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Ethical issues and challenges in Autonomous vehicles and transport

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Abstract: Autonomous vehicles, which are touted as a game changer in transportation technology, have the potential to revolutionize how we get around in our communities. These self-driving cars, equipped with sensors, artificial intelligence, and cutting-edge technology, hold the promise of making us safer on the roads, reducing traffic congestion, and improving our mobility. Yet amidst all the progress they bring, there are challenges that need to be addressed. This article delves into the dilemmas presented by vehicles, ranging from safety concerns and liability issues to privacy matters, job displacement worries, environmental impacts, and how humans interact with these vehicles. Our goal is to contribute to a future where this transformative technology is used responsibly and ethically.

I. INTRODUCTION

Autonomous vehicles (AVs) hold potential for enhancing safety and efficiency in transportation [1]. By reducing errors like alcohol consumption, drug use, distractions, and speeding, AVs are expected to minimize traffic accidents by 90% [2] [5]. Moreover, AVs can also contribute to work efficiency by reducing travel time [6]. These advantages have led to the development of AV technologies, with Google conducting extensive testing of autonomous driving over 1.5 million miles in the United States [7]. Uber has also initiated passenger trials of AVs on Pittsburgh roads and streets [8][9]. In addition to it, Tesla, GM, Audi, Volvo, Ford, Nissan are major car manufacturers and they are exploring technologies actively for their vehicles. In Nevada and Colorado, autonomous trucks are undergoing testing on highways [10], while Finland and Switzerland are conducting trials of buses [11].

However, it is important to acknowledge that automated vehicles can still experience accidents. In 2018, there were three incidents involving level 2 vehicles, that include Tesla and Uber. It is not easy to ensure a crash free environment completely with the help of automated vehicles and this is due to the unpredictable hurdles associated with roads such as human driven automobiles, pedestrians, bike riders and animals wandering at roads. This indicates that the ideal vision of vehicles is still distant from reality. As crashes cannot be entirely prevented, it is crucial for the computer systems to be equipped with tools that can swiftly assess and calculate the way to handle a potential collision based on factors such as the probability of results and wellbeing contemplations in the given circumstance. This sort of direction can immediately turn into a quandary, particularly when there is an involvement of people. For instance, AVs (abbreviation of automated vehicles) may confront the decision of forfeiting themselves to save people on foot, or they might try to avoid crashing into multiple humans by swerving and sparing someone passing by. Once a collision becomes unavoidable, AVs will have to decide between two outcomes: giving sacrifice by their own along with their passengers to save pedestrian's lives etc. It's an issue that requires addressing with guidelines during the development of AVs in order to handle such hypothetical situations. Some researchers have suggested incorporating rules into AV programming so that they can make sound crash decisions. However, there is research on how these ethical paradigms impact the algorithms used by AVs when making crash decisions [14].

The primary obstacle in adopting the techno innovation is generally the ethical or moral considerations.[1]. Before vehicles can gain the trust of customers, there needs to be a consensus on decision-making. This survey paper makes two contributions: first, it provides an overview of the social and ethical challenges that autonomous vehicles may face, highlighting how commonly held ethical assumptions can be questioned. Secondly, it examines the efforts and progress made by academia, policymakers, and automakers in addressing these challenges associated with vehicles. The paper puts forth suggestions on how to tackle the dilemmas that may arise in certain domains. Section II provides an overview and summary of the challenges and public responses. Following that, Sections III and IV introduce the initiatives taken by domains to address these concerns. The paper concludes with Section V.

II. ETHICAL CONUNDRUMS FACED BY AUTONOMOUS VEHICLES

The establishment of large hospitals where hundreds to thousands of patients are treated, it has created a serious problems of biomedical waste management. The seriousness of improper biomedical waste management was brought to the light during summer 1998. In India studies have been carried out at local / regional levels in various hospitals, indicate that roughly about 1-5 kg/bed/day to waste is generated. Among all health care personnel, ward boys, sweepers, operation theatre & laboratory attendants have come into contact with biomedical waste during the process of segregation, collection, transport, storage & final disposal. The knowledge of medical, paramedical staff & ward boys, sweepers about the biomedical waste management is important to improve the biomedical waste management practices. The biomedical waste requiring special attention includes those that are potentially infectious, sharps, example needle, scalpels, objects capable of puncturing the skin, also plastic, pharmaceutical & chemically hazardous substances used in laboratories etc.

