix.

Also in 2016 also the technology company NVIDIA showed 98% autonomous ride with the support of a single convolutional neural network. This was possible via imitation learning to directly predict vehicle control based on input of images (Bojarski et al., 2016).

Further in 2016, TNO had organized a second edition of the Grand Cooperative Driving Challenge, also in the Netherlands, in Helmond, with the same focus on the behavior of cooperative autonomous driving. The winner of this second challenge was team Halmstad, selection of the winning team was based on points assigned by a system to the participating teams (Janai et al., 2020).

2018
In 2018, a few last-mile delivery projects were performed, as Nuro (Metz, 2018). The project was launched by two former Google self-driving vehicle engineers and Scout (Scott, 2019).

In 2018 also a fully electric delivery system was developed for packages by Amazon for customers by using devices for autonomous delivery.

2019
During 2019 Google worked with some scientists that were well-known in the autonomous driving field, and that were part of the DARPA challenge. Google launched their own autonomous driving program to develop a new custom made multi-beam LiDAR scanner, on basis of the accident reports of 2016 ("Traffic Collision Involving an Autonomous Vehicle," 2019). The autonomous vehicle of Google was 14 times involved in accidents, that 13 times were caused by others.

Also in 2019, Bosch and Daimler introduced a fleet of autonomous vehicles, on pre-selected routes for a shuttle service with autonomous vehicles ("Bosch and Daimler. Metropolis in California to become a pilot city for automated driving," 2019).

Nowadays
The previous part of this chapter the historical development of autonomous driving is presented. The situation nowadays is completely different from how vehicles are working, the technique is different, and the way how consumers are using vehicles.

In relation to autonomous driving and the general development there are also still problems that exists now, there are several dilemmas to solve before we can use AVs. Whereby the emphasis during this thesis will be on the ethical dilemmas, as this is one of the most important parts when control from humans will be handled over to machines. Nowadays the major ethical dilemmas are (Hansson, Belin, & Lundgren, 2021):

- Responsibility
- Safety
- Control
- Information

In section (see Section: 2.1.4) is more explained of these dilemmas whereby for this research the mentioned ethical dilemmas would be the definition for ethical dilemmas for autonomous driving if there will be referred to.

2.1.2 Autonomous driving next 5 - 10 years

The expectation is that on the short-term we will not see many AVs on the roads. Due to the used technologies in AVs prices are still high, even in mass production the prices will be high, they will be relatively expensive because the manufacturing, installation, repair, testing and maintenance (T. Litman, 2016). Beside the high price, there are two other barriers that may prevent AVs from being massively spread in the beginning, regulation and the acceptance of the consumer. Despite there being more tests with customer interaction and user acceptance in the field of autonomous driving (Piao et al., 2016). Several studies indicated that men's are feeling more comfortable with AVs and are more interested in purchasing and using it (Payre, Cestac, & Delhomme, 2014).

In general the acceptance of AVs is slowly improving. This will increase when customers will share their experiences (Giffi, Vitale, Robinson, & Pingitore, 2017), (Piao et al., 2016). Important is to create gradually trust that can increase the acceptance of AVs for consumers. Also connected vehicles can deliver barriers for the consumers, by linking personal data to vehicles without the guarantee of data anonymity (Eurobarometer, 2014).

Regulation and user acceptance are important to spread autonomous driving.
New challenges will be met of regulatory challenges, liability, security, and access to data protection of personal data. At the moment worldwide teams are been working on these challenges. At the moment there are no obstacles for level 3 systems, a lot open points are there for AVs with level 4 or higher systems that are needed for subsequent AV generations. Activities are needed for regulations by developing a legal framework to allow AV testing and the use of AVs on the public roads (Trommer et al., 2016).

In relation to the high numbers of older vehicles on the road, indications are that it will take a long time before conventional vehicles and AVs will be able to work together. This can take a longer period, and without regulation for undetermined time as some people only want to use conventional vehicles (Schoettle & Sivak, 2014b), (Schoettle & Sivak, 2015). The "mixed traffic period" is defined, as the period that interaction between conventional vehicles and AVs will be needed based on the levels of automation. Problems with the communication between AVs and manual driven vehicles will be expected in this mixed traffic period. Manual driven vehicles will be surrounded by AVs, that can affect the human (manual) driver by missing the eye contact feedback, due to lack of verbale communication between a human driver and a AV (Schoettle & Sivak, 2015).

Most of the accidents with AVs till now were due to the incapability of human drivers to anticipate on a stopping AV in front, or by objects lying around on the road. Therefore, time is needed that human drivers will understand that AVs are anticipating different, because of that it's not the expectation that AVs will directly create a safer traffic environment from the first moment that they will come on the roads. Regarding the circumstances were the AVs will be affected with, AVs will not by definition be safer in this mixed traffic period, this can result in increasing of total accidents were AV's are involved (Schoettle & Sivak, 2015).

A safety topic for AVs that needs attention is the relation and collaboration with Vulnerable Road Users (VRU) and other road users such as pedestrians and bicycles (Y. Li, Cheng, Zeng, Liu, & Sester, 2021). Another aspect is the attention for security is something that is needed, in case of cyberattacks, and the attention for system failures (Sheehan, Murphy, Mullins, & Ryan, 2019). With the come of AVs capacity for roads can be reduced, by using available space as the AVs can react very precisely. It will be possible to anticipate better on other fellow road users (Hwang & Song, 2020).

2.1.3 Evolution of AVs

With the coming of self-driving vehicles way of our transport and how we will travel will radically change. The introduction will probably lead to there being a need for massive investments in vehicles and infrastructure. This will require a lot of adjustments for manufactures, supplier, governments, and consumers that are required during this transformation. This will affect the whole chain from producing, regulation till consumers.

The transition is needed if we will use AVs in the future, according to (Kyriakidis et al., 2019) expectation is that we will have a long period where gradual introduction of AVs will take place. Maybe that fully automated vehicles, as AVs, are only allowed in specific segments on the road, special for AVs, as highways or highway lanes, and small specific areas as parking facilities where the speed limit is not that high. Also, this transformation will ask for major changes in the development of autonomous driving in general. Related to these major changes is the anticipation of the social changes that the introduction of the new technologies will bring.

Ethical evolution

With the coming of AVs many new technologies will be used. These technologies will require social changes in case of traffic accidents with AVs. In the meantime, there is an ethical evolution started now on which needs are really required for the introduction of AVs. In perspective of the ethical evolution will follow as next topics that are addressed now and are under investigation currently (Hansson et al., 2021). The next topics will address different aspects of this ethical evolution. The topics are still under investigation.

Responsibility for Safety

There is a lot of discussion ongoing about self-driving vehicles and the related issues with responsibility. Today we don’t know better than that there is human available in the vehicle who controls the vehicle and has the responsibility while driving. In some cases, the vehicles are already able to drive partly autonomously. Even then there is still a human needed that can take over control if necessary. The expectation with fully self-driving vehicles as AVs, is that there is human needed that can take over control if necessary. It will be a huge change for driving of vehicles in general. It may even be needed during a period to have special roads only for AVs, this will be a huge evolution.

There will arise new questions about responsibility. Because there will be no driver more who controls the vehicle. Who needs to be responsible for passengers in the vehicle and for the control of the vehicle in traffic? In case the vehicle is controlled and steered by a computer possessing artificial intelligence, does the intelligence constitute an entity than responsible if something will happen? This will lead to questions as, what are the responsibilities of the vehicle owner? What is the responsibility of the manufacturer? What will this mean for the responsibility of the traffic control center for the communication of the vehicles?

Without autonomous vehicles, the last decennia there is already a lot changed in reference to responsibility and road traffic. For further analysis of responsibility issues related to autonomous driving, it must be stated that responsibility can be categorized in two types, task responsibility and blame responsibility (Hansson et al., 2021).

What Can and Should Be Accepted?
Even if the manufactures and public traffic administrations are preparing for automatized road traffic, the introduction itself of autonomous driving, for at least democracies, will be based on how the development of public attitudes will go.

In several studies is stated that large parts of the of the population in most countries have a quit positive attitude of AVs (Kyriakidis, Happee, & de Winter, 2015). Despite this such studies must be interpretate carefully. There must be careful with such kind of studies and the interpretation of it as not many have experience with autonomous driving, as there is no large-scale usage of a traffic system like this at the moment. Other studies on the other hand indicate a less positive attitude (Hansson et al., 2021). Some studies are referring to the public expecting less smaller failure rates in vehicle technology compared to driver behavior (P. Liu, Yang, & Xu, 2019). According to a study done by the American Automobile Association, they were mentioning, that three out of the four Americans are sceptic of riding a fully autonomous vehicle, because they are afraid (Hansson et al., 2021).

Therefore, high safety requirements for autonomous vehicles, from a public perspective can be influenced by different factors. People are not experienced with new technology and responsibility will be hand overed to machines. There are already examples of enraged opponents slashing tires, throwing rocks, trying to stop the vehicle, and pointing guns at travelers sitting in a self-driving vehicle. Most times the problem was due to safety concerns (Cuthbertson, 2018). With the provided previous examples, it’s not clear yet what can and should be accepted. Further study, research of acceptance will be needed coming period.

Safety and the Trade-Offs of Constructing a Traffic System
During the development of a new traffic system, the safety aspect will be one of the most major concerns and it is expected that it will lead to many discussions in public deliberations. Although the basis is known for a traffic system, as we are using them now also. In practice this can lead to complex issues in reference to safety, as safety is related to ethics, all components of a new traffic system need to be designed with a higher safety aspect in mind than we have now.

External Control of Driverless Vehicles
The way we are looking to AVs are in most times, is that humans will tell where there AV need to bring them, and the AV will follow-up this instruction. Where last is talked about, the possibility that the that the decision given by drivers can be overridden in case of urgency, as in example a traffic system. This can take place if there is interruption on the road, as a traffic jam or other obstacles, and the vehicle can be lead through the traffic with less delay. We are already known with suggestions via messages, for alternatives routes in case of traffic jams. With AVs there will be no need for passengers to choose an alternative route, as the vehicle will select choose automatically the best route.

Enforced taking control of a vehicle due to congestion, can be seen as an infringement on the freedom of its occupants. Off course questions as this will be important to answer for the future of AVs. To create regulations and acceptance of what we can expect in reference to autonomous driving.

Information Handling
AVs with communication systems are only reachable if the communication systems, are very well designed and developed. The communication between the vehicles, can deliver benefits such as avoiding accidents, and with vehicle-to-road-management communication systems would have the possibility to share information about traffic and accessibility. Both of this information types would be information, collected through the vehicle. Information about obstacles ahead can be obtained before they are registered by the car's own sensors.

The information that a vehicle is defect can be shared, for example where sensors are defect of vehicles that information can be shared that there is a vehicle with a defect. With the use of vehicle-to-road-management systems in theory it would also be possible to connect the information on a larger scale for the usage of traffic flow information (Van Wyk, Wang, Khojandi, & Masoud, 2019).

Effects on Health and the Environment
In case that public transport will be replaced by AVs, the AV is able to come to a user his location. It will not be necessary anymore for walks of the users to stops for public transport. This is one of the examples that health of people can be influenced, walks are needed and related to the physical exercise that the population is doing now. In this scenario this can has impact on the general health effects on a negative way (Sallis, Floyd, Rodríguez, & Saelens, 2012).

Social and Labour Market Consequences
When the introduction of AVs will take place, it will come with important social consequences. Some people not able to travel today, will be able to travel around by using AVs, as children, disabled in practice. They can visit their friends and will able to travel easier alone over longer distance, even when there is no adult needed to associate and to support during travelling. Activities as this that are likely willing to change with the come of AVs and will impact our social and labour market consequences. We will also be able to move further from work for better living circumstances (Harb, Xiao, Circella, Mokhtarian, & Walker, 2018).

Criminality
Major social changes are related to new ways of criminality. This will also the case with autonomous driving and will not an exception. The most potential forms of criminality with vehicles are illegal transportation, unauthorized access to data, sabotage, and new forms of auto theft. With autonomous driving, this will change and will the used data more valuable than nowadays.

2.1.4 Ethical dilemmas

It can be stated that there several different ethical dilemmas will occur with the come of AVs. There will be a need to focus on the ethical dilemmas and how they are possible to tackle the coming period and years. The several dilemmas will be further discussed during this thesis. Below are the major dilemmas that are prioritized as major ethical dilemmas in reference to autonomous driving and AVs.

Ethical dilemmas:

- **Responsibility**
- **Safety**
- **Control**
- **Information**

Responsibility

A lot of change is expected with the introduction of AV in regard to the responsibility in case of accidents.

In the near future, the responsibility will probably be transferred to the manufactures of vehicles, and the connected communication systems, whereby the expectation is that roads and infrastructure need to be prepared for autonomous driving.

Safety

In reference to the safety aspect, AVs can bring some benefits to control of the speed limit, and the short reaction times will help to avoid accidents. A consideration will be required between speed and safety. This will be the case for platooning that can take place on highways. Vehicles will be able to move closer to pedestrians. A fully automatic vehicle is able to transport several passengers that are not able to drive alone in a vehicle as we know now, in example a few of inebriated daredevils, or children without their parents.

Safety is more difficult to ensure, when children will avoid wearing a seatbelt or will do other things during driving as opening of the windows and lean out the vehicle that can lead to risky situations. Blind trust, and over reliance on collision avoiding systems can trigger people will do actions that are dangerous and risky. For example, pedestrians can step in front of a vehicle, assuming that it will stop automatically. These were a few examples that in reference to autonomous driving and safety is a major ethical dilemma, were attention is needed before introduction of AVs can take place.

Control

Stopping vehicles can be take place most reasonable electronically by the police. From that perspective it would be much safer to control speed limits on this way. Despite that, there will always reasons to stop vehicles, as stopping vehicles must rely on the purpose and procedures, where needed the right balance must be found between the interests of law enforcement and other legitimate interests. A riskier scenario is when criminals will hack the vehicle and takes over the control and will be able to crash the vehicle or to make it unusable.

Terrorists can use self-driving vehicles in case they want redirect transport, for the goods or to use it, to dive into something and creating a crash, or to install bombs in the vehicles, or to disturb some places or to create complete chaos in a country to shut down the roads and the traffic infrastructure.

Information

Information is one of the parts that have a key role in guiding the AVs through routes and destinations that are gathered with the purpose to optimize the movements and behavior of self-driving vehicles during driving. This information can also if there is a wrong intention, be stolen or hacked. It can be used to spread wrong messages or used for political news to vehicles. That can give the possibility for an authoritarian state to use it to influence or control people. For the safety of other pedestrians as cyclists, and people travelling in conventional motor vehicles, this information can be integrated with the vehicle communication systems of vehicles. Pedestrians may carry transponders, to be in connection with the vehicles systems, to keep distance and avoid accidents by tracking their behavior in traffic. Regarding privacy for pedestrians this will be the same as transponders in vehicles that is ongoing for AVs.

2.1.5 Ethical dilemmas and AI

In the previous section was described which ethical dilemmas are typified as major, in relation to Artificial intelligence (AI) would be possible to solve or partly solve, the ethical dilemmas when AI will be applied.

Responsibility
The responsibility is something that will be transferred from humans to self-driving vehicles. Therefore, this dilemma will need much attention to solve risks that are uncovered regarding responsibility now. The usage of AI will continue and improve development in several areas of autonomous driving, by self-learning, controlled updates and, by using an update strategy can bring many benefits for the quality of AVs. Through the self-learning principle will AI indispensable for the responsibility part of autonomous driving.

Safety
For the ethical dilemma regarding to safety, it’s almost the same as for responsibility. Development of vehicles is needed to realize better AVs. By using AI, roads can be observed better in case of obstacles, or the vehicle can detect that the passenger is unconsciousness during a drive, and that the vehicle can call for emergency services. So are there several benefits conceivable for safety and the use of AI.

Control
The ethical dilemma related to control can be deliver with AI a better quality of driving, due to continuously learning, up-to-date road information, the integration of sensors to observe the environment better. Also, there can be for some parts of driving the speed reduced, as during accidents speed limit can be reduced for a better flow and control of the traffic.

Information
Accurate and actual information of roads is needed in the future to guide vehicles through the traffic. This must be current information. By application of AI information can be collected to optimize the driving experience and to improve safety in general. There will be much information needed to let AVs drive in traffic. With all that information it will be possible to improve also other aspects as tracking driving behavior.

In the next subsection 2.2 Dilemmas, will be described about the dilemmas in the field of autonomous driving. In subsection 2.2.1 with examples of expected dilemmas and in subsection 2.2.2 the Dilemmas in relation from perspective of the user acceptance.

2.2 Dilemmas

2.2.1 Expected dilemmas

With the coming of AVs the expectation is that there will be a lot of benefits; traffic flow will be improved (Van Arem, Van Driel, & Visser, 2006), less pollution from vehicle emissions (Spieser et al., 2014) and after a while there will be less traffic accidents, with an expected decrease of 90 % (Gao, Hensley, & Zielke, 2014). This will be result in a drastic reduction of traffic accidents. Nevertheless it is insurmountable that there will be no accidents at all. In some cases during a crash AVs will be need to take difficult ethical decisions, in some cases damage will be unavoidable (Goodall, 2014b). Think hereby in the scenario as when an AV may avoid harming several pedestrians by to divert and hit a passerby who could die, or the AV will have the option of to crash and sacrifice his own passenger, where the AV has the choice to save one or more pedestrians, examples in figure 4 (Bonnefon, Shariff, & Rahwan, 2016).

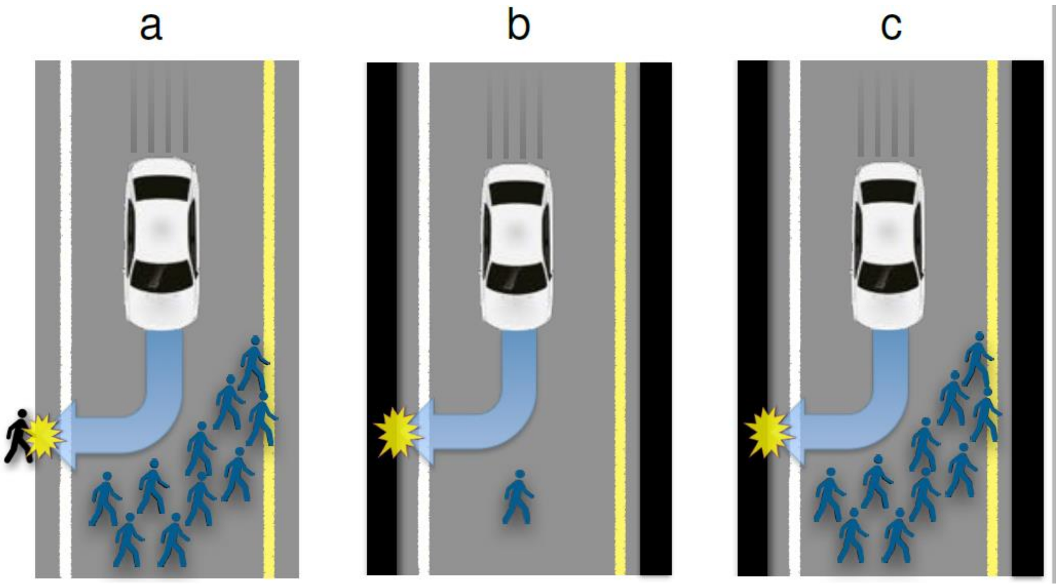

Figure 4 Three traffic situations where damage will be inevitable (Bonnefon et al., 2016)

This scenario will be maybe in practical not often the case, more low-probability events will take place on the road by the introduction of AVs. Also, if the scenarios will never occur, the programming of AVs must have decision rules what to do in such hypothetical situations. Therefore, before AVs will be introduced and will be used, this kind of decisions are needed to make a well-considered choice. The decision of AVs in case of accidents are decisions that needs to be universally considered and belongs to the moral domain (Gray, Waytz, & Young, 2012), (Haidt, 2012). Algorithms used by AVs there is need to include moral decision making, this can be by adding machine morality for decisions in unavoidable harm situations (Wallach & Allen, 2008). The development of machine morality was started during the implementation of driverless trains, the “trolley cases” founded by ethicists with purpose to study the moral dilemmas. This was not that easy, and was challenging to fulfill. One of the most difficult task to realize for the designers of systems included with machine morality is to define and to learn the system what is good or bad. The task of the manufacturers and regulators is to embed systems in AVs that can be divided into three objectives:

consistency, to ensure that there is no public outrage, not to discourage customers from purchasing and using AVs.

However, pursuing these goals can lead to moral inconsistencies. By taking figure 4 scenario A, in account, is that the most realistic moral attitude is that the AV should swerve. Assume on the utilitarianism principle this suits well (Rosen, 2005), what seems like the most obvious moral scenario to minimize the number of casualties. In figure 4 scenario B, is the scenario displayed to kill one pedestrian or to kill the owner of the vehicle (passengers). The situation will be completely different by watching to the scenario displayed in figure 4 scenario C. The most utilitarian way and steps, in a scenario like this would be for the AV to swerve and kill the occupant of the AV. This way of programming can discourage customers to buy an AV, as the consumer of an AV will first care of its own safety instead to make other considerations. Even tough situations like this will be extremely rare, their attention and emotional saliency will lead to broad public focus and a negative reputation in general for public decisions about AVs. In relation to more moral algorithms and acceptation by the society, for the ethics of AVs, there is a broader cooperative discussion needed about the moral algorithms and what will be acceptable from the perspective of the society, AV owners and from the manufacturer. Several studies are in progress, as data-driven study of driverless car ethics. The focus of these studies is on methods of experimental ethics (Greene, 2014).

2.2.2 Dilemmas in relation to user acceptance

In section 2.1.5, the ethical dilemmas and the usage of AI were presented (see Section 2.1.5) In this section, there will be watched to the dilemmas that will occur with the come of autonomous driving, and how they will influence the user acceptance.

With the introduction of new AVs major transformations will take place that the urban mobility will affect, changes in urban dynamics and city form will be changed by the coming of AVs. In Duarte & Ratti (2018), is mentioned how AVs will change our lives and the design of the cities, there are concrete five questions formed that will be addressed.

The questions below should give an idea how the earlier mentioned ethical dilemmas are linked, to eventual situations in the future with self-driving vehicles. In this way an impression will obtained, which areas are important for self-driving vehicles from a user acceptance perspective.

1. Will AVs be different in the future than now?
2. Will AVs lead to less traffic?
3. With a mobility web of AVs, do we need more or less parking spaces?
4. AVs will that result in more or less sprawl?
5. Do we need less roads with AVs?

1. Will AVs be different in the future than now?
In Mitchell, Borroni-Bird, & Burns (2010) is presented how vehicles and roads can be redesigned. The suggested vehicle will have the weight one third of a Toyota Prius, will be folded and take up 40 percent less space than a “Smart” vehicle. In the suggested

proposal its's possible to change the wheel and door configurations of vehicles according to the number of passengers. With several autonomous technologies and a broad network of charging points for vehicles. In the suggestions of Mitchell et al. (2010) a benchmark is provided for the possibilities of vehicles and cities of the future. Two topics are constant; driver and parking spaces. Further is suggested to disassemble the car in its multiple uses. In daily life, a family with a few children, a parent will bring the kids to school and will drive further to work. Most time of this duration, there is only one seat in use, the trunk is empty and when the parent is at work the car will be do nothing and will be parked for a few hours during the workday (Mitchell et al., 2010).

In Duarte & Ratti (2018) a few scenarios are explained. The first scenario, a parent will stop at a supermarket back to home, four seats will be still empty and in the most cases the groceries won't fill the entire trunk. In some another scenario the driver is driving through a red light and will stopped by a police car. In the first scenario, there is need to move people, the second to move goods and in the third, enforcement of the law is needed. Applying such uses to the same form factor restricts the possibilities of rethinking AVs. By outlining the different scenarios, it is possible to decouple the use of a moving platform from the established form of a vehicle. AV platforms for only transporting groceries can designed very small, same as the size of a trunk. Maybe this will not be the case right from the start, this indicates that there is a lot of room for change with the advent of AVs. This will have to be considered and decided at an early stage in order to decide how we want to organize our vehicles, roads and cities.

Therefore it's not exactly known how AVs will look in the future. It seems that the current form of vehicles is a constraint for realizing the full potential AV, therefore reshape of how we are living and design of the cities will be expected in the future (Duarte & Ratti, 2018).

2. Will AVs lead to less traffic?

Furthermore in Duarte & Ratti (2018) is stated that the amount of cars continuous to grow in the world, in relation with economic growth. The only solution to reduce the number of vehicles on the road is to invest in large-scale public transport. With all the technological successes, it is not expected that AVs will be a replacement for public transport. Also, by combining car trips or coordinating fleets, throughput can be largely increased. Nevertheless would it for vehicle platoons hard to compete with the average capacity of public transport.

In Stanford, (2015) is described, this will be the battle between individual and collective modes since the introduction of cars in the early Twentieth Century. Expectation of AVs is that they can negotiate in daily traffic without risks of collision and frequent stops on all type of roads. Replacing public transport as metros and trains with a fleet of AVs can cause also congestion on the road. Even though there are a lot of arguments from public transport advocates, and from cities that have done high investments in mobility transformations, the mobility offered by point-to-point vehicles will be in high demand by consumers who want to move from a to b. As Robert Cervero is referring, "The marriage of self-driving vehicles and car sharing could be America's true mobility game changer." (Cervero, 2017).

AVs will deliver benefits when used in cities, for parking, cleaner emissions, and flow of traffic. Whereby urban mobility is related to other innovative technologies and urban design strategies, as Transit Oriented Development (TOD) (Lu, Du, Dunham-Jones, Park, & Crittenden, 2017). On the other side, the more younger generation are starting later to driving vehicles than generations before. Also a large amount of younger people don't want a driving license. Younger people often have less strict specific work hours and jobs that are not always location specific. This causes mobility and displacement to increase as daily life becomes more hectic (Alessandrini, Campagna, Delle Site, Filippi, & Persia, 2015).

The question if AVs will bring more or less vehicles in traffic is very difficult to answer, this will be based on the lifestyle of people and the organization of cities. This question is related to social aspects, that move sometimes in opposite directions and different then is predicted. Urban sprawl could be fostered by using AVs and more quiet traffic. Nevertheless, if we look to ride-sharing apps and the acceptance in a lot of countries, shows there is a trade-off between A: paying less for fuel and B: avoiding problems with searching for parking spots in exchange, by sharing the ride with others, or strangers make sense. Data-driven research in combination with AVs and apps for ridesharing apps, has proven that AVs will have more rational use of personal vehicles, by taking into account the numbers of the vehicles that will be reduced in the future in (Duarte & Ratti, 2018).

3. With a mobility web of AVs, do we need more or less parking spaces?

According to Hawken (2017) "The contemporary car is not a driving machine, rather a parking machine". During the life cycle of a vehicle, cars are for 96 percent inactive, and AVs can have an occupancy rate of more than 75 percent ("If autonomous vehicles rule the world," 2015).

Martinez & Crist (2015) have calculated that with the use of agent-based algorithms traffic in Lisbon could decrease with 90 percent if humans would use more shared transports as taxis and public transport. With a positive impact on the driving duration of vehicles and the pollution that would decrease. One of the benefits of AVs is that there will be less parking spaces in cities needed.

For many years parking has been a problem, due to the amount of vehicles that is growing the last decennia, and the limited amount of parking spaces at interesting locations, such as shopping centers, in town centers and such kind of places. The related problems, due to limited amount of less parking spaces are pollution, congestion, additional cruising, and irritation due to not finding a parking place (Paidi, Håkansson, Fleyeh, & Nyberg, 2022). In Melbourne parking places occupy an equivalent area of 76 percent of downtown (Lipson & Kurman, 2016). In Los Angeles, the parking places are using an area of 331 hectares, almost 81 percent of the area in downtown. With the sharing potential opportunities and taking in account that AVs can move constantly, a lot of parking places will be not needed anymore (Tachet et al., 2017). With the introduction of AVs the possibility exist to redesign urban areas, creating more urban spaces to improve the quality of the cities and by better organization of the traffic infrastructure for all kind of participants. The optimists are stating that with the introduction of AVs the vehicle traffic in cities will decrease, mainly as people will make more use of car sharing. This brings the possibility to realize vehicle free areas. On the other side more pessimists people about this topic are pointing to the risk of more suburbanization and urban sprawl, due to acceptance of people for longer travel times and distance that vehicles need to drive, due to the possibility that during travelling people can relax or work in the vehicle instead of focusing on driving (Papa & Ferreira, 2018).

Despite this will it be a challenge to predict the effects on the longer term and what the impact will be of AVs on urban development, and which role AVs will fulfill in the future in the society (T. A. Litman, 2019).

Taking in account that AVs are able to be used by multiple users daily, this can reduce parking spaces in comparison with the vehicles of today. The other option is that AVs can move to, in example cheaper parking spaces or back to home, on a time that it will have less impact for the overall traffic (Duarte & Ratti, 2018). When parking costs will be reduced, this stimulates people to use AVs. If we look to all the given arguments and the fact that AVs will be freed from the vehicle form factor, and by the option of AV platforms with multiple and combinatorial functions, this will lead that parking needs a more radical approach in the future. Storage of the AV platforms can be together, just as containers are stored, this will reduce space. If AVs will be moving platforms and not vehicles, there can be initiated initiatives for new cities and new design of roads (Duarte & Ratti, 2018).

4. AVs will that result in more or less sprawl?

Driving without stress and AVs that are coordinating together the traffic by themselves, less traffic jams will reduce travel durations, this will allow for passengers to have other activities and no need to focus on traffic, commuting can be easier and will be more restful (Duarte & Ratti, 2018). In comparison with and to engage in other activities the current way of travelling, AVs will give us more freedom travelling with no need to do other activities (Van den Berg & Verhoef, 2016). Less stress during commuting will turn driving into a productive or pleasant time. Where to live will became less important in relation to the distance between work and home. Expectation is that 10 percent of the AV market penetration can reduce traffic up to 15 percent, and a 90 percent market penetration will bring 60 percent less freeway congestion. That will expect and estimate saving of about 2,700 million hours and 9 percent of reduction that vehicles will travel (Fagnant & Kockelman, 2015). The direct impact of this could be a further increase in urban expansion. This can lead to people when using their AVs can be decided to move from the cities, more conform long-lasting American ideal to single houses with backyards. Environmentally conscious people can justify their option because the expectation will be that AVs will be electric. Other technological developments also support increasing expansion. Currently, one consequence of urban sprawl is, that it is significantly linked to fatal vehicle accidents (Ewing, Hamidi, & Grace, 2016).

