Human-Computer Interaction Design for Ethical Decision Support Systems in Autonomous Vehicles

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1. Introduction to Human-Computer Interaction and Autonomous Vehicles

The man–vehicle interface needs to provide the necessary information and manage the human-robot collaboration in: (1) cooperative driving scenarios with a manually driven vehicle which has to dynamically react to the electronic vehicle planner of an AV; (2) teleoperation scenarios which require the human driver to safely drive his/her truck from external situations like traffic congestion or blocked routes [1]. Moreover, the actions of a human driver can supply knowledge to inform the future evolution of Fleet Operator's decision [2]. In this paper, we have described the traffic situation for each category of the known strategies, the navigation planner intercepts the corresponding attribute of a concatenated vector and then applies the desired action to be provided by a Renault Trucks' telemanipulated vehicle.

Interactions between humans and computers have become an integral part of our daily lives, whether we are interacting with computers while using our smartphones, computers, and other technological devices, or while interacting with an artificial intelligence system [3]. Inclusion, privacy, and ethics are promoted while designing the human-computer interaction in the various domains of the smart city. Considering its emerging application domains, the special edition falls within the scope of the smart city special issue. If AVs continuously collect data, they can also easily collect spatial and personal mobility travel behavior time. However, these tracking data need to be processed to ensure privacy protection. In this instance, literature (Kai et al., 2014) has studied how to preserve privacy while sharing data through a combined private command established using homomorphic encryption and secure two-party protocols.

1.1. Definition and Importance of Human-Computer Interaction

For instance, one of the most common ethical dilemmas arising in Human-Computer Interaction is the concept of transparency. While designing an autonomous vehicle, we should consider the autonomous driving systems of it, as transparent as possible, for a responsible and a more trustworthy Human Computer Interaction [4]. For further investigation, we can observe the etymology of the word "autonomy". It comes from “autos” (self) and “nomos” which means law or regulation and dtom meaning control. Autonomy has also been defined as the ability of an intelligent system to run on its own, without the help of human intervention, for the recognition of driving situations, the making of predictions and choosing the optimal decision. Therefore the fact whether the system is capable of taking an ethically sound decision at run-time, Generally, raises the following question: is it possible to design a realistically transparent autonomous vehicles and if not, how to decrease the gap in terms of ethics.

One of the main reasons that makes Ethical Design of Autonomous Systems an active research area is the high impact of such systems. Articial Intelligence (AI) (both in software and hardware forms) is becoming an integral part of modern autonomous systems. While designing an intelligent system, AI raises specific ethical, societal and legal issues. This point highlights the fact of the close intertwinement of ethics and technology transfer [2]. Nowadays, a crucial topic that animated the philosophical reflection on technology is the augmented autonomy. There are differ-ences of opinion on the robots in disguise’ problem. In his famous paper Ethics for Artificial Intelligence Worker, Wallach remarked that “One could imagine users of warfare robots claiming that they didn't kill anyone, because they only destroyed buildings and material, not people. It can be seen as not as unethical as to send soldiers to the battlefield”.

The term "Human-Computer Interaction" is used to refer to the practice or the discipline that examines the design, evaluation and implement of interactive computing systems for human use and with the help of computer systems, computers are capable of performing intelligent tasks [5]. In the context of the military, the interaction of people with such large and complex computerized systems may have some ethical consequences. For example, in higher levels of autonomy such as autonomous combat systems, it is highly important to allocate who should be responsible for the decisions and acts of that system and if there are any drawbacks in delegating authority to machine. To define and develop autonomous systems, both technical and ethical issues should be realized. It seems Ethics will be the main challenge in this context as engineering ethics could not allow delegation of particular activities without any responsibility. Thus, human-computer interaction design for Ethical Decision support systems (EDSS) in the field of Autonomous, Intelligent System shall be a multidisciplinary field in which both technical and ethical issues will be solved.

1.2. Overview of Autonomous Vehicles

It has often been the case in the past that the development of new technologies and practices for human mobility have been celebrated as freedom, but in the discourse on AVs, there is also an ambivalent understanding of freedom, on the one hand, as a release from transportation in the context of forced passivity and idiocy of the system, meaning an opportunity to buy and use new consumer products, the so-called smart vehicles and a convenient infrastructure of digi-places onsensing networks, and on the other hand, handing over care to ethical AV, where moral responsibility, making difficult ethical decisions in traffic, does not rest on the shoulders of individuals who have given up control over it. We want to highlight that there could be a danger of uncritically equating reason and freedom with autonomy- conceivedas self-service imposed on machines. While drawing our attention to the loss of human dignity and intellectual autonomy in traffic, some eagerly forget that this potential is in a large part the result of an increased emphasis on the individual's inviolability and moral autonomy in western societies. It is due to this lived reality of moral autonomy and dignity that we can question the previously introduced liberal device-centered mobility vision more clearly, taking the human rights perspective into account.