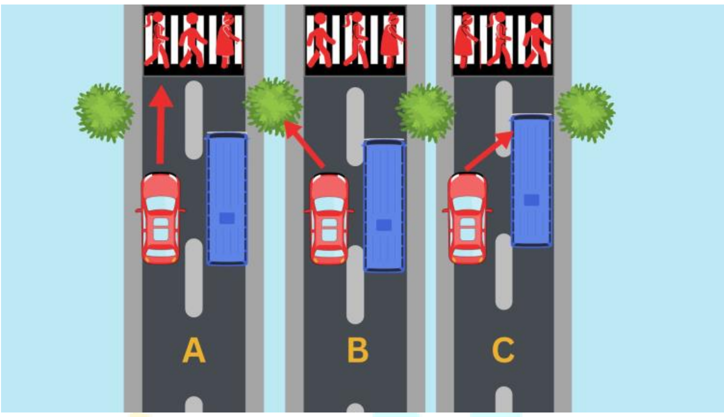

Fig1: Ethical dilemma: three options for the AVS in the inevitable crash (A) Crash with three pedestrians (B) crash into the tree, on right (C) self-sacrifice crash with the bus on the right.

2.1 The Trolley Problem

The trolley problem is a known experiment that has been extensively discussed [15] [16]. In this scenario, there is a trolley heading towards four individuals who are unknowingly standing on the tracks [17]. The situation presents 2 basic ways for the trolley: (a) to keep on moving and hit the people, (b) potentially hit someone on side tracks and turn to right for it. Similarly, autonomous vehicles can encounter dilemmas. For instance, imagine a vehicle driving at high speed when suddenly four people block its path. The vehicle doesn't have time to stop before reaching them. It can. Swerve onto the sidewalk and potentially harm a pedestrian, or continue straight and risk hitting all five people in front of it [18] [19].

So, what would be the decision in this case? A person who focuses on the consequences and treats them as a measure of cost might argue that it is better to turn the steering wheel and cause the death of one pedestrian out of four individuals. They believe that the cost of losing four lives outweighs the cost of losing one. On the other hand, those who adhere to consequentialist beliefs might see a moral distinction between actively causing someone's death and simply allowing people to perish. For instance, turning right could be seen as taking step towards killing a person walking around. While five people will potentially die by doing nothing. Some people who follow consequentialist ethics argue that it is morally worse to intentionally kill someone than to let them die.

This ethical dilemma has implications for equipment manufacturers (OEMs), who will bear the responsibility for the outcomes of autonomous vehicle-related accidents. If the autonomous vehicle takes control away from the driver and decides to turn, resulting in the death of a pedestrian, then the OEM could be held accountable for this tragedy. On the other hand, if the vehicle does not intervene and allows four people to be killed, the OEM may not be considered responsible for their deaths.

2.2 Sacrificing for others

There's another dilemma that autonomous vehicles (AVs) might face, known as self-sacrifice. Let me give you a couple of examples to illustrate this. Imagine you're driving your AV on a winding mountain road with a cliff on one side. Suddenly, you come across a tourist bus carrying 30 people coming from the direction and encroaching into your lane. Given the distance and speed involved, it seems impossible to avoid a collision [20] [21]. In this situation, the AV is faced with two options: (1) drive off the cliff in an act of self-sacrifice to save the lives of those on the bus, or (2) apply emergency braking and collide with the bus, endangering everyone's life. Which decision should be considered correct?

The general public may lean towards a consequentialist perspective where saving lives takes precedence over sacrificing one person—the driver. However, can we expect a vehicle driver to possess noble intentions and willingly sacrifice themselves for others? Even if you believe that driving off the cliff would be the right decision, it becomes a different issue when you consider allowing a machine to make that choice without your awareness of the outcome being your own sacrifice. Presently, there is a lack of clarity and openness in programming these decisions in vehicles. While willingly sacrificing oneself may be seen as honourable, being forced into self-sacrifice could be viewed as behaviour [23]–[26].

