Autonomous Vehicles: A Distant Possibility

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***Abstract*—Autonomous Vehicles are vehicles that can drive by themselves and do not require any human input to operate it. With new inventions, new problems and limitations arise. We have identified and highlighted three main issues. (1) Naturalness of Interaction with Autonomous Vehicles. (2) Acceptance of Autonomous Vehicles. (3) Ethical Issues in Autonomous Vehicles. We have identified and expanded on these problems and illustrated the cost benefit analysis of Autonomous Vehicles. We have gone through the challenges that Autonomous Vehicles face and to provide a perspective, we have included results and steps taken by some of the companies leading in Autonomous Vehicles(AV) technology. We argue that there is still a long way to go before a fully automated vehicle can hit the roads safely.**

***Index Terms*—Autonomous Vehicles, Ethical Issues, Acceptance, Naturalness, Sensors**

I. Introduction

Autonomous vehicles are the vehicles that are fully automated, can perform all the driving by itself in any condition without requiring any human interaction or effort. With massive companies like Google, Tesla, China's Baidu, GM Cruise, Argo AI investing in autonomous vehicles, many claim that autonomous vehicles are going to be the main means of transportation in the near future. Firms are rapidly progressing towards what looks like a bright future with some companies doing real world or practical testing already. In 2020, we have already seen driving assistance and partially automated cars that can steer and accelerate or decelerate themselves but all other functionalities should be handled by human drivers and it seems like we are headed the right way.

When it comes to transportation, accidents are bound to happen, may it be a vehicle driven by humans or an autonomous vehicle that is run by an artificial intelligence. The only difference between these is the frequency and the severity of the accidents. It is a simple principle, if the benefit of the cars being out on the market is more than the cost of it being out on the market, we will take it. However, if these accidents keep happening at a greater frequency with autonomous cars, it will be very difficult for it to be legalized due to the social, economic and ethical issues that surround it. There is also a big question that always arises, who will be held responsible if there is an accident involving an autonomous vehicle? Will it be the manufacturer or will it be blamed on the vehicle or do we just blame the person inside the vehicle? For now, it is easy to say that the manufacturers will be held accountable, but there is more to it than that as every situation is unique and has its own variables.

When we look at things on the bright side, autonomous vehicles could possibly reduce the frequency and severity of accidents. Even though that might be the case, liability will still be an important and potentially limiting consideration for manufacturers. [1] There will always be a potential danger of a defect sneaking into the cars out in the market which might cause an accident compared to the present where most car accidents are attributed to human driver errors. Even though autonomous vehicles will eliminate the human error factors from driving, there are a lot of questions that need to be answered before we can give a verdict on whether we should use autonomous vehicles in the future. In this paper, we are going to discuss those questions and different issues that may arise while developing autonomous vehicles and try to find a reasonable answer to address it.

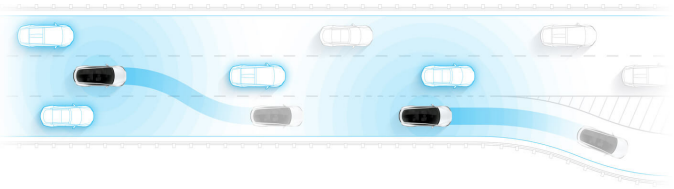

Fig. 1. Autonomous Vehicles changing lanes on its own based on traffic [2]

II. Human Computer Interaction in Autonomous Vehicles

When we go out on a drive, what factors are important for you to have a safe ride and return home safely? When we take a look at it from this standpoint, there is a lot of information that needs to be absorbed and processed, which also means that there are a lot of places where things could go wrong. We have to interact with our vehicle, we also have to interact with other vehicles, the other drivers, the traffic lights, the sidewalks, the pedestrians, the trees next to the road, the buildings, the bus stops, and all the things present in the surrounding we are driving in. There is a lot of complexity in the social activities when people communicate, negotiate and anticipate what other road users are going to do and coordinating the traffic flow in an orderly manner in such an environment is challenging.

[3]There is a very low margin of error when it comes to driving on a road with other users.

In today's world the way they interact with each other is constantly changing and evolving. So, there is a big question if autonomous vehicles can communicate with its environment better than humans can in order to maintain safety of its users and everyone around it. The interaction between two autonomous vehicles might not be in as much scrutiny as the interaction between an autonomous vehicle and its environment. The autonomous vehicles could possibly communicate with other autonomous vehicles efficiently and effectively using lights, gestures, sounds or icons. The problem arises when the autonomous vehicle needs to interact with a human, who might be walking on the street or who might be driving a non-automated car. The same lights, gestures, sounds, or icons would not work as intended with humans as for humans those indications are open to different interpretations. It depends on the perspective of the human which makes them decide their next move which might lead to an accident. Hypothetically, if the indicators work for people in one setting, it might totally fail in another which might possess a big setback for autonomous vehicles. The human-computer interaction error might lead to a lot of accident and will be a major problem that the manufacturers need to figure out, The human-interaction with autonomous vehicles will lead to multiple challenges including but not limited to ethical issues in decision making, naturalness of interaction with autonomous vehicles, acceptance of autonomous vehicles and shared situation awareness between driver and vehicle. [4]