A safer urban area, with less accidents, and reduction of noise and pollution, can lead that more people will move to the centers of the city. Also is expected that it will lead to more shared autonomous vehicles. Time that people spend on commuting is important, also to choose where to live. With more shared vehicles cities can be more attractive than suburbs or exurban areas. Tradeoffs between AVs and how cities can be best built are still unknown at the moment, progress in changes in land are going often slowly and will take years before realized. When AVs will be used, probably the way we design cities will change (Duarte & Ratti, 2018).

5. Do we need less roads with AVs?
In the past, with the coming of vehicles as main transport cities were reshaped. The streets were adapted, to made it possible to maneuver vehicles as best as possible, by making wider, longer and straighter roads. There are also some futuristic ideas already, Elon Musk's suggested an underground roadway system for AVs, where vehicles are able to escape ground traffic via high-speed tunnels (Duarte & Ratti, 2018).

In the early Twentieth Century, it was more the case that planners of cities gave up city-centered and multimodal approaches, the focus was more on highway-centered and single mode urban freeways (Brown, Morris, & Taylor, 2009).

The view of a traffic architect for this solution will appear attractive. However most urban cities are crowded with bicycles and pedestrians traffic, in a lot of cities pedestrians need to walk a while to pass a wide urban road not being hindered by the flow of traffic. Examples are passageways in Hong Kong between commercial buildings. Passageways are part of the city in this architecture. Most times street levels are not accessible for pedestrians (Duarte & Ratti, 2018).

Beside flashy solutions and aligning speed levels in negotiating with other vehicles, AVs are able to reduce more than 10 percent of fuel consumption if they will be used by forming trains, platoons, or travelling using the bumper to bumper principle on roads (Waldrop, 2015). That results in duplication of road capacity. By organizing when freight AVs are constantly on the move, reduction of need for warehouse capacity can be created, because less storage is required (Flämig, 2016).

Design changes in infrastructure and cities will come when AVs will be seen and extended as technology that is integrated and exchanging data with urban infrastructure. An example is the traffic lights, during the introduction traffic lights were functioning for conflicting traffic at intersections. Traffic lights could be eliminated with the come of distributed systems of traffic data exchange following (Tachet et al., 2016). The authors are speaking about a slot-based solution at intersections, where vehicles, by sharing data of location, speed, are able to coordinate among on a correct way by themselves. The throughput speed of slot-based intersections organized in such a way can be twice as fast, in comparison with traffic lights (Duarte & Ratti, 2018).

Important is how humans will react on AVs when they are pedestrians and users (Bonnefon et al., 2016). Expectation on longer term is that number of accidents with AVs will be much lower than with normal vehicles, but they will not be inevitable. Dealing with decision making of swerving and sacrificing a passerby or to avoid running into many pedestrians, or even sacrificing its own passengers in scenarios were more pedestrians can be saved. In Bonnefon et al. (2016) is stated that utilitarian logic prevails among potential users, humans are able to minimize the number of casualties on the road, however when humans will use AVs, their choice will be to protect themselves at all times. Beside technological and planning aspects about the use of AVs, the society will face with the social and moral dilemmas that AVs will bring.

In the next chapter the technology of AI will be discussed (see Section 2.3). The different ethical dilemmas are described in subsection: 2.1.4 Ethical dilemmas.

2.3 AI technology

Autonomous driving is associated with AI technology, with AI is meant that:

Artificial intelligence (AI) is standing for the simulation of human intelligence in machines that are programmed to think like humans and copy their actions. This is also the case with any machine that exhibits traits related to a human mind with the aim to learn and solve problems.

In context of AI, this chapter will provide insight in the used technologies related to AI.

2.3.1 Used Technologies

The AVs will be self-driving vehicles that will make autonomous decisions, with systems that can process streams of observations that will come from several integrated sources of the vehicle. The most used systems, and were development is focused on at the moment are; cameras, radars, light detection and rangings (LiDARs), ultrasonic sensors, global positioning system (GPS) units and/or inertial sensors (Grigorescu, Trasnea, Cocias, & Macesanu, 2020).

In order to be able to make driving decisions, the observations are working with a computer that's included in the vehicle. In figure 5 are the basic blocks presented of an AI powered AV. The calculation of driving decisions are taking place via a modular perception, planning action sequence (Figure 5), or taking place via End2End learning fashion (Figure 5 b), after that sensor information passed and linked to the control output (Grigorescu et al., 2020).

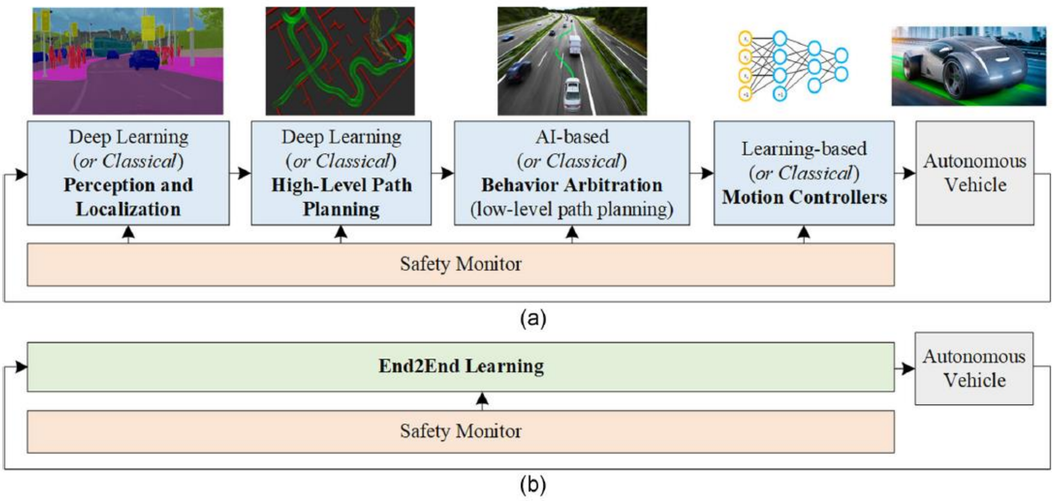

Figure 5 Deep learning-based AV(S. Grigorescu et al., 2020)

Implementation based on this architecture is possible via sequential perception-planning-action pipeline, as in figure 5 a, or on the basis of a End2End system in figure 2.5 b. In case of perception-planning-action, components can be designed with the use of AI and methodologies for deep learning or on the methodology of the classical nonlearning approaches. With deep learning is meant the part of machine learning that is based on multi-layered neural networks. There are many examples of deep learning where the technology is performing better on activities than humans. Most End2End learning systems are using the methods of deep learning. With support of the safety monitor there can be ensured for each module the safety (Grigorescu et al., 2020).

According to Grigorescu et al. (2020) modular pipeline components are in most cases designed and based on AI and deep learning methodology or are working with the more classical approach of nonlearning. There are several permutations of learning possible as, nonlearning and based components. The safety monitor can track the status and availability of the modules. In (Figure 5a) the modular pipeline is hierarchically divided in four components, that can be designed with the approach of deep learning and AI or the classical methods (Grigorescu et al., 2020).

The following components are included:

• Perception and localization,
• High-level path planning,
• Behavior arbitration, or low-level path planning,
• Motion controllers.

These four components are forming the basis on a high level, related to deep learning methods used, designed and developed for autonomous driving systems. Further are algorithms, data sources, and hardware aspects important in regard to the design of deep learning modules for AVs (Grigorescu et al., 2020).

To follow a planned route through a road network, first it's needed for an AV to know and localize the vehicle in the environment he is surrounding. Based on this representation, a continuous path can be set and needed actions of the vehicle are possible to determine due to the behavior arbitration system. A motion control system is integrated, that is reactively correcting errors that are occurring during the execution of the planned motion (Grigorescu et al., 2020).

The Classical non AI design methodologies, for these four components are further explained in Paden, Čáp, Yong, Yershov, & Frazzoli (2016).

2.3.2 AI applications in Vehicles

In this section there will be described the integration of AI in vehicles, and the technique behind it. How AVs are making decisions and how the vehicles are able to operate autonomously.

Hardware
Deep learning methods are in general well suited for detecting and recognizing objects in two-dimensional (2D) images and 3D point clouds are derived from video cameras and LiDAR devices. The perception of 3D is especially based on LiDAR sensors, that is providing a 3D representation of the immediate vicinity in the form of 3D point clouds. Results of LiDAR are measured on basis of view, range, resolution, and rotation/frame rate. Most times 3D sensors have a 360◦ horizontal field of view. An AV requires at least 200m of range on high speed, allowing the vehicle to react on needed changes that occur on the road (Grigorescu et al., 2020).

The accuracy of the 3D object detection depends on the resolution of the sensor, there are LiDARs that are able to provide a 3-cm accuracy. The company Waymo, has at the moment more than 10 million miles driven with AVs and are developing their vehicles directly with level 5 systems (Grigorescu et al., 2020). Tesla is deploying the vehicles with its AutoPilot as an advanced driver assistance system (ADAS) that can be switched on and off at the customers choice (Grigorescu et al., 2020). Advantage of Tesla is the large database with driving experience of autonomous driving, included with more than 1 billion driven miles. The database exists of data from customers that are owner of a vehicle (Grigorescu et al., 2020).

The main sensing technologies differ in both companies. Tesla is making use of camera systems, Waymo's driving is based on LiDAR sensors technology. Both technologies have advantages and disadvantages (Grigorescu et al., 2020). The technology of LiDAR delivers high resolution and is very accurate also in the dark, but very vulnerable when weather is bad e.g., (Hasirlioglu, Kamann, Doric, & Brandmeier, 2016). Also, cameras sensitive for bad weather, and the weather conditions can interrupt the view. At the Cornell University researchers were trying to replicate LiDAR-like point clouds from visual depth estimation (Y. Wang et al., 2019). This was done by estimating a depth map and projecting them into 3D space. The pseudo-LiDAR data is thereafter used by 3D deep learning processing methods, such as PointNet (Qi, Su, Mo, & Guibas, 2017) or aggregate view object detection (Ku, Mozifian, Lee, Harakeh, & Waslander, 2018).

In Grigorescu et al. (2020) are Image-based 3D mentioned, estimation is of high importance for the large-scale deployment of autonomous vehicles, LiDAR is mostly the most expensive hardware component in AVs. Radar and ultrasonic sensors are used to improve enhance perception. To give an idea of what the vehicles are equipped with, Waymo is using three LiDAR sensors, five radars and eight cameras, in Tesla's you can find eight cameras, twelve ultrasonic sensors, and one forward-facing radar.

Driving scenarios

According to Grigorescu et al. (2020) it is required for an AV to detect traffic participants and areas where it's allowed to drive, especially in urban areas where different objects are present. Perception of deep learning-based perception, in particular CNNs, can be seen as the standard for object detection and recognition, and has achieved great success during competitions, an example is the ImageNet Large-Scale Visual Recognition Challenge (Russakovsky et al., 2015).

Neural networks

Neural networks are artificial systems inspired on biological neural networks. With the aim to learn the system executing tasks by being exposed to several datasets, this takes place without any task-specific rules are defined. The goal is that the system is possible to identify characteristics in the data, and that there is no programming needed with a pre-programmed view of the data that is used.

Difference between deep neural networks and deep learning

The most important difference between learning and neural networks is that for deep learning it can be defined as deep neural network that exist of various layers and each node exists of various nodes. A neural network is performing the activity less precisely compared to deep learning, that can use more layers to perform the task and is more precise. A neural network needs less time to train to know the network, because the complexity is lower, where a deep learning network requires a longer training period.

Several neural networks architectures are available for detecting objects like 2D regions of interest (Dai, Li, He, & Sun, 2016), (Girshick, 2015), (Iandola et al., 2016), (Law & Deng, 2018), (Redmon, Divvala, Girshick, & Farhadi, 2016), (S. Zhang, Wen, Bian, Lei, & Li, 2018), or segmented areas in images related to the pixels (Badrinarayanan, Kendall, & Cipolla, 2017), (He, Gkioxari, Dollár, & Girshick, 2017), (Treml et al., 2016), (Zhao, Qi, Shen, Shi, & Jia, 2018), beside that there are 3D bounding boxes in LiDAR point clouds (Luo, Yang, & Urtasun, 2018), (Qi et al., 2017), (Y. Zhou & Tuzel, 2018), and also 3D representations of objects in relation with the data of camera-LiDAR (X. Chen, Ma, Wan, Li, & Xia, 2017), (Ku et al., 2018), (Qi, Liu, Wu, Su, & Guibas, 2018).

In figure 6 there are examples presented of scene perception. In general, the image data is more useable for the object recognition task. The real-world 3D positions of the detected objects is based on estimation, as depth information will be lost during projection of the imaged scene to the imaging sensor (Grigorescu et al., 2020).

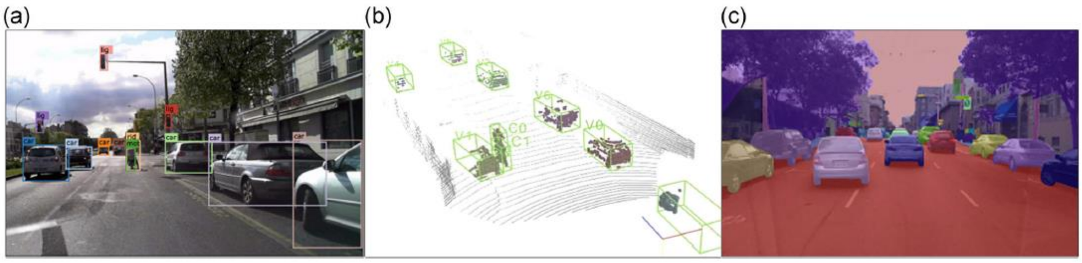

Figure 6 Scene perception examples (S. Grigorescu et al., 2020)

Figure 6 shows 2D object detection in the images, figure 6b shows the 3D bounding-box detector which is based on LiDAR data, and figure 6c is showing semantic segmentation results on images.

Object detectors

Most used architectures for 2D object detection in images are single- and double-stage detectors. Popular single-stage detectors are "You Only Look Once" (Redmon et al., 2016), (Redmon & Farhadi, 2017), (Redmon & Farhadi, 2018), the Single Shot multibox Detector SSD; (W. Liu et al., 2016), CornerNet (Law & Deng, 2018), and RefineNet (S. Zhang et al., 2018).

Double-stage detectors, as Regions with CNN (R-CNN) (Girshick, Donahue, Darrell, & Malik, 2014), Faster-RCNN (Ren, He, Girshick, & Sun, 2015), or complete convolutional network, region based R-FCN (Dai et al., 2016), are splitting detection of the object in two sections: in the region of interest of participants proposals and classification based on bounding boxes.

The single-stage detectors do not need the same performance in comparison to the double-stage detectors and are considerably faster. When the computing resources are scanty in a vehicle, detectors as SqueezeNet (Iandola et al., 2016), in (J. Li, Peng, & Chang, 2018) can be used, due the possibility to work with embedded hardware.

Single-stage detectors mostly have a smaller architecture of the neural network, that gives the possibility to detect objects with less operations, at the expense of detection accuracy. A few publications presented object detection on raw 3D sensory data, and also for the combined video and LiDAR information.PointNet (Qi et al., 2017) and VoxelNet (Y. Zhou & Tuzel, 2018) are detecting objects solely from 3D data, by providing 3D positions of the objects. Only point clouds don't have the rich visual information included in the images. To give meaning to this, it will make use of combined camera-LiDAR architectures, in example as Frustum PointNet (Qi et al., 2018), Multiview 3D networks MV3D; (X. Chen et al., 2017), or RoarNet (Shin, Kwon, & Tomizuka, 2019).

The main disadvantage of using LiDAR in the sensory suite of an AV is the high cost (Grigorescu et al., 2020). Neural network architectures can be a solution for this, as AVOD (Ku et al., 2018), that make use of LiDAR data for training proposes, whereby images during training and deployment are used. In the implementation phase, AVOD is possible to predict 3D bounding boxes of objects solely from the data of an image. For systems like this, a LiDAR sensor is required only for training data acquisition. Same as the vehicles that we are using today to collect for navigation maps of the road (Grigorescu et al., 2020).

Segmentation
According to Grigorescu et al. (2020) the understanding of a driving scene can also be reached with semantic segmentation, due to the categorical labeling of every pixel in an image. For the use of autonomous driving, pixels can be selected with categorical labels that is showing the area where to drive, detection of pedestrians, traffic participants and buildings. This is one of the activities that makes it possible to fulfill complete scene understanding, that is embedded in autonomous driving, indoor navigation, or virtual and augmented reality (Grigorescu et al., 2020). Some related semantic segmentation networks are SegNet (Badrinarayanan et al., 2017), ICNet (Zhao et al., 2018), ENet (Paszke, Chaurasia, Kim, & Culurciello, 2016), or AdapNet (Valada, Vertens, Dhall, & Burgard, 2017), and Mask RCNN (He et al., 2017), are encoder–decoder architectures that are included with a pixelwise classification layer. That is based on building blocks of a few common network topologies, in example AlexNet (Krizhevsky, Sutskever, & Hinton, 2012), VGG-16 (Simonyan & Zisserman, 2014), GoogLeNet (Szegedy et al., 2015), or ResNet (He, Zhang, Ren, & Sun, 2016). Just as with bounding-box detectors, optimization was done to improve the computation time of the systems of the integrated targets.

There were also some authors that were mentioning that remarks were added to speed up with the data processing and inference of the integration of devices for autonomous driving (Treml et al., 2016), (Paszke et al., 2016). Both architectures are mostly delivering the same results as SegNet and light networks, with the benefit of that it will reduce computation cost.

Semantic segmentation of the robustness objective is improved in AdapNet (Valada et al., 2017). This models makes a robust segmentation possible in various environments through learning features of expert networks based on scene conditions. The average of mean intersection over union (mIoU) is related to multiclass segmentation, each pixel is labeled and is part of a specific object class, whereas per-category mIoU refers to foreground (object)–background (nonobject) segmentation. The size of the most common samples are 480 px × 320 px (Grigorescu et al., 2020).

Positioning

The purpose of localization algorithms is calculating the position in his environment during driving (Grigorescu et al., 2020). The realization of this is possible with GPS systems. Visual odometry (VO) also called visual localization, is working by matching key point landmarks in consecutive video frames. Based on the current frame, the key points will be the input of a perspective-n-point mapping algorithm to calculate the position of the vehicle in relation to the previous frame.

Deep learning can be used to improve the accuracy of VO by directly influencing the precision of the key points detector. In Barnes, Maddern, Pascoe, & Posner (2018), a deep neural network is trained to learn key points distractors in monocular VO. Ephemerality masking, is realizing a rejection scheme for key points outliers that can decrease the accuracy of the localization of the vehicle. With the calculation of the camera position, the structure of the environment will be incrementally visible. The method is also called SLAM simultaneous localization and mapping (Bresson, Alsayed, Yu, & Glaser, 2017).

The several neural networks PoseNet (Kendall, Grimes, & Cipolla, 2015), VLocNet++ (Radwan, Valada, & Burgard, 2018), (Walch et al., 2017), (Laskar, Melekhov, Kalia, & Kannala, 2017), (Melekhov, Ylioinas, Kannala, & Rahtu, 2017), (Brachmann & Rother, 2018), (Sarlin, Debraine, Dymczyk, Siegwart, & Cadena, 2018), are making use of data of an image for the estimation of the 3D positions of cameras.

Scene semantics can differ from the estimated position (Radwan et al., 2018). LiDAR intensity maps can also be used for learning a real-time, calibration-agnostic localization for AVs (Barsan, Wang, Pokrovsky, & Urtasun, 2020). With the use of a deep neural network the method is able to gather learning information of the scene of driving from LiDAR sweeps and the intensity maps.

The vehicle his locality can be obtained through convolutional matching. Learn descriptors for localization in urban and natural environments usually becomes laser scans and a deep neural network applied (Tinchev, Penate-Sanchez, & Fallon, 2019). For safely navigating during driving, an AV needs to estimate the conditions of the environment, that is called scene flow.

In the past LiDAR-based scene flow estimation techniques were mainly based on manually designed features. Today this is changed, and are the classical methods with deep learning architectures able to learn the scene flow automatically (Grigorescu et al., 2020). In Ushani & Eustice (2018), the encoding deep network is based on occupancy grids (OGs) with the aim to find matching or nonmatching locations between consecutive timesteps.

There has been reported progress in the field of deep learning-based localization. VO techniques most times rely on classical key point matching algorithms, in relation to acceleration data that is gathered of inertial sensors. The main reason for this is that key point detectors are computational efficient, and easy to integrate on embedded devices (Grigorescu et al., 2020).

Occupancy maps

The Occupancy Grid (OG), also called an occupancy map, a means to present the environment by splitting the space of driving in a set of cells and is calculating for each cell the occupancy probability (Grigorescu et al., 2020). Popular in robotics (Garcia-Favrot & Parent, 2009), (Thrun, Burgard, & Fox, 2005), where the OG applications seem to be a solid solution to use for AVs. In figure 7 there are presented a few OG data samples. The images below shows different snapshots of the driving environment along with the associated OG.

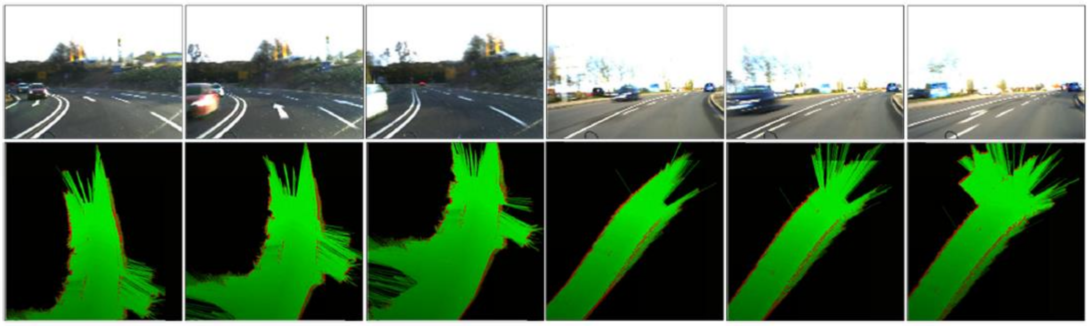

Figure 7 Occupancy grids (OGs) examples (S. M. Grigorescu, Trasnea, Marina, Vasilcoi, & Cocias, 2019)

Deep learning is used for occupancy maps, for dynamic objects detection and tracking (Ondruska, Dequaire, Wang, & Posner, 2016), probabilistic estimation of the occupancy map around the vehicle (Hoermann, Bach, & Dietmayer, 2018), (Ramos, Gehrig, Pinggera, Franke, & Rother, 2017), or to infer the context of the driving scene (Marina et al., 2019), (Seeger, Müller, Schwarz, & Manz, 2016). In the last situation OG is built by collecting data over time, a deep neural network is labeling the environment in the context of driving classes, for driving on the highway, parking spaces, or driving in the inner-city.

Occupancy maps is presenting a virtual environment in the vehicle, whereby the perceptual information will be presented on a way that is better useful for path planning and motion control (Grigorescu et al., 2020). Deep learning is important for the estimation of OG, the information is used for grid cells and is derived from processing image and LiDAR data using the method of scene perception.

2.4 The Role of data for AVs

2.4.1 Data labeling

The research about autonomous driving and the use of datasets and associated algorithms is already ongoing for a few years. In this section, there will be performed a summary of the related works regarding datasets and the most relevant algorithms.

Several recent datasets have the aim to solve each individual visual task for robot navigation, like 3D geometry estimation (Scharstein et al., 2014), (Silberman, Hoiem, Kohli, & Fergus, 2012), localization (Kendall et al., 2015), (Sattler et al., 2018), segmentation and instance detection (Everingham, Van Gool, Williams, Winn, & Zisserman, 2010), (Lin et al., 2014).

Although, the focus of autonomous driving, is about preferring a set of comprehensive visual tasks that are collected consistently inside a unified dataset from driving videos, that makes it possible to research advantages between different problems. The last years datasets have been gathered in several cities, with the purpose of increase variability and complexity of urban street views for the application of autonomous driving.

In the context of semantic annotated videos, the first dataset is from the Cambridge-driving Labeled Video database (CamVid) (Brostow, Fauqueur, & Cipolla, 2009). The dataset is not large, and exists of 701 manually annotated images with 32 semantic classes. Later the KITTI vision benchmark suite was funded, that collects and consists of different computer vision activities like 2D/3D object detection, tracking stereo and optical flow (Geiger, Lenz, Stiller, & Urtasun, 2013).

Regarding semantics, the major focus is on the detection part, for which 7,481 scans for training images and 7,518 test images are annotated by 2D and 3D bounding boxes, every single image contains 30 pedestrians and maximum 15 vehicles. In general, less images contain pixel-level annotations for segmentation, the result is a relatively weak benchmark for semantic segmentation.

Dataset	Real	Location Accuracy	Diversity	Annotation			
				3D	2D	Video	Lane
CamVid [26]	✓	-	day time	no	pixel: 701	✓	2D / 2 classes
Kitti [2]	✓	cm	day time	80k 3D box	box: 15k pixel: 400	-	no
Cityscapes [3]	✓	-	day time 50 cities	no	pixel: 25k	-	no
Toronto [27]	✓	cm	Toronto	focus on buildings and roads exact numbers are not available[1]			
Mapillary [28]	✓	meter	various weather day & night 6 continents	no	pixel: 25k	-	2D / 2 classes
BDD100K [29]	✓	meter	various weather day 4 regions in US	no	box: 100k pixel: 10k	-	2D / 2 classes
SYNTHIA [30]	-	-	various weather	box	pixel:213k	✓	no
P.F.B. [31]	-	-	various weather	box	pixel:250k	✓	no
ApolloScape	✓	cm	various weather day time 4 regions in China	3D semantic point 70K 3D fitted cars	pixel: 140k	✓	3D / 2D Video 27 classes

[1] database is not open to public yet.

Table 1 Comparison datasets (Huang et al., 2019)

In table 1 a comparison is presented between the ApolloScape dataset and the other street-view self-driving datasets. “pixel” shows 2D pixel-level annotations. “point” is showing 3D point-level annotations. “box” indicates bounding box-level annotations. “Video” indicates whether 2D video sequences are annotated. “3D fitted cars” Is showing the number of vehicle instances that is already included in the images with a 3D mesh model.

More recent is the Cityscapes dataset (Cordts et al., 2016). This dataset is a collection special for collecting for 2D segmentation that are included in 30 semantic classes. Almost, 5,000 images are included with detailed annotations, and around the 20,000 images are available with coarse annotations. There are even video frames, of each video there is only one image labeled manually. That means that activities like video segmentation are not possible. The same for the Mapillary Vistas dataset (Neuhold, Ollmann, Rota Bulo, & Kontschieder, 2017) that is providing a large set of images with fine annotations, that have 25,000 images consisting of 66 object categories. The TorontoCity benchmark (S. Wang et al., 2016) is collecting LIDAR data and images that include stereo and panorama images of driving vehicles and drones. Even though it's a huge dataset, that is covering the area of Toronto, it's not an option to perform per-pixel labelling of each frame on a manual way. There are only two semantic classes available for benchmarks of segmentation, i.e., building footprints and roads. The database of BDD100K (Yu et al., 2020) includes 100K raw video sequences, with more than 1000 hours of driving hours and 100 million images. Just as Cityscapes, selection is based on one image from each video clip for annotation. On the level of the bounding box there 100K images annotated and 10K images on the level of pixel.

The collection of real data is intensive work. In order to deal with difficulties during the collection of real scene, a few synthetic datasets are proposed to be applied. SYNTHIA (Ros, Sellart, Materzynska, Vazquez, & Lopez, 2016) is building a virtual city with the Unity development platform ("Unity Development Platform," 2021). For the benchmark Play (Richter, Hayder, & Koltun, 2017) extracts ground truth are based on the GTA game engine. Although there is a large amount of data and ground truth available, a domain gap is still not solved (Hoffman, Wang, Yu, & Darrell, 2016) of the real images and the appearance of synthesized. In case of usage of real data it's important to take ethics on the usage of this data in consideration. In Europe this is supervised by the European Commission and the terms are described in the Ethics and data protection (European Commission., 2018). In this regulation is described that when data is used, this usage must be covered by the local and central applicable regulations. The models that are learning during real scenario performing better, and where real applications are used, like object detection and segmentation (Y. Zhang, David, & Gong, 2017), (Y. Chen, Li, & Van Gool, 2018). In table 1, properties are compared with the SOTA datasets for autonomous driving, this shows that ApolloScape is both unique in terms of data scale and granularity of labelling of task variations in real environments.

2.4.2 Security and privacy

The distributed control of hundreds of thousands of vehicles is not easy, and a complex task to organize. In case of a sudden natural disaster, like an earthquake, vehicles must have the possibility to coordinate the evacuation of critical areas very quick in a clear structured and orderly manner. Therefore it's needed to have the possibility to communicate with each other, that is known where in case of need, such as emergency services, detailed information will provided to an AV about alternative routes, and images about damage that needs to be avoided (Lee, Gerla, Pau, Lee, & Lim, 2016).

Communication can be taken place to secure from, or to prevent from malicious attacks. Attacks on AVs can have disastrous consequences, because there is no standby control and split-second chance to intervene directly by the driver, as the driver is maybe doing something else, as reading or working in the vehicle.

The environment for this communication and distributed processing, can be realized with a new network and computing paradigm, that from the begin is designed for vehicles, called the vehicular fog. The mobile cloud can offer several services that are essential, such as routing, content searching, spectrum sharing, dissemination, attack protection, and several other possibilities, can be applied in AVs via open interfaces (Lee et al., 2016).

An important aspect for participants of vehicles is the protection of data, by allowing users to decide which information is needed and required for processing and which information is private. By making this clear, this can be an incentive for participants for the use of data for autonomous driving. Functions as data and trust validations of mobile applications can be accommodated to a vehicular fog, in case when mobile devices and mobile users are temporarily disconnected (Lee et al., 2016).

The vehicular fog also provide protection to devices that are penetrated by the adversary, or exhibit uncontrolled, disruptive behavior. In an AV security requirements such as confidentiality, integrity, privacy, and authentication are required, as an AV is vulnerable to vicious attacks. For example in case where the steering or the brake system will be disabled. This kind of attacks are important to prevent by normal vehicles with human drivers, in the case of an AV this will be extremely dangerous as there is no driver standby to intervene (Lee et al., 2016).