2.3 Unanticipated Animal Encounters

When analyzing an accident involving animals unexpectedly, we get a glimpse of the complexities faced by vehicles (AVs) when making decisions [27]. AVs should possess the ability to make optimal decisions within a split second in these intricate situations. There are primarily three challenges presented to AVs when it comes to decision-making caused by animal encounters. Firstly, should AVs apply hard braking when on a road an animal appears suddenly in front of them? The choice of braking depends on factors like road conditions. Whether there is a tailgater, it could lead to a rear-end collision. Secondly, what criteria should determine which animals can be hit? Smaller creatures like raccoons or squirrels may be considered permissible compared to ones like deer or cows, which pose greater risks of causing severe damage to both the occupants in the car and AV motor vehicle. Other animals, like our cats or dogs, should be avoided if they don't come with any additional costs.

Now let's consider a situation where a self-driving vehicle encounters an animal, such as a deer. If the vehicle takes a decision to avoid it and swerve, should it violate traffic laws by turning right? Swerving to the right could potentially lead to collision with a road shoulder or any tree. This is likely to damage the automobile and people inside it. While, a head on collision is expected with incoming vehicles in case of swerving into lane and crossing over the single or double yellow line is against traffic regulations. In this scenario, should we consider breaking traffic laws as a constraint or cost when making decisions?

2.4 Various Other Factors

There are factors that should be considered while executing the dynamic program. These variables incorporate the sort of street shoulder (whether it is missing, made of rock, or cleared), the quantity of travellers and whether they are wearing safety belts, the state of the vehicle's brakes and tires, and checking either the motor vehicle has dangerous materials that might actually detonate or fall and cause harm. It is essential to allocate loads to these elements and targets in view of their significance while integrating them into the moral dynamic rule.

III. ADVANCEMENTS IN THE ACADEMIC SECTOR: THE EVOLUTION OF AC ETHICS AND MACHINE ETHICS

The ethical issues surrounding vehicles (AVs) have gained increasing attention from sectors, including academia, policymakers, and car manufacturers. Each of these groups has made their own contribution. Implemented experimental trials independently. Notwithstanding, the moral and lawful ramifications of AV dynamic in mishaps have seldom been examined. Previously, machine morals essentially cantered around machine knowledge [28] and applications [29]. With regards to robot morals, there are two rule-based approaches: deontological and consequentialist speculations. Deontological approaches view roboticists or the robots themselves as adhering to a set of rules, with decision-making involving computing the appropriate outcome based on these rules using a logical framework. Examples of this approach include Asimov's three laws of robotics and Kants categorical imperative in robot ethics. On the other hand, consequentialist ethics Utilitarianism. Propose that morality aims to maximize overall utility by considering the positive consequences of an action against its negative consequences. In recent years, some pioneering researchers in academia have conducted studies on AVs based on machine ethics.

This section provides an overview of the considerations surrounding autonomous vehicles (AVs) and their applications. When establishing guidelines for AVs, two primary challenges arise. The first challenge involves determining the value of scenarios. The second obstacle lies in translating rules into a computer-understandable language without the need for human intervention. In circles, there are generally three categories of ethical decision-making approaches: approaches, AI and the combination of other rational as well as AI ways.

3.1 Logical Approach:

There are typically two approaches when it comes to vehicles. The first is the rule, which requires AVs to adhere to a set of principles. The second is consequentialism, which focuses on maximizing the good within the system. Engineers often find these rational approaches appealing because they are feasible when rules are followed and cost functions are optimized by the computers.