III. Effects of Driving an Autonomous Vehicle

It is very obvious that autonomous vehicles will be used primarily for the reason to make the traffic flow better and transportation much easier. However, there are some unintended effects that it might have on transportation. The first thing that can possibly happen is that the people will start travelling more just because it is convenient to travel. [5]Since travelling will have less hassle and be more convenient, people will travel much more frequently and longer distances than they normally would. This might not only create traffic flow issues but also issues regarding overuse of certain resources. Also, since autonomous vehicles will be used due to their efficiency, it might be able to save some resources at the same time.For example: when a car starts moving from a stop position in traffic, the cars behind it can read that more efficiently and move simultaneously compared to moving after a few seconds which causes more traffic and wastes more resources.

Another scenario that is possible, people will not be able to trust the automated vehicles when the human input factor is eliminated as one might feel unsafe depending on a computer. [6] Some people feel that when they are not in control of something themselves, there is danger involved and will refrain from using it. Whenever we talk about autonomous vehicles, we have always associated it with certain advantages as well as disadvantages. However, economists believe that the advantages of autonomous vehicles outweighs the negative effects it might have on the society. Although autonomous vehicles will help the transportation process more smoother and easier, it will cost us some casualties along the way which has to be addressed. [7]The degree of casualties is still questionable which is why there are big questions that need to be answered before autonomous vehicles can be sold and used in the market.

IV. Naturalness of Interaction with Autonomous Vehicles

Interaction is an extremely important factor when it comes to driving in a real world scenario. We see interaction being involved in everything we do, from stepping outside of our door to nodding our head to say yes. It is also heavily involved in vehicles that we drive. First of all, we interact with the cars that we drive. We look at the tire pressure, we look at the amount of gas in the car, we look at the indications, and many more. Our interaction with vehicles driven by other humans, our interaction is still there. It is subtle and sometimes easily recognizable. We might also interact with pedestrians who are crossing the road or just walking on the sidewalk. The interaction can vary from a showing of a palm which can mean stop, nodding of the head which shows appreciation for stopping or glancing over to indicate that you must stop so that I can pass. We are fully in control of the vehicle, so if the interaction is not perceived the way you want by the other vehicles or pedestrians, we can act on it and do whatever is needed to avoid an accident.

However, we might not have the same luxury with autonomous vehicles. When the driver is absent to take the decision for the vehicle, it has to directly interact with its surrounding, pedestrians, other autonomous vehicles, or human driven vehicles. There is a big question of how autonomous vehicles can accurately interpret the message sent by the environment(pedestrians, other vehicles, surrounding) or send a message that can be accurately interpreted by everyone else. With thousands of lives at risk, these interactions between the autonomous vehicle and everything else in the surrounding should happen in split seconds and should accurately simplify the intentions of everything present in the surrounding. The intentions of everything in the surrounding is very complicated as it can be unique depending on the situation. [8] If we take a pedestrian as an object in the surrounding, the autonomous vehicle should simplify what the pedestrian is doing and act accordingly. If the pedestrian wants to cross the road, the autonomous vehicle should see that and act accordingly. But when there are multiple objects in the surrounding, things can get overwhelming. Autonomous vehicles can use lights, sounds, signals and symbols, or connection to communicate with its surroundings.The meanings of those indications could be interpreted in different ways by different objects which might create a big issue for autonomous vehicles to operate in an environment with non-automated cars and pedestrians involved.

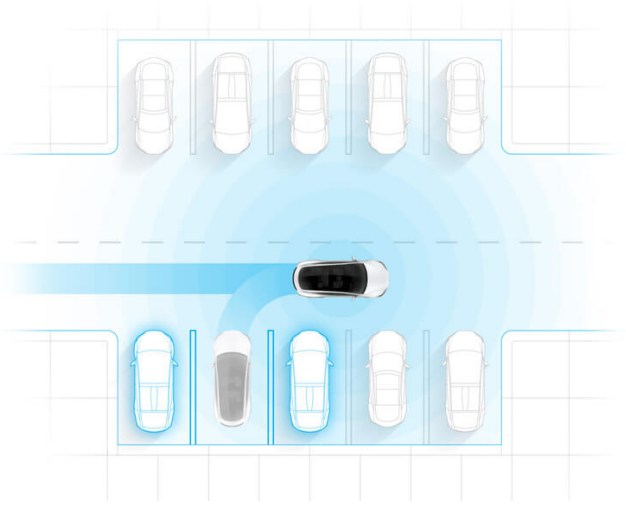

Fig. 2. Autonomous Vehicles find a parking spot by itself and parks [2]