Therefore, the protection against attacks, both from external as internal (other AVs) threats need to meet strict conditions and be designed with the needed conditions. Access to the internal mechanism of an AV must be possible, for on-board diagnostics (OBD), also when an AV is out of control, in case of internal malfunctioning or malicious attack (Lee et al., 2016).

Proper enforcement is in these scenarios needed for access control, as a first-line protection strategy in the vehicular fog. Therefore, it’s not enough to manage this with a simple password and role assignment (Swati, 2014).

There is also special attention spend on botnet research as a threat. Using botnets will be reality in the IoT (“Proofpoint Uncovers Internet of Things (IoT) Cyberattack,” 2014) and its consequence in the vehicular fog can have very unpleasant consequences, in the next chapter more about crashes and decision making (see Section 2.5.1). Another important part is Denial of service (DoS), as most communications including V2V are based on wireless medium.

Jamming of Radio-frequencies (RF), will result in communication-blind areas. In that case it will be not possible to deliver messages with warnings on time, that is required for critical safety applications (Puñal, Aguiar, & Gross, 2012).

The influence of AI for the ethical dilemmas, that were mentioned earlier (see Section 2.1.5) AI can assist here to solve problems on the operational field. As with AI technology, as provided in this chapter, ethical dilemmas can be solved or partly by mitigating the risks of the ethical dilemmas, responsibility, safety, control and information.

As the importance of AI, will be to reproduce human handling to a system. This means that AI will be a necessity for autonomous driving, if we want AVs that drive themselves in the same way as humans are doing today.

2.5 Decision making

2.5.1 Accident prevention

During and before crashes, also mentioned in the previous paragraph and in extension of it in reference to IoT (see Section 2.4.2) the human driver of a vehicle often make poor decisions, that result in an accident. Drivers need to handle with time constraints, less experience with their vehicles in terms of handling, and a narrow field of view.

The AVs of today will also have somewhat limited sensing and processing power. The aim is to eliminate crashes with future sensors and algorithms (Goodall, 2014b). In a realistic case, even perfect vehicles will occasionally crash, therefore the need of an ethical decision-making system will remain necessary. With the advanced autonomous vehicles, the vehicles have the ability to make pre-crash decisions with advanced software and sensors, detecting nearby objects and performing evasive maneuvers at high speed. That means that AVs will be able to overcome many limitations that are experienced by humans today. During crashes that are unavoidable, the computer is able to quickly calculate the best location where to crash, taking into account the safety, the outcome of the crash, and certainty in measurements much quicker and very accurate compared to a human. The computer can calculate that to brake alone is not enough, and will decide to brake and swerve, or to swerve and accelerate during an evasive maneuver if needed. A characteristic of AVs that during crashes the AV will be in lead in case of decision-making, were the human driver can take the decision by themselves how to crash. For the AV the decision of how to crash was defined by a programmer already a period ago (Goodall, 2014a).

An AV makes use of sensor data and will make a decision on basis of that, the decision that the AV will make is probably developed and coded months or a few years earlier. This scenario won't be a problem when a crash will be avoided, the vehicle will select than the safest way to continue his road. In case injury cannot be avoided, the AV will take the decision what the best way is to crash. Decision like this quickly becomes a moral question, as presented in next example from Marcus (Gary, 2012). An AV is driving on a bridge that have two lanes, when a bus in the opposite direction suddenly swerves into the lane where the AV is driving (see Figure 8). In this case the AV needs to decide what the reaction will be, with the use of logic that has been programmed. This results in three possibilities:

1. Move to the left, off the bridge, that will result in a serious crash with one vehicle.
2. Choosing to have a head-on collision with the bus, with the outcome of a two-vehicle crash.
3. Trying to pass the bus on the right side of the road. When the bus suddenly will move back to its own lane (the chance of this event is very low, depends on how far the bus has drifted) in that scenario a crash is prevented. When the bus will not go back to his own lane, a high-probability event, then a severe, between two vehicles will take place. This would be a smaller crash, offset crash, which carried a greater risk of injury if a frontal accident will take place as in scenario 2 (Sherwood, Nolan, & Zuby, 2009).

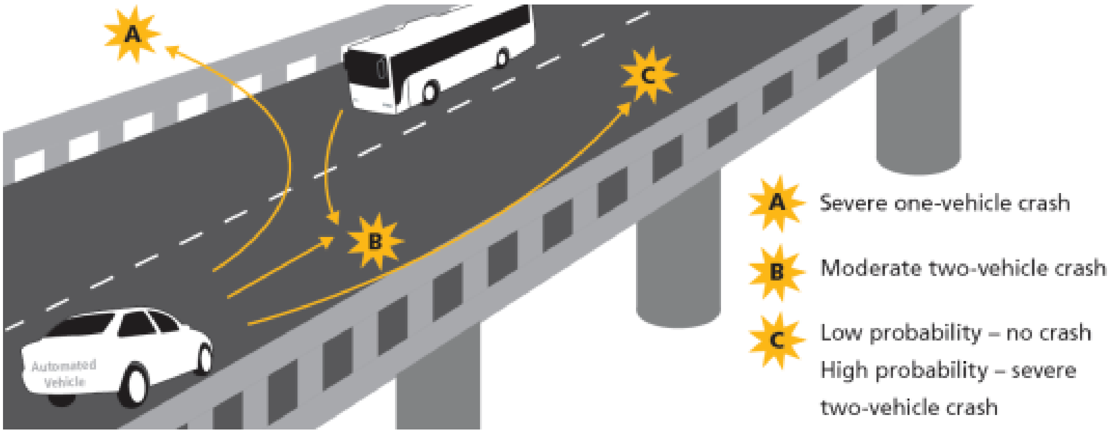

Figure 8 Three crash scenarios AV and a bus (Goodall, 2014a)

These results can only be predicted by the AV and are not certain. The AV his path-planning algorithm needs to estimate fast the possible scenarios and outcomes of each option, where the feasibility has to be calculated, and the algorithm's confidence in these estimates, whereby the quality of sensor data and other factors will make an important contribution (Goodall, 2014a). At latest, the algorithm must meet the objective function over the range of considered paths and able to decide fast the safest route.

2.5.2 Benefits of AI

Many years already automated language translation is based on rules that are designed and developed through experts. Expected was that language could be based on rules, and later learn the rules and convert to code. Other approach is with algorithms, that is able to study and learn language automatically, without need of formal rules, has reached more success in comparison than the rule-based approach (E. Davis, Norvig, & Russell, 2010). Techniques like this are known as artificial intelligence, by AI as stated earlier (see Section 2.3). One benefit of AI is that decision making can take place during autonomous driving. As AI is equipped to perform the same functions as a human driver, this makes AI very useful for the decision-making part during autonomous driving. Language translation provides an appropriate analogy for ethical systems. In both areas, AI methods are useful when the rules are not possible to articulated.

By observing methods based on artificial intelligence have the potential of learning human ethics, due to observe human actions or by rewarding them for their own moral behavior. Computers can detect the components of ethics by themselves, without the need of a human to know exactly why an action is or isn't ethical (Goodall, 2014a). Wallach and Allen were referring to AI techniques as "bottom-up" approaches, that exist of genetic algorithms, connectionism, and learning algorithms (Wallach & Allen, 2009). Therefore, the usage of AI in vehicles must always be verified and tested if the conditions are fulfilling the requirements that are defined for the need to integrate vehicles in traffic in all circumstances, as bad weather, cities or during road work and roads are closed.

Artificial neural networks, are using layers of nodes in a connectionist computing approach to detect complex relations between inputs and outputs, to classify hypothetical decisions if they are moral or amoral (Guarini, 2006). Hibbard, pointed to in a formulation of a consequentialist approach to machine ethics, by adding an ethical dimension to machines, a similar method where independent artificial intelligence agents estimated the moral weights assigned by humans. After the study participants were interviewed across a wide range of hypothetical scenarios (Hibbard, 2012). Carnegie Mellon's Autonomous Land Vehicle in a Neural Net, an early automated vehicle project, is using a simple back-propagation-trained artificial neural network by learning itself steering in 2 minutes by observing a human driver (Batavia, Pomerleau, & Thorpe, 1996). A sort of a similar technique is able to use, with much more training data, to know how humans are making decisions in morally question in the area of complex driving scenarios if time is not an important factor. There is a possibility to train a neural network, by an combination of simulation and recordings of crashes and near crashes, feedback of humans can take place in the field of ethics.

Techniques in the area of AI have also a few shortcomings. If the design will not take place careful, there will be a risk, as humans behave rather than what they believe. For example as in a scenario, if a human will choose to push a close driving vehicle into oncoming traffic to avoid his own crash (Goodall, 2014a). One other disadvantage of AI is traceability. Complexity of AI can be large, and artificial neural networks specific are difficult to explain in a understandable way how decision making is happing on basis of data input. There is already anecdotal evidence found of computers, that indicate relationships in science, that researchers are not able to understand (Arbesman, 2013). There are relations available that are incomprehensible to humans, that are hidden in gigabytes of data and linked within an artificial neural network. Bostrom & Yudkowsky (2014) stated that opaque systems that not are able to inspect, are unpredictable, and manipulation can be easy done.

The use of a decision tree is to create transparency, that another type of deontology is. The chance of manipulation is important in the field of road vehicle automation. Although ethics mean that all humans should be given equal value, from the view of a vehicle manufacturer there is an incentive to build vehicles that will protect its own occupants as first. We may expect that vehicles are able to operate autonomously in traffic at least at circumstances we have now in the field of regulation, and were AI can assist during the operation of driving the vehicle. As AI approaches are allowing computers to learn human ethics without the support of humans, in case of difficult tasks of articulating ethics as code, they produce actions that will not be possible to justify or to explain in an understandable way. When training will take place with a small data set, AI can teach behavior that is completely unintentional and unwanted. When further testing will not take place, AI approaches cannot be advised to be used for automated vehicles without rules that are designed by humans, this is needed to increase transparency and to prevent that unethical behavior will take place (Goodall, 2014a).

2.6 Insurance

2.6.1 Customer information

In reference to the aspect responsibility, during accidents with autonomous driving, insurances companies may have a key role in the future when it comes to responsibility. There are suggestions to shift this responsibility complete or partly to insurance companies, and not to the owner or the manufacturer of the vehicle. Therefore, in this section the impact of autonomous driving from the perspective of the insurance companies will be explained.

The way insurance companies will offer their vehicles insurance products will be changed with come of AVs. Their risk models will change and insurance companies will be able to use different methods to receive data of their customers. In the begin there are more accidents expected between AVs and traditional, manual driving vehicles (during the mixed traffic period). Later when AVs will be more presented in traffic the number of accidents will decrease.

Mostly insurance companies are interested in customer information to verify the risk level associated with the customer or to collect other customer insight. The collection of customer information must be take place in ethical responsible manner, therefore should be decided which information an insurance company is allowed to collect. Based on the type of insurance chosen by the driver/owner different types of information can be interesting for insurance companies. For example; the insurance risk in case of an accident can be derived from driving behavior of a person, a risky driving style or not a risky driving style, and information about the location of the policy holder regarding theft insurance, some regions are considered calculate as more risk full, so there is chance of more or less theft risk for specific vehicles (Maurer et al., 2016).

To gather this information from customers, seems to have benefits, as in first place this will stimulate cost reducing behavior, on the other hand it means that customers will be under more surveillance, without reasons and explanation of the associated risks and opportunities. Most insurance companies are making decisions based on a score system or details that are unknown to customers, these specific data about customers are considered “trade secrets”. Insurance companies want to keep that confidential, as protection in a very competitive market, and thereby gain a competitive advantage (Maurer et al., 2016). Therefore, it can be that a customer will be surprised about the outcome of a decision, for example in the rejection of an upgrade of a contract or a fee raise.

Nowadays insurance companies are already interested in information of behavior of customers. AVs and the connection to the internet and the growth of data will result in more data being available. The usage of data must be done in ethically responsible manner, for example when insurance companies use it for calculation a monthly premium. Therefore, restriction of data being allowed or not to be collect by insurance companies is important. Policies need to match defined requirements in the future with the come of AVs.

2.6.2 Responsibilities and liability

In the current situation of technical and legal development, the human driver is still needed. In the current state, liability regimes are covering the need for vehicle driving. With the coming of autonomous driving, there will be some gaps in the liability regimes, that need attention, rules and policies will have to be adjusted (EUROPEIA, 2017). By shifting the liability in case of vehicle accidents from the human or owner of a vehicle to the manufacturer of an AV, there is a possibility that this will have a negative impact on the development of AVs (Lohmann, 2016), (Marchant & Lindor, 2012), (Anderson et al., 2014), (Garza, 2011), (Schellekens, 2015).

The vehicle manufacturer Volvo had already stated that they will accept the full liability, in case one of its vehicles will be involved in an accident during driving in the full autonomous mode (Gorzelany, 2015), (Branman, 2015). Nevertheless, such an inhibiting effect of liability law should be considered, more important will be that the victim of an AV accident is not worse than a victim that is involved during a conventional vehicle accident. In that scenario, a first-party insurance regime is helpful in order to prevent that the victim of a collision with an AV is not confronted with questions about proving guilt from an involved party (Schellekens, 2015), (Van Wees, 2016), (De Schrijver & Van Fraeyenhoven, 2016).

Compensation to victims will processed via the insurance company, thereafter the insurer can take recourse against the another party. If this becomes the case with the advent of autonomous driving, then autonomous driving will be a lot safer than now with conventional vehicles, controlled by humans, this will be attractive for insurance companies to insure such a new technology. In that case the risk of accidents would be less in comparison with the risk of an accident with a conventional vehicle. The unknown risks of the new technology could be offset by the lower accident risks. If the numbers of accidents will decrease with vehicles, insurance companies can offer lower premiums to their consumers (Anderson et al., 2014), (Anderson, Heaton, & Carroll, 2010)

Responsibility of the manufacturers
Another thought that is present regarding liability, is that the autonomous technology manufacturers should be liable during most accidents when the vehicle is operating in an autonomous modus (Marchant & Lindor, 2012). If an accident will take place when the vehicle is in autonomous mode, it will be probable that the technology of the manufacturer is failing, as the technology was managing the vehicle and not the driver self (Gurney, 2013). There are situations that the manufacturer will not be liable or should have its liability reduced.

In general product liability its primary purpose is to make sure that manufacturers are delivering reasonably safe products to the market, and that the manufacturer will be liable for harm caused by defective products they offer (Shea, 1963).

In case the algorithm is written by the manufacturer, is the expectation that they are also responsible for the integrated technology into the vehicle (Gurney, 2013). By leaving the liability at the manufacturers, the result will be that they need to constantly improve and update the algorithm, in order to make sure that the safety of the AV will increase. This way the manufacturer will have a driving force to update their algorithm. A plaintiff can ask the manufacturer to update the algorithm to solve an error, that would not be easy to do, and it may be very expensive for a plaintiff to prove taking into account expert testimony and the complexity of the lawsuit (Graham, 2012).

From the perspective of courts to ensure the safety of AVs, would be to hold the manufacturer liable in case of accidents that are taking place when a vehicle is operating in autonomous mode.

2.7 User Acceptance

2.7.1 Social Acceptance

The social acceptance of fully automated systems is currently low. The main reason is that there are a lot of reports that are written about a lot of failures in the area of autonomous driving, with electronic and mechanical components of vehicles. Also there is fear for data connections that can be unstable, and that data connection will be necessary during driving.

Therefore, there is a need that AVs must be included with reliable software (artificial intelligence), to react during all possible scenarios, for example when humans and animals are available on the roads (Maurer et al., 2016). Also judging from a legal perspective, autopilot systems outside of factory grounds is a new area. The AGT (automated guided transport) and AGV (automated guided vehicles systems,) that are already used, are handled according to the Machinery Directive, with strict safety concepts for vehicles and drivers. It will be required that new laws or adjustments to the existing legal framework will be realized (Maurer et al., 2016).

By using AVs in road traffic would require the abolition of the legal restrictions as defined in Vienna Convention on Road Traffic. This conventions mentioned that a driver of a vehicle always must be able to take control over the vehicle. There is already some progress on this development going on at the moment in the United States, where the law has been changed to allow deviation from the rule/requirement that as the system can be overridden or turned off by the driver of a vehicle (Maurer et al., 2016). If this legal change will be also accepted in Europe, that will mean that there will be a superordinate actor that always will have the option to intervene in controlling the vehicle.

In several other areas, as rail maritime and air traffic systems are already developed, designed and used on this way. In case of rail and air traffic the use of superordinate actors is already accepted. Such an actor is not created yet for road freight transport.

For the social acceptance of AVs there are a lot things to do yet, in particular, it is important to properly regulate the legislation on this so that the application and actual use of AVs (fully automated) can take place, this can be results in a more quickly acceptance to take place (Maurer et al., 2016).

2.7.2. Technology Acceptance Model (TAM)

TAM, is originally derived from the Theory of Reasoned Action (TRA) from the authors Fishbein and Ajzen (Fishbein & Ajzen, 1977). The central argument of TAM is that perceived usefulness and perceived ease of use are the determinants of behavioral intention priorities for the acceptation of a technology, where the aim is the antecedent of the actual use (F. D. Davis, 1985). UTAUT is based on TAM theory and further elaborated, combined with singular acceptance models into a comprehensive one (Venkatesh, Morris, Davis, & Davis, 2003). The purpose of technology models as TAM and UTAUT, shows which factors influence people's intention to actually use a product and proposes that perceived ease of use and usefulness of a technological tool determines the extent of consumer acceptance.

Venkatesh is introducing in this model for the use of system two factors, the factors introduced by him are "facilitating conditions" and "behavioral intentions". For the behavioral of intention, the definition of determinants are as follow "performance expectancy", "effort expectancy", and "social influence", by Venkatesh, as shown below (Venkatesh et al., 2003).

A. Performance Expectancy: "is the degree to which an individual believes that using the system will help him or her to attain gains in job performance."
B. Effort Expectancy: "is the degree of ease associated with use of the system."
C. Social Influence: "is the degree to which an individual perceives that important others believe he or she should use the new system."

UTAUT is considered as a robust support tool, used for explanation of user perception and acceptance behavior and applied on an individual level. In several studies this theory is described, and in general commonly integrate as Information Systems and Internet applications, within organizations, like mobile banking (T. Zhou, Lu, & Wang, 2010), e-government sources (AlAwadhi & Morris, 2008) and information technology regards concerning health (Kijsanayotin, Pannarunothai, & Speedie, 2009).

Despite this being the case, UTAUT is not broad tested on a wide range in the research of factors that can influence the acceptance of automated vehicles (see Table 2).

Theoretical frameworks (summarised) and analogous methodological tactics.

Conceptual frameworks	Sociopsychological construct Attitudinal and intended behaviour models	Related to discounting Cost	Economics Cost	Selected other UTAUT
Methodological approach	Attitudinal survey, experimental and activity analysis	Stated preference surveys (contingent valuation choice experiment)		Ethnographic interview

Table 2 Theoretical frameworks and analogous methodological tactics (Adnan, Nordin, bin Bahruddin, & Ali, 2018)

In table 2 are shown the theocraticals frameworks and analogous methodological tactics. Research in the field of autonomous vehicles has shown relations between these two objects, in the direction of technology implications and user functions. Howard & Dai (2014) have illustrated the preferences of the technology that will change the variables of autonomous vehicles, while Payre et al. (2014) had addressed some more factors in relation to the theoretical acceptance of the transport mode, which represented the attendees interests well.

In 2016, Hohenberger, Spörrle, & Welpe (2017) did research to the effect of gender on the respondents, regarding the use of AVs. In the study of Hulse, Xie, & Galea (2018) there is attention on several type of consumers, by classifying perceptions into a few demographic categories, as age and gender. The paper was stating that younger male groups will accept new technology sooner as they are more open and willing to take risks in trying new features.

In Kyriakidis et al. (2015) is mentioned that men are less worried about failures of automation systems in comparison to women, yet men are more aware of the potential liability risks and problems. In the study of Bansal & Kockelman (2017), the conclusion is that older people are less willing to pay for AVs. This can be clarified as they are probably less willing to learn to use them due to trust issues.

People that have higher incomes have more concerns about the liability issues, challenges and questions in regard to control issues, in comparison with people with lower incomes. People with lower income are more worried about safety and control issues (Daziano, Sarrias, & Leard, 2017), (Schoettle & Sivak, 2014a). For both higher and lower-income people meanwhile the costs are an issue (Begg, 2014). Nevertheless, people with higher income are more willing to pay for their future vehicle, and they are also more interested to purchase vehicles with automated driving systems (Kyriakidis et al., 2015).

Kyriakidis et al. (2015) mentioned also that people that are already using cruise control during driving in their conventional vehicle are potentially more interested to purchase an AV. Regardless of the point that they have trust issues with automated driving features. Also some studies are mentioning that the driving experience of the user regarding the driver assistance systems after actual experience with the systems are positive (Adell, 2010), (Brookhuis, De Waard, & Janssen, 2001). Several studies have attention for the psychological aspect of users to gather information about the acceptance level of AVs. An other aspect that is observed is sensation seeking, that is associated with a willingness to engage in risky behaviors, such as risky driving and speeding.

Drivers that are searching for pleasure sensation, are more likely to drive faster, keeping less save distance to other vehicles and are braking generally heavier (Cho, Park, Park, & Jung, 2017), (Geldmacher, Just, Kopia, & Kompalla, 2017). For this group the AVs will not a pleasure, and they will not prefer to use it, because they are getting more pleasure by controlling vehicles them self. The proposition of trust, is one of a major factor to influence and support the acceptance of AVs (Adnan, Nordin, & Rahman, 2017), (Choi & Ji, 2015). Bazilinskyy, Kyriakidis, & de Winter (2015) can relate to this, and mentioned a segment of the population that doesn't trust AVs, and prefer either manual operated vehicles or partly automated driving instead of a fully automated driving vehicle.

A high level of trust is one of the major obstacles that needs to be surpassed for the community in the acceptation of AVs. In a different study about the user acceptance of autonomous system, from Osswald, Wurhofer, Trösterer, Beck, & Tscheligi (2012), the Car Technology Acceptance Model (CTAM) is developed. This can be seen as an extension of UTAUT. This study introduces some other attitudinal constructs like anxiety and safety. The paper is notifying the impact of factors on behavioral intentions concerning the technology. In Adell (2010) there is attention for the user acceptance in the area of driver assistance support function.

The results are supporting the use of UTUAT, and both “performance expectancy” and “social influence” determinants appear to influence intentions regarding the use of the system. Nevertheless, it’s not the case for “effort expectancy”. However, it is interesting to mention that the model can only explain 20% of the variance in behavioral intentions. This is quite low, if it will be compared with an average of 70% variance in adoption intention of IT technology from an organization perspective (Venkatesh et al., 2003).

In the next section the methodology will be explained that will used to see which elements are important from a perspective of the community in the field of autonomous driving. Random participants of the community, will be interviewed. Their opinion will be collected to see what’s important for them and what will influence their acceptance of AVs.

3 Methodology

In this section, the methodology will be explained that will be applied in this thesis. As first will be focused on data gathering. The purpose with the collected data is to answer the research and sub questions, in the next subsection Data collection 3.1 is mentioned how this will take place. In subsection 3.2 Data Analysis will be mentioned after the data is collected how the data will be analyzed to come to the results. In the last subsection Research implications 3.3, there will be attention for the implications and these will be discussed further in detail.

3.1 Data collection

For this thesis research, the data collection part consists of two phases, during a time of 1,5 month. During both phases, in which each phase had different target groups, interviews were held to collect the needed data. The data that is collected during the first phase is related to information for answering the research and sub questions. In the second phase, interviews were conducted with experts in the field of autonomous driving, to validate the data from the first phase, and to verify possible answers of the research and sub questions. The data collected from the interviews and the literature that is used for this research together, forming the data collection of this thesis study.

3.1.1 Community interviews

The first phase of the interviews (see Appendix E), the interview questions have been added to the appendices, for this research will there be performed interviews with 25 participants. Random participants as family, friends and colleagues will be asked for this exercise. The duration of the interview were around the 20 - 30 minutes with each participant. For the interviews of the first phase the focus was more on younger people. The audience were participants from 25 – 45 year that were interviewed. The reason that not people from all ages were interviewed, is to get a representative result. To get a sample from the whole population would be very time consuming and will be too large for this research study. Also, a reason to interview this group of audience is that the younger people are more interested in new technology as autonomous cars, and they use new technologies more often during daily activities. Further this audience is selected as the chance is bigger that younger people in the future, when autonomous vehicles will be available with SAE level 5, will use AVs by themself or get in contact with AVs than older people.

Moderators

For this research technology acceptance is an important part, as autonomous driving is a technology that is new and in full development currently. The model that is related and will be used for this research, is he Unified Theory of Acceptance and Technology Use (UTAUT) (Venkatesh et al., 2003), (Venkatesh, Thong, & Xu, 2012). This was also earlier mentioned in subsection 2.7.2. Technology Acceptance Model (TAM), there are four moderators that are important during technology acceptance:

- Age
- Gender
- Experience
- Voluntariness of use

The focus of this research are people that have the age between the 25 and 45, were the purpose was to select as participants 50% men and 50% women. In the selection of the participants it was required that they were in possession of a valid driving license, affinity with AVs was not mandatory, preferred was that the participants were open to new techniques and technology in general.

In the table below presented the condition of the four moderators for this research:

Moderator	Condition
Age	25-45 years
Gender	Men 50% and women 50%
Experience	No experience needed with AV's. Driving license required
Voluntariness of use	Open to new techniques and technology

Table 3 Condition moderators

For the research is specifically chosen for participants that are in possession of driving licenses, because the chance is bigger that they will accept autonomous driving earlier, as they have already driving experience and knowledge of the vehicles from nowadays.

Despite the groups without driving licenses could also be an option for participants and interesting to interview, but due to a strict separation between this group there is chosen to only selecting the group that having a license. The participants are random selected, fellow students that are following the program ICT in Business at the University of Leiden, colleagues at work, friends and families. This can skew the results as the audience is broad selected. During the selection of participants, the affinity with vehicles and the readiness for change in mobility is taking in account.

For this research is chosen for community and expert interview, together with the literature study as method, to collect information to answer the research and sub questions. During research in the field of (technology) user acceptance, its preferred to have a broad generalization instead of a more deep and specific research. Therefore, to find elements that are leading to user acceptance it's recommended to make use of questionnaires or the surveys technic (Jonker & Pennink, 2010).

During the interviews the aim is to search unidentified elements that are missing yet in the research to fulfil the research and sub questions with the right answers. Therefore, for an open character of the interviews is chosen with open-ended question structure (Jacob & Furgerson, 2012). The idea behind the open interviews is that participants will be encouraged to deliver influencing elements at their own input, instead of selecting from a prefilled list with options of elements.

This is to avoid that the participant will be influenced by elements that already are given, which can lead to prejudice among the participants. Otherwise, the participants that haven't created a mental view of AVs can be influenced by the structured questions.

In Payre et al. (2014) is this mentioned as example, in the article is stated that a quarter of the variance in acceptance by the interest in impaired driving, this element is not playing a prominent part in other literature.

In Maurer et al. (2016) is mentioned that impaired driving can be maybe an important element, this can also be the case due to idiosyncrasies in the questionnaire, where the chance exists that this can lead to invoke a bias of the feedback of the participants. Therefore, an overview will be given to the participants at the end of the interviews, with elements that were found, to avoid that it will lead that participants will be influenced about their feedback during the open questions.

In the list at the end of the interviews, participants were asked to select 5 elements, based by ranking the most important, to create a better understanding of elements that were not covered during the interview. The outcome of the list with additional ranking of the interviewers are to verify and confirm the outcome of the open questions, and to make sure that the participants haven't overlooked elements that can be more important for them, to detect a lack of awareness of important elements of the participant.

Afterwards the participants were not asked if their opinion was changed, or that some elements were unknown. In case the participant asked this specific, or their vision was different, there was off course a new possibility to go over the open questions again.
The aim and the expected result of the first part of the interviews and the additional list on the end of the interviews is that the research question can be answered:

How will AI technology influence social acceptance and decision-making by accidents during autonomous driving, and which ethical dilemmas will this cause?

Also, the interview participants were asked about their opinion of acceptation by decision making through artificial intelligence and how they see this with the ethical dilemmas that will occur by decision making on this way.

The main goal is to find an answer on the research question. After analyzing the answers given on questions of the participants the purpose is to find answers on the sub questions:

1. *What are the characteristics of autonomous driving?*
2. *Which different ethical dilemmas are already under attention?*
3. *How are ethical aspects and user acceptance correlated?*
4. *How will the user acceptance be influenced?*

The responses of the participants during the interviews will be based of suggestions done by the participants and will be taken as basis to form the conclusion to give answer on the research question.

Validation
The interview questions were first tested before the interviews with participants took place. Therefore, three test phases were organized and where needed the interview questions were adapted to improve the quality of the set of questions. The outcome of the test is used to verify the questions and collected data or that more tests and validation were needed.

3.1.2 Expert interviews

The second part of the research study, are also interviews with a different audience and will be otherwise organized than the first interviews. In the appendices letters are attached with the outcome of the expert interviews. In this second round of interviews 2 experts will be interviewed in the field of autonomous driving. The results, after conclusions has been drawn from the first interview round, will be discussed with the experts. During the interviews, the elements that were found will be discussed with the experts. Whereby also the dilemmas that will occur during accidents based on artificial intelligence decision making will be shown to the experts. Feedback will be asked from the experts and their thoughts about the situation of the presented conclusion and the defined ethical dilemmas. The experts were asked about their opinion of the conclusions of the first round of interviews. In addition was asked which dilemmas they will think will occur with the come of AVs, and the best way to solve them according to the experts. Also the experts was asked which contribution the experts have delivered to the defined research and sub question or other elements in the field of self-driving vehicles. The results and conclusion of the expert interviews will be compared to the outcome and conclusion of the first interview round for extra validation and will be verified against the defined research and sub question. Estimation of the expert interviews will be around the 1 hour, as first will be started to present the findings of this study and the first interview round.

The reason why is chosen for semi-structured expert interviews to have a discussion with as guideline the research topic related to the research and sub and other key questions of this research, was that experts were able to give direct response. For this research it’s better to get direct feedback, and to have a more in-depth conversation instead of Q&A’s. For the interviews there are a few main questions prepared in order to have a guideline during the conversations. There was enough space for further discussion.

During the study there was specific chosen to held expert interviews, as the experts that were interviewed, are working on a daily basis on topics of autonomous driving. The experts are involved in their work area, with the ethical dilemmas of autonomous driving and the technology behind self-driving vehicles. This means that they have a broad knowledge of the topics that are related for this research. Therefore, the feedback and input of the experts is valuable for this study, also to verify with them earlier findings of the literature study and expert interviews.