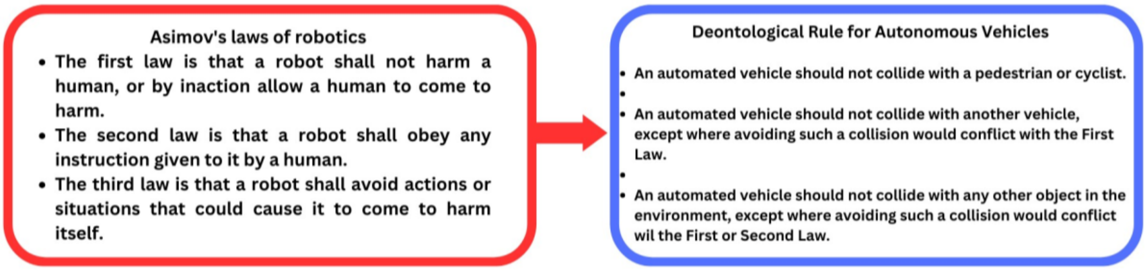

Fig2: Deontological rule for autonomous vehicle.

3.1.1 Deontological Ethics

In their paper titled 'Incorporating into AI vehicles control various considerations' [30], the creators propose two rules that can act as systems for dynamic in independent vehicles (AVs): deontology [31]. Deontology morals submits to a bunch of rules to decide choices. In the field of robotics, an iconic example is Isaac Asimov’s Three Laws of Robotics [32], which outline three laws that AVs should adhere to, as depicted in Figure 2. A duty-based ethical theory called 'W.D.' has been developed as a software tool [33]. In its decision-making process, this tool employs machine learning techniques to assess the implications of actions based on rules and identify the most crucial ethical rules involved. Deontological principles can offer guidance in traffic situations. Nonetheless, it is critical to take note of that they don't comprise a system because of their impediments and the difficulties engaged with communicating the intricacies of human morals. There are situations, for example, mishaps, new street plans, and upgrades to vehicle systems, that would require consideration. Furthermore, these principles may not effectively address the challenges posed by factors in situations where a social dilemma arises, as depicted in Figure 1. For instance, should a vehicle prioritize the safety of its passengers? Collide with a pedestrian? Would the age or pregnancy status of those involved have any bearing on this decision [34]?

3.1.2 Consequentialist Ethics

Consequentialism is another principle that examines the anticipated benefits of a situation. Assesses the outcomes of actions based on what generates the most positive results. This approach offers a way to create a decision-making algorithm that treats it as an optimization problem [35]. One example of software tools is "Jeremy" [36]. This software incorporates guidelines by considering factors such as the intensity, probability, and duration of expected outcomes. In the context of vehicles (AVs), utility can be defined as the estimated costs resulting from accidents, taking into account their intensity, possibility and time on the basis of crash models. On the other hand, no limitations are there in ethical theory.

One of the challenges is Evaluating the cost function well and making it comprehensive [37] For example, how do we quantify harm or damage? If we rely on values like estimating damage costs based on insurance industry data, it can lead to practical issues. In situations where a collision's likely to cause injury, autonomous vehicles (AVs) may prioritize crashing into another vehicle to protect humans or choose to collide with a motorcyclist wearing a helmet rather than one without. This creates a dilemma where individuals who have invested in safety precautions in various emergency situations are not targeted fairly [38]. If on the road, this approach turns out to be common place, people would be less inclined to invest money in purchasing cars with warranties, or some motorcyclists might opt not to wear helmets so as not to be singled out in exceptional cases. Unfortunately, there is no solace when decisions of this nature are left up to computers.

To investigate sense dynamic inside the space of AVs, scientists executed a computational model utilizing information from the Ethical Machine [32]. Moral Machine is a MIT-created web application that gathers viewpoints on difficulties including AVs. In each gathering, members were given an ethical machine situation. I was approached to pick between two choices that had shifting moral results and compromises. As of October 2017, they had accumulated in excess of 30 million reactions from people living in more than 180 nations around the world. To direct their dynamic interaction, they use a utility capability that evaluates standards in view of how individuals esteem parts of moral issues, like orientation, age, and economic wellbeing. They then break down 130,000 choices from the Ethical Machine site to more readily comprehend the variables affecting individuals' decisions. Both deontological morals and consequentialism have their impediments.