[6] [7]Self-driving cars are in the public eye, and ethical challenges arising from the design and deployment of autonomous vehicles (AVs) are multiplying from the very first moments of their emergence of AVs on our roads. Reading current research papers on the ethical aspects of self-driving cars, one could get the impression that the most important ethical issue in traffic and mobility is the traditional trolley problem, supplemented with similarly formulated ethical dilemmas that reputable media outlets are eagerly hyping. The situation is exacerbated by the dominant approach to the development of AV algorithms, which consists in appealing to a certain degree of technical enlightenment and the use of reinforcement learning, machine learning or other notions of artificial intelligence to deploy AVs. This approach occasionally takes ethical dilemmas into account, framing them namely as technical problems that could have already been implemented in real devices thanks to accumulated knowledge and

sophisticatedly designed sensors onboard AVs. Consequently, AVs are imagined in the perception of the wider public, as smart machines placed in the driver's seat, taking care of everything, and at the same time equipped with some kind of conscience that, in every single situation, will only make a decision respectful of moral values. In this way, the critical analysis of those perceptions at the junction of machine learning sophistication, the digital revolution and the development of autonomous mobility is of particular importance.

2. Ethical Decision Making in Autonomous Vehicles

In this article, I discuss different aspects of human health when it comes to autonomous vehicles. Some of these aspects are, first, ethical value in daily traffic, favoring a machine instead of a human driver under certain conditions. Second, I elaborate on what ethical aspects during the conception, design and construction phases in machines themselves. An ethical solution should be, I believe, to introduce so-called topsoil ethics constructor in relation to legal interplay and application. Human and machine need common ethical beliefs and rules. Finally, I problematize together with some possible solutions with regard ethicism and traffic in day-to-day traffic. Into the problem of driver oaths, ethics exam and law-abiding machines and Human-Machine legal partnership. Perhaps a machine equipped with linguistic creativity also could be transformed, be inspired, from the creator to be sharper in traffic than what was initially introduced in the machine.

[8]An interesting question in the field of ethical ICT system design is: would a machine thing be more suitable than a human being as a driver in vehicle in everyday traffic? Could it be more ethically correct? For example, a machine might be able to take into consideration ample of different bodies of laws, natural laws, ethical rules and maybe even the ethics of being, and the mesh of restrictions affecting other bodies of laws and regulations. Opposed to this, a bit calculating the "outcome of a single incident" seems a bit 'static' thinking, and to be unable to take the weight of the further physical and psychological condition of, for instance, people in focus now, consequences that a human would not miss to see. To further pinpoint, some are thinking about producing machines which should be able to tell if human a driver is intoxicated or overloaded with anger at the steering; steps towards that have already been taken, yet it is still too dangerous to leave the vehicle for a "drunk-driver-vehicle" when this vehicle was initially driven by a sober person. [9]

2.1. Challenges and Dilemmas in Ethical Decision Making

Thus, it is important to recognize these ethical and social risks early on to address them in software engineering. This is the primary topic of discipline-based studies guided by ethical guidelines or requirements proposed by multi-disciplinary experts. It will be particularly important in AVs since engineers and researchers, policymakers, certifiers, and users may have different perceptions of what is ethically acceptable or unacceptable. AVs make a significant contribution to the environment and society; thus, there is a potential to incentivize diverse, creative, and ethically oriented HCI design research. AVs can be used in preventive maintenance network operations and provide quantitative decision-making support to drive decision support system design and scrutiny technologies provided by environmental researchers in the field. When designing a preventive maintenance information system (PMIS), the goal is to mitigate the possibilities of floods that cause unplanned downtime and identify solutions that contribute to not only the reliability and performance of subway infrastructure but also cost savings through energy management that is realised by the PMIS.

[10], that is, the trolley problem, in which the vehicle is in an unavoidable collision situation and the system must react by deciding which action will be less harmful. One interest of ethical problem-solving systems is to ensure that AVs operate safely and avoid harm for all agents involved, including passengers and pedestrians, such as pedestrians in the AV's surroundings [11]. AVs need to make ethical decisions in very complex, dynamic, and uncertain environments, posing a great challenge for computer vision, machine learning, motion planning, and control tasks. Besides, current and emerging technologies have the potential to give power and insights to decision-making systems that lack autonomous ethical understanding. Unlike traditional technologies, the operation of these systems is not only constrained by hardware limitations, recommendations, or work rules. Instead, they are built on learning from data and inference, which makes them susceptible to adversarial attacks, misunderstandings, incompetence, biases, and malfunctions, contributing to ethical indegeneration. Hence, when AVs are integrated into society and start contributing to their real-world activities in complex, dynamic, socio-technical environments, it will be necessary to evolve these technologies to avoid unforeseen and unpredictable conflicts with other agents' individual and organizational goals as well as the behavioural norms of society [1].