Benefits of semi structured interviews with the experts are the possibility to have an in-depth conversation with the experts, to verify assumptions directly, specific questions could be asked and research gaps could be discussed. Also it is beneficial during the interviews to have the opinion of an outsider that is experienced in the work field of autonomous driving and ethical dilemmas.

3.2 Data analysis

3.2.1 Community interviews

The interviews could not always be held on location, therefore some interviews took place via a video conference call. With software, during video or mobile phone during physic interviews and permission of the participant the interviews were recorded. Afterwards the interviews were summarized and delivered to the participant as a reference of the interview. The elements of the interviews were processed in a table for a better overview and are used to code the interviews. Were the setup is, that the chosen elements will be count on basis of the feedback of the participants. Beside the space for some open topics, of elements that were less addressed or not could discussed more in detail. As the chance is that they will be important for the study as they are may not mentioned during the interviews or other parts during the research. Nevertheless, the feedback of participants that were not that familiar with autonomous driving should not be underestimated and taken seriously. As sometimes the participants that are not that familiar with the subject area can bring up some important elements that needs attention and can support to clarify the defined questions and dilemmas. At the end of the interviews an overview of the results was given to the interview participants as summary and for verification of the outcome meets their expectations.

3.2.2 Expert interviews

Expert interviews were executed the same way, recorded with smartphone or computer software if the meeting was a video conference call. During the interviews the focus was, to follow the experts during the conversation and to detect the body knowledge of them to see if they understood the questions correctly, to avoid misunderstandings. Side notes were made if needed, in case of important information during the interview. With the recorded information, a summary of the interview was created and afterwards sent to the expert for verification and validation (see Appendix: F). The summary of the interview is also the result in the form empirical data and was used to refine an form the conclusions of the first interview results.

3.3 Research implications

In this section of the thesis the implications of this thesis research are described. For the gaps found during the literature reviews, additional data will be searched, data collections methods are defined to investigate what is missing to fulfil these requirements.

The criteria that influence the social acceptance during accidents with AVs, that are not found during the literature review will be researched through interviews with open end questions, the result of the interviews will be analyzed and verified, and these inputs will be the basis for the second interviews with experts where there will be asked for their opinion by performing open questions and verifying the conclusions from the first interview round.

The results, from the methodology as described in this chapter will be presented in the chapter results of this thesis (see Section 4).

For the interview with participants and experts was chosen for semi-structured questions. This was to bring the knowledge together that was gathered during the literature study, aligned on the research topic. In order to prepare questions and areas of interest for the participants, community and experts interviews, to fulfill gaps in answering the reach and sub questions. In other methods it is more complex and less complete to allow for a broader conversation. The semi structured method, gives also the possibility needed to explain questions, when things were unclear there was room for more detail. With the diversity of the questions and the information that is required, a semi structured method to organize the interviews with an open character to have a real conversation with the participants was possible.

The outcome of the community interviews was, that most of the participants are open to new technology, and are seeing benefits by using AVs, the part of safety was often mentioned by the participants. One of the remarks was that it has to be safe enough in order to use it. The topic more related to the ethical side in relation to the dilemmas the answers were more divided of the participants, the questions about decision making were most times an eyeopener, that accidents with AVs, are coordinated by systems and maybe decisions before an accident needs to be take place by an system. Also the information about the AVs, safety, self-learning, communication were topics that often were addressed. During the mixed traffic period there will be communication between self-driving vehicles and vehicles coordinated by humans will interact together.

The outcome of the expert interview was the purpose to verify the outcome of community interviews. The conversations with the experts were interesting and the outcome of community interviews, the knowledge gathered during the literature study, allowed for interviewing the experts on an open manner, useful and of added value for the research.

The outcome of the interviews with the participants and experts has a relation with the ethical dilemmas as earlier stated in section 2.1.4. The outcome of the interviews have a strong connection with the earlier mentioned ethical dilemmas. The ethical dilemmas discussed are:

- Responsibility
- Safety
- Control
- Information

Responsibility
As for the participants the responsibility was often mentioned, who can we hold reliable? Also it should be known what to expect from who.

Safety
Safety is one of the aspects that was mentioned and often referred to by all participants.

Control
Control of the vehicles, in case of accidents without software problems operating and in case of violations and hacking was also often discussed with the participants.

Information
That enough information is available to operate the AV to the destination was often referred to. Most participants were not that scared for their privacy. Most participants were also seeing the benefit of a lot of data is available, and when vehicles would be connected, it would give each other an improved driving quality in general.

In this section the methodology for this thesis is explained, in the next section, chapter 4 Results, will present the outcome of the community interviews that were held.

4 Results

In the previous section, chapter 3 Methodology, the methodology explained was applied to this thesis. In this section the outcome of the community interviews will be analyzed. The elaboration of the community interviews are attached in the appendices (see Appendix E).

In subsection 4.1 the perspective of the participants will be discussed and in subsection 4.2 the discussion will be described from the technology perspective. In section 4.3 will be discussed the outcome of the additional table of most interested elements chosen by the participants, the area of interest of the participants and finally, in section 4.4 the validation of the interview results.

In the first part of the interviews 25 participants participated during the interviews to give their opinion of autonomous driving and ethics. The participated were 12 females and 13 males, all with the Dutch nationality. All the participants that were interviewed, were in possession of a driving license. The participants were between the 25 and 45. The average age of the participants was 32, 36 years, with a median of 35 years old. Before the interviews were held, the questions were tested and adapted for a proper alignment to define the right questions for this research.

The responses from the participants of the interviews are summarized in table 51. With coding elements, the feedback is presented in the table below (see Table 4). The elements of interviews are structured and clustered in two types: Participants & Technology perspective. The results of the elements were created after clustering of the feedback of the participants, and statements were defined to explain the feedback on a understandable method for this thesis.

Type	Sub type	Code
General knowledge AVs and ethics		GKAE
Social acceptance		SA
	Artificial intelligence	SA1
	Decision making	SA2
Technical safety		TS
	Safety fallback plans	TS1
	Prevention of threats (e.g. cybersecurity threats)	TS2
	Testing on the road without harming humans	TS3
Responsibility and risks		RBR
	Decision-making and risk allocation process	RBR1
	Implementation of decision making	RBR2
Human agency		HA
	Human’s possibility to override	HA1
	Processes that can enhance human agency	HA2
Privacy & data governance		PDG
	Data collection	PDG1

	Data sharing third parties	PDG2
Responsibility, liability & accountability		RLA
	Regulations changes on product liability	RLA1
	Extension of traffic laws	RLA2
	Transparency investigation of an accident	RLA3
Non-discrimination & inclusiveness		NI
	Incorporation of biases in systems	NI1
	Needed features for accessibility and inclusiveness	NI2
Societal & environmental wellbeing		SEW
	Increase societal and environmental benefits	SEW1
	Safely integration during mixed traffic	SEW2
	Infrastructure development	SEW3

Table 4 Clustering feedback participants

4.1 Perspective participants

First the personal elements of the participants of autonomous driving and ethics will be looked into. The elements will be compared and the differences between the characteristics of the participants will be investigated.

In section 4.2 Technological perspective, there will be a discussion between the pros and cons, that also differs per participant. Can be seen in first place as the characteristics that belongs to the technology. Some of the elements that were discussed during this chapter can be seen as benefits or detriment, depending on the opinion of the participant.

In Payre et al. (2014) is mentioned that the interests of participants is an import part to take into account during research. During the selection of the participants to interviews, this is taken into consideration when participants were selected. That are quite interested in technology in general. The interest of participants was verified by asking the participants to their willingness to interview them and their general interest in technology.

In Payre et al. (2014) is age also mentioned as important element. By interviewing the selected audience group this will give in general a basis to understand the view of the community for this research. Not all age categories will be compared. In future research this can be done by comparing the results with other groups. The importance of some identified elements, as reliability (Maurer et al., 2016), will be verified, their reason and importance will explained more in detail, by providing reasons why the element is mentioned, as during the research was concluded that this element is important after outcome of the questions.

4.1.1 General knowledge

The interviews started with a short introduction. The first question that was asked was about their general knowledge of autonomous driving. This question was directly raised to the participants instead of identifying it via an open question.

This information can play a significant part for the identification of the opinion of the participants about autonomous driving and ethics. All the participants answered the question, 25 times feedback was given on this question. In most cases the response was that they have general knowledge of the topic. They heard about it, read about it and some of them saw some videos. All 25 participants indicated during the interview that they know a bit about autonomous driving.

The statements in the table below are indicating this with responses done by the participants.

Statement	Participant
I have read something about autonomous driving, and then fully autonomous driving.	**4**
I saw on the television a documentary of AVs.	**24**

Table 5 Knowledge autonomous driving

All of 25 participants responded that that they know about Tesla and the possibility of self-driving. Most of the participants saw some videos on the internet. Also, all 25 participants are familiar or are using, driving assistance as lean assist and adaptive cruise control.

The next statements are representing this with the responses of the participants.

Statement	Participant
I'm familiar with lane assist. We have since last year a new vehicle and in begin we were new with it. Now we are using it often.	**8**
I'm using the feature that the vehicle can park itself.	**21**

Table 6 Familiar with driving-assistance

Looking at the responses, most of the participants are quite aware of the topic autonomous driving, with SAE level 3 or higher. Most participants know a bit or heard about it.

4.1.2 Safety

When it comes to safety, most participants mentioned this as the most important part of the transition to autonomous driving. The participants had questions like, if the technology in combination with AI will be well enough prepared that it will be safe enough. What will this mean for the regulations that needs to be changed, who is in control during driving and when? Is this continuous the vehicle or human driver or a combination?

This part was mostly discussed during the open part of the interviews 24 participants stated that safety is an important aspect. Below a few statements that refer to the responses of the participants in the area of safety.

Statement	Participant
I think autonomous driving will lead to less accidents in the future.	**1**
Safety is for me the most important aspect in reference to autonomous driving and AVs in general.	**4**
I know something about driving assistance, as lane assist. And that different manufactures are working on the possibility to drive autonomously, where safety is important. I think autonomous driving will take some time before it will be introduced, safety is one of the aspects that this will take some time.	**5**
I think the point of attention in total development of autonomous driving must be safe.	**6**
Safety is the most important aspect for me of autonomous driving.	7
I saw a program about autonomous driving where the front seats were turned around to the back seat, I thought that will be a bit scared. I don't know if I would do that.	**8**
I have seen at TU Delft University that they were working on safety aspects of autonomous driving.	**9**
I'm known with driving assistance as automated breaking.	**10**
It will be a bit scared to give the control to a vehicle or a system in general in begin. This needs time before this will be accepted.	**12**
I see more benefits for autonomous driving on the highways. As there it can be taken safe place. So, I'm for the short-term sceptic about fully autonomous driving.	**15**

Table 7 Importance of safety

The mixed traffic period was also mentioned a few times as a challenging period. In special is mentioned the safety of driving, and how this will not interrupt the flow during driving with manually driven vehicles (MVs) and autonomous vehicles (AVs). From 23 participants that were referring to the mixed traffic period, 20 participants mentioned safety as a challenging part for the introduction of AVs.

In the table below statements of the participants, with the responses of the participants about safety related to the mixed traffic period are grouped together.

Statement	Participant
We need to make sure that it will be work together autonomous driving and manual vehicles.	**2**
Verbale communication will be not possible anymore with AVs as we are doing now.	**3**
That will be a challenge during the mixed traffic period. I expect, that both type of vehicles need to interact with each other in traffic.	**9**
I read something about the mixed traffic period and interaction between manual and AVs.	**10**

Tesla is using it already at the moment. Before SAE level 5 during the mixed traffic period will be introduced the functionality will be step introduced by step I think	**12**

Table 8 Safety related to mixed traffic period

Safety was mentioned a few times in response to the question, "Which aspects are for you important to use in the future an autonomous vehicle"? During that question safety was most times mentioned. In below table statements that are representing the responses of the participants. 22 participants mentioned safety as important aspect before they will use AVs.

Statement	Participant
Very important that it will be safe, as we will rely than full on the vehicle.	**2**
Very important, that this will be safe before I will use AVs in the future	**4**
It will be very important for me that the vehicle will be safe. Only than it will be possible to rely and trust on the technology that is related to AVs	**6**
For me it's important that there will be so less as possible damage during accidents.	**7**
Safety will be important, and I have trust that AVs will be safer to use. Also, during long rides, and in the night.	**8**

Table 9 Aspects to use of AVs in the future

Ethical issues that will arise, and the relation to the safety to use AVs was also a few times mentioned as important. In the beginning trust of the AVs will take time. The more people will use it the faster the numbers will increase of AVs. Ethical issues and safety of the AVs was mentioned 20 times by the participants. In the table below statements of the participants are presented rely on their response.

Statement	Participant
I think autonomous driving will be regulated, speed i.e., that there will be less accidents.	**4**
How will my safety guarantee, that are all questions that are important during the use of an AV.	**7**
Trust is the most important aspect to use AVs	**9**
AVs must be safe, also on ethical aspects, as we will rely on software by AVs.	**11**

Table 10 Ethical issues related to safety

4.1.3 Privacy & data governance

Privacy was not that much of a topic during the conversations with the participants. Sometimes an additional question was asked what their opinion is about the aspect privacy. Often was mentioned that they didn't have problems with it. In total 8 participants were asked about their privacy during open questions. One of them explained to see this not as a problematic topic. Below statements are referring to the responses of the participants.

Statement	Participant
I think with the delivery of data autonomous driving can be safer take place.	**2**
I see no problem to share my basic data that are in line with the EU regulations for data processing by companies.	**3**
I see privacy as not at that important.	**13**

Table 11 Privacy

8 participants mentioned seeing privacy as something to be careful with and have their concerns how manufactures will deal with the privacy of the consumers. Below a statement is presented that refer to the response of a participant in the area of privacy.

Statement	Participant
I'm curious which data they will collect of me. As route information.	**1**

Table 12 Privacy and awareness

The quality of the data was mentioned 7 times by participants. In below table a statement is presented that is related to a response of a participant.

Statement	Participant
For data it's important that it will be useful, and if decisions will be relied on data it must be trustful.	**17**

Table 13 Quality of data

In the question about the importance of data, 7 participants mentioned the usefulness and reliability of data. This can be addressed with the statement in below table, that exists of a response of a participant.

Statement	Participant
If there will decisions rely on data that will be gathered the quality of the data must also be trustworthy.	**22**

Table 14 Use of data

4.1.4 Responsibility & accountability

Also, an interested area during the conversations was the responsibility & accountability. A specific question was asked to participants who they think they is reliable during traffic accidents with AVs.

The following statements were given as response from the participants in the field of responsibility & accountability, in the table are shown the statements of the participants in this area.

Statement	Participant
What for me ethically responsibility is that they will be less as few, or avoid, casualties much as possible.	**1**

I think we cannot avoid that in few cases we need to make unethical decisions. The owner must responsible, as he need to do first research before, he will buy the vehicle. I think in 1st place the owner must be responsible during accidents.	**2**
I will always be focused on the road. Despite the vehicle will drive autonomously.	**8**
We are just consumers, as just in a train or metro. I don't think now also not, if I use public transport, who will be responsible in case of accidents.	**10**

Table 15 Responsibility & accountability

24 participants answered the question, one of them wasn't able to make a choice, because future research was appointed to investigate more in this area before they can decide.

Statement	Participant
I will use at least an AV if more than 50 % of the vehicles are AVs.	**14**

Table 16 Switch to AVs

A few of the participants, 8 in total, are thinking the manufactures must be reliable in case of accidents with AVs.

Statement	Participant
The manufacture is reliable as they are delivering the vehicle. The human is now only a consumer.	**1**
The manufacture is responsible during accidents. As if there are problems the product is not working as expect.	**4**
I see that the manufacture must reliable. As they have the responsibility for the product that they sold. The drivers are only the consumer, that make use of the travel moment that he used to move from A to B.	**5**
From my point of view the driver is the consumer of the vehicle. So, from that perspective the customer must not be reliable during accidents.	**6**
We don't have any more influence during driving, so from my perspective the manufacture must be reliable I case of accidents.	**10**

Table 17 Manufactures reliable in case of accidents.

Another part of the participants, 14 are thinking that the human driver must be reliable during traffic accidents with AVs. Below statements given as response by the participants.

Statement	Participant
It's important that there will be broad (international) regulation from manufactures how vehicles will operate in practice.	**1**
In case of technical defects, I see the manufacture responsible, in case this will lead to traffic accidents.	**3**

For technical issues with AVs the manufacture must be reliable. Also, if this lead to an accident. (In case of product faults).	**5**

Table 18 Human drivers reliable in case of accidents

Another thought of 2 participants, was that the insurance can be held reliable during accidents with AVs. That there is no control of humans needed or maybe possible and therefor this can be done by the insurance companies. In table below some statements of the response of the participants.

Statement	Participant
The insurance companies must be held responsible, off course there will be different kind of products as all risk now. But in basis the insurance company see I as responsible.	**3**
The insurance company must be reliable in general during traffic accidents. As they have the most knowledge, f how to handle during traffic accidents.	**7**

Table 19 Insurance companies reliable in case of accidents

4.1.5 Conditions participants (Age/ Gender)

The gender of the participants is one of the elements that can play a role in the acceptance of new technologies. During selecting of the interview participants was to have an equal distribution between men and women. Therefore, 13 men and 12 women participated of the 25 participants.

For the user acceptance of AI, related to decision making during accidents with AVs no patterns were signaled to indicate a difference between gender. The men in general were mentioning more the pleasure experience during driving, that would something they will miss with the arrival of AVs.

In this category, 17 of the 12 responses were men, and 8 of the men stated that the pleasure of driving is an important factor for them, from 2 of them the response was they will not miss it that much and they don't like to travel long drives in vehicles. And 2 participants responded that they see it not as an important factor.

From the women responding, 5 stated that they found pleasure in driving. The other 7 women didn't mention something about driving pleasure specific.

So, in general the men stated more that they enjoy driving and have pleasure of driving vehicles.

Statement	Participant
Driving by yourself would always be something that will be a pleasure for me.	**3**
Vehicles are already changing now, that's also the case with EVs.	**12**
During a long trip driving can also be relaxing. That you have the full control and that you can decide what you will do, as driving too fast or slowly.	**23**

Table 20 Pleasure during driving vehicles

During the selection of the participants, the range was set between the 25 and 45.

As earlier stated in section 3.1.1 Community interviews, the age of the youngest participants was 25 and the oldest participants had the age of 45. The average age of the participants was 32, 36 years old, the median of the participants was 35 years old.

There was no pattern or correlation detected during the research between age and acceptance of technology, with AI and decision-making during accidents. There were some responses of 3 participants, that younger people will accept new technology earlier. The statements below is referring to the responses about that.

Statement	Participant
Younger people are faster in learning and accepting new technologies.	**4**
I'm working with new technologies, as home demotics, compare to my children they are working often with new technologies quit faster as they use it more in daily life.	**21**

Table 21 Accepting of new technology by younger people

4.1.6 Summary feedback perspective participants

In table 22 feedback of the participants perspective during the interviews is given after clustering the related elements. In figure 9 the outcome is shown in a chart.

Elements	No.	Feedback interviews area: Perspective participants
General knowledge AVs	A	How much participants were stating that they know a bit about autonomous driving?
	B	How much participants were stating that they know about Tesla?
	C	How much participants are familiar with driving assistance?
Safety	D	How much participants were stating that safety is an important aspect?
	E	How much participants were mentioning the mixed traffic period?
	F	How much of the participants were mentioning safety as a challenging part for the introduction of Avs
	G	How much participants were mentioning safety before they will use an AV?

	H	How much participants were mentioning ethical issues and the safety of Avs?
Privacy & data governance	I	How much participants were asked during open questions about their privacy?
	J	How much participants were explaining to see this not as an important topic?
	K	How much participants were mentioning they see privacy as something to be careful with and have their concerns how manufactures will deal with the privacy of the consumers?
	L	How much participants were mentioning the quality of data?
	M	How much participants were mentioning the usefulness and reliability of data?
Responsibility & accountability	N	How much participants did answered the question, who is reliable during traffic accidents?
	O	How much participants do not made a choice?
	P	How much participants were mentioning the manufacture must be reliable?
	Q	How much participants were mentioning that the human driver must be reliable during traffic accidents?
	R	How much participants were mentioning that the insurance company can be reliable during traffic accidents?

Table 22 Feedback interviews perspective participants

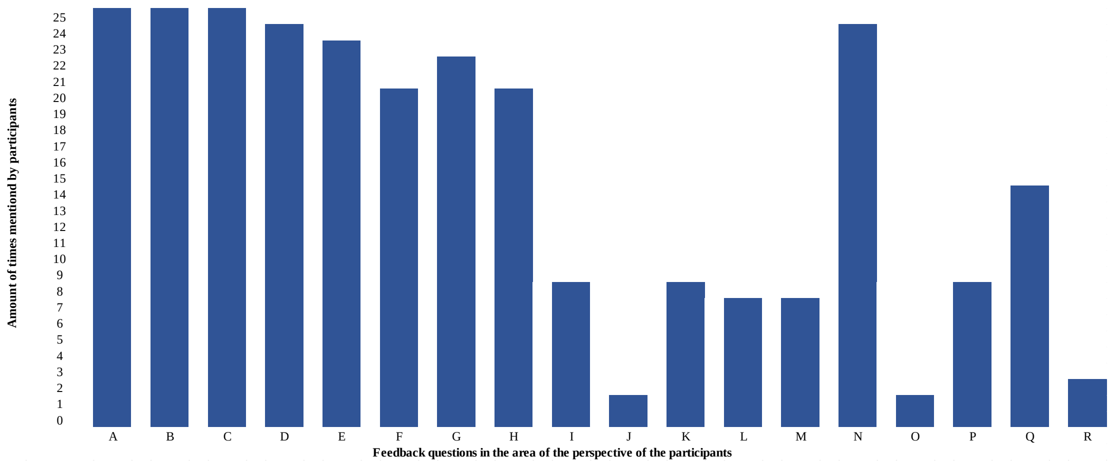

Figure 9 Chart perspective participants

4.2 Technological perspective

This section describes the responses for autonomous driving and ethics, in relation with the use of AI, discussed the outcome of the interviews. As in the previous subsection this was discussed from the perspective of the participants, will be in this section the focus on the elements of AVs from a technical perspective.

During the community interviews the input will be based among others on input of the literature study, to had enough knowledge of the field which the interviews were held (Jonker & Pennink, 2010).

For the ethical dilemmas that were stated with the introduction of AVs the literature study is the reference, and compared with the answers given by the participants. From technological perspective will be analyzed which scenarios are playing on the side of the community in the area of user acceptance of AI related to decision-making during accidents, to have a broader research for the interviews, from technical and personal perspective (Jonker & Pennink, 2010).

4.2.1 Artificial intelligence

During the start of the interviews, to the participants was explained what AI means and a few definitions as AI and SAE Levels. By providing them a letter with this information, this was provided to all the participants, that they had all almost the same understanding, to avoid misunderstanding during the conversations.

Most of the participants were curious and are looking forward to the possibilities with AI and AVs. From the 25 participants there were 18 participants mentioning to use AI in the future. From the 18 participants that were interested all 18 responded to take ethics in consideration on a broad scale before AVs can be used and that we can trust the decisions that will be taken.

Statement	Participant
The vehicle must be so safe as possible before I want to use it on the road. This is important for me before I want to use AVs.	**1**
Without AI I think autonomous driving can't succeed.	**2**
It's important that the consumer will be easy to understand what they will buy. This is also for AVs.	**3**
The expectation is that AI will response faster than humans. So, that is optimistic and will be good for the acceptance in general.	**8**
I've read that AI can also be dangerous AI.	**12**
Jurisdiction is not always black or white. The police will give you also not directly a speeding ticket if you drive 53 kmh instead of 50 kmh is allowed.	**18**

Table 23 applying and using of AI

There are different opinions of how AI will be integrated into AVs. There are questions about the liability and what will be moral when it comes to AI and decision-making during accidents. 20 participants were stating ethics in relation to decision-making during accidents with AVs as important. In the following table several statements of the participants who substantiate this.

Statement	Participant
I have trust in the development of AI and think this will create more safety for autonomous driving in general.	**1**
The decision making will also bring a lot of benefits in case of traffic accidents. I expect in most cases we will get more benefits	**3**
I think, this is important if we want to have success with autonomous driving.	**4**
It stays difficult to rely what is ethical in case of decision possibilities how to crash or who to hit.	**7**
I think the system for decision making will be able to act very fast, instead faster than humans.	**9**
The software will be very important in case of decision making, so we need able to rely and trust on the software.	**11**
We are using AI now more as we are thinking sometimes.	**12**
With AI it's also possible to see what was happened in the past, as it's documented as a data set.	**18**

Table 24 AI and decision making during accidents

4.2.2 Decision making

The decision-making part was briefly discussed with the participants, there was a specific question asked about their opinion during the interview, about how they were thinking about decision-making during accidents with AVs. All the 25 participants answered the question. From the 25 participants there were 14 participants sceptic how to organize this. 20 participants are thinking further research is still needed before introduction of AVs can be take place, that technology can be used for decision making during accidents with AVs. Below quotes are referring to responses of the participants.

Statement	Participant
I'm curious and have trust in a positive result of the several researches that are ongoing now and how we will use this in the end in practice.	**1**
I think this will take a long time before AVs will be introduced, because there are now too many aspects that needs attention yet.	**5**

Table 25 Further research to AVs needed

In most cases technology was mentioned to be important and trustable, 23 participants responded that as feedback.

Statement	Participant
Safety is one of the most important aspect to take in consideration during decision making. The human will not create the decision anymore, so this must be trustful.	**1**
Everything must be pre-programmed before we can use AVs.	**2**

It will be important that everything will be registered when an accident will take place. That will be traceable, responsibility and other import needs can be correctly processed.	**3**

Table 26 Importance of technology

Also, what is acceptable was often given as feedback and weather it would be needed to program all the scenarios, or will the vehicles be self-learning? 13 participants were stating this, below in the table a quote that refer to a response of a participant.

Statement	Participant
I think the vehicle must be designed as that can be updated afterwards. Especially for safety changes, if this will result to less accidents.	**10**

Table 27 Self learning possibility vehicles

4.2.3 Safety fallback plans

Regarding safety fallback plans the opinion of the participants was divided. Some of them were in favor of mechanism to intervene. Of the 15 participants who indicated these, 11 participants preferred that there will be a mechanism in place to intervene and that it would be possible to take over the control of the vehicle in situations where it wouldn't be possible for the vehicle to maneuver during a specific situation. In the next table statements are presented that were given as responses by the participants.

Statement	Participant
If this will be needed what will be the benefits than of autonomous driving?	**2**
Override possibility will give challenges about responsibility. Who is when responsible?	**5**
I'm not sure if we will reach 100% full autonomous driving vehicles.	**18**

Table 28 Mechanism to intervene for AVs

7 participants were mentioning that safety fallback plans are needed for AVs and that intervention only must be possible in specific situations.

Statement	Participant
I think it will only be possible to use partly autonomous driving, not in the cities and villages but only on the highway.	**18**

Table 29 Need of safety fallback plans

Further fallback plans were discussed during the interviews and 1 participant was mentioning that they don't think this will be needed.

Statement	Participant
I think the organization will be difficult to integrate safety fall back plans.	**8**

Table 30 Safety fallback plans unnecessary

4.2.4 Prevention of threats

The prevention of threats was mentioned 23 times by participants. Specific cyber security was mentioned by 10 participants that were stating that there is attention needed in this area to avoid problems as hacking.

Statement	Participant
It will be driven computers, the AVs therefore it will be important that the vehicle is protected against hacking.	**4**
Will be important that the system will be protected for hackers.	**12**
Important that the system will secure and protected against hackers	**13**

Table 31 Prevention of threats

Also, 7 participants were mentioning that vehicles must be protected with an own network.

Statement	Participant
I think it will not a bad idea to give AV's their own network to communicate.	**12**

Table 32 Own network for vehicles

4.2.5 Testing

Most participants indicate that before they would use AVs, vehicles must be tested properly. From the 25 participants were referring 19 participants that testing of the AVs with national and international standards must be take place, regulations for testing must be prepared and adjust for the use of AVs. Below statements of the participants that were given as response during the interviews.

Statement	Participant
For a continuous improvement of the vehicles, it will be important the vehicle will be self-learned. Also to avoid accidents this can be create benefits during the life cycle of the vehicle.	**6**
Self-learning is an important part of autonomous driving, if this will take place on a coordinated way. Where a human will be always in charge about the possibilities.	**12**

Table 33 Testing of AVs

In extension of the question about testing, a few times was stated that vehicles must be self-learning, this was 17 times stated by the participants. Whereby 10 participants, are seeing this as needed. Below statements that are corresponding to the feedback of the participants.

Statement	Participant
In NL it's maybe easier to implement autonomous driving, than as in Asia. Therefore, broad worldwide regulation is important for a simple implementation	**4**
The Netherlands has good circumstances to test AVs in the practice. As we have organized roads. Also, the cities are well structured.	**5**
Broad regulations are needed, world-wide to introduce AVs world-wide. Otherwise, it will not be possible for manufactures to develop vehicles anymore. As they are not delivering for county specific vehicles.	**10**

Table 34 Testing in relation to self-learning of vehicles

4.2.6 Override possibility

One of the topics that was discussed and was appointed during the conversations by the participants was the override possibility of an AV during driving, this was mentioned 14 times by the participants. From the 14 participants there were 12 participants seeing this as requirement before we can use AVs on daily basis and the introduction in general. Below a few quotes that are referring to the responses of the participants.

Statement	Participant
It must be possible to interrupt the vehicle system always.	**2**
Follow my opinion it will be required that it will be possible to interrupt in emergency situations. Just as in airplanes.	**4**
It must be required that there will be a button to interrupt the system and take over control of the vehicle as human.	**9**
From my perspective must it be possible always to override the system.	**12**

Table 35 AVs and override possibility

The override possibility was mentioned a few times, 12 times the participants mentioned this as a related safety aspect that will be useful in daily practice to support the acceptance of AVs. See also, table 36 “Override possibility and safety”, in specific circumstances**.**

Statement	Participant
I think it will be difficult if we cannot interrupt the AVs during driving and take over the control. Question will than, how will we organize that?	**8**

Table 36 Override possibility and safety

A few participants, 10, were also mentioning the option of an override possibility during specific situations, and to let the vehicle drive only autonomous on highways. The driver of the vehicle will be responsible outside highways for the control of the vehicle.