Deontological rules often rely on principles that may not always be feasible or could conflict in unique situations. On the other hand, actions arising from consequentialist approaches can sometimes be deemed objectionable. The common drawback shared by these two approaches is their incompleteness. Consequently, relying solely on these approaches is insufficient for vehicles ethical decision-making due to their limited applicability. It becomes necessary to adopt an approach that compensates for these shortcomings.

3.2 Various approaches of Artificial Intelligence

The logical methods mentioned rely on rules that are programmed by humans into vehicles (AVs). However, these approaches have limitations when it comes to dealing with environments. As a result, alternative artificial intelligence (AI) methods have been more successful [39]. These AI approaches can learn about ethics by observing behaviour or by receiving rewards for ethical actions they perform [40]. The computer can operate autonomously. Summarize guidelines without requiring human input to determine the ethicality of actions. The computer-based intelligence or Artificial intelligence is procedure referenced here is frequently alluded to as a "base up" approach [41], which envelops strategies like learning and hereditary calculations. Nonetheless, there are additionally limits to AI draws near. The main downside is that the way of behaving learned or concentrated by artificial intelligence can't completely focus on security out and about as it misses the mark on self-protection senses inborn in people. For instance, a human driver could naturally decide to drive one more vehicle into a mishap to try not to slam into themselves. While this conduct would be advanced by the computer-based intelligence calculation and make the guidelines more practical, it may not really be viewed as moral.

In this way, it is pivotal for AI strategies to be painstakingly planned to catch conduct. The second impediment of AI approaches is detectability [42]. ANNs (Artificial Neural Networks) frequently battle to make sense of how choices were made in view of information, making their connections vast for people. Bostrom et al. have contended that such hazy frameworks are eccentric and not effectively dependent upon examination [43]. It's conceivable that a self-insurance factor installed inside a vehicle's system could be hidden inside a complex ANN and just found through long haul crash investigation. University needs to exercise caution when adopting AI approaches. While AI's ethical capabilities enable computers to imitate ethics without intervention, there is a concern that they may not be able to ensure their actions are justified or explained in a comprehensible manner. Moreover, if trained with a dataset, there is a risk that AI systems could learn behaviours. Without conducting tests, it is not advisable to endorse the use of AI techniques in vehicles (AVs) unless accompanied by rational guidelines. These guidelines would serve the purpose of preventing any action and promoting transparency.

3.3 Integrated Rational and Artificial Intelligence

As referenced before, both normal and AI approaches have their restrictions. To address these restrictions, a consolidated reasonable and AI approach could offer an answer. This half breed approach includes involving AI methods to dissect reactions and activities in genuine world and speculative mishap situations. The aim is to establish rules based on this analysis while still considering the boundaries set by the rational approach. Although sophisticated software for this approach is not currently available, neural networks show promise as candidates for training using recorded data and across diverse circumstances simulations of crashes and near crashes. By incorporating approaches to provide boundaries, we can ensure that the decisions made by vehicles are reasonable. In outline, this cross-breed approach keeps up with the standard framework as a necessity while using simulated intelligence techniques explicitly for circumstances not covered by judicious principles. Goodall presented a three-layer stage for dynamic in vehicles. The main layer follows standards in view of deontology and consequentialism, while the other two layers include the coordination of simulated intelligence procedures and a blend of judicious artificial intelligence draws near. Wallach et al. have pushed for thoughts featuring the impediments of both hierarchical and granular perspectives [41]. In light of the clarification gave above, conceiving frameworks for vehicles (AVs) would require a versatile incrementalism approach likened to machine morals [43]. It's important to note that reaching a solution in a short period of time is not feasible. However, as ethical knowledge advances, the optimal algorithm would be a rational AI approach that takes into account various scenarios to establish reasonably comprehensive ethical rules for AVs. At the time, training artificial intelligence to show the moral actions justified and this would necessitate the long-term efforts.