3. Ethical Theories and Principles in Decision Making

To this end, philosophers have proposed several ethical theories and principles to serve as normative yardsticks in the context of AVs. Some demands are as follows [12]: (i) They should be applicable regardless of the stakeholders involved in an accident; (ii) they should provide clear and unambiguous guidelines for resolving moral conflicts; (iii) they should guide decisions when information is incomplete; and (iv) they should handle value trade-offs. After considering different ethical theories and principles and their specific characteristics and challenges, we compiled a set of them into a pattern language with particularly stringent threshold values for particular principles [13]. We allow the fusion of ethical theories but propose to keep preliminary thresholds to compensate for challenges posed by preferences and aggregated assessments of individual theories. The results of the AV ethics project suggests that blending insights from several distinct ethical theories may offer the best normative platform satisfying the demands of disclosure, transparency, and descriptiveness.

Tremendous efforts have been made to design autonomous vehicles (AVs) in compliance with strict legal and ethical principles. However, it remains problematic to identify valid, generally accepted ethical theories and principles to inform design decision making [2]. In the field of philosophical ethics, different normative theories have been developed over the years, including utilitarianism, deontology, and virtue ethics.

3.1. Utilitarianism

This approach to ethical challenges has been integrated by car manufacturing companies in order to develop AVs that are both as safe and as ethically applicable as possible. In most cases, the focus has been on an industrialised version of utilitarianism—what would be referred to as Utilit-AV [ref: article_id:4f14f7d2-5128-4c87-a155-82538069f3f8]. This means assessing and evaluating ethical situations from a utilitarian perspective taking the different later consequences into account. This might for example include different measurable dimensions of harm, affected persons (pedestrians, passenger), time frames, and so on. This also means that the decision-making should be guided primarily by two ethical guidelines—1. Favour outcomes that are better and 2. Mitigate negative consequences.

Utilitarianism, as a normative theory, is an important foundation for moral decision making by vehicles. Within machine ethics, utilitarianism is connected to optimizing for human welfare as a reasonable starting point for moral agency [ref: article_id.34910429-10e7-47a2-ac22-a32786844d76]. Utilitarianism aims to make moral decisions based on the consequences of the action. In its simplest form, utilitarianism aims to maximize overall welfare, including making the best possible trade-offs when a moral decision is confronted. Autonomous vehicles in general need to understand how to react in dilemmas involving potential harm and a deviation in trajectory—effectively solving a trolley problem in the context of AVs [ref: article_id:152407ab-ee2b-496f-80ad-5001b6af3e9d]. The Utilitarian formula 'the greater good for the greater number' has so far been widely used as the theoretical model and is the first one that will be considered in the following.

3.2. Deontology

User shows a selected topic and that discusses with a rich content and theoretical analysis, taken from deep reference. However, when discussing the development of Automated Vehicles (AV) a stronger Deontological perspective is missed, where, for example, the rights of the driver and the rights of the pedestrians play a crucial role. The research supports the observations made here that people's moral judgments are mainly made using emotional and automatic reasoning, but it is crucial that this aspect of decision-making also considers problem-solving methods, such as Kant's categorical imperative (Deontological perspective), which does not stick to individuality.General public population opinions about AVs have been collected, but no data exists on specific user groups like car owners. Further research needs to focus on such targeted groups and possible differences across nations e.g., with respect to culture [14]. An instrument should be developed to provide a measure of people's morality for use in studies requiring inference of moral guidance for autonomous vehicle behaviour. Chosen traffic design features and AV actors in the experiments should focus consciousness of all, morally interested and inconsequential external actors. User wants to include an understanding of the consequences including affective empathy as judgments decisions make.

Public acceptance and perception of autonomous vehicles: a comprehensive review [9] highlights that deontological rules guide autonomous vehicles (AVs) to follow set principles. For example, Isaac Asimov's famous Three Laws of Robotics - "A robot may not injure; a human being or through inaction, allow a human being to come to harm; a robot must obey orders given it by human beings except where such orders would conflict with the First Law; a robot must protect its own existence as long as such protection does not conflict with the First or Second Law". While the deontological approach provides a simple and clear rule-based guideline to guide ethical decisions, it also has limitations in addressing complex human ethics and human factors in edge scenarios. One of the main challenges in defining the formal constraints for deontological rules is compartmentalising research and representing societal values across different scenarios and preferences into a formal language that the vehicle can understand and act on. In addition, it is hard to represent complex contextual information neatly enough for a fully rule-based decision base to effectively encompass necessary action in complex scenarios. For example, if a self-driving car encounters a pedestrian crossing at a red light, the deontological approach can be brought into question. A deontological car would refuse to proceed, as it is a normated societal trust that actions, which might cause personal harm, must be avoided under all circumstances. It would follow that deontological moral principles tend to overvalue the importance of individual rights, but undervalue the goals which autonomous artificial agents are actually to optimize. Instead of a simple rule base, it could be more appropriate for the autopilot to somehow adapt and balance its decision on a case-by-case basis depending on the context and predisposition of the other party.