Statement	Participant
I think fully autonomous driving we will not reach the coming 40 years. Too much complexity and obstacles to program vehicles to drive everywhere autonomously. Despite, I believe that in some cases vehicles can only drive autonomously as on highways.	**25**

Table 37 Override possibility in specific circumstances

4.2.7 Required information

For the use of the data that is needed for AVs the participants were most of the times not against of the use of customer data, if this is for a better driving experience and when this contributes the safety during use of an AV. From the 19 participants that were mentioning to collect required data, 14 participants were in favor to use their data. Below a statement is given that is referring to the response of a participant.

Statement	Participant
For emergency services it can be useful. To communicate with vehicles. Or to give information to the vehicles in traffic jams.	**16**

Table 38 Required data AVs

If this will be used for vehicle communication, was stated 13 times by the participants, that they are in favor using this. In the next table a statement is presented related to a response of a participant.

Statement	Participant
I think on busy places that will be a challenge how to organize the vehicle communication.	**4**

Table 39 Data and vehicle communication

Another small part, 10 participants were explicit mentioning that the gathered data must be only for benefits of the vehicles, and in advance verified the purpose of the data and where it will be used for. Below in the table, a quote of the response given by a participant.

Statement	Participant
Important is that the storage of data will be only used for the purpose that is needed.	**14**

Table 40 Purpose used data

9 participants were mentioning the data is needed for several purposes and are thinking that some data will be needed for the use of AVs, as storage of the driving history, planned routes. There is already a lot of data being gathered from customers by the manufactures. Below a quote of a participant that refer to this.

Statement	Participant
Without consumer data it will be difficult to learn from each other. Now we are also using consumer data to detect that there is a traffic jam or traffic is stocked somewhere.	**19**

Table 41 Need of required data

4.2.8 Changes regulations

One of the areas that often were discussed during the interviews was the need for the changes of regulations that are required before we can use AVs on public roads. Of the 21 participants that stated to the need of change of regulations, all 21 participants mentioned that changes in regulations are needed before introduction can take place of AVs. Below statements are referring to responses of the participants.

Statement	Participant
Policy and legislation need to be adjusted, as the current ones for driving and accidents will not sufficient anymore.	**2**
For introduction of AVs, worldwide regulation need to be changed.	**4**
I think in NL it will be more difficult to drive autonomously compared to America. But compared to Asia a bit easier. Regarding regulation that is required in NL.	**6**
It will be needed that the regulation will be verified external/independent for the creation of policies.	**10**

Table 42 Change of regulations

Also, all 21 participants were referring to international standards that should be required and that there will be strive towards to a worldwide regulatory coverage for the usage of AVs, and all the 21 participants were further mentioning this is a big challenge to organize this. In the next table a few quotes related to the responses of the participants.

Statement	Participant
Will be difficult to create broad regulation with all continents and countries in the world.	**2**
In cities that are more crowd I think it will just be easier to implement the regulations, as the speed limits are quit lower compared to countries were road infrastructure is more organized.	**9**

Table 43 International standards AVs

One of the participants was remarking the need for change of regulations specifically before public use of AVs can take place. In below table, a response of a participant summarized in a quote.

Statement	Participant
Without new regulation for vehicles, it will not be possible to introduce AVs.	**4**

Table 44 Need of new regulation

4.2.9 Mixed traffic

During the interview conversations often was mentioned a period that AVs and regular vehicles as we know now will interact together and will be at the same time in public. This mixed traffic period was 25 times mentioned by the participants. From the 25 participants there were 24 referring to the verbale communication during driving that we have now, in case of that we give precedence in traffic situations to another road users. Below statements of the participants about the mixed traffic period:

Statement	Participant
Now is verbale communication possible. How will we handle this with fully autonomous driving?	**2**
Motorists during this period will be not able to make verbale contact with other road users. This will be needed to take in consideration.	**3**
Communication with AVs and manual driven vehicles will be a challenge. How we will deal with that.	**4**
About the transition period, we have that also now a bit with EVs.	**5**
Specially by round abouts pre linaria is now often given to each other in traffic. I see this also as challenge to organize this with AVs.	**6**
It will be a benefit, if in case of emergencies the vehicles are able to communicate together.	**10**
Interaction with manual and AVs during the mixed traffic period will be also a challenge, and areas where development attention is needed.	**11**
This will be a difficult period. I think this is one of the most difficult parts of AVs, the introduction.	**12**

Table 45 Mixed traffic period

Situations as communicating together during traffic on a verbale way with AVs and humans would not possible. On the other side, it also will depend on the way we will organize that AVs will be act. Fully autonomy everywhere or only in some situations. In that case it will ask for a different approach of the organization for we can use AVs. 17 participants were mentioning this. In next table a quote of a participant, as response during the interview.

Statement	Participant
I think the human, the driver must be able to override the vehicle on any moment.	**15**

Table 46 Communication during mixed traffic period

4.2.10 Infrastructure development

Another topic that often was discussed during the interviews, was the change that cities and the infrastructure of the cities will change with the come of AVs. This was mentioned 20 times by the participants.

Statement	Participant
It will be required that cities will be change. It will be also a challenge for AVs with the roads in not western countries.	**2**

I have no clue yet, how the roads will be organized. Maybe there will be special lanes for AVs.	**4**
Cities will be changed and mobility in general, I expect, also the way we will do things in daily life, as shopping, parking, and lot of other things will change.	**5**
I think there will be special lanes for AVs.	**12**

Table 47 Change of infrastructure

From the 20 participants that mentioned infrastructure changes, 11 participants of them were referring specific to changes that they expect that cities will look with AVs.

Statement	Participant
More organized cities will be needed, as separate lanes for AVs.	**2**
Cities will be redesigned during the years, if AVs will be given other possibilities and will create benefits and disadvantages in the current infrastructure.	**5**
Cities can be designed on a more organizational way, that can lead to less traffic.	**15**

Table 48 Future cities

Also, the possibility of smaller vehicles, mobility sharing and less vehicles was 16 times mentioned by the participants. The need of less parking spaces, and the ability to avoid parking issues was 15 times appointed by the participants.

Statement	Participant
I expect that there will be fewer parking spaces needed. With the development of AVs, I hope that this will change the way we use vehicles.	**5**
I'm asking myself also, will the vehicles be payable. Or will it required to share vehicles if we want to use vehicles also in the future. This can also result in less cars in general, if we can organize our infrastructure and roads efficient.	**9**
I think that there will less vehicles needed, as it will be much easier to share vehicles, also we see similar initiatives now with rent scooters. Also, the younger generation is less interested to own a vehicle.	**10**
Were we will live, and work will be change, if it will not anymore be required to drive the vehicle self. During driving can be focused on other things, than driving the vehicle.	**17**

Table 49 Need of parking spaces

4.2.11 Summary feedback technological perspective

In table 50 feedback is given of the technological perspective during the interviews after clustering the related elements. In figure 10, and 11 are charts shown of the outcome.

Elements	No.	Feedback interviews area: Technological perspective
Artificial intelligence	A	How much participants will use AI in the future more?
	B	How much participants will take ethics in consideration before they will use AI?
	C	How much participants were stating ethics in relation to decision-making during accidents with AVs as important?
Decision making	D	How much participants were sceptic about decision making with Avs?
	E	How much participants are thinking further research is still needed?
	F	How much participants were stating that technology for decision making must be trustful?
	G	How much participants were stating to self-learning in relation to decision making?
Safety fallback plans	H	How much participants where stating to safety fall back plans?
	I	How much of them want a mechanism to override the vehicle?
	J	How much participants were stating that overriding can take place only in specific situations
	K	How much participants were thinking that safety fall back plans are not needed?
Prevention of threats	L	How much participants were stating to the prevention of threats?
	M	How much participants were stating to cyber security?
	N	How much participants were stating that for AVs a own data network is needed?
Testing	O	How much participants were stating that testing of the AVs with national and international standards must be take place?
	P	How much times were participants stating that AVs must be self-learned?
	Q	How much participants were sure that AVs will be self-learned?
Override possibility	R	How much participants were stating to the override possibility for AVs
	A1	Total amount of participants that were stating to override possibility
	B1	How much participants were seeing the override possibility as required before we can use AVs?
	C1	How much participants were referring to override possibility in relation to safety?
	D1	How much participants were referring to the override possibility in specific situations?
Data collection	E1	How much participants were referring to data collection?
	F1	How much participants were stating to the use of their data what will happen with their data?
	G1	How much participants were stating to vehicle communication?

	H1	How much participants were stating that the use of data must be only needed for the purpose to make autonomous driving with Avs possible, and not for other activities?
	I1	How much participants are thinking personal data is required to make autonomous driving with AVs possible?
Changes regulations	J1	How much participants were stating to change of regulation?
	K1	How much participants were stating to changes in regulation before we can use AVs
	L1	How much participants were stating to international regulations?
	M1	How much participants were stating this will be a big challenge to organize?
Mixed traffic	N1	How much participants were stating to the mixed traffic period?
	O1	How much of the participants were referring to verbale communication?
	P1	How much participants were referring to autonomous driving only in specific situations?
Infrastructure development	Q1	How much participants were stating cities will change with the come of AVs?
	R1	How much participants were stating specific how cities will look like?
	S1	How much participants were stating that possibility of smaller vehicle, mobility sharing and less cars
	T1	How much participants were referring to that with come of AVs less parking spaces are needed?

Table 50 Feedback interviews technological perspective

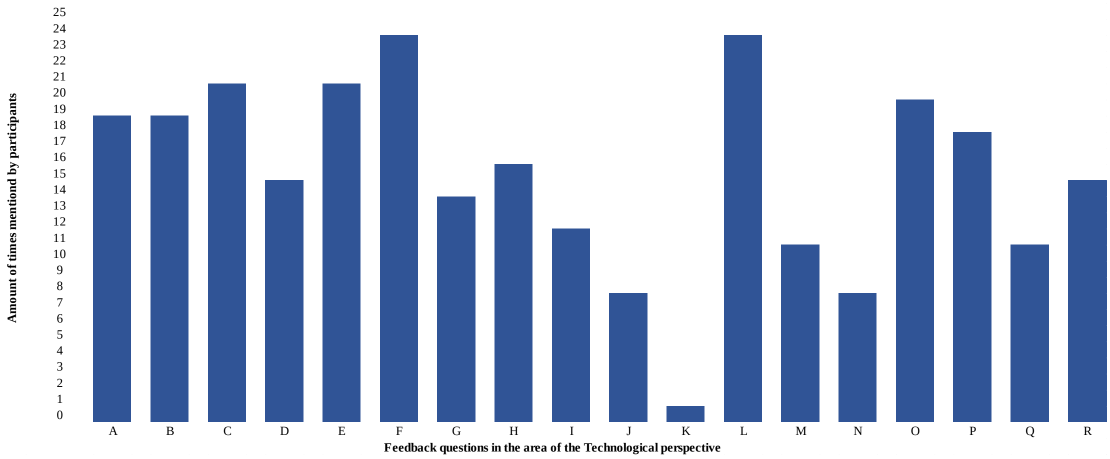

Figure 10 Chart technological perspective (part 1)

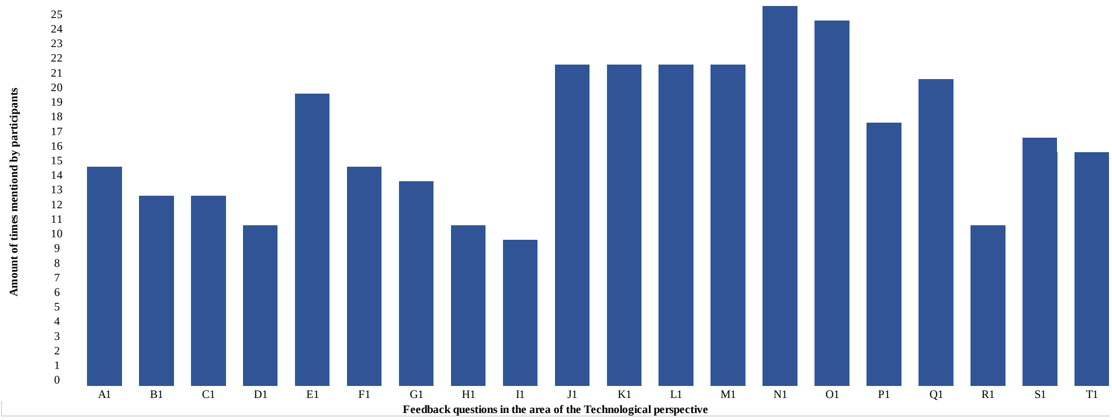

Figure 11 Chart technological perspective (part 2)

4.3 Area of interest participants

The last question of the interview was about a table (see Table 51) presented to participants with elements that were pre-defined beforehand. The table exists of elements that during the previous (literature) research and own needs and interests was originated and processed into this table. The idea behind this table is to verify the responses of the participants and to see if they were responding different if the important elements for this research, are presented on a summarized way. With the use of the table, it will be possible to detect areas that are not mentioned often during the interviews. If there are elements that were ranked low, this can indicate that there is less interest or attention of the perspective of the participants for that specific area. A higher ranking can indicate a lack of awareness of this element.

In table 51 Interest of participants, the outcome of the participants is ranked in their opinion for the 5 most important elements of autonomous driving and ethics. It was not strange, that “Safety of the self-driving vehicles” was chosen as most important by the participants. Also, not strange is as 2nd most important mentioned was “Policies and regulations for self-driving vehicles”. On the other side “Mix period with normal vehicles and self-driving vehicles” was mentioned the fewest times of elements in the table, 2 times in total even though during the interviews this was mentioned by all the 25 participants. Also that the self-driving vehicle must be self-learning was mentioned 17 times during the interviews and 2 times in the table. Looking to the “continuous development of self-driving vehicles”, this was stated 11 times by the participants in the table and 0 times during the interview conversations. This way, it’s clear that there is difference of the participants their opinion, that were given during the open questions and the prefilled table with elements on the last question.

Other interested aspect is that elements “Required use of event Data Recorder in self-driving vehicles, was also barley mentioned during the open conversations, and in the table 10 times mentioned by the participants. The element “Artificial Intelligence” was just mentioned 1 time in the table compared during the interviews. That was less, during the open interview questions this was mentioned 20 times by the participants, in relation of importance to autonomous driving and ethics. Watching the elements that were stated by the participants during the interviews and most important elements that were given in the table, there is not much different, as “Safety of self-driving vehicles” was mentioned as most important during both ways of questioning. For some elements, its visible that opinion was changed by presenting various elements in advance. As example there is the “continuous development of the self-driving vehicles”. That on the end was ranked as the 4th most chosen element and totally not during open conversations, the same for “Liability during traffic accidents” that was ended on the 5th placed as most mentioned in the table. Looking to the “Policies and regulations for self-driving vehicles was this equally divided in the table and during the open questions, whereby there was chosen more for the “Required use of event data recorder in self-driving vehicles”. As the last question, with the table were the elements of autonomous driving and ethics were already summarized, it’s difficult to objectively choose the most important aspects. That is why this should be seen as an extra addition for the interview in total.

First conclusion is that “Safety of the vehicles” was stated on both methods as most important element, also from various aspects. This is the view in general also for the other aspects, in that sense it’s not strange that there is a difference if humans need to choose elements by selecting the most importance ones.

In the next subsection, 4.4 Validation interview results, there will be more focus on the outcome of the interviews. In table below (see Table 51) the total score after feedback of the interviewers of question 8 of the interview questions.

No.	**Elements**	**Ranking**					**Times selected**	**Total Score**
		1	**2**	**3**	**4**	**5**		
A	Decision making during traffic accidents	3	1	2	1	1	**8**	**280**
B	Artificial intelligence technology				1		**1**	**20**
C	Safety of the self-driving vehicle	15	3		1	2	**21**	**910**
D	Policies and regulations for self-driving vehicles	2	8		2	3	**15**	**490**
E	Liability during traffic accidents with self-driving vehicles		1	3	3	1	**8**	**200**
F	Data gathering & storage of the users of self-driving vehicles		1	1	1		**3**	**90**
G	Privacy of the users of the self-driving vehicle				2	1	**3**	**50**
H	Cyber security of the self-driving vehicle		1	6		2	**9**	**240**
I	Continuous development of self-driving vehicles	1	3		3	4	**11**	**270**
J	Override function available in self-driving vehicles	2		2	2	1	**7**	**210**
K	Self-driving car must self-learning		1		1		**2**	**60**

L	Self-driving cars without control of humans (lonely driving, no control of humans)			3	2	2	**7**	**170**
M	Insurance of self-driving vehicles		1	2	1	3	**7**	**140**
N	Social acceptance of self-driving vehicles		1	1		1	**3**	**80**
O	Mix period with normal cars and self-driving vehicles				1	1	**2**	**30**
P	Vehicle communication system self-driving vehicles		1	1	1	1	**4**	**100**
Q	Vehicle communication with emergency services		2	1	1		**4**	**130**
R	Required use of Event Data Recorder in self-driving vehicles	2	1	3	3	1	**10**	**300**

Table 51 Interest of participants

Total score is calculated:

Ranking position 1 =	**x 50**
Ranking position 2 =	**x 40**
Ranking position 3 =	**x 30**
Ranking position 4 =	**x 20**
Ranking position 5 =	**x 10**

Table 52 Score calculation

The total score of an element, is calculated, by how many times a ranking was selected. Each ranking needs to be multiplied, with the number of the ranking with the number in the cell (see Table 52). By calculating the rankings together you will receive the total score.

4.4 Validation interview results

After all the elements were discussed that were found during the interviews, the drawing below is created (see Figure 12). In figure 12 the elements are presented that are important and ethical dilemmas. The elements are summarized that are related to AI and the influence on social acceptance during accidents with autonomous driving.

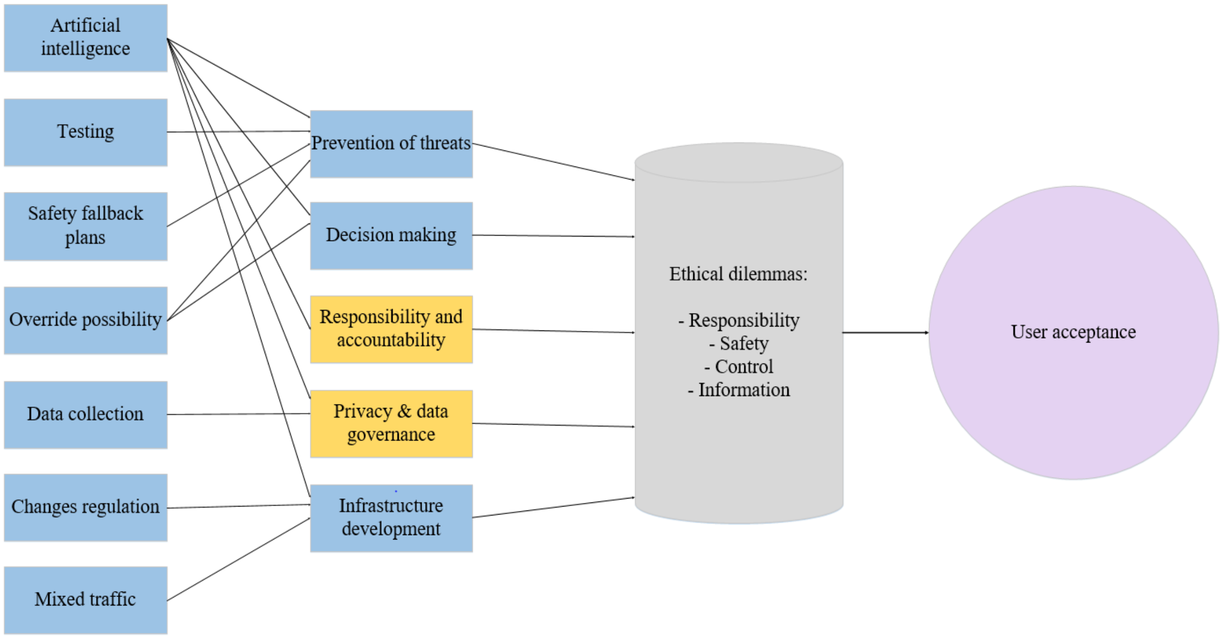

Figure 12 Relationships found elements interview and ethical dilemmas

For the categorization of the elements different colors are used. The ethical dilemmas of autonomous driving in this area are categorized with the color grey. The more personal elements of the participants are stated in yellow and the technical one of the participants blue. In the drawing is visible that some dilemmas are directly influencing the social acceptance of AI, and decision making with AI. The drawing is to make visible which factors are playing a role in the social acceptance of AI during accidents with AVs.

The Technology Acceptance Model (TAM) of F. D. Davis (1985) was founded to understand better the user acceptance of information systems, and over the years the TAM model is extend with many adoptions that can be used in other research areas. The work of Choi & Ji (2015), is an example of this. It extend the model also for usage to examine user acceptance of self-driving vehicles. The areas that are shown in the model are interesting to explaining the phenomenon of user acceptance. Also why certain factors playing a role can be explained by the perceived usefulness and the perceived ease of use.

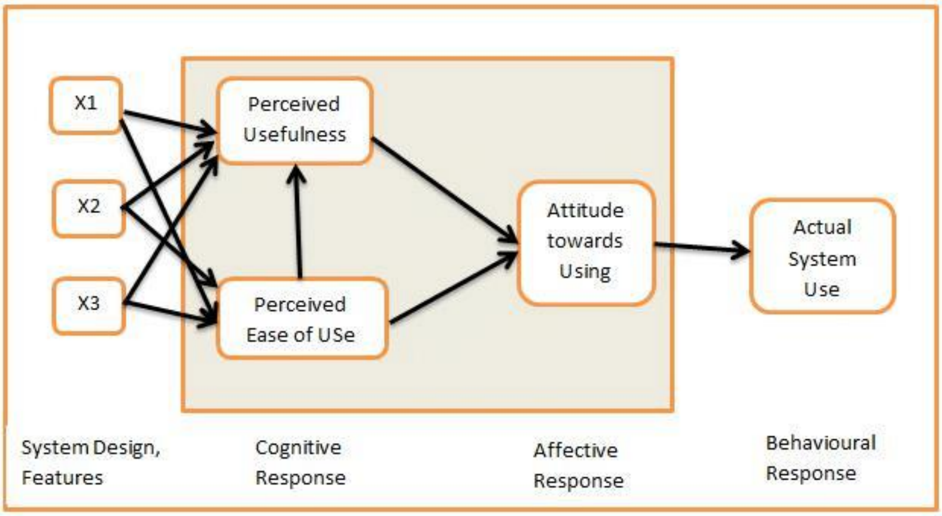

Figure 13 Technology Acceptance Model. (F. D. Davis, 1985)

The elements that are important are not always predictable on the literature that was referred to earlier, in the drawing, (see Figure 13) Technology Acceptance Model. (F. D. Davis, 1985). The connections between the elements became more visible. In the model cognitive response is part of the Technology Acceptance Framework that affect other elements as affective and behavioral response. In the literature of Choi & Ji (2015) there are also elements that rely on trust and influence, see figure 14.

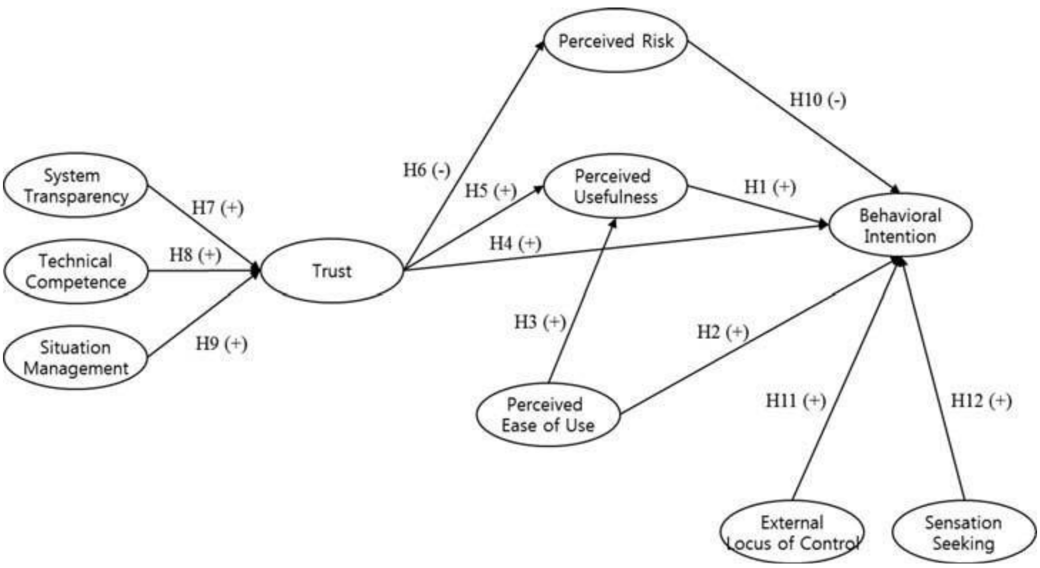

Figure 14 Research model (Choi & Ji, 2015)

To measure trust is mostly not easy. During the interviews it became clear that the participants were referring trust also to elements that are influencing the trust as safety or more technical parts (Choi & Ji, 2015). There is no connection with figure 13 Technology Acceptance Model. (F. D. Davis, 1985), that is showing less important than safety, that corresponds to the literature of acceptance. After the interviews it became clear that the participants are less interested in the technology behind autonomous driving and more in the functionality. In the literature there is less attention for this kind of areas that influence the acceptance of technology. Also, it's difficult collect information of conversations with participants during the interviews. In the area of user acceptance, and the models that are often used, almost in all of them there is room for interpretation. This leads to not covering all areas and that it is sometimes important to look deeper what's behind the elements to know how this is affected.

In this section the outcome of the community interviews were presented. In the next section, chapter 5 Discussion, the main findings will be presented and the outcome discussed.

5 Discussion

With all the information that is collected, it was possible after processing the data to detect patterns and to point out findings. The outcome of the community interviews was mentioned in chapter 4 Results. Based on the conversations during the interviews, and the total behavior of the participants in general, verbale as non-verbal, by including this in the answer when there was a reason for it. This is a benefit of interviewing personal compared to the use of surveys, where it's possible to see the reaction of the participants directly and non-verbal communication that was given (Schoettle & Sivak, 2015).

Below are the main findings of the outcome of the community interviews summarized:

- Almost all participants were open to use new technologies and new devices, and most of them were looking forward to getting involved with AVs.
- One of the findings that was clear after analyzing the outcome of the interviews, was that the participants are in general more interested in the functionalities of autonomous driving, than the technology behind it.
- Most of the participants were aware of the ongoing development around autonomous driving.
- Also most of the participants, were familiar with AI, and want or use it already in their daily life. In reference to AI and autonomous driving few of the participants are making use of it in their own vehicles. In general most of the participants were aware of the benefits of AI in relation to autonomous driving.
- Regarding the responsibility during accidents with AVs, the participants were divided. As some of them see this responsibility belonging to the manufacturer, or owner of the vehicle, a few of them to insurance companies.
- In the field of ethics, the participants were also divided. Few of them will expect less ethical dilemmas if decision making will take place through AI, if this is well programmed and tested. On the other side there were some participants that were more skeptical about decision making through AI and to shift the responsibility during driving to a system.

The most participants were open to use AI for decision making with AVs, some of them were sceptic about the outcome when a decision will be taken with AI, and if this will be ethical responsible, a few of them were thinking it would impossible anyway on the short term. As the participants were mentioning often it will be difficult to make moral decisions during accidents with AI, and will be very challenging to organize it in a correct way (Hansson et al., 2021).

Therefore, in most cases the given response by the participants was that a minimum possible casualties should be aimed for and to prevent injury as possible. The influence of manufactures on humans will be interesting in coming years, as a lot of the participants and humans in general are already familiar with driving assistance. The expectation is that new vehicles will have more features that forerunners will be of autonomous driving. That will make it possible for the manufactures to influence the interest of their potential customers, with advertising and marketing strategies, to show the benefits and possibilities of AVs. The manufacturer is also able to build his own network for facilitating vehicles, that as a service can be offered.

By informing the community on time about the development of AVs and to involve them, the community will be able to gather more knowledge and understanding for it. From the feedback of the participants during the interviews it was clear, that most of them have more knowledge about the functionalities that AVs will bring, than the technology behind it. Most of the participants collect their knowledge of AVs through the internet, (social) media and television. Where manufactures and other parties provide information, they are able to influence the community their opinions about AVs (Giffi et al., 2017).

Some of the participants were aware that bigger vehicle manufacturer companies like Google or Tesla are working on AVs and have a major influence on their opinion and what they know about autonomous driving. The participants were responding all that they have is some general knowledge of AVs, most of them about Tesla or gathered via other channels as internet or social media. A few of them only know something about the possibilities. This was asked during the interviews, about the participants their knowledge is about AVs. All of them answered it, and all of them had some general knowledge. This shows that they are interested in the development that is ongoing for AVs.

In the area of AI, the feedback was different and were the participants more sceptic about decision making with AI during accidents as was mentioned by 2 participants. Without AI it would not possible that autonomous driving will succeed. 3 participants responded that it’s important that the consumer will understand what they will buy in a simple way. There was 1 participant who mentioned that vehicles will be safer with AI. A clarification for this outcome can that the participants do not know much about the technology behind autonomous driving and how decision making works in combination with AI. This can influence the social acceptance to understand the possibilities with the technology of AVs in case of decision making.

The first impression after the interviews; that there is much difference between the participants expectation of autonomous driving, and that they do not know much about the technology of autonomous driving. Therefore, important was to collect what they were aware of already and during open conversations, sometimes to explain more about the technology behind it, to get the opinion of the participants. As there are benefits and drawbacks on the technology of autonomous driving and in general with AVs. Most times the participants mentioned more about the dilemma’s they see with the come of AVs, as no full control anymore, pleasure of driving, the mixed traffic period (Schoettle & Sivak, 2015). This means that the participants still see a lot of challenges to tackle and that several dilemma’s will arise that come with AVs. Most of the mentioned topics of the participants are related to ethical dilemmas, that earlier were mentioned in section 2.1.4 Ethical dilemmas:

- Responsibility
- Safety
- Control
- Information

The ethical dilemmas were in section 2.1.4 discussed and the relations with AI and ethical dilemmas in section 2.1.5. In the previous chapter 4. Results, is mentioned the outcome of the interviews. The table of "the participants their interest" was chosen to make some elements clear to the participants that are playing now related to autonomous driving (Jonker & Pennink, 2010). Differences for the elements of "General Knowledge" as most of the participants were responding have general knowledge of autonomous driving. In table 51 we see differences in the technology part of autonomous driving. During presentation of the table 51 to the participants, table participants of interest, they were curious about some elements, and gave them a different view on certain things. This is mentioning that it's not always needed to defense elements of autonomous driving, to explain the elements more in detail and relation between them, the reasons why this can influence the acceptance of technology, this is also for the social acceptance of AI (Venkatesh et al., 2003).