V. Acceptance of Autonomous Vehicles

Considering the risks we talked about with the naturalness of interaction with autonomous vehicles, it is unlikely that everyone will accept the arrival of autonomous vehicles in the market. It is true that autonomous vehicles will most likely solve most of the problems in our transportation systems right now which may include but not limit to issues regarding the safety of passengers, environmental impacts and efficiency of mobility. It is also true that these autonomous vehicles will reduce the accidents caused in the roads due to human error. However, it will also create problems regarding the increase in miles travelled and traffic overflow. [9]

When economists look at this they will analyze it using the cost benefit analysis which is "a systematic approach to estimating the strengths and weaknesses of alternatives." [10] Here the cost of using autonomous vehicle does not look bad when we compare it to the benefits that we get from it. However, if we look at the ethical and psychological perspective of it, the statistics show something else. In 2020, only 10 percent of Americans are sure that they trust autonomous vehicles, whereas 27 percent of them were unsure about it. The majority of the remaining trusted vehicles only when they drive themselves. [11] The acceptance of Autonomous Vehicles will face a lot of challenges from economic, psychological as well as legal perspective before it can be widely available for general use in the market and it is still a big question if the idea is going to be a success due to uncertainties involved with it. According to researchers available at this moment, the US economy will be helped by USD 27 billion with a market penetration of just 10 percent whereas with higher penetration rates the US economy will massively be boosted with benefits around USD 450 billion annually. Looking at this, it would be easy to say that the market will readily accept autonomous vehicles. However, autonomous vehicles will be expensive which will not be affordable to a lot of people. Also, there is a big question regarding the framework of driverless vehicles which could be a downside. [13]

Fig. 3. Waymo Autonomous Vehicles [12]

VI. Ethical Issues in Autonomous Vehicles

What will Autonomous Vehicles do if there is a case where an accident is inevitable? If there is a kid crossing the street, a group of people walking on one side of the road, and an old lady walking on the other side, whose lives would the Autonomous Vehicles decide to save including the passenger in a case where an accident is unavoidable? The addressing of this ethical issue is directly linked with the public acceptance of autonomous vehicles. [14] The scenario laid above is also known as "Trolley Cases" and the cases that come out of it is always conflicting. It possesses a huge challenge to the ethics of Autonomous Vehicles. Many have argued that the 'distribution of harm' is a very important aspect to be addressed. However, every case is different from each other which makes it very challenging. [15] Some other scenario might present where distribution of harm is not necessary, where the collision might be avoidable. But at that point, if the car is already out of control, a failure system should be established. There is a very big level of inconsistency here in ethical issues which makes it more demanding. Trolley cases possess a technical limitation and are solely based on assumptions which adds up to the inconsistency of it. What the researchers and producers are looking for here is not only the politically correct answer to the scenarios but also morally correct ones. There will be many problems and scenarios that may arise that will require complex moral algorithms to be developed. There is no both morally and politically right answer as of now. [16]

VII. Current Situation

Elon Musk's Tesla has been doing a great job of testing their features by including it in customer owned cars. Although the cars are not fully autonomous, the self driving features have not created too many problems so far except some scenarios which were not addressed, like going on an overhead bridge which detected cars from the road underneath and would result in malfunction of the car. The amount of data that Tesla

collects is overwhelming and very impressive. This shows the level of attention to detail that this company is focusing on to deliver a flawless autonomous vehicle. Tesla uses a log system where it takes note of any instance where the autopilot has to take any action. This can create a big reference for developing advanced features into its cars in the future. Compared to Tesla's 300,000 cars in the market, Waymo has delivered its own 500-600 minivans. While Tesla has a strategy of learning from real world driving miles to develop even better versions of their cars, Waymo is solely based on computer simulations to make the decision making better in their cars. In my opinion, Tesla is doing a far better job in the development process than Waymo as they have been using real world miles which gives you scenarios that a computer simulation cannot produce. Tesla is doing a good job of addressing the ethical issues that it might face by using real world scenarios. Both the companies have been very careful in their production where they have avoided any ethical issues that could hinder their progress. Although it looks like the future is close for autonomous vehicles, it is going to be very challenging to address all the problems that are thrown at it.