3.3. Virtue Ethics

Ethical decision-making in ADs is complicated since different moral viewpoints and ethical virtues (e.g., patience, tolerance, justice) might lead to different decisions in the same ethical problem. This situation shows that an AD needs to adapt to regional ethical preferences and moral guidelines rather than common ethical problems that have taken place before and are not limited to the fields of transportation and the origin of the AD. For example, an AD that evolved to be more ethical in emissions due to ethical alternatives and different moral attitudes in different regions would become a more ethical and demandable AD in the market [15]. Additionally, an AD that evolved properly will be able to understand regional ethical attitudes and the moral dispositions of the drivers. It is important that these impulses should be calculated as necessary by the virtue ethics considering the expectations of the driver in real-world driverless vehicle solutions.

Referring to the ethical decision-making approaches, the majority of the developed AD modules have adopted a utilitarian approach, which prioritizes the greater good. This approach assumes that ADs should make decisions to minimize risks and harm, and to cause the least possible damage when the risk is inevitable (e.g., killing a pedestrian to save a larger number of car passengers). This approach could lead to various problems ranging from undermining individual rights and freedom, societal and cultural values, and the other moral points of view to ethical issues in value determination, problem situations, capabilities (e.g., calculating every calculation), and the situations where objectives cannot be prioritized [9]. On top of utilitarian approaches, which are designed to consider the overall benefit to all stakeholders, other deontological approaches based on ethical codes and rules (e.g., moral values for pedestrians in traffic) and virtue ethical approaches based on characters and intentions are also employed in AD modules. In the deontological approaches, ADs select decisions based on ethical rules such as protecting human life and adhering to ethical attitudes (e.g., discipline, honesty, politeness, safety, tolerance) that constitute the basic principles of societal morality. Furthermore, an AD with the ability to adapt to different success criteria and ethical virtues could emerge by employing virtue ethical approaches [16].

4. Designing Ethical Decision Support Systems

The actual design concepts specifically for autonomous and automated driving by German manufacturers are already now well advanced, as previously shown. The usability of the extensive functions by the occupants inside and outside of the vehicle is essential and is a key factor in the acceptance, market success, and company brand for autonomous driving. BMW's vision for HMI of autonomous driving based on car-to-human dialog is shown in Fig. 17. This extends existing vehicle-to-vehicle or vehicle-to-infrastructure dialog by to adding communication in the form of information exchange with human beings in another vehicle or with road users nearby the vehicle in the autonomous driving context. The dialog mainly provides human beings with an understandable interpretation and emotional acceptance of the car's activities. [2]

The vehicle interior environment offers great potential for AUC functions. For example, cameras with emotion recognition algorithms offer a relatively low implementation complexity. For example, when recognizing that a passenger is concerned, the vehicle can reduce collisions and use comfort functions to raise the sense of security and comfort to help the passenger relax. This effect has a similar function to that of the corresponding notification aid and could thus be dispensed with. The residential area car offers significantly more potential for other functions mediated by the environment – in addition to those mentioned above. In the following, AUC-HMI components will be shown mainly with a focus on internal support systems. [17]

4.1. User-Centered Design Principles

Starting with conducting multiple face-to-face interviews with the senior specialists, and later on discussing the multi-disciplinary working and co-creating team, we gained the most relevant, valuable and reasonable principles that were assessed as crucial to affect support of the ethical decisionmaking with the aid of computer systems. This can also be an argument for the teachers, to include a special ethics programs on further stages undergraduate studies, especially in the engineering faculties in order to develop their students ethical competences. The guidelines identified by us as significant in various areas of the street state changes and also other ecological aspects including street emissions, ecological interaction, and nature conditions are interconnected and affect one another during decision-making. The ethical dilemmas are becoming one of the central issues concerning the human – computer interaction design and development because can be nowadays really seen in the direct human life. Therefore, this is an element that should be observed and explored in professional decisions [18].

The creative thinking and problem examination method is the main key method many taxi drivers sincerely appreciate. However, educational studies have proved such skills can be taught and practiced by users. Therefore, we would like to emphasize that the development of these guidelines will support the formal education about the ethical decision-making, and will contribute to the users' ethical competences development as well as the practitioner's ethical empowerment in some scientific projects [19]. Using the same approach in the multi-disciplinary working team comprising the human – computer interaction design professionals, ethicists, and members of the technical staff co-founded by psychologists was engaged. Only by discussing and observing each other and being forced to understand each other, the key principles guaranteeing the ethical decision-making will be identified and implemented in the interface design, but in the decision-making model as well, among others. The aim of the research was to identify the principles of computer systems design that may facilitate ethical decision-making process of professionals that design open wearable systems and also to improve the HCI design development [20].