With regard to the element "privacy", during the conversations there was less attention for it, and more awareness when it was presented in the table of "the participants their interest" (see Table 51). Therefore, the outcome can be different if the elements are all summarized for the participants, and they need to make a choice by selecting the elements which they see as most important. This is an indication that awareness of some important elements of autonomous driving were missing by the participants. The mixed traffic period will be a period, in which participants are seeing as challenge; How to manage and organize both type of vehicles, specific the safety aspects the see as challenge. Some of them were referring, before they will use AVs they need to be able to trust the vehicle (Hansson et al., 2021).

Most times the participants were sceptic about the mixed traffic period and curious how manufactures and governments will realize this in practice and what it will mean for the changes that are needed for the regulation. Specially in case of accidents, it will be problematic to identify who is responsible if the vehicle is driving autonomously. There are signs that the mixed traffic period will bring challenges. Nevertheless, in general the expectation is that vehicles will be safer on the long term, this will lead to different focus areas as we have now.

A lot of the participants were stating to use the autonomous technology only if it's safe, and proven to be trust worthily. Where a lot of the participants first want to see, that it's full embedded and accepted, before they start using it. Regarding accidents and decision making the participants were divided, some of them don't see problems and trust the technology where others were more interested and were asking more questions about the specific discussed elements. Some of the participants were thinking that decision making can't take place with AI. The need to change the regulation, requires that governments and all other parties need to work together, not only in Europe but also in other continents, as this would be more important than the technology (European Commission., 2018). This was mentioned often by the participants as challenge to introduce AVs in general on a short term. The technology is already there, as example with Tesla, where most participants were familiar of the possibilities of autonomous driving with Tesla's.

Cyber security was during the open conversations of the interviews mentioned a few times by the participants (Sheehan, et al., 2019). Compared to the table of interest of the participants (see Table 51), was this a few times less. This can indicate that the participants were not taking that into account before they were confronted upfront, this creates more awareness. As most participants are not aware of the full details that are relying on driving, it is expected that the participants are not familiar with all the elements, and in some cases some extra explanation was given about a certain element during the interviews. Therefore, the table of interest of the participants, was used to bring attention to the most obvious parts related to this research.

Also a few participants were referring that AVs never will drive autonomously, everywhere but maybe only fully autonomously on highways or specific areas. Regarding decision making, a lot of participants were sceptic about it. And if this would be any way possible with AI. It would be very difficult to program good or fault. Other part is that some participants were referring is that nowadays we also have restrictions during driving, and if you violate those restrictions, this will not always directly have consequents. In case of example speeding; people tend to violate these restrictions. This means that this grey area, if everything will be programmed would disappear.

Data labelling is an element that was also mentioned during the conversations of the interviews, 19 participants, and less during the feedback of table of interest of the participants, 3 times in total. This makes clear that it can also be the other way around; if it turns to importance of several elements of autonomous driving and ethics, that during open conversations other areas were discussed than if the selection must be done on importance in table 51.

See this also, in the earlier mentioned ethical dilemmas (see Section 2.1.4), were data labelling can be linked to information. When it comes to the responsibility during accidents and decision making with AI, the participants were divided about who this must be, the manufactures the driver or the insurance company was often answered. Also, this depends on the situation that will occur, in example for a technical defect that will lead to an accident the manufacturer must be reliable. This will also depend on the regulation that will change, this was also often mentioned during the open conversations, 21 times in total, during the selection in the table this was, 15 times selected.

For this part there is also a relation with the earlier mentioned ethical dilemma responsibility in paragraph 2.1.4. Also during the interviews with the participants, responsibility was an important component in general for self-driving vehicles.

There was also attention of the participants for testing during the interview questions. This was mentioned in total 19 times by the participants. Were the focus must be for testing that international standards will be implemented (Trommer et al., 2016).

The intelligent use of vehicles in the future was also a few times mentioned, as there is less need to own a vehicle in general, as a vehicle can be shared, rent or offered as service. Regards to the need of parking spaces; will we need less spaces and what possibilities there will be possible (Paidi et al,. 2022)? The testing element was not added to the table of interest, as the focus was more related to interested aspects to answer the research questions, the same was the case for the parking spaces and the possibility of shared AVs. The conversations and open discussions with the expert interviews, were given insight in the areas that as found during the literature study and the results of the “community interviews”. It was familiar for the experts what was collected for this study. That was resulting in pleasant conversations with the experts, were topics that are currently playing for autonomous driving and ethics could be discussed in an efficient way.

The lack of the deep-technology knowledge, of the participants often was covered by extra explanation if there was need for. Nevertheless, it will have no impact on the overall score that the participants sometimes thoughts that they are more aware of parts of the technology of AVs than the results are showing. This indicates that the participants are more interested in the functionality of the use of autonomous driving. The ethical part they are aware of, if you confront them, was that all the participants had a another view on autonomous driving after the interviews, and were giving the feedback that the topic of autonomous driving in combination with decision making is very interesting, and they look different to it now. Instead of only using it, the acceptance of AVs will be important for further development and integration.

6 Conclusion

6.1 Final consideration

In this thesis is investigated which ethical dilemmas will be occur during the introduction of AVs. The dilemmas are related to social acceptance of decision making with AI during traffic accidents. The purpose of this research is to investigate which ethical dilemmas will occur and are playing a role during to social acceptance with AI, and to have a deeper look which factors can influence the social acceptance of the shift to autonomous driving.

During the research, the aim was to answer the defined research question:

How will AI technology influence social acceptance and decision-making by accidents during autonomous driving, and which ethical dilemmas will this cause?

After the literature study, in chapter 4 Methodology the interview method is described, that is used to collect feedback from the community for verifying the elements that are important for answering the research question. The elements were divided in the participants and technology perspectives.

During interviews using open questions a discussion was held with the participants, about factors that are applying with the found factors earlier during the research. This way, the input could be collected from the participants in an efficient way using an efficient method by interviewing them personally. To verify earlier findings during the research and in case needed to ask for clarification and more a deep dive during discussions (Jonker & Pennink, 2010). At the end of the interviews there was a table presented, to select the most important defined elements. To verify if there were differences between important elements if they are summarized. Were needed clarification was given for elements in the table.

After analyzing the results of the participants the indication is that the participants were stating to have basis knowledge of AVs, where the results were showing that there is a less knowledge about the technology of AVs. During the interviews there were being deeply clear signals that most of the participants are more interested in the functional parts that AVs will bring rather than interested in technologies. Taking this in account, it can have impact on the outcome of the results in the way the participants were looking to specific topics. As most participants were giving the response that they are known with AVs (this was also opening discussions), participants were less aware of it or attention had before the interview.

Therefore, the impact of influencing the community with videos or with (social) media, is playing an important role, of the knowledge of humans about AVs. Also, a topic that often was mentioned, and that most participants were referring to, that it will be a challenging period during the mix traffic period, were AVs and manual driven vehicles will interact together (Schoettle & Sivak, 2015). During this period, the organization of both type vehicles needs to take place without interruption between them. This is required, to let the evolution from manual driven vehicles to autonomous driving succeed. For the participants safety was the most important element.

In the literature, the mixed traffic period is described as a challenging period. Wherein begin the expectation is that more accidents will happen, and teething problems can be also part of the challenges in begin.

For the sub questions of this research that are defined, the participants supported also to find answers during the interviews, by delivering their feedback during the interview questions. Below the sub questions summarized:

1. *What are the characteristics of autonomous driving?*
2. *Which different ethical dilemmas are already under attention?*
3. *How are ethical aspects and user acceptance correlated?*
4. *How will the user acceptance be influenced?*

The research question was answered by collecting information during the research, during the literature study and interviews. The outcome on headlines is that there will be less impact with the use of AI for the acceptance and decision-making during accidents. In general, people seeing safety as important, nevertheless the lack of knowledge of AI technology of the participants has a strong presence, what can be seen as a reflection of the community the focus is more on new functionality and benefits that autonomous driving will bring.

For the defined sub questions, the answers were also collected during this research. First sub question: *What are the characteristics of autonomous driving?*

The characteristics are in the first place the benefits, as no driver needed, that will result that focus can be on other things during driving. Expected is that the infrastructure will be changed. The legalization needs to be different organized for vehicles. The preparation is ongoing now to introduce autonomous driving, on several levels, world-wide, per continent in Europe and so on (European Commission., 2018), where the reference are the SAE Levels.

Second sub question: *Which different ethical dilemmas are already under attention?*

The ethical aspects that are related to autonomous driving, is something that is often discussed in all areas as community, scientists manufactures. In the literature this is also often described. That makes that drawing of a conclusion not that easy. If we look to this question specific, the aim is to find institutes already and organizations working on the legalization of AVs (Trommer et al., 2016). In the area of acceptance there is a need for attention. From a technology perspective, it’s already a lot possible, as examples often was given Tesla, where lot of people were referring to. Lot of ethical questions are still open to make the people aware of, this is strongly required for the acceptance of AVs in general.

Third sub question: *How are ethical aspects and user acceptance correlated?*

The ethical aspects are strongly correlated to the user acceptance of autonomous driving. Not directly, more when people are aware of the technology and decision making that needs to take place with AVs. In scenarios where people are more knowing about AI, and when AI will be used more in normal life, people are not always aware of the risks. Therefore, for ethical aspects, people in the first place are relying on safety

(Hansson et al., 2021). From a broader perspective most people don’t have the knowledge to create an opinion.

Fourth sub question: *How will the user acceptance be influenced?*

User acceptance can be influenced by making people more aware of the technology that is used, by giving examples to people that are similar in AI and robotics. Now people are more focused on the functionality benefits and less on the used techniques. By making people more aware they will better understand what is behind the technology, which will make the process behind decision making more transparent. In order to make this reachable, on high level the technology of AVs needs to be understandable for all people in a simple way. The acceptance of autonomous driving, can be influenced by creating more awareness of autonomous diving for potential customers (Venkatesh et al., 2003).

6.2 Limitations

There are drawbacks related to the open question method used in this research of interviewing the participants as during the interviews the open question method was used. That means that by the open questions, the participants were already sent in a certain direction during the conversation. Therefore, there was less space to start the conversations from the participants perspectives directly.

For this research and the associated interviews, the focus was on 25 participants and 2 expert interviews. With the amount of 25 participants for the community interviews the gathered information is on the small side for the used open question method. Nevertheless, this is supplemented with the extra table of interest and the 2 expert interviews. The conditions of the participants, as age gender, is specific selected for this research, that can give a distorted picture in some areas. Therefore, the aim was to gather information on a broad basis of the participants for answering the research and sub questions.

Another aspect that can be seen as limitation for this research is that there are different methods used, as community and expert interviews, combined with a table of interest of the participants that are all together forming the conclusion. On the other hand, brings this also benefits, as that the results are verified a few times in several ways, as in the table with the interest of the participants in a summarized way and feedback of the participants with the experts that are involved in the development of autonomous driving. Another topic that was addressed was that the ethical decision during interviews, mostly relies on safety that is associated with it together. This can also be caused by the age of the participants; more younger people will respond different than people without work. So, the selected audience is a dominant component for this research.

Therefore, the feedback that was collect from the participants was categorized by using elements for verification before the conclusion could be determined. Another important conclusion is that the participants have in practice less knowledge than they think of technology. Therefore, it’s difficult to collect feedback from them in the area of decision-making, because most people have a lack of knowledge in that area. For the purpose of this research the feedback of the participants was enough, and sufficient in combination with the literature study to answer the research question and sub questions. The lack of technology is not strange as there is yet a lot of development ongoing in the field of autonomous driving. The main conclusion is that most people are not aware of the ethical aspects of autonomous driving. There is more focus on functionality and after explanation about the ethical relation, they all have a different view what's needed to make decisions with AVs in an ethical way that it will be social accepted. This is one of the most challenging parts that most of the participants were referring to and will play a prominent role in the adoption of acceptation of autonomous driving.

6.3 Future research

In case of future research, I recommend to organize a few parts different, after having the experience that is gained during this research. At first the recommendation for future research will be, to look broader than only one specific age group. Also, in extension to that it will be interesting to categorize more target groups, such as students, families, workers and more to gather knowledge of people from a broader perspective. Beside that it will be interesting if the participants would be explained beforehand about the technology behind decision making of autonomous driving. As the technology seems an element that is important and connected to the acceptance of decision making. In the area of acceptance and decision making it will be worth considering also examples of decision making with AI which provide an advantage and have a positive effect during accidents, or were accidents were prevented. This can help to influence the acceptance of AVs in a positive way.

Acceptance of new technology is something that is relying partly on experience with a product. It will be interesting to look in future research also to the effect of accepting new other technologies, and to see which elements are important that had influenced the people. The relation with new technologies was involved in this research, beside that it can be more in detail investigated and what the relation is with the new technology and acceptance. Also, an interesting aspect to research in the future are the SAE levels of autonomous driving, and what the acceptance will be of people related to the condition of each level. In this way, the acceptance criteria can be divided more into period and the timeline of the introduction of parts of autonomous driving.

6.4 Reflection

The outcome of the research and the results that were presented gives the possibility to review the situation of the acceptance of decision making with AI. There are a lot of elements that are relevant for the acceptance of new technology. Therefore, the scope and the target audience are significant for a research like this.

My purpose was not to influence the participants during conversations during the interviews. In some situations, it was needed to explain topics more in detail, or to challenge the participants for a specific element to get a more in depth conversation. This happened only a few times; when there was some misunderstanding or to verify the given opinion of the participant. And in a way that this wasn't influencing the opinion of the participant, as the purpose was to obtain an objective opinion from the participants. A few times, during the interviews there were areas discussed that ended in an eye opener for the participants, not that they were not aware of the existence of a topic or scenario, but more in the area that there was need to think about it in a specific context.

This thesis is providing an overview of the ethical dilemmas that will occur with the onset of autonomous driving with the use of AI and the acceptance of it by society. With the end of this thesis, it creates a new starting point for those who want to perform further research in the coming years in the field of autonomous driving. Whereby this thesis proposes a view from the perspective of the related ethical dilemmas of autonomous driving. The outcome of the focus areas of this thesis will be helpful for various further research areas. This is not only in the area of ethical dilemmas of autonomous driving but, also to other areas related to mobility solutions. For the coming years the question will be, how vehicles will evolve to AVs and when the real innovation will start.

The main result of this thesis is:

With integration of AI in AVs, this will influence the acceptance of AVs by society in a positive way. In general the feedback of the community was; that they are more interested in the functionalities of AI, rather than the technology aspects. With AI it will be able to drives vehicles autonomously, and benefit in many ways. For as in example avoiding of traffic jams, parking of the vehicles can be closer to each other and traffic become safer, because AVs automatically obey the traffic rules. In case of decision making with AI trough AVs, the community was more divided if this can be organized in an ethical way.

With my thesis the following ethical dilemmas are imbedded in a framework which may helped to characterize and analyze future problems:

Ethical dilemmas:

- Responsibility
- Safety
- Control
- Information

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Appendices

Appendix A: Interview questions

Interview introduction

As first, thanks for your time to do this interview with you. This interview is for my master thesis ICT in business which I follow on the University of Leiden. In my master thesis I'm researching the topic Autonomous driving and ethics. Important for me is to gather much as possible knowledge in a certain time frame, that is important in the field of Autonomous driving and ethics, to fulfil answers on my defined research and sub questions. The interview result will not be shared and will be used only for this research, also your name will not be shared to others or used in this report, your identity will be stay anonymously. I preferred to have an open interview and that you will be comfortable to answer the questions openness based on your opinion.

To begin ask the interviewer his or her name, age and whether the person has a driver's license.

The topic for my thesis is for me very interesting to research, there are a lot of open gaps and questions about ethics and autonomous driving, this topic is for the future very important for a successful introduction of autonomous cars to the market.

Interview questions

1. **Wat weet je al over autonoom rijden, en in hoeverre ben je bekend met het begrip volledig autonoom rijden?**

   What do you already know about autonomous driving, and are you already familiar with the understanding of fully autonomous driving and ethics?

   Related to, and points to discuss eventually during question:
   - *SAE Level of autonomous driving (explain this).*
   - *Introduction dilemmas*
   - *Improvements*
   - *Benefits*

2. **Denk je dat door middel van intelligente technologie, zoals kunstmatige intelligentie, dit voor een betere sociale acceptatie van autonoom rijden kan zorgen?**

   Do you think that intelligent technology, as artificial intelligence, will be able to improve the social acceptance of autonomous driving?

   Related to, and points to discuss eventually during question:
   - *Acceptance*
   - *Decision making*
   - *Technology*
   - *Artificial intelligence*

- *Benefits users*
- *Safety*

3. **Denk je dat intelligente techniek, zoals kunstmatige intelligentie, voor een betere besluitvorming kan zorgen bij ongelukken met autonome voertuigen? (denk hierbij aan uitwijken en een zwangere vrouw aanrijden i.p.v. een oude opa.).**

   Do you think with intelligent technology, as artificial intelligence, this can lead to better decision making in case of traffic accidents (e.g. swerve to hit an old grandpa instead of a pregnant women)?

   Related to, and points to discuss eventually during question:
   - *Artificial intelligence*
   - *Decision making*
   - *Liability / responsibility*
   - *Insurance*
   - *Manufactures*
   - *Mixed traffic period*

4. **Wat vind je ethisch verantwoord in het geval van besluitvorming gedurende ongelukken plaatsvindt door artifical intelligence?**

   What is following you ethical responsible, in case of decision making during traffic accidents will be takes place through artificial intelligence?

   Related to, and points to discuss eventually during question:
   - *Artificial intelligence*
   - *Decision making*
   - *Liability / responsibility*
   - *Insurance*
   - *Manufactures*
   - *Mixed traffic period*
   - *Human agency*

5. **Wie zou aansprakelijk moeten zijn in het geval van verkeersongelukken bij een voertuig dat autonoom wordt bestuurd?**

   Who should be held liable in the case of a traffic accident with a vehicle that is driven autonomously?

   Related to, and points to discuss eventually during question:
   - *Decision making*
   - *Liability / responsibility*
   - *Insurance*
   - *Manufactures*
   - *Drivers*
   - *Discrimination manufactures*
   - *Human agency*

6. **Als je in de toekomst een autonoom voertuig gaat gebruiken, in hoeverre is ethiek belangrijk voor het overgaan tot gebruik van een autonoom voertuig?**

   If you will use in the future an autonomous vehicle, how important is ethics before you will use the autonomous vehicle?

   Related to, and points to discuss eventually during question:
   - *Privacy*
   - *Decision making*
   - *Benefits/ improvements*
   - *Functionality*

7. **Welke aspecten zijn voor jou belangrijk om in de toekomst gebruik te gaan maken van een autonoom voertuig?**

   Which aspects are for you important to use in the future an autonomous vehicle?

   Related to, and points to discuss eventually during question:
   - *Privacy*
   - *Societal & environmental wellbeing*
   - *Benefits/ improvements*
   - *Functionality*
   - *Time*
   - *Freedom*
   - *No focus needed*

8. **In onderstaande tabel zijn verschillende elementen opgenomen die betrekking hebben op autonoom rijden en ethiek. Wil je 5 items hiervan selecteren, en in de volgorde plaatsen die voor jou het meest belangrijkst zijn?**

   In the table below, there are elements mentioned of autonomous driving and ethics. Can you arrange 5 items, in the order which you think that the most important are?

No.	Elements
A	Decision making during traffic accidents
B	Artificial intelligence technology
C	Safety of the self-driving vehicle
D	Policies and regulations for self-driving vehicles
E	Liability during traffic accidents with self-driving vehicles
F	Data gathering & storage of the users of self-driving vehicles
G	Privacy of the users of the self-driving vehicle
H	Cyber security of the self-driving vehicle
I	Continuous development of self-driving vehicles
J	Override function available in self-driving vehicles

K	Self-driving car must self-learning
L	Self-driving cars without control of humans (lonely driving, no control of humans)
M	Insurance of self-driving cars
N	Social acceptance of self-driving cars
O	Mix period with normal cars and self-driving cars
P	Vehicle communication system self-driving cars
Q	Vehicle communication with emergency services
R	Required use of Event Data Recorder in self-driving cars

Table 53 Template interest areas during interviews

Thanks for your time again, to support me to participate in this interview. I will now make a summary of our conversation and will send you that via email in a few days, please confirm this with your approval or if something needs to be adjusted your feedback. In the case I will get no reply in 2 weeks, I will assume that you agree with the summary.

Appendix B: Calculation of table of interest

Table below will be used to count and calculate the total score after feedback of the interviewers of question 8 of the interview list.

No.	Elements	Ranking 1	2	3	4	5	Times selected	Total Score
A	Decision making during traffic accidents							
B	Artificial intelligence technology							
C	Safety of the self-driving vehicle							
D	Policies and regulations for self-driving vehicles							
E	Liability during traffic accidents with self-driving vehicles							
F	Data gathering & storage of the users of self-driving vehicles							
G	Privacy of the users of the self-driving vehicle							
H	Cyber security of the self-driving vehicle							
I	Continuous development of self-driving vehicles							
J	Override function available in self-driving vehicles							
K	Self-driving car must self-learning							
L	Self-driving cars without control of humans (lonely driving, no control of humans)							
M	Insurance of self-driving cars							
N	Social acceptance of self-driving cars							
O	Mix period with normal cars and self-driving cars							
P	Vehicle communication system self-driving cars							
Q	Vehicle communication with emergency services							
R	Required use of Event Data Recorder in self-driving cars							

Table 54 Template calculation interest of participants

Total score is calculated:

Ranking position 1 =	**x 50**
Ranking position 2 =	**x 40**
Ranking position 3 =	**x 30**
Ranking position 4 =	**x 20**
Ranking position 5 =	**x 10**

Table 55 Score calculation method

Appendix C: Matrix related elements

The next table will be used to cluster the answers of the interviewers in several types and will be processed in the chapter results. Feedback will then be dived on basis of the types. Each type will be explained in general with feedback of the interviewers a conclusion.

Type	Sub type	Code
General knowledge AVs and ethics		GKAE
Social acceptance		SA
	Artificial intelligence	SA1
	Decision making	SA2
Technical safety		TS
	Safety fallback plans	TS1
	Prevention of threats (e.g. cybersecurity threats)	TS2
	Testing on the road without harming humans	TS3
Responsibility and risks		RBR
	Decision-making and risk allocation process	RBR1
	Implementation of decision making	RBR2
Human agency		HA
	Human's possibility to override	HA1
	Processes that can enhance human agency	HA2
Privacy & data governance		PDG
	Data collection	PDG1
	Data sharing third parties	PDG2
Responsibility, liability & accountability		RLA
	Regulations changes on product liability	RLA1
	Extension of traffic laws	RLA2
	Transparency investigation of an accident	RLA3
Non-discrimination & inclusiveness		NI
	Incorporation of biases in systems	NI1
	Needed features for accessibility and inclusiveness	NI2
Societal & environmental wellbeing		SEW
	Increase societal and environmental benefits	SEW1
	Safely integration during mixed traffic	SEW2
	Infrastructure development	SEW3

Table 56 Template clustering of interview areas

Appendix D: Interview validation

General knowledge AVs			C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	C23	C24	C25	Total
	1	How much candidates were stating that they know a bit about autonomous driving?	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	25
	2	How much candidates were stating that they know about Tesla?	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	25
	3	How much candidates are familiar with driving assistance?	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	25
Safety																												
	4	How much candidates were stating that safety is an important aspect?	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	24
	5	How much candidates were mentioning the mixed traffice period?		1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	23
	5.1	How much of the candidates were mentioning safety as a challenging part for the introduction of Avs			1	1	1	1	1	1		1		1	1	1	1	1		1	1	1	1	1	1	1	1	20
	6	How much candidates were mentioning safety before they will use an AV?	1	1		1	1	1	1	1		1	1	1	1	1	1	1		1	1	1	1	1	1	1	1	22
	7	How much candidates were mentioning ethical issues and the safety of Avs?	1	1		1		1	1	1		1		1	1	1	1	1		1	1	1	1	1	1	1	1	20
Privacy & data governance																												
	8	How much candidates were asked during open questions about their privacy?	1	1	1		1								1					1	1	1						8
	8.1	How much candidates were explaining to see this not as an important topic?													1													1
	9	How much candidates were mentioning they see privacy as something to be careful with and how their concerns how manufactures will deal with the privacy of the consumers?	1		1		1													1	1	1			1		1	8
	10	How much candidates were mentioning the quality of data?	1	1	1		1								1					1	1							7
	11	How much canidadates were mentioning the usefulness and reliability of data?	1	1	1		1								1					1	1							7
Responsibility & accountability																												
	12.1	How much candidates did answered the question, who is realible during traffic accidents?	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	24
	12.2	How much candidates do not made a choice?																				1						1
	13	How much candidates were mentioning the manufracter must be reliable?	1			1	1					1		1	1		1				1							8
	14	How much candidates were mentioning that the human driver must be reliable during traffic accidents?		1				1		1	1		1			1		1	1	1			1	1	1	1	1	14
	15	How much candidates were mentinong that the insurance company can be reliable during traffic accidents?			1				1																			2
Age& gender																												
	16	How much candidates?	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	25
	16.1	How much women?	1		1	1		1		1		1	1					1	1		1		1			1		12
	16.2	How much men?		1			1		1		1			1	1	1	1			1		1		1	1		1	13
	17	How much candidates were stating to the pleasure of driving?	1	1	1	1		1	1	1	1			1	1	1	1	1	1	1		1	1	1		1	1	20
	17.1	How much were women?	1		1	1		1		1		1	1					1	1		1		1			1		12
	17.2	How much were men?		1			1		1		1			1	1	1	1			1		1		1	1		1	13
	18	Median?																										
Artificial intelligence																												
	19	Total candidates?	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	25
	19.1	How much candidates will use AI in the future more?	1	1	1	1		1	1	1	1	1	1	1	1	1	1		1	1	1	1						18
	19.2	How much candidates will use AI in the future more? Again	1	1	1	1		1	1	1	1	1	1	1	1	1	1		1	1	1	1						18
	19.3	How much candidates will take ethics in consideration before they will use AI?	1					1	1	1	1	1	1	1	1		1	1			1	1	1	1	1	1	1	18
	20	How much candidates were stating ethics in relation to decision-making during accidents with AVs as important?	1	1		1		1	1	1	1	1	1	1	1	1	1	1	1				1	1	1	1	1	20
Decision making																												
	21	Total candidates?	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	25
	21.1	Again total candidates?	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	25
	21.2	How much candidates were sceptic about decision making with Avs?		1		1						1	1		1			1	1	1	1		1	1	1	1	1	14
	22	How much candidates are thinking further research is still needed?	1		1			1	1	1	1	1	1	1	1			1	1	1	1	1	1	1	1	1	1	20
	23	How much candidates were stating that technology for decision making must be trustful?	1	1		1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	23
	24	How much candidates were stating to self learning in relation to decision making?		1		1		1	1		1	1		1	1	1			1	1	1	1						13
Safety fallback plans																												
	25	How much candidates where stating to safety fall back plans?		1		1	1		1	1	1	1		1	1	1	1		1	1	1	1						15
	25.1	How much of them want a mechnism to override the vehicle?		1		1	1		1		1			1		1	1			1	1	1						11
	26	How much candidates were stating that overriding can take place only in specific situations		1		1			1					1			1			1		1						7
	27	How much candidates were thinking that safety fall back plans are not needed?								1																		1
Prevention of threats																												
	28	How much candidates were stating to the prevention of threats?	1	1	1	1	1			1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	23
	29	How much candidates were stating to cyber security?				1	1			1	1			1	1		1			1	1	1						10
	30	How much candidates were stating that for AVs a own data network is needed?				1	1							1	1					1	1	1						7
Testing																												
	31	Total candidates?	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	25
	31.1	How much candidates were stating that testing of the AVs with national and international standards must be take place?		1	1	1	1	1		1	1			1		1	1	1		1	1	1	1	1	1	1	1	19
	32	How much times were candidates stating that AVs must be self learned?		1		1	1				1			1	1	1	1	1		1	1	1	1	1	1	1	1	17
	32.1	How much canidates were sure that AVs will be slef learned?		1				1			1			1	1	1	1			1	1	1						10
Override possibility																												
	33	How much candidaes were stating to the override possibility for Avs		1		1	1				1	1	1	1	1	1	1		1	1	1	1						14
	33.1	Total amount of candidates that were stating to override possibility		1		1	1				1	1	1	1	1	1	1		1	1	1	1						14
	33.2	How much canidateds were seeing the override possibilty as required before we can use AVs?		1		1	1				1	1		1	1	1	1			1	1	1						12
	34	How much canidadates were reffering to override possibilty in relation to safety?		1		1	1				1	1		1	1	1	1			1	1	1						12
	36	How much canidates were reffering to the override possibility in specific situations?		1		1	1				1				1	1	1			1	1	1						10
Data collection																												
	37	How much canidates were reffering to data collection?	1	1	1	1	1			1	1	1			1			1	1	1	1	1	1	1	1	1	1	19
	37.1	How much canidates were stating to the use of their data what will happen with their data?	1	1	1					1	1				1			1	1	1			1	1	1	1	1	14
	38	How much candidates were stating to vechicle communication?				1				1	1	1						1	1	1		1	1	1	1	1	1	13
	39	How much candidates were stating that the use of data must be only needed for the purpose to make autonomous driving with Avs possible, and not for other activities?	1		1	1	1			1	1	1							1	1		1						10
	40	How much candidates are thinking personal data is required to make autonomous driving with AVs possible?		1	1	1	1			1	1								1	1		1						9
Changes regulations																												
	41	How much candidates were stating to change of regulation?	1	1	1	1	1	1		1	1	1			1	1	1	1	1		1	1	1	1	1	1	1	21
	41.1	How much canidates were stating to changes in regulation before we can use AVs	1	1	1	1	1	1		1	1	1			1	1	1	1	1		1	1	1	1	1	1	1	21
	42	How much candidates were stating to international regulations?	1	1	1	1	1	1		1	1	1			1	1	1	1	1		1	1	1	1	1	1	1	21
	42.1	How much candidates were stating to international regulations? Again	1	1	1	1	1	1		1	1	1			1	1	1	1	1		1	1	1	1	1	1	1	21
	42.2	How much candidates were stating this will be a big challenge to organize?	1	1	1	1	1	1		1	1	1			1	1	1	1	1		1	1	1	1	1	1	1	21
Mixed traffic																												
	44	How much candidates were stating to the mixed traffic period?	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	25
	44.1	How much candidates were stating to the mixed traffic period? Again	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	25
	44.2	How much of the candidates were reffering to verhicle communication?	1	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	24
	45	How much candidates were reffering to autnomous driving only in specific situations?	1	1	1	1	1									1	1	1	1	1	1	1	1	1	1	1	1	17
Infrastructure development																												
	46	How much candidates were stating cities will change with the come of AVs?		1			1	1	1		1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	20
	47	How much candidates were stating cities will change with the come of AVs? Again		1			1	1	1		1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	20
	47.1	How much canidates were stating specific how cities will look like?		1			1					1		1	1	1	1		1	1	1	1						11
	48	How much candidates were stating that possibility of smaller vehicle, mobility sharing and less cars					1	1			1	1		1			1	1	1	1	1	1	1	1	1	1	1	16
	49	How much canidadates were reffering to that with come of AVs less parking spaces are needed?					1	1			1	1		1			1	1	1	1		1	1	1	1	1	1	15