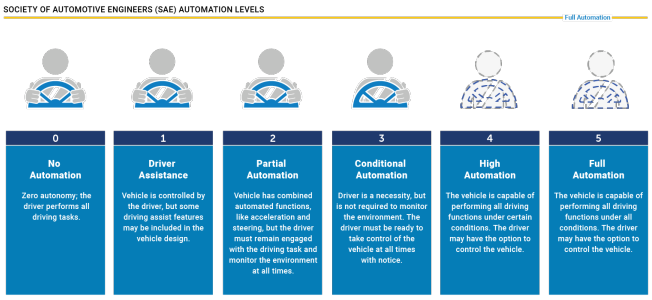

Fig. 4. Levels of Autonomous Vehicles [17]

VIII. Conclusion

Building a perfect Autonomous Vehicle is a very challenging task and will take a lot of trial and errors before it can be available to the general public. As companies invest millions in researching and making these autonomous vehicles, it is very important to address the issues we discussed. It looks like the possibility of building this flawless piece of technology might take a lot of time, but the automation technology has been slowly but surely improving with companies like Tesla, Waymo, Google and many more on top of it. Autonomous Vehicles will definitely give a huge advantage to the way we travel in the future. Some of it might be better traffic flow, reduced accidents, giving mobility to people who cannot drive, or even improve engine efficiency and fuel economy. However, there are some downsides like the technology is going to be very expensive, the vehicle itself might be vulnerable to cyber attacks or hacking or even the systems failing which might be brutal for many reasons. [18] There are barriers which must be overcome before the perfect autonomous vehicle can be ready. Investing millions and billions into transportation will improve a huge aspect of quality of life but will not be successful unless the right policy is in place.

References

[1] G. E. Marchant and R. A. Lindor, "The coming collision between autonomous vehicles and the liability system," *Santa Clara L. Rev.*, vol. 52, p. 1321, 2012.

[2] Tesla, "Tesla autonomous vehicle image," 2020.

[3] G. Eden, "Transforming cars into computers: interdisciplinary opportunities for hci," in *Proceedings of 32nd BCS HCI Conference, Belfast, UK, 2018*, British Human Computer Interaction (BHCI), 2018.

[4] A. Meschtscherjakov, M. Tscheligi, P. Fröhlich, R. McCall, A. Riener, and P. Palanque, "Mobile interaction with and in autonomous vehicles," in *Proceedings of the 19th International Conference on Human-Computer Interaction with Mobile Devices and Services*, pp. 1–6, 2017.

[5] W. Gruel and J. M. Stanford, "Assessing the long-term effects of autonomous vehicles: a speculative approach," *Transportation research procedia*, vol. 13, no. 2016, pp. 18–29, 2016.

[6] J.-G. Lee, K. J. Kim, S. Lee, and D.-H. Shin, "Can autonomous vehicles be safe and trustworthy? effects of appearance and autonomy of unmanned driving systems," *International Journal of Human-Computer Interaction*, vol. 31, no. 10, pp. 682–691, 2015.

[7] S. A. Bagloee, M. Tavana, M. Asadi, and T. Oliver, "Autonomous vehicles: challenges, opportunities, and future implications for transportation policies," *Journal of modern transportation*, vol. 24, no. 4, pp. 284–303, 2016.

[8] K. Mahadevan, S. Somanath, and E. Sharlin, "Communicating awareness and intent in autonomous vehicle-pedestrian interaction," in *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*, pp. 1–12, 2018.

[9] C. J. Haboucha, R. Ishaq, and Y. Shiftan, "User preferences regarding autonomous vehicles," *Transportation Research Part C: Emerging Technologies*, vol. 78, pp. 37–49, 2017.

[10] E. J. Mishan and E. Quah, *Cost-benefit analysis*, vol. 454. Praeger New York, 1976.

[11] K. Raats, V. Fors, and S. Pink, "Trusting autonomous vehicles: An interdisciplinary approach," *Transportation Research Interdisciplinary Perspectives*, vol. 7, p. 100201, 2020.

[12] Waymo, "Waymo image," 2020.

[13] D. J. Fagnant and K. Kockelman, "Preparing a nation for autonomous vehicles: opportunities, barriers and policy recommendations," *Transportation Research Part A: Policy and Practice*, vol. 77, pp. 167–181, 2015.

[14] F. S. De Sio, "Killing by autonomous vehicles and the legal doctrine of necessity," *Ethical Theory and Moral Practice*, vol. 20, no. 2, pp. 411–429, 2017.

[15] J. Himmelreich, "Never mind the trolley: The ethics of autonomous vehicles in mundane situations," *Ethical Theory and Moral Practice*, vol. 21, no. 3, pp. 669–684, 2018.

[16] J.-F. Bonnefon, A. Shariff, and I. Rahwan, "The social dilemma of autonomous vehicles," *Science*, vol. 352, no. 6293, pp. 1573–1576, 2016.

[17] NHTSA, "Automated vehicles for safety," 2020.

[18] W. Schwarting, J. Alonso-Mora, and D. Rus, "Planning and decision-making for autonomous vehicles," *Annual Review of Control, Robotics, and Autonomous Systems*, 2018.