4.2. Transparency and Explainability

[21] The increased black-box nature of machine learning algorithms has led to some challenges, such as understanding and interpreting the results or how an algorithm made a particular decision. The lack of interpretability of trained models in machine learning is known as the "black-box" problem. Several techniques such as global and local explanation methods have been proposed to interpret the model. Techniques such as LIME and SHAP are commonly used global and local explanation models, respectively. Combining global and local models is known as "a hybrid model", which is widely used for better explainability. Only a few review papers exist that summarize these black-box model explanation methods and present harmonizing synthesis. This paper presents a comprehensive review of the research methods that have been proposed for the explanation and interpretability of black-box models, describing how they work and comparing their strengths and weaknesses to aid future research. We explore a wide variety of explanation methods to interpret trained models and their results, with respect to usefulness and usability. Consequently, this comprehensive survey enables researchers and practitioners to easily identify the models suitable for diverse tasks and datasets, yielding potential directions and areas for future research in interdisciplinary scientific fields using machine learning models.[22] Mobilizing automated vehicle (AV) software, from development in experimental scenarios to market-ready consumer products, requires integrating off-the-shelf independently manufactured modular software components. Future AV ecosystems will consist of a diverse collection of commercially owned software and hardware platforms that are integrated by multiple groups across the entire supply chain; thus, it is unlikely that a fully integrated AV will be optimized as a unified system in the same way that traditional AVs are engineered. The fragmented and non-standardized approaches to manufacture and integrate AV software, hardware and business models demand formal verification and validation from independent authorities. Whereas this paper provides a full technical overview of our work, including considerations for inclusion into an ISO standard or similar legislative rules, we anticipate the reader may require further clarity on how our investigations and formal explanation models could apply to AV modular software in practice. Therefore, a review for the societal contract and technological, interdisciplinary recommendations regarding explainability for AV invalidation, certification processes, and public engagement are also provided. This paper claims that in order to be acceptable and deemed trustworthy in having responsibility, the interpretability and transparency of AV software modules could be of an inherent and private nature in the long run, as human interpretable explanations in every part of the decision-

making process is otherwise unfeasible. In the interim, these automated vehicle entities (AVEs) should have to exhibit transparency and reciprocity in providing regulators, the public, and stakeholders, formal simplified validated explanations thereof.

5. User Interface Design for Ethical Decision Support Systems

The row of specific instances/interpretations of the ethical algorithm represented by the EP forms the first model describing the first level of moral reasoning in AVs. From the expression of the algorithm to the design of a serious video game which --as an engaging user interface of the EDSS-- presents a situation where an ethical rule rebukes the driver, it was also necessary to express the interaction of the decision system in the second level of the moral reasoning. To this end, a second model, the ethical theory, is also described. It is based on virtue ethics, which means a balance is found between the need of the vulnerable and everyone's well-being. These two levels of reflective moral reasoning happening and then openly communicated to the driver through the decision system are presented here in details in the form of original game design artifacts.

[23] [24]The concept behind the Ethical Decision Support System (EDSS) in autonomous vehicles (AVs) is that when an ethical obstacle emerges during a journey, rather than having the AV canceled, the EDSS, after a short deliberation process, could make a proposal to the driver. This proposal is a compromise between following general rules and ensuring comfort. These general rules are called the ethical algorithm and represent the moral judgments during the design process of higher-level ethical reasoning. They can take the specific form of a bi-level ethical theory, such as what is called here the general Kantian principle: give priority to the safety of the vulnerable and sacrifice the interest of the nonvulnerable if necessary for the safety of the vulnerable. Another example of an ethical algorithm is Asimov's laws of robotics, or, more generally, a deontological ethics. From a moral viewpoint, one of the main contributions of the present paper is the development of a general reasoning process that captures several adaptations of the General Kantian Principle.

5.1. Visual Design Principles

On the matter of design possibilities for audio interaction, it is interesting to note that drivers and prospective car buyers often put communicating with the car through speech on the top of the list over all other interaction methods when asked about preferences for using the car's infotainment system. Currently, it remains to be seen whether speech recognition is developed well enough to accommodate all the ambitions listed among the participants in our current studies. Few studies of AV driver interactions have investigated DSS issues and there are issues of both power, responsibility and accountability in the navigation (Baram & Hutson, 2017) process of deciding where the vehicle should go. Factors such as aesthetic preferences among humans, attainable visual perception thresholds for the population at large, current legislation within sound pollutions in public and the technical availability when building the speaker system [25].

Integrating communication for autonomous vehicles (AVs) that addresses user-specific preference by using a design-driven Human-Computer Interaction (HCI) methodology in order to achieve the prescribed Intentional Binding with a simple, tidy interaction design may help build driver trust (Gröndahl, 2016). A touchpoint of sight to driver control could be acknowledged in conversation, where ideas of responsibility to some extent could float around. A set of HCI design principles for ethical Decision Support Systems (DSS), implemented in AVs and interfaced by visual design, e.g. to promote the possibility to disagree or to express doubt, rather than be forced to act out of machine loyalty. Perceptual and physiological measures should be used to determine if participants get a congruent or dissonant experience in absorbing the visual message from the interface of the AV [23].