IV. THE PROGRESSION OF AUTOMAKERS

Major car manufacturers, like Tesla, Mercedes, Volvo, and GM, who are actively pursuing vehicles are supposed to have a pause for some time till the various kind of ethical challenges are observed and resolved. The principal of vehicle operation is likely to be added in the AVs as expected. The AVs will be instructed to slow down to avoid accidents when this principle is added along with some other additional features such as keeping pedestrians, cyclists and valuable properties under priority. They may also consider selecting the course of action in a crash scenario that minimizes harm for all parties involved [44]. However, it is important to note that the ethical algorithms developed by car manufacturers are still in stages and have yet to reach maturity. Car makers have openly acknowledged that they have been teaching their rules aimed at minimizing damage [45].

However, the program that reduces damage to vehicles lacks transparency. Can sometimes be misleading. Public authorities do not have the means to fully monitor these vehicles, even though they claim to prioritize minimizing costs. In reality, their main focus is on minimizing costs. This raises concerns because car manufacturers may operate transparent programs solely to minimize liability exposure and protect their own interests. In such cases, it may be necessary to assess the compensation for damages that the car manufacturer or insurance company may face. Additionally, hidden biases within these transparent programs can further complicate matters. The question arises for the accountability, who should be held responsible, program designers of car manufacturers both are answerable.

For instance, Google's search engine has faced criticism for advertising paid jobs as predominantly white male positions. Similarly, algorithms often target individuals with skin or religious affiliations for inspection purposes. While discrimination already exists independently of these programs, its impact may be amplified through their adoption in certain scenarios. This discussion is now gradually shifting towards quandaries, departing from the initial assumption that algorithms must be 'neutral' [47].

When it comes to dealing with challenges, some smart market players have taken the initiative to establish safety regulations in order to take responsibility for preventing traffic accidents. They argue that if all autonomous vehicles (AVs) adhere to these safety rules, the number of crashes and ethical dilemmas will decrease. This framework, known as "Responsibility Sensitive Safety (RSS)," sets out guidelines for scenarios such as merging inside the traffic, lane changing, taking all the cautions while driving especially when pedestrians and other traffic is obstructed partially from the main or driver's view. The sense approach humans use is used in RSS in the determination of accident causing factors. An objective is not to ensure that their ethical agents never cause accidents but also to acknowledge that being involved in an accident may be unavoidable despite taking precautions. RSS is created by formalizing four "sense" guidelines: 1. Maintain a distance from the car ahead of you so that if it suddenly breaks, in time stoppage. 2. From the cars that are beside you, keep distance. While merging and changing lanes, making it sure that plenty of space is available and other cars can respond well. 3. The rule of right of way should be implemented. It has to be kept in mind that it is not taken, it is given. 4. Be very careful about zones that may be obstructed, like a parked car hiding a child. Furthermore, this guideline has already been implemented into the driving platforms being developed by BMW, Fiat Chrysler, and several parts manufacturers [46].

V. CONCLUSION

AVs (autonomous vehicles) have gained much popularity since they are reportedly linked with transportation efficiency and safety. AVs can take driver's responsibility. On the other hand, an important aspect that has to be kept in mind is that for these vehicles, the control components and sensors are working ideally, there is still a possibility of crashes. In certain situations, AVs must possess the capability to make decisions. This review paper aims to serve as a guide for those who're new to systems applied in AVs by providing an understanding of the central idea of problem framing and offering various important guidelines regarding this field in the coming times. With AVs, there are various social as well as ethical challenges involved. The main concerns include trolleys at roads, dilemma of self-sacrificing and the animal encounter at roads. Efforts are needed to address this situation and for this purpose policy makers and auto manufacturers have to take appropriate steps. The academia suggested a current way but it is not yet comprehensive or realistic enough. Car manufacturers typically adopt rules that prioritize their own interests rather than impartiality. Policymakers have established regulations for automated vehicles; however, they lack guidance regarding challenges. In conclusion, it can be inferred that there is no solution to address all challenges faced by self-driving vehicles in every circumstance. One potential solution could be for car manufacturers to offer information about crash scenarios, including detailed explanations of the vehicle's capabilities and how it would respond in those situations. In the world, a combination of thinking and AI methods is employed to create ethical guidelines that align with the values of society and culture, aiming for impartiality.

Over time, through this process, a natural agreement may develop regarding dilemmas, which can then be incorporated into laws and regulations.

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