Appendix E: Community interviews

Participant 1	
Question 1	Ik ben een beetje bekend met autonoom rijden. Ik heb hiervoor gewerkt bij een bedrijf voor verkeersveiligheid, zij deden onder ander ook onderzoek naar autonoom rijden. Ik weet niet of hun onderzoek ook betrekking had op volledig autonoom rijden. Wel weet ik nog dat ze testen/onderzoeken deden met bussen, die volledig autonoom ging rijden. Als groot voordeel denk ik dat er minder ongelukken zouden gebeuren met bijvoorbeeld fietsers of voetgangers als bussen volledig autonoom zouden gaan rijden.
Question 2	Ik denk het wel, ik dat dat door middel van kunstmatige intelligentie de auto's beter geprogrammeerd kunnen worden wat uiteindelijk alleen maar veiliger wordt in het verkeer. Ik heb wel vertrouwen in de techniek. In het dagelijkse leven maak ik nog niet echt gebruik van kunstmatige intelligentie, maar bijvoorbeeld wel op mijn telefoon: autocorrectie. En misschien is onze Toon (van Eneco) een beetje een voorbeeld ervan.
Question 3	Ik denk het wel, maar ik ben wel benieuwd naar hoe het onderzoek zal gaan. Want er wordt nu natuurlijk al best veel onderzocht en hoelang het zal duren voordat het ook daadwerkelijk zo ver is. Ik denk wel dat autonome auto's goed geprogrammeerd kunnen worden zodat zij zelf in staat zijn om te beslissen wat te doen mocht er iets gebeuren. Ethisch gezien vind ik het wel lastig om een keus te maken, maar als het eenmaal geprogrammeerd is dan moet je er maar vanuit gaan dat de beste keus gemaakt zal worden. Op gebied van fabrikant vind ik dat zij de auto zo goed mogelijk moeten af- en instellen zodat de auto op alle situaties voorbereid is. Dat dit ook van de voren getest is. En dat alle fabrikanten 1 lijn moet trekken in het instellen van autonomen voertuigen.
Question 4	Een lastige vraag, maar ik denk wat voor mij ethisch verantwoord is, is zo min mogelijk slachtoffers. Want dat is uiteindelijk wel wat je zou willen als men volledig autonoom gaat rijden. Of het voorkomen van slachtoffers.
Question 5	Ik denk bij volledig autonoom rijden dat de fabrikant verantwoordelijk is. Want de fabrikant stelt de auto dusdanig in dat je zelf niet hoeft in te springen omdat er geen pedalen zitten en ook geen stuur.
Question 6	Ik denk dat het een beetje te maken heeft met kunstmatige intelligentie. Voor mij is ethisch verantwoord, zo min mogelijk of geen slachtoffers. En dat de auto dusdanig geprogrammeerd is om zo veilig mogelijk de weg op te gaan. De vraag blijft wel, wat is veilig. Maar nu gebeuren er wel veel ongelukken doordat bestuurders bijvoorbeeld onder invloed zijn van alcohol of drugs. Of mensen die niet opletten, door afleiding. Met autonoom rijden heb je dat allemaal niet.
Question 7	Voor mij is het belangrijk als de auto veilig is en zo goed geprogrammeerd is dan zal ik er in de toekomst gebruik van maken. En dat er zo veel mogelijk autonomen auto's zijn. Ook ben ik wel benieuwd hoe en waar data wordt opgeslagen. Ook bijvoorbeeld als er een ongeluk gebeurd, wordt er dan naar data gekeken? Een groot voordeel zou ook zijn als ik bijvoorbeeld naar het werk zal gaan met de autonome auto dat ik wat meer tijd heb om alvast mijn werk voor te bereiden.

Participant 2	
Question 1	Eigenlijk wat ik beetje op tv heb gezien, maar dat ziet er heel futuristisch uit. Als ik er over nadenk dat duurt het denk ik wel heel lang voordat we zover zijn. Ook voor alle zaken die daarvoor geregeld moeten worden. Voor de rest hoor en zie ik er nog wel weinig over. De auto die ik nu rij kan ik bijvoorbeeld wel cruise-control aanzetten, dat is misschien ook een voorbeeld van autonoom rijden. Het is een soort rijondersteuning. Ik ken ook adaptieve cruise-control, maar dat heeft mijn auto volgens mij niet. Bij autonoom rijden stel ik mij voor dat ik alleen hoef in te stappen en de auto zelf rijdt waar je naartoe wilt. En voor de rest hoef je niks te doen. Ik ben wel benieuwd wanneer dit zal gaan komen.
Question 2	Ik denk zonder kunstmatige intelligentie het niet zal gaan slagen. Want als de auto niet de rij intelligentie heeft wat een mens ook heeft dan zal het naar mijn mening niet slagen. Als je aan het rijden bent dan denk je na, bijvoorbeeld je ziet een bord met

	maximum snelheid van 50 km dan pas je je snelheid aan. En zo moet de auto ook denken. De auto moet zelflerend zijn. Want soms ben je in situaties waar verkeersregels onduidelijk, een mens kan dan zelf snel schakelen. De auto moet dat ook kunnen. Alles moet voorgeprogrammeerd zijn. Ook in het geval met voorrang, dat men elkaar de ruimte geeft..
Question 3	Ik weet niet of je de auto zo kan voorprogrammeren dat deze een keus moet maken. Natuurlijk kan je de auto wel voorprogrammameren, maar dan krijg je te maken met een stukje ethiek. Is het ethisch om te zeggen, dan rij ik de opa maar aan maar hij heeft niet zo lang te leven? Als je het zo al voorgaat programmeren dan komt de ethiek wel om de hoek kijken. Of moet de persoon in de auto beschermd worden? Als dit zich zo gaat ontwikkelen dan moet je ook andere wet- en regelgeving hebben hierom heen. Ik denk dat het in het begin vaak fout gaat, zo kan je er alleen maar van leren. De wet- en regelgeving van nu is dan niet meer van toepassing op volledig autonoom rijden. De auto maakt uiteindelijk de keus hoe ermee om te gaan, omdat deze zo geprogrammeerd is.
Question 4	Een lastige vraag. Bij autonoom rijden moet de beslissing voor de auto al zijn gemaakt. Ik denk niet dat je er aan ontkomt om een niet-ethische verantwoorde beslissing te nemen. Je moet erop voorbereid zijn, of er 2 keuzes zijn of misschien bijvoorbeeld 5 keuzes. Ik denk dat je niet kan voorkomen om een beslissing te voorprogrammeren waarvan men denkt; dit kan niet. Misschien word het ook per land anders naar gekeken.
Question 5	Ik denk de eigenaar, ondanks dat hij/zij niet zelf rijdt. De fabrikant kan misschien ook, maar uiteindelijk denk ik wel de eigenaar. Want als hij de auto koopt, moet hij er wel in verdiepen. Eindelijk zou je altijd wel een optie moeten hebben om toch zelf in te grijpen. Of je moet naar een systeem toe waar je bij het autonoom rijden helemaal geen fietsers of voetgangers tegenkomt. De eigenaar weet wat hij koopt dus hij is er zelf verantwoordelijk voor, dat is nu ook zo.
Question 6	Ik vind het wel belangrijk. Het totaal plaatje vind ik belangrijk. Het is belangrijk om erin te verdiepen wat de auto kan en niet. Ik denk dat het sowieso veiliger wordt op de weg. Dan zou je eventueel ook met een slokje op, de auto instappen. Maar dan zit je er wel mee, moet je ingrijpen ja of nee? Zo ja, dan mag je niet drinken. Ook ligt het aan de infrastructuur, deze zal ook veranderd moeten worden.
Question 7	Veiligheid vind ik het belangrijkste. Als je altijd gewend bent om zelf te rijden, en je moet het dan nu overlaten aan de auto, dan lijkt mij dat wel lastig. Daarom vind ik veiligheid het belangrijkste. Ook functionaliteit is wel belangrijk, dat de auto mij van A naar B brengt. Een voordeel zou ook kunnen om bijvoorbeeld te werken in de auto, tenzij er niet ingegrepen hoeft te worden.

Participant 3	
Question 1	Ik weet wat het inhoud maar ik heb me er nog niet in verdiept.
Question 2	Ik denk wel dat mensen goed geïnformeerd moeten worden wat hen te wachten staat en zodat ze het kunnen accepteren. Want als men iets begrijpt, dan wordt het sneller geaccepteerd. Ook de voordelen moeten duidelijk zijn. Ik denk dat het voor de natuur ook beter kan uitpakken.
Question 3	Ik denk het wel, want als je nu een ongeluk hebt dan moet je op het woord van een mens vertrouwens. En straks kan je het voertuig uitlezen wat/hoe/waar het ongeluk is gebeurd. Dat zal veel verwarring uit de wereld helpen. Ik denk in de overgang dat men het misschien ook lastig kan gaan vinden dat je een auto ziet rijden zonder bestuurder.
Question 4	Ik dat de auto net zoiets als een vliegtuig moet hebben, zodat er precies geregistreerd kan worden wat er gebeurd. Als dat er niet is dan denk ik dat het lastig is mocht er een ongeluk gebeurden. Als je precies alles kan uitlezen, dan is dat veel beter.
Question 5	De verzekering, want jij vertrouwd de auto op wat deze doet en daar verzeker je naar. Ook denk ik dat er verschillende gradaties moeten zijn qua verzekeringen. Bijvoorbeeld een all-risk verzekering, dat de verzekering voor alles verantwoordelijk is. En een zwarte doos zou ook veel schelen, want dan kan er uitgelezen worden wat er aan de hand is geweest. Het kan misschien ook aan de auto liggen.
Question 6	Wat voor mij persoonlijk de voordelen zijn en wat het mij gaat opleveren en ik denk ook prijs/kwaliteit. Ik kan er misschien voor gaan betalen maar als het mij geen

	voordelen oplevert, dan niet. Dus de voordelen zijn voor mij het belangrijkste. Ook privacy vind ik wel belangrijk, waar worden mijn gegevens opgeslagen
Question 7	Zoals ik net zei, de functionaliteit en wat voor mij de voordelen zijn.

Participant 4	
Question 1	Ik heb er wel wat over gelezen, ook weet ik de verschillende levels. Level 2 heb ik veel over gelezen en level 5 is zonder stuur. Volgens mij is Tesla het verste hiermee.
Question 2	Ik denk het wel, ik denk dat dit wel de toekomst is. Of eventueel een robot laten rijden. En je gaat steeds meer vertrouwen in de techniek van tegenwoordig. In de zorg zie je al dat ze robots gebruiken. En voor het milieu zou het beter zijn.
Question 3	Ik denk het niet, ik denk wel dat je het kan gebruiken om te remmen. Maar niet om een keus te maken. Want waar leg je de grens? Ik denk dat je het bijna niet kan inbouwen. Dan moet je al de situaties voor geschetst hebben, ik denk echt niet dat dit kan. Ik zou eerder zeggen je zou een of ander remsysteem moeten hebben.
Question 4	Het hangt ervan af in welk op zich. Ik denk dat je wel een remsysteem moet inbouwen. Zodat er tijdig geremd kan worden. Wel een lastige vraag ik weet niet zo goed waar ik aan zou moeten denken. Maar ik denk niet dat de auto een keuze kan maken. Ik ben wel benieuwd hoe ze dit willen gaan inbouwen. Vooral voor kinderen zodat zij goed beschermd zijn. En misschien dat er zo veel mogelijk hulpmiddelen worden ingebouwd. Zodat de auto beter zichtbaar en hoorbaar zijn. En veiligheid inbouwen. Ethiek is wel moeilijk met auto's.
Question 5	De auto/fabrikant. Want de auto wordt zo ingebouwd. Ik weet niet of je kan ingrijpen of over kan nemen bij een autonomen voertuig. Want in noodsituaties moet je kunnen ingrijpen. Ook moet de auto geüpdatet blijven. En als de auto niet doet waarvoor ik de auto gekocht heb, dan ga ik terug naar de fabrikant.
Question 6	Ik vind ethiek niet echt bij een auto horen, wel veiligheid. Dus voor mij is veiligheid het belangrijkste. Wel zijn er vraagstukken: wat is ethisch verantwoord? Kan je alles inbouwen? Kan de auto een keus maken? Want bijvoorbeeld een keus maken tussen een oude opa of een kind is niet te maken. En wordt er gediscrimineerd? Wordt er verschil gemaakt tussen arm en rijk? Want duurdere autofabrikanten hebben meer budget om alles in te bouwen dat bijvoorbeeld een kleinere automerk. En kan er gehackt worden, want het is een computer bestuurbare auto?
Question 7	Veiligheid is voor mij het allerbelangrijkste. Veiligheid moet voor mij voorop staan wil ik voor zo'n auto kiezen.

Participant 5	
Question 1	Nee ik weet nog niet zo veel over autonoom rijden. Het enigste wat ik heb gelezen over dat het wordt aangestuurd door gps. En dat Mercedes, BMW en Volvo er iets mee gingen doen.
Question 2	Ik denk naarmate dat het voor een beter acceptatie zal gaan zorgen. Het zal in het begin wennen zijn, maar daarna zal het geaccepteerd worden.
Question 3	Ik denk van wel, nu heb je het al een beetje al. Nu met de Volvo van mijn vrouw ook, deze remt al beetje als er wat is. Nu moet je knipperen om van rijbaan te wisselen anders werkt het stuur niet mee. Voor de veiligheid is het wel veel beter.
Question 4	Dat vind ik een moeilijke vraag. Het wordt voorgeprogrammeerd, dus ik denk dat het uiteindelijk een menselijke fout blijft. Ik denk als er een fout gemaakt wordt, dat er dan ook echt een grote fout gemaakt wordt. Die keus is lastig om te maken.
Question 5	De fabrikant, omdat de fabrikant de auto op de markt brengt en beweerd dat de auto veilig is.
Question 6	Ik denk dat het voor iedereen persoonlijk is hoe hij of zij er in staat. De vraagt blijft wanneer is iets verantwoord? Je moet ergens beginnen, maar het is net hoe mensen het oppikken. Ik zou zeggen, ik wil het proberen kijken hoe het loopt en dan kan je zien wat er fout gaat.
Question 7	Ik zou er zelf zeker gebruik van maken, zeker omdat ik niet van auto rijden hou. Gewoon zitten en de auto brengt je van A naar B. Je kan gewoon werken in de auto, de functionaliteit is belangrijk.

Participant 6	
Question 1	Ik weet dat veel bedrijven ermee bezig zijn en dat vooral Tesla ermee bezig is. Ik weet een beetje af van de levels. Ik denk dat level 5 wel binnen 5 jaar mogelijk is.
Question 2	Ik denk het wel, vooral als iedereen de nieuwe technologie gaat gebruiken. Ik zie wel dat de meeste mensen het nog beetje eng vinden dat bijvoorbeeld robots het gaan overnemen, maar ik als IT'er zie er alleen maar de voordelen van.
Question 3	Ik denk het wel, ik dat als iets eerder is gebeurd dat er in de toekomst er een beter besluit kan genomen wordt. De technologie is ook zelflerend dus het wordt alleen maar beter. Het heeft ook wel veel met wet- en regelgeving te maken, het zal per land ook verschillen. Bijvoorbeeld in Amerika zou het heel anders zijn of Bali.
Question 4	Ik weet niet precies hoe het nu ingesteld is, dus dat vind ik wel lastig. Volgens mij is de auto nu ingericht op de verstelbaarheid. Ik denk dat het altijd slim is dat de auto kan kiezen om zo min mogelijk slachtoffers te maken en zo min mogelijk schade. Ik denk wel dat het moeilijk is om dit zo goed mogelijk in te bouwen.
Question 5	Dat vraag ik mij ook wel af, want officieel ben je de bestuurder dus ben je zelf verantwoordelijk. Maar als je zelf niet verantwoordelijk bent om te rijden, maar de auto, dan is het wel lastig. Maar ik denk wel de bestuurder.
Question 6	Ik denk dat ik het lastig vind om de controle aan de auto te geven. Ik moet er toch vertrouwen in gaan krijgen. Ook dat de auto de juiste keus gaat maken.
Question 7	Ik vind de veiligheid het belangrijkste. Ik zou wel de zekerheid willen dat alles goed voorbereid is, dat er niet onverwachts iets kan gebeuren dat ik de weg af rij.

Participant 7	
Question 1	Zelf weet ik er nog niet zo heel veel van, ik weet dat ze er in de toekomst mee bezig zullen zijn. Ook voor de veiligheid. Ik ben ook niet echt bekend met de verschillende levels. Wel dat Tesla met het een en ander bezig is.
Question 2	Ja ik verwacht het wel. Ook dat het eerder door de maatschappij wordt geaccepteerd. Ook dat het veiliger wordt op de wegen, minder ongelukken.
Question 3	Een lastige vraag, in de zin van betere besluitvorming. Ik weet eerlijk gezegd ook niet of het wel mogelijk is, of de autonomen auto in een split second een beslissing kan nemen. Het is voor mij dan: wat wordt er geaccepteerd. Uitgangspunt moet voor mij zijn zo min mogelijk slachtoffers of schade aan te richten. Het is ook een soort dilemma, is het de veiligheid van je eigen auto of de veiligheid van iemand anders.
Question 4	Voorkomen dat andere mensen schade of een letsel krijgen. Dat de auto dusdanig daarop geprogrammeerd is.
Question 5	De verzekering, omdat zij rekening houden met de risico's die erbij komen kijken. Ik denk dat het ook ligt aan hoe een ongeluk is ontstaan. Als het een foutieve fout is van de auto, dan de fabrikant.
Question 6	Ik denk dat het voor mij belangrijk is hoe veilig het is voor mij als bestuurder. Hoe wordt mijn veiligheid gewaarborgd? Of wordt er rekening mee gehouden met de overige weggebruikers.
Question 7	Prijs, gebruiksvriendelijk of het wel echt zo handig is: instappen en helemaal niks doen en eindigen op je bestemming

Participant 8	
Question 1	Ik heb er wel eens programma's over gezien. Ook heb ik gelezen dat Tesla ermee bezig is. Ook heb ik gezien dat je in de tegengestelde richting in de auto zit kan zitten.
Question 2	Ik denk het wel, ook omdat het een heel stuk veiliger wordt. Je bent er zelf bij, maar je rijdt met 2 personen, de auto en jezelf.
Question 3	Ik denk het wel, ook omdat ik zelf een soort gelijke situatie heb meegemaakt. Ik was in de polder en ik wilde een eend ontwijken maar dat ging niet helemaal goed, ik had over de kop kunnen slaan. En een autonome auto had dan gewoon gekozen om de eend aan de rijden en mijzelf veilig te houden. Maar ik zou er nog niet helemaal op durven vertrouwen.

Question 4	Ik denk hoe je zelf redeneert, ik hou zelf heel erg van dieren dus ik zou dat belangrijk vinden. Maar dat is voor iedereen persoonlijk. Ik zou zelf niet iemand kunnen aanrijden in het uiterste geval, ik zou mezelf dan laten botsen.
Question 5	Ik denk hoe je zelf redeneert, ik hou zelf heel erg van dieren dus ik zou dat belangrijk vinden. Maar dat is voor iedereen persoonlijk. Ik zou zelf niet iemand kunnen aanrijden in het uiterste geval, ik zou mezelf dan laten botsen.
Question 6	Ik vind het wel belangrijk, maar ik zou altijd wel zelf blijven opletten. Ik denk niet dat je er iets in moet bouwen om de auto te overrulen, maar toch wel zelf blijven opletten.
Question 7	De veiligheid, ik denk dat het veel veiliger wordt op de weg.

Participant 9	
Question 1	Ik heb op tv gezien dat ze bij de TU Delft bezig zijn met een onderzoek naar een volledige autonome auto. Ik heb op mijn bedrijfsauto ook een aantal systemen zitten, dat hij automatisch gaan remmen bij bijvoorbeeld file en dat hij zich automatisch corrigeert.
Question 2	Ik denk het wel, want AI maakt onderscheid tussen mensen en auto's. Mijn deurbel heeft ook AI, deze maakt ook onderscheid tussen mensen en dieren. Het wordt er alleen maar beter op. Ik denk dat het systeem ook sneller reageert dan een mens zelf.
Question 3	Ik vind eigenlijk dat het gelijk moet zijn, dat je geen onderscheid kan maken tussen verschillende mensen. Uiteindelijk ga je voor de beste keus en niet om onderscheid te maken. Ik vind niet dat je dat mag besluiten, ik zou kiezen voor de beste keus. Wat die ook mag zijn.
Question 4	Ik denk letselschade zo min mogelijk te beperken en zo min mogelijk slachtoffers. Ik denk dat het ook minder chaotischer wordt op de weg.
Question 5	De eigenaar, je ben ten alle tijde zelf verantwoordelijk. Ook al heb je er zelf geen invloed op, want je gaat zelf in de auto zitten om naar je bestemming te komen.
Question 6	Dat het echt 100% veilig is, dat je er vertrouwen in moet hebben. En je moet het meer om je heen zien, hoe meer mensen het gebruiken hoe meer vertrouwen erin komt.
Question 7	De veiligheid is voor mij het belangrijkste. En of het betaalbaar is.

Participant 10	
Question 1	Ik ken het van films en ik weet dat auto's van nu zelf kunnen parkeren en zelf kunnen afremmen. Dat zijn ook soort van voorbeelden, niet van level 5 maar wel rijondersteuning.
Question 2	Ik denk eigenlijk dat het een voorwaarde is. Ik denk ook dat de maatschappij het beter gaat om armen. Ook als je kijkt hoeveel mensen er zijn en hoeveel verkeer er is. Ik zou er zeker een voorstander van zijn.
Question 3	Ik vind het wel ver gaan om zo'n keuze te maken. Want hoe ver ga je erin mee, hoe maak je daar een keuze in? Ik denk niet dat we daarin te ver moeten gaan. Ook denk dat ik dat je dit soort keuzes niet door AI kan laten bepalen. Maar aan de andere kant denk ik ook dat het wel voordelen heeft. Zo min mogelijk slachtoffers zou mijn uitgangspunt zijn.
Question 4	Zo min mogelijk slachtoffers, zo min mogelijk ongelukken.
Question 5	De fabrikant of de software ontwikkelaar. Want zelf heb je geen invloed meer of wat je doet, want je zelf kan je niet meer ingrijpen. Uiteindelijk denk ik dat dit misschien niet ter sprak is, omdat er geen menselijk handelen is. Dus dat er sowieso niks meer gaat gebeuren qua ongelukken.
Question 6	Ik denk eigenlijk dat het er niet meer toe doet, omdat het handelen van de auto is overgedragen aan AI. Ik denk dat ethiek nu meer een rol speelt met normen en waarden. Bij autonoom rijden laat je het eigenlijk los.
Question 7	Veiligheid staat bovenop. En het is laagdrempelig. Kosten zijn belangrijk. En ook qua duurzaamheid zou het echt top zijn, ook om samen te rijden. Niet iedereen heeft meer een auto nodig.

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Participant 11	
Question 1	Ik weet er nog niet zo veel over, wel heb ik van level 2 gehoord. Omdat het ouders bij leerlingen van mij voorkomt, dan hoor ik het van leerlingen. Ook heb ik wel iets gelezen over level 5 dat er onderzoek naar gedaan wordt.
Question 2	Ik denk het wel, omdat het makkelijker zou zijn en je hoeft er niet over na te denken. Je hoeft minder te focussen.
Question 3	Ik denk dat er wel ongelukken gaan gebeuren maar met de juiste software zal er wel zeker minder ongelukken gebeuren. Ik vind eigenlijk niet dat er een keus gemaakt kan worden, tussen bijvoorbeeld 2 mensen wie je bijvoorbeeld aanrijdt. Ik zou kiezen voor de situatie met het minste impact.
Question 4	Ik denk zo min mogelijk slachtoffers en zo min mogelijk impact.
Question 5	Ik denk dat het ligt per situatie. Ik denk de fabrikant en de eigenaar. Want het is de software van de fabrikant, maar als ik de auto bijvoorbeeld een fietser aanrijdt, dan zou ik de eigenaar verantwoordelijk stellen.
Question 6	Ik vind het belangrijkste dat alles goed is doordacht en veiligheid staat echt op nummer 1. Dat vooral kinderen veilig vervoerd kunnen worden.
Question 7	Gemakzucht, vooral het gemak. En dat er meer tijd over is, zoals make-uppen achter het stuur. En ook dat er misschien minder auto's nodig zijn.

Participant 12	
Question 1	Ik ben er heel erg bekend mee. Je hebt shuttle bussen op Brainpark, die zijn ook zelfrijdend. Ik weet dat Tesla best ver is in het onderzoek.
Question 2	Het is wel een beetje eng omdat het toch een robot blijft. Wij als mens hebben normen en waarden, we weten wat goed en slecht is. En het lijkt mij moeilijk dat een computer emoties en gevoel kan nabootsen. Maar ik denk wel dat het zal helpen qua acceptatie. Maar ik heb ook wel eens gehoord van Elon Musk dat AI ook wel eens gevaarlijk kan zijn, omdat ze bijvoorbeeld een eigen taal kunnen aanleren.
Question 3	Ik vind eigenlijk dat AI geen keus kan maken, ik weet niet in hoever ze dan zijn om een keus te maken. Nu zijn de computers er nog niet klaar voor, tegen die tijd wel. Maar ik zou het wel eng vinden om mijn vertrouwen volledig te geven aan een computer/autonome auto.
Question 4	Dat de auto goed uitwijkt en over alles goed heeft nagedacht. Voor de veiligste scenario, eigenlijk voor helemaal geen slachtoffers. En zo min mogelijk schade maakt aan zichzelf en aan andere.
Question 5	Je zou zeggen de fabrikant. Maar ook wet- en regelgeving zou er mee te kunnen maken hebben. Want wie is er aansprakelijk? Daar zouden goede regels over moeten zijn. Ik vind eigenlijk ook dat de bestuurder altijd een mogelijkheid moet hebben om in te grijpen. Ik denk ook dat er speciale wegen worden gemaakt voor autonomen auto's.
Question 6	Ik ben van mening dat ze bij AI nooit een emotie van een mens kunnen nabootsen. Ik denk dat je alleen goed en fout kan inbouwen.
Question 7	Ik weet niet of ik een autonomen auto zou aanschaffen, omdat ik altijd zelf de controle wil hebben. Ik vind het eng om de auto volledig te vertrouwen.

Participant 13	
Question 1	Ik weet er nog niet echt veel over, wel weet ik wat het inhoud. In de auto zitten en deze brengt mij naar mijn bestemming.
Question 2	Op zich zou het wel moeten, het zou voor mij wel logisch zijn. Ik denk ook wel dat het meer voordelen heeft, meer veiligheid.
Question 3	Ik denk niet dat het echt wenselijk is, maar het zou wel het meeste logische zijn. Want nu denk je er niet bij na. En bij een autonome auto moet er al over nagedacht zijn.
Question 4	Lastige vraag, want eigenlijk zou je ervan uitgaan dat er geen ongelukken mogen gebeuren.
Question 5	Eigenlijk niemand, maar dat kan niet. Er moet altijd iemand verantwoordelijk zijn. Ik denk dat je alle voor- en tegens moet afwegen, want ik denk niet dat je zomaar de fabrikant verantwoordelijk kan houden.

Question 6	Ik denk dat ethiek wel belangrijk is, vooral dat er vastligt als het fout gaat. Dus goede wet- en regelgeving. En dat alles goed gecontroleerd en gewaarborgd is. En dat de cybersecurity veilig is.
Question 7	Het zou zakelijk gezien voor mij ideaal zijn, ik zou dan kunnen werken in de auto. Of even uitrusten.

Participant 14	
Question 1	Niet zo heel veel, wel heb ik gehoord dat Tesla bezig is met het een en ander.
Question 2	Ik denk het wel, want op een gegeven moment ontkom je er niet aan. Het zal ook normaal worden. In het begin is het wennen, maar op een gegeven moment wordt het normaal.
Question 3	Ja, want dan is er maar 1 besluit. Maar dan nog is het een lastige vraag. Want wat zijn de mogelijkheden en hoe is de auto geprogrammeerd? Uitgangspunt zou zijn, zo min mogelijk slachtoffers.
Question 4	Zo min mogelijk slachtoffers. En ook een onderscheid maken tussen de wegen, bijvoorbeeld binnen de bebouwde kom mogen dan ook nog normale auto's rijden en buiten de bebouwde kom alleen maar autonomen voertuigen.
Question 5	Je gaat er van uit dat de autonome voertuig de juiste beslissing neemt. Het zou lastig zijn om deze als schuldige aan te wijzen, want de auto houdt zich aan de verkeersregels. En het ligt ook aan het ongeval. En anders de fabrikant.
Question 6	Als meer dan 50% van de voertuigen uit autonome auto's bestaat. En dat het veilig is. Dus dat ook alles getest is.
Question 7	Veiligheid staat voorop. En dan gemak, comfort, extra vrije tijd of anders met je tijd omgaan.