5.2. Interaction Design

Sharing decision making: we need to enable cars to reason ethically about decisions and act in accordance with such decisions. It is a part of the transformation into a world where cars are not only our slaves but need to participate in the decision-making process together with us. The challenge is the merge of human and machine view; the solution is a democratic-bounded transformation of a money-based economy into a social sharing and promoting contribution-based economy. The focus is not only on the car, but also on the use of it, on mobility offered. Different cars should also be able to talk each other, understand each other. Being able to interact and share their action in real time with the possibility to be rescheduled if a different action is deemed better.

Referring to the needs of all the parties involved should be the goal of good interaction design in autonomous vehicles as it was discussed in [6]. The autonomous car should provide necessary information to the passenger, symmetrically it should receive information from the passengers in the benevolent environment. The vehicle should respect the beliefs of the customer, and if somethings go wrong between the transaction between them, it should try to anticipate, understand, solve the issues or at least apologize, as it was stated in [4]. Interaction should ensure trust, trust between user and car, trust in low driving forces, trust in people walking or bikers and in authorities. Another aspect to take care regards the ethic in numbers as the different car passengers, persons walking or biking close to the car are not only numbers, but real people in real interactions [26].

6. Evaluation and Testing of Ethical Decision Support Systems

The overall study design was the same for both studies, but they differed in terms of focus and content. The inclusion of the simulator provided both access and a home for naturalistic observations like the participants' speed adjustment on the approach to the critical scenarios in Scenario 1 and 4 and the frequency of the decision to end an encounter in Scenario 4. The detailed description of each setup scenario provides opportunity for replication, and EDDS developers might use them to validate newly created EDDS's in the future. With a more methodological orientation, the validity of the results is focused on the extent to which they provide information about what would really happen in real life. The verdict on the real-world validity of the various route deviations simulated depended on participants' insights into their own safety margin, in particular the real-life question of how high the likelihood of an encounter with the pedestrian must be in order to consider a route deviation, and how much time it would normally take them to do this. In scenario 1 participants took extra time but continued driving. [6] We are confident that the systematic evaluations reported in the present work, which exposed the first open questions to the integration of an EDDS into the design of HMI features, will inform future experiments that aim at answering these open questions. In particular, users' subjective judgments, based on a suitably weighted set of preferences, should provide quantitative mappings between changes to the algorithm and changes to the HMI (control twiddle), and hence provide a non-negligible contribution to the next open question identified earlier. Furthermore, based on the same mappings, decisions will have to be made about what transition mechanisms can be used to support communication between the autonomous vehicle and the user about the ethical decisions it makes. Related provisional results are available at the time of writing, and surveys, like the one discussed in the present contribution, are now being carried out in order to continue to unpack the subjective judgments that constitute the precedents of the three open questions raised in this section.

[27]After developing the EDDS for our scenarios and its description and evaluation, it was also necessary to test the EDDS with participants. Feedback on the EDDS at this stage of development often identified errors, unclarities and places where improvement was necessary. To facilitate evaluation we decided to place the users in a driving simulator to make the experience of driving a car environ- ment more realistic and allow us to develop more naturalistic measures of participation in the interaction. As depicted in the goal image we proposed two simulator studies.

6.1. Usability Testing

Moral dilemmas of autonomous vehicles exemplify situations in which a machine agent is faced with a situation in which no decision can be made without guilt. Instead of these moral dilemmas, the main focus in psychological research is on the automated actions and their impact on the users' mental models. His ethical assessment of algorithms incorporated in many convenience and critical systems will only be touched here briefly. Fear or poor mental models of safety technology, e.g., of LiDAR, have negative consequences for labor safety and could foster human errors [14].

An interactive, user-centered and ethics-oriented design for autonomous driving will be an important key success factor for the market introduction of autonomous vehicles. "Perception Based Testing" will play a major role in future assessments of Artificial Intelligent based systems integration in vehicles. A normal highly automated vehicle or level 5 SAE autonomous vehicle can demonstrate lawful behavior towards any relevant object in the roadway traffic. In the context of autonomous driving, a special semantic content developed for the moral dimension should be worked out. This article presents first approaches for the conception of a new test procedure for an international standard based on this approach [28].

It is shown that automakers and regulators also face significant challenges in legal liability for the introduction of highly automated vehicles. Through "human-in-the-loop" methods and concurrent driving or psychophysiological measures, naturalistic human interaction with a vehicle can be analyzed and personalized safety technology further developed. Through formalized Ethical Design Leadership, human factors engineering, and technology-driven safety design are understood as tasks for the development of a self-driving car that has the trust of the customer [6].

6.2. Ethical Impact Assessment

Three tier-levels of Abbreviated Ethical Impact Assessment are given where normative ethics, empathy and scenario-based strategy cater for autonomous on-the-fly architectural/operational cognitive abilities driven by global/local economy and safety. The paper discusses cognitions from onboard systems to stakeholders. The human intelligence drives the vehicle and is expected to increase efficiency and raise safety on the public road network. The infographics of Abbreviated Ethical Impact Assessments unlock the achievable balances of the indicated ethical consequences in our future society. The methodology thereby supports requirements engineering to identify moral implications of the economically vehicles. By reversing methodology, the ethical impact assessment can eventually impact the development of autonomous vehicles such that these vehicles can be employed in our future society conforming to our societal norms [11].

[6] The ethical roadmap consists of ethical tension, ethical foresight, and an ethical impact assessment founded in the three pillars of normative ethics, empathy and scenario-based strategy [29]. The ethical tension forces stakeholders to think of a place where technology cannot reach only by societal demands which is beyond what the profit motive can extract. Ethical foresight deals with anticipating possible and plausible technology's future, yet unknown benefits and deficits mapped as ethical consequences. It is explained for ethical decision-making processes of stakeholders from academia, industry, policy decision makers and society, and the paper postulates 'the circular reasoning' of responsibilities among these stakeholders. The ethical impact assessment forces stakeholders to decide by employing measurable maximum utility in contrast to the intractability of infinite outcomes.

7. Case Studies and Examples

For each case study, we first lay the definitional groundwork for ethical concepts and then describe the implementation of the HCI and ethical design aspects and interactions for AV applications. Finally, we present the conclusion. We also want to be clear that these principles, while applicable in a wide range of situations, do not apply to every possible autonomous vehicles [30]. There are, for example, likely to be principled disagreements in autonomous vehicles whenever the ethical decision making in the Autonomous Vehicles (AVs) and observer's moral expectations come into conflict morally. The available research to date indicates that ethical decisions in such cases might affect willingness to pay for Autonomous Vehicles. One of the goals of this research was to understand the ways in which the AVs realizes moral natures through its robotic actions in the progression of the next Autonomous Vehicle company.

A considerable body of research has been devoted to understanding ethical dilemmas in self-driving vehicles to date. However, there is little consensus on an appropriate ethical decision making policy for autonomous vehicles (AVs), which is especially difficult because autonomous vehicles could lead to radical changes to the values and norms formation process as well as the decision-making results in society [9]. In this chapter, we present three case studies that illustrate various ways in which ethical principles and HCI design for ethical decision support systems could be integrated in AVs. The first case study explores ways in which HCI can be used to increase the ethical accountability of AVs in dealing with Dense Four-way Intersection problems. The second case study examines ways of enhancing procedural ethics in AVs by engaging moral justifications in predictive perspective taking. The third case study explicates the role of HCI in increasing the moral sensitivity of passenger AVs through ethical decision support interactions.

7.1. Real-world Applications of Ethical Decision Support Systems in Autonomous Vehicles

In commercial scenarios, conflicting requirements exist between more forgiving motion planning and hard game-theoretic approaches with potentially large value at the intersection. It is clear that most car manufacturers now use HRI in the form of Ethical Decision Support Systems (EDSSs) primarily provided by rule-based statements of so-called "must-rule" procedures in order to resolve possible ethical dilemmas in the case of a possible accident. According to multiple market researchers, 50 to 70 percent of all future car purchases will have some form of ADAS and near to or fully autonomous driving in higher and highest (talking about L3/4/5) levels in the AV spectrum. Any such technology sold and in use on the market has to be positively certified by countless technical safety and compliance bodies, international and national legislators and, last but not least, by the potential future consumer. With a lack of sectoral guidelines for the ethical use of advanced drone systems, deployment and experimentation occur within a vacuum of meaningful interaction and legitimacy [24].

The findings of this study could pave the way for meaningful applications in various industrial scenarios and the automotive industry. Besides robot behaviour, robot acquisition or robot-oriented scenario generation is essential in HRI design to give state-of-the-art insight into a multidisciplinary approach between reflection and practice. Automotive industries are currently making an earnest effort to commercialize the industry standard for advanced driver-assistance systems and autonomous driving, because they include ethically sensitive situations that are especially relevant for applications such as pedestrian protection [14].

8. Future Trends and Challenges

Whereas various ethical dilemmas are frequently being discussed in different disciplines, the dialogue is scarce in self-driving vehicles' research. This means that despite the advances in AV technology, we can hardly recognize the attempts to solve the moral dilemmas of autonomous vehicles effectively. Although more researchers show a keen interest in ethics being problematized while developing AVs, they point out that there are no firm theories that could provide an ethical design of an autonomous car. The groups of researchers currently dealing with machine ethics are in agreement that one of the most important tasks is to extend the ethical knowledge of AVs' control into their algorithms in a manner that is reason-based and easy to operate. Among the values, it is especially crucial to distinguish moral ones. There are attempts in the literature to develop machines being able to decide, prioritize, and categorize ethical principles. But it is too early to use it in practice due to the fact that the concept is only limited to changes of priority among principles, with the priority changing only slightly yielding another solution with similar weight. It turns out that the issue needs a mental move from the decision to ability and capability, and it is necessary to redesign the decision-making process in order to make it ethics-friendly: focused on consequences, duty, or law because, unlike these, machine ethics still concentrates on values. Therefore, it is necessary to develop a model that will be able to help developers of autonomous systems in a systematic way in reaching solid design and AI solutions, including moral dilemmas [30].