Participant 15	
Question 1	Eigenlijk nog niet zo heel bekend, ik ken het alleen van Tesla en van filmpjes die ik heb gezien.
Question 2	Ik denk dat het nog onbekend is bij mensen. Maar ik denk wel dat het kan bijdragen in het verkeer. Aan de ene kant lijkt het mij heel goed om te doen en aan de andere kant geef je ook controle weg.
Question 3	Dat is wel een lastige vraag, ook omdat het niet je eigen keus is. Ik denk wel dat het heel ver gaat als de computer dit gaat beslissen. Ik zou zelf wel controle willen houden
Question 4	Ik denk toch dat er altijd wel iets ingebouwd moet zijn dat een mens kan ingrijpen mocht er een situatie zich voordoen.
Question 5	Lastige vraag omdat je zelf eigenlijk geen invloed hebt op het rijden dan zou ik zeggen de fabrikant. Want de fabrikant heeft de auto gebouwd en de software ook ontwikkeld.
Question 6	Ik denk toch wel heel belangrijk. Als een voertuig zelf dingen kan beslissen, dan is het wel heel belangrijk dat je weet dat het goed gaat en goed geprogrammeerd is.
Question 7	Veiligheid is denk ik wel het belangrijkste. En een stukje rust.

Participant 16	
Question 1	Ik weet er nog niet veel over. Het had niet zo mijn interesse. Wel ben ik bekend met rijondersteuning.
Question 2	Ik denk het wel. Gevoelsmatig vind ik het wel lastig om mijn vertrouwen te geven aan de auto.
Question 3	Ik zou er geen voorstander van zijn, ik vind niet dat er een keus gemaakt kan worden van te voren. Ik denk dat het uiteindelijk wel zou moeten want de auto moet helemaal geprogrammeerd worden, maar een keus van te voren maken vind ik heel lastig. Maar ik denk ook dat er wel iets ingebouwd moet worden dat de auto abrupt stopt zonder iemand aan te rijden of schade te maken.
Question 4	Uitgangspunt moet zijn zo min mogelijk lichamelijk schade. Maar voorkeuren mogen niet van invloed zijn.
Question 5	Lastige vraag, ik denk niet dat de fabrikant zit te wachten op verantwoordelijkheid. Ik denk dat toch de bestuurder. In de ideale wereld zou iedereen een level 5 auto moeten

	hebben en dan maakt de verantwoordelijkheid eigenlijk niet meer uit. Omdat je er dan vanuit gaat dat alles goed gaat.
Question 6	Dat vind ik wel belangrijk. Vooral de veiligheid.
Question 7	Dat de auto zelf inparkeert, want parkeren vind ik echt heel lastig. Dus vooral de functionaliteit.

Participant 17	
Question 1	Ik weet wat het betekent en ik ken de filmpjes van internet.
Question 2	Dat lijkt mij wel. Want de auto moet wel zelflerend zijn.
Question 3	Ik denk het wel, want de emotie kan je loslaten.
Question 4	Eigenlijk niks, want je kan geen onderscheid maken tussen mensen. Ik zou dan kiezen voor de keuze met het minste impact, zo min mogelijk slachtoffers.
Question 5	De bestuurder, zoals hoe het nu is. Want jij stapt in de auto.
Question 6	Ik vind het wel belangrijk, maar ik vraag me wel af in hoeverre je erover nadenkt als je daadwerkelijk tot de koop overgaat.
Question 7	De functionaliteit, meer het praktische ervan. Gewoon de auto instappen en gaan.

Participant 18	
Question 1	Ik ben er bekend mee, mijn auto doet het ook voor een deel. Mijn Volvo zit op level 2, ik heb zelf lean-assist. Ik ben een gebruiker ervan maar niet echt op de hoogte van alle technische details.
Question 2	Ik denk niet voor een acceptatie. Of er wel of niet iets met AI gebeurd, denk ik niet dat het zorgt voor een betere acceptatie. Ik denk eerder dat het een beetje tegenwerkt. Want de Belastingdienst gebruikt ook AI en daar heeft het niet goed uitgepakt.
Question 3	Het voordeel van AI op basis van regels tot een bepaald besluit komt. Dus het is veel exacter en logischer. Als je iets doet volgens AI regels dan zou je dat kunnen documenteren en uitlezen. En als de AI is zover is om te kiezen, dan kan hij dat documenteren. Dan is het een andere level van discussie. Een mens is moeilijk te documenteren waarom hij/zij een keuze maakt.
Question 4	Aan de ene kant denk ik dat het heel makkelijk is, maar ethische kwesties zijn heel moeilijk om helemaal formeel te maken. Aan de ene kant is het de ideale wereld, maar aan de andere kant wil je ook niet in de ideale wereld leven. Want nu zit er een flexibiliteit in het systeem.
Question 5	De bestuurder, omdat de bestuurder altijd eindverantwoordelijk moet zijn. En dat mag nooit bij de leverancier liggen.
Question 6	Voor mij persoonlijk niet zo. Ik zou meer naar de functionaliteit kijken.
Question 7	Functionaliteit is voor mij het belangrijkste.

Participant 19	
Question 1	Ik heb er wel van gehoord en ook wat filmpjes gezien op internet.
Question 2	Ik denk het wel, omdat het wat veiliger wordt. En dat je dan ook minder de asociale rijders ertussen hebt.
Question 3	Ik denk van niet, want ik denk dat het iets menselijks is als je nu een keuze moet maken. Ik denk dat je zoiets kan programmeren.
Question 4	Dat is een lastige, ik denk dat het een dunne scheidslijn is. Ik zou kiezen voor zo min mogelijk letsel.
Question 5	De bestuurder, want ik vind dat hij of zij altijd verantwoordelijk blijft.
Question 6	Ik denk dat het wel belangrijk is, maar als mens zijnde moet je er wel altijd goed over nadenken.
Question 7	Ik denk ook als er iets ingebouwd wordt dat je zelf nog kan ingrijpen, dus zelf ook een soort van besluitvorming hebt.

Participant 20	
Question 1	Het enigste wat ik ervan weet zijn de onderzoeken en filmpjes van Tesla.
Question 2	Ik denk het wel, ook omdat ik denk dat mensen zullen denk dat AI het veiliger maakt.

Question 3	Ik weet niet of het er beter op wordt. Ik denk dat de ethiek te moeilijk is. Ik denk niet dat AI zo ver is om een beslissing te nemen.
Question 4	Ik vind het wel lastig, want wie is de veroorzaker. Want een ongeluk komt van 2 kanten. Ik denk ook een besluit nemen met zo min mogelijk letsel. Materiele schade zou voor mij niet uitmaken.
Question 5	Ik denk de bestuurder, omdat hij verantwoordelijk is voor de auto. Hangt ook van de wet- en regelgeving af.
Question 6	Extreem belangrijk. Ik zou alle resultaten en onderzoeken willen zien. Ik wil niet achteraf te weten komen dat de auto een beslissing maakt die ik zelf van te voren niet gezien heb.
Question 7	In hoeverre AI is ingebouwd en dat deze zo veilig mogelijk is. En dat ik kan werken in de auto.

Participant 21	
Question 1	Ik ben er al redelijk bekend mee. In mijn huidige auto gebruik ik ook voornamelijk de functionaliteit van automatisch parkeren. Ook werk ik veel met slimme thuisoplossingen (home domotica), zoals met verlichting of geluid. Mijn kinderen zijn er veel handiger in.
Question 2	Ik denk het wel, uiteindelijk moet je ervan uitgaan dat de auto de juiste beslissing neemt. Je moet erop kunnen vertrouwen.
Question 3	Ik weet het niet zo goed, ik ben er een beetje sceptisch over. Eigenlijk denk ik dat hier echt nog jaren onderzoek naar gedaan moet worden, vooral om alle scenario's goed uit te lichten.
Question 4	Eigenlijk niks, want ik denk niet dat iets goed of fout is. En dat in handen te geven van een auto vind ik wel lastig. Misschien maakt de auto een keus die ik zelf nooit zou maken.
Question 5	De bestuurder. Hij of zij is degene die in de auto zit of bezit.
Question 6	Ik denk dat het wel heel belangrijk is, maar ik zou zelf echt alles willen weten over het hoe, wat en waarom.
Question 7	Voornamelijk de veiligheid. Ook meer tijd overhouden, bijvoorbeeld dat ik nog het een en ander voor het werk kan doen.

Participant 22	
Question 1	Ik lees er wel het een en ander over, ook weet ik dat Tesla met een aantal onderzoeken bezig is.
Question 2	Ja, als het eenmaal zo ver is, moet je ervan uit kunnen gaan dat alles goed onderzocht en getest is. Je moet erop kunnen vertrouwen.
Question 3	Ik zou er zelf niet over willen nadenken, maar ik denk wel dat je ervan uit moet gaan dat mocht er iets gebeuren dat de auto de juiste beslissing gaat maken.
Question 4	Uitgangspunt voor mij zou zijn, geen mensenlevens, dan maar schade aan auto's bijvoorbeeld. Of bomen of iets dergelijks.
Question 5	Ik denk de bestuurder, hij is degene die de auto heeft gekocht.
Question 6	Ja wel belangrijk. Al zou ik wel willen weten wat er met alle data gebeurt. Waar wordt dit opgeslagen? Is de data vertrouwelijk of kan iedereen erbij? Dat zijn wel vragen waar ik over zou nadenken.
Question 7	De vrijheid, je kan in de auto zitten en die gaat naar plaats van bestemming. Zonder dat je zelf hoeft na te denken.

Participant 23	
Question 1	Ik heb er over gelezen en een aantal programma's over gezien. Ook heeft mijn auto een aantal functionaliteiten.
Question 2	Ik denk het wel, uiteindelijk moet je je er wel aan overgeven, omdat je dan geen andere keus meer hebt.
Question 3	Ik denk het wel, ik denk dat de autonome voertuigen dusdanig zijn ingesteld op allerlei situaties en wat ze daarin moeten doen.

Question 4	Lastige vraag, maar ik denk uitgangspunt moet zijn zo min mogelijk slachtoffers. Dan maar materiele schade.
Question 5	De bestuurder. Je bent nu ook verantwoordelijk voor als je een ongeluk maakt, waarom zou het dan anders moeten zijn? Je rijdt zelf dan niet, maar de auto is alsnog van jou.
Question 6	Heel belangrijk. Nu is het wel ontspannen om bijvoorbeeld lange stukken te rijden. Bij autonoom rijden heb je dat niet meer. Dan kan je bij wijze van gaan slapen, want je hoeft niet meer op de weg te letten.
Question 7	Veiligheid boven alles.

Participant 24	
Question 1	Ik ben er een beetje bekend mee. Ik heb een aantal programma's en documentaires op televisie gevolgd die gingen over autonoom rijden. Ook weet ik dat Tesla ermee bezig is.
Question 2	Ik denk eigenlijk van wel. Ik denk dat het grootste voordeel is dat het een heel stuk veiliger gaat worden op de weg. Je kan er veel ongelukken mee voorkomen.
Question 3	Ik denk het wel, maar ik denk dat er wel veel onderzoek naar gedaan moet worden.
Question 4	Dat is lastig, want je moet vertrouwen op een computer en niet meer je eigen instinct. Je moet er maar vanuit gaan dat de auto het beste besluit neemt.
Question 5	De bestuurder. Ook al is het autonoom rijden, de auto is van jou. Jij bent er verantwoordelijk voor.
Question 6	Heel belangrijk. Want je moet erop kunnen vertrouwen dat als er wat gebeurt, de auto de beste keuze maakt.
Question 7	Ik denk dat voor mij het ethische aspect heel belangrijk is. Voornamelijk met wat voor keuzes er gemaakt kunnen worden. Ik zou wel eerst alles onderzocht willen hebben of goed ingelicht willen zijn.

Participant 25	
Question 1	Ik heb een aantal programma's gezien. Ook volg ik op Linkedin een aantal bedrijven en personen die met onderzoeken over autonoom rijden bezig zijn.
Question 2	Uiteindelijk denk ik wel. In het begin zal het nog wel lastig zijn, omdat we nu gewend zijn om zelf in te grijpen in dergelijke situaties.
Question 3	Ik denk dat je er uiteindelijk wel vanuit moet gaan dat AI de beste keuze kan maken. Voor nu denk ik dat nog niet zo ver zijn en dat het nog wel even gaat duren voordat ook daadwerkelijk zo ver is.
Question 4	Ervan uit kunnen gaan dat de beste keus gemaakt wordt, wat die in dat geval ook mag of kan zijn. Dat hangt ook per geval of incident af.
Question 5	Ik denk zoals nu, de bestuurder. Nu is de bestuurder ook verantwoordelijk. Ik denk niet dat daarin wat gaat veranderen.
Question 6	Heel belangrijk, je gaat er dan vanuit dat de beste keuze gemaakt wordt. Al denk ik wel dat ik het er bijvoorbeeld de komende 40 jaar er nog niet van gaat komen. Ik denk dat er nog heel veel obstakels zijn. Ik denk het heel lastig is, en een heel proces is, om auto's dusdanig in te programmaren met AI. Ik weet ook niet of dit bijvoorbeeld in de bebouwde kom kan, ik den eerder alleen op snelwegen.
Question 7	De veiligheid is voor mij het aller belangrijkste.

Appendix F: Expert interviews

Expert interview: 1

Beste meneer Paardekooper,

Naar aanleiding van het interview, heb ik zoals ik aangaf een samenvatting gemaakt, waarin ik de kern van het gesprek gedurende het interview samenvat. De samenvatting zal ik als empirisch materiaal toevoegen aan de bijlage van mijn scriptie.

U bent werkzaam bij TNO voor de afdeling Integrated Vehicle Safety, als onderzoeker naar kunstmatige intelligentie. Daarnaast bent u 1 dag in de week verbonden aan de Radboud Universiteit voor de afdeling kunstmatige intelligentie, waar u onderzoek doet naar het gebruik van kunstmatige intelligentie in zelfrijdende auto's en met name hoe dat toegepast kan worden om auto's veiliger te maken, maar ook hoe we kunnen testen dat kunstmatige intelligentie in voertuigen veilig is voor deze de weg op gaan. Verder gaf u aan, dat u voornamelijk met de techniek bezig bent en minder met de gebruikers en de acceptatie kant.

Op het gebied van autonoom rijden en ethiek geeft u aan het volgende te doen voor uw werk; als eerst, ethiek binnen zelfrijdende auto's is een lastig onderwerp omdat het heel moeilijk is om de waarden, de ethische waarden van mensen te vertalen naar iets wat een computer begrijpt. De manier waarop nu kunstmatige intelligentie wordt getraind, met name in de machine learning en deep learning modellen, is door heel veel data aan te bieden. Bijvoorbeeld hoe mensen rijden en dat de computer dat dan uiteindelijk nadoet op basis van wat die leert. Het enige probleem is uit data kan je geen ethiek leren, dit komt omdat op deze manier leer je correlaties. Op basis van wat voor informatie erin gaat hoe die informatie correleert met hoe een mens rijdt, maar je leert geen causaliteit, want dat kunnen de modellen nog niet, dus je leert niet waarom het gebeurt. En juist in het waarom zit de morele waarden van mensen. Dus wat wij aan onderzoek doen, dat onderzoek staat nog erg in de kinderschoenen, is hoe kunnen we menselijke waarden vertalen naar, een deskundige vertaling die een computer kan begrijpen. Om dat uiteindelijk mee te geven aan een zelfrijdende auto, dus ervoor te zorgen, dat deze echt rekening houdt met de waarden van mensen tijdens beslissingen. Dat doen we dan niet op basis van heel veel voorbeelden te geven maar op basis van kennis van mensen en hoe willen we dat zo een systeem zich gedraagt, dat is uiteindelijk het ethische doel.

Op de vraag of door toepassing van kunstmatige intelligentie dit voor een betere acceptatie zal zorgen door de maatschappij gaf je het volgende aan; op heel hoog niveau, denk ik dat voor de acceptatie van zelfrijdende auto's, deze zich zeg maar zo mensachtig mogelijk moet gedragen, ze gaan uit eindelijk samen met mensen de weg op, dus moeten ze zich ook verhouden als mensen en gedragen zoals mensen dat verwachten, uiteindelijk zullen het een soort menselijke machines moeten worden. Dat kan alleen maar als je kunstmatige intelligentie gebruikt, dus ik denk dat dat het gebruik van kunstmatige intelligentie ervoor zorgt dat de zelfrijdende auto's zich menselijker gaan gedragen, en dit de acceptatie zal vergroten.

Over de samenwerking tussen autonome en manuele voertuigen gedurende de mix traffic period gaf u aan; ik vraag me af of er wel ooit een eind komt aan de gemengde periode (mixed traffic period), het zelfrijdende voertuig zal goed moet kunnen interacteren met menselijk bestuurders. Andere oplossing is zelfrijdende auto's een speciale baan te geven, waar alleen zelfrijdende auto's komen, maar daarvoor hebben ze de trein al voor uitgevonden. Ook gaf u aan, dat er verder onderzoek gedaan zal moeten worden naar de samenwerking gedurende de gemengde periode, naar een manier dat autonome en zelfrijdende voertuigen goed (vloeiend) kunnen samenwerken met elkaar.

Met betrekking tot besluitvorming met kunstmatige intelligentie met autonome voertuigen gaf u het volgende aan; dat gaat een beetje terug naar het begin waar ik over vertelde naar het onderzoek wat we aan het doen zijn. Ik denk, we kunnen nooit een zelfrijdend voertuig expliciet programmeren voor alle situaties die hij tegen gaat komen, dus de bekende morele problemen uit de literatuur, dat je moet kiezen tussen die en die, dat kan je niet allemaal heel expliciet in een zelfrijdend voertuig programmeren. Wat je wel zou kunnen programmeren, of in elk geval wat je kunt laat weten aan zo een systeem is de waarden die wij als wij maatschappij hebben en die we zouden willen dat zo een voertuig heeft, om zo een beslissing om te vormen naar een optimalisatieprobleem. Dus je hebt bepaalde morele waarden en hoe kun je zo optimaal mogelijk daaraan voldoen bij het nemen van je beslissingen. En dat werkt net zo goed in hele normale verkeerssituaties als bij een ongeluk of bijna-ongeluk, want juist daar wordt het heel belangrijk.

U gaf het volgende aan, over welke ethische aspecten u belangrijk vindt bij het gebruik van kunstmatige intelligentie; denk dat we dit soort ethische beslissingen vooral niet door mensen als ik, die zo een voertuig ontwerpen moeten laten nemen, maar dat we daar als maatschappij over moeten nadenken. Dus dat het niet de kunstmatige intelligentie experts zijn die de ethische waarde van zo een zelfrijdend systeem bepalen, zoals het op dit moment is, maar dat we daar een maatschappelijk brede discussie over moeten hebben. Zodat we eerst kunnen bekijken hoe willen we dat zo een systeem zich gedraagt op de weg en dat we dan kijken hoe krijgen we dit technisch voor elkaar. We kunnen wel een zelfrijdende auto de weg op laten gaan, maar voldoet deze wel aan onze ethische waarden? Dus dat zou ik willen omdraaien. Eerst maatschappelijk brede discussie wat de maatschappij wil en dit dan zo laten programmeren.

Over aansprakelijkheid met een zelfrijdend voertuig gaf u het volgende aan; ik heb geen idee, er worden nu proefschriften geschreven over dit onderwerp. Ik laat dit over aan de experts op het gebied van wetgeving. Ik denk dat er nieuw soort wetgeving moet komen hiervoor, dat moet sowieso, omdat de wet nu voorschrijft dat je als bestuurder je handen aan het stuur moet hebben. Bij een zelfrijdende auto is dat niet meer zo, dus dat zal per wet al anders geregeld moet worden. Ik denk dat hetzelfde geldt voor aansprakelijkheid. Maar hoe dat precies geregeld moet worden heb ik zelf niet zoveel verstand van.

Met vriendelijke groet,
Vikram Koelfat

Expert interview: 2

Beste meneer Van Montfort,

Naar aanleiding van het interview, heb ik zoals ik aangaf een samenvatting gemaakt, waarin ik de kern van het gesprek gedurende het interview samenvat. De samenvatting zal ik als empirisch materiaal toevoegen aan de bijlage van mijn scriptie.

U werkt nu meer dan 20 jaar bij TNO, wel in wat verschillende rollen. Formeel nu senior consultant. Draai nog wel in veel projecten mee, ik voer ook wel nog steeds zelf testen uit en inspecties uit voor Euro NCAP.

Op de vraag of door toepassing van kunstmatige intelligentie dit voor een betere acceptatie zal zorgen door de maatschappij gaf u het volgende aan; zonder kunstmatige intelligentie krijgen we het nooit voor elkaar om autonoom rijden op de weg te krijgen. Er zijn wel veel vormen van AI, en ook hoe ze ingezet worden. Camera's van tegenwoordig gebruiken al AI, om objecten te detecteren. Deze hebben geleerd via AI hoe een voetganger of een brandweerwagen eruitziet. Dus er wordt al deels AI gebruikt. Ik ben benieuwd hoe dit in de toekomst eruit gaat zien. Als je kijkt naar typegoedkeuringen, waar TNO nauw bij betrokken is, is het belangrijk dat goed te regelen. Dat we zeker zijn dat een auto die op de weg komt veilig ontwikkeld is. Je kunt wel zeggen AI is iets heel nieuws en ongrijpbaar, aan de andere kant een miljoen code regels is ook ongrijpbaar. Dan krijg je ook een grote spaghetti. En kan je ook deels de controle kwijtraken. Voordeel is wel dat het wat eenvoudiger terug te leiden is, omdat het uit splitsbaar is. Het nadeel van systemen die door AI getraind zijn, is dat het veel lastiger terug te leiden is. Ze zijn nu wel aan het kijken om dit op een of andere manier traceerbaar te maken. Om ervoor te zorgen bij fouten, dat je kan traceren waar het fout is gegaan. Stel een auto rijdt een voetganger aan, het kan zijn fout gegaan dat de auto het object niet zag. Hij dacht dat het object een blaadje was, of dat het object iets anders was, dat hij dacht dat het object een andere kant op ging. Misschien heeft hij meerdere sensoren die conflicterende resultaten gaf. Zo zijn er een hele hoop mogelijkheden, dit dan alleen op gebied van sensoren. Zo is er ook nog het beslissingsstuk. Ik vraag me af, waar wordt AI allemaal ingezet? Op sensor niveau wordt het al gebruikt, daar hoef je in principe minder over uit te leggen en te rechtvaardigen, waar het lastiger wordt is bij beslissingen nemen, zoals nu remmen ja of nee. Hoe ga je daar om met AI. Waar ik zelf huiverig voor ben, maar wel zal meevalleen, gaat een individuele auto ook nog zelf verder leren. Stel een fabrikant brengt een auto op de markt, wordt dit dan zo ontwikkeld dat elke voertuig zichzelf verder zal ontwikkelen door middel van AI bij alles wat hij gaat tegenkomen. Ik denk dat het wel mee gaat vallen, dat elke auto zich een hele andere kant op zal ontwikkelen, want de auto is waarschijnlijk getraind op miljoenen km. Ik denk eerder dat er een systeem komt, waarbij fabrikanten voertuiginformatie gaan verzamelen en als iets interessants wordt tegenkomen, ze het in een leer poule van AI stoppen. Wanneer dan een beter systeem is ontwikkeld dat goedgekeurd is, de fabrikant het dan in een keer naar alle voertuigen update. Zodat toetsing plaatsvindt, voor het zelflerende stuk in de praktijk wordt toegepast. Dit zal vanuit de overheid, vanuit het type goedkeuringen op aangestuurd moet worden. Anders komt straks een voertuig in een ongeluk, als blijkt dat door iets in het algoritme het voertuig een andere kant is opgeslagen, dat is natuurlijk niet te controleren. Het is wel belangrijk dat de overheid zeker vanuit typegoedkeuring zorgt dat daar voldoende getest wordt, om te verzekeren dat het AI gedeelte afgedekt is. Er gaan ongelukken gebeuren. Dat moeten we accepteren, alleen voor de gemeenschap is dit lastig te accepteren, wanneer een zelfrijdende auto een ongeluk krijgt. Want dat ligt dan aan de zelfrijdende auto. Wijzelf veroorzaken tig ongelukken per dag, en kijken niet meer terug als het ware. En dat accepteren we, van de mensen hebben we het geaccepteerd. Soms hele kwalijke fouten maken, zoals beschonken rijden en dan een ongeluk krijgen, zelf dat accepteren we in zekere mate. Als we het niet zouden accepteren zouden de straffen veel hoger zijn, zouden we bijv. met een alcohol slot werken. Er zijn namelijk wel manieren als we dit helemaal zouden willen uitbannen. Dus dat is een beetje zoals ik zie waar AI nu gebruikt gaat worden en in de komende toekomst, maar dat het wel afgedekt gaat worden, maar hoe dat is nog wel een beetje een uitdaging.

Met betrekking tot besluitvorming met kunstmatige intelligentie met autonome voertuigen gaf u het volgende aan; het zit er al in, en komt steeds meer en meer. Ik zie het niet als iets compleets anders, misschien kijken we er anders naar, maar het moet mogelijk zijn voldoende te traceren waar het fout is gegaan. De auto wordt niet één grote black box. Dat we zeggen we hebben geen idee, en dat we zeggen we hebben alleen gezien dat hij geremd heeft. Dat gaat de overheid niet accepteren. Die willen misschien, bij een ongeluk terug kunnen zien wat gedetecteerd is. Is er iets gedetecteerd, hoe was de besluitvorming. Misschien zat een kabel los naar het rempedaal of remactivatie. Dat is een ander probleem, dan als de AI vond dat het een blaadje was en geen persoon. Als je kijkt naar ongevallen, moet daarnaar gekeken worden.

U gaf het volgende aan, over welke ethische aspecten u belangrijk vindt bij het gebruik van kunstmatige intelligentie; kijkend naar het algemene publiek, dat het mogelijk is om te verantwoorden welke beslissingen er zijn genomen, dus dat het traceerbaar is in hoeverre bepaalde keuzes gemaakt zijn. Dat hoeft niet tot in de kleinste beslissing, maar wel in een paar hoofdstappen dat het traceerbaar is. Data is daarbij belangrijk, welke data zou je willen, wat is beschikbaar? Dit is een vaak een probleem met de vertrouwelijkheid richting de fabrikant. De fabrikant is vaak beschermend naar zijn gegevens, vaak heeft de autofabrikant zelf ook geen toegang tot de data. Die koopt bijvoorbeeld een camerasysteem in bij een leverancier. Het enige wat hij ontvangt is een draadje met signalen. Soms is het helemaal een black box en kopen ze het volledig in en krijgen ze alleen een draadje naar de remactivatie. Wanneer de overheid eist van de fabrikant jij moet data aanleveren, zal hij dit moeten opeisen bij zijn toeleveranciers. Dat is vaak een hele keten, hier zit vaak veel informatie over vertrouwelijkheid en development in. Sensordata, dat bestaat uit gigantisch veel data, terabytes. Vaak willen de toeleveranciers dit niet prijsgeven, want daar zit vaak hun kennis in. In het model van New Assessment/Test Method for Automated Driving (NATM) wordt uitgelegd hoe (de toekomstige) typegoedkeuringen tot stand komen. Door AI en autonoom rijden gaan veel dingen voorkomen die we nooit allemaal kunnen af kaderen, wat nu onderdeel van de goedkeuring is wordt dan monitoring genoemd. Wanneer de auto al is overhandigd aan de klanten blijven ze de auto in de gaten houden. Om te leren, maar ook bijvoorbeeld om een fout, AI gedreven of niet, te ontdekken. Om maar iets te noemen, phantom braking, dat de zelf remmende systemen dat die onverwacht remmen. Komt weleens voor in tunnels, dat er eigenlijk geen reden is om te remmen, maar dat toch wordt ingegrepen door het remsysteem. Dit zijn dingen waar het vertrouwen in dit soort systemen minder door wordt, wel of geen AI aan boord. Hierbij zou de monitoring fase (model NATM) bij kunnen helpen, als dit soort fenomenen ontdekt worden, die dan direct te adresseren. We moeten ons realiseren als het systeem op de markt komt, dat we niet kunnen garanderen dat er geen fouten aanwezig zijn of verbeteringen nodig zijn.

Over aansprakelijkheid met een zelfrijdend voertuig gaf u het volgende aan; ik ben bijna tegenstander van de SAE levels, omdat het voor mij enorm verwarrend is, wat er nou mee bedoelt wordt. Ik ben voorstander van een eenvoudigere aanpak, we hebben het over assistant dat zijn systemen die de bestuurder ondersteunen, de bestuurder blijft verantwoordelijk, en het systeem moet ook zorgen dat de bestuurder zich ook bewust is van zijn verantwoordelijkheid en geen andere dingen gaat doen die er niet bij horen, dat is assistant, aan de andere kant heb je automated, dan moet het systeem zo goed zijn, dat ook als de bestuurder niet meer kan reageren, het zelf kan afhandelen. Ok, dan stopt die misschien maar op de vluchtstrook, maar er is dan een systeem dat die het volledig zelf kan afhandelen (als het noodzakelijk is). Voor mij zou het een automated systeem moeten zijn onder de condities dus dat die zelf alles kan doen, dus onder de 60 km op de snelweg, in de file. Dan kan het zijn dat daarbuiten de bestuurder verantwoordelijk is, alleen er zit wel een transition of control (assisted ←→ automated), die je zo klein mogelijk moet houden, vanwege de verantwoordelijkheid voor de rij taak, wie is er dan verantwoordelijk? Dat is erg lastig, daarom moet je proberen, die zo kort mogelijk te houden, je zal een paar min. transitietijd hebben, dat je op een gegeven moment zegt er is maar een hele korte periode, waarbij ze gedeelde verantwoordelijkheid hebben. Automated is de auto verantwoordelijk, bij assistant is de bestuurder verantwoordelijk. Als dat de basis zou zijn zou dat erg helpen met de discussies. Want voor mij een SAE level 3 systeem, wie is er verantwoordelijk bij een SAE level 3 systeem? Ik denk niet dat een auto voor een keuze komt, ik rij nu het kind in plaats van de oude oma, ik denk dat het voertuig al zoveel beslismomenten heeft voor dit gebeurt. Ik denk niet dat daardoor een groot ethisch dilemma gaat ontstaan. Hierbij kan monitoring goed van toepassing komen, alleen de vraag is wie gaat wat daarin doen? Zeg je fabrikanten, jullie doen zelf de monitoring en jullie melden zelf als er een probleem is. Dat is natuurlijk heel gevoelig, want dan melden ze het natuurlijk alleen als het echt helemaal is misgegaan of ga je zeggen, dat is het andere uiterste bijna, fabrikant je moet alle gegevens geven en dan gaan wij (typegoed keuringsinstantie) zoeken naar rare dingen. Dit zal een tussenweg worden denk ik, want met die data kun je ook wel door AI weer toe te passen op die data misschien patronen ontdekken, dit kunnen allerlei patronen zijn.

Met vriendelijke groet,
Vikram Koelfat