Lately, there have been a lot of discussions and research on the topic of machine ethics and the values instilled into robots [27]. This trend has also impacted the development of autonomous vehicles. Brining morals into making proper decisions is a challenge for multi-agent systems, making it much more difficult to reach utilitarian solutions and avoid problems that would arise from the very onset of planning. It is even more difficult in the context of the trolley problem and is especially delicate from the point of view of the precinct of law since the system is now not just another machine working in a closed environment, but it has entered the realm of the outer world and interacts with society, including other road users. It is worth pointing out that it is also a new challenge for human-computer interaction design (HCID) for autonomous vehicles' control interfaces as it will be necessary to adapt general guidelines to the specific properties of these new systems. It is thus possible to say that the discussions relating to the possibilities of using AVs can be divided into two categories—technology, on the one hand, and ethics, on the other.

8.1. Emerging Technologies and Their Implications

Evaluate a drone delivering a first aid package as a robotic vehicle for which an ethical reflection is necessary. Done that? What would happen if there were 50 connected drones just like the first one? Done that? And if it were 500? As one could expect, ethical examination is not limited to the single case. Depending on the single or mixed use of our vehicles by the human and nonhuman environments, daily decisions in AVs that are based largely on ethics may become obsolete. The anticipation of future advances in technologies and lifestyle is impossible, but the effects on the moral–ethos dialysis of a society founded in relationships give us the possibility of not being overwhelmed by the impact of a stream of ethical issues [31].

Widespread automation through AI will see technologies and systems embedded within all aspects of society. We have focused here on the contribution of AV technologies and their implementation in automated transportation systems. These systems are challenging due to their complexity, the ethical considerations that underpin such systems, and the integration of experts with different technological and application experiences. The moral landscape is ever-changing and sees ethical questions being raised as fast as supplanting moral dilemmas. The suitability of AVs in various locations, such as highways, rural, and urban, is an important factor. Advances and constraints in AV technologies and artificial intelligence will change public expectations of ethical reasoning and considerations of accidents beyond the Trolley Problem.

9. Conclusion and Recommendations

Enhanced decision support systems that offer explanations are more beneficial for engagement with humans as well as in terms of trust compared to explanations dispensed to physiological phenomena alone. Therefore, making greater use of technological progress in explanatory technologies can help ethical AVs avoid a low explanatory gap and help increase the trust of users with a quick but plausible reason for action. This represents one, possibly incomplete, deontological consummation. A virtue or pleasure theory could lead us to critically examine these advantages, but regarding painful AV decision making augments our suggestions to include this perspective and, in particular, to measure the degrees to which moral reasoning is persuasive and satisfying or could be improved from the perspective of an honor or conduct ethic. [14], [24]

Decision support technologies such as TLD systems and ethical rules can help AVs decide between the least bad alternatives and are likely to affect overall dal outcomes, as explored in 5. Conversely, impacting a more direct overview of the utility functions they optimize by considering additional layers of information inherent to each decision is a totally different approach, which nevertheless may be seen as complementary. Because the solutions offered by DAL or MCS decision support technologies represent a middle ground through the selection of acceptable outcomes with some minimal ethical orientation, the hope is that adding visualization, explanations, and justifications can better convey the ethical reasoning of the machine to the human. This could avoid situations where humans exhibit stress from the lack of control and deep frustration due to the apparent unexplainability of the machine during morally challenging situations or actions.

9.1. Summary of Key Findings

"A digital ethics and privacy impact assessment method for emerging technologies" [32] presents a digital ethics and privacy impact assessment (DEPIA) method, supporting the assessment of privacy and ethical issues emerging from innovative digital technologies. The importance of aligning innovation with emerging societal values and the necessity of the end-user acceptance were captured within our novel method. Additionally, it aims to identify the potential ethical concerns and risks to privacy and security created by the collection, storage, and processing of personally identifiable information and non-identifiable data that concern all stakeholders and throughout the lifespan of an emerging technology.

"Future Intelligent Autonomous Robots, Ethical by Design. Learning from Autonomous Cars Ethics" [33] addresses the ethical issues raised by the 2020 Rulebook of the Fédération Internationale de l'Automobile (FIA) that introduced caravan sliding doors and beyond (seven Levels of Driving Automation). Beyond ethical principles, the focus was the Framework and Methods necessary to carry out the necessary checks and balances as self-governance and transparency in enabling trustworthy robotic systems. Additionally, the architecture can beneficially serve for other trustworthy self- governed autonomous robotic systems.

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