Self-Driving Cars – challenges and opportunities

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Introduction

More than a million lives are lost each year due to road accidents and around 90% of these accidents are to do with irresponsible driving (Machine Design, 2019). There is always some sort of human error in every accident that occurs on the road due to speeding, reckless driving, or inattentiveness. Luckily, this can be soon reversed by autonomous vehicles, where no emotion would be involved. Every decision on the road would be made possible by the computer in control of the car through the combination of a variety of sensors to perceive its surroundings such as radar, lidar, sonar, GPS, odometry and inertial measurement units (Wikipedia, 2020).

Automation would require less lighting systems, as cars would be in communication with one another. The flow of traffic would become more efficient without congestion and traffic accidents would finally be eliminated (Cybercom Group, 2019).

Automated Driving Systems are starting to be developed in many regions of the world. In 2009 Google had begun testing their own self-driving cars, and many other manufacturers have ambitions of moving the industry towards automation with the ambition of a fully driverless car.

There are six distinct levels of automation. The first two levels are already common today, while the others are currently in development. Most vehicles today are level zero, where the driver is in control of all aspects of driving. The car's automation is limited to minor warnings displayed on the dashboard and emergency breaking (Autoglass, 2020).

The next stage is level one, where driver assistance is present. These cars can handle steering or acceleration and braking, but never both. However, the driver is still responsible to take over when necessary. Systems like self-parking and lane assistance also fall into this category (Autoglass, 2020).

When it comes to level two, this is all about the handling of the steering, acceleration and braking and has been already implemented in Tesla's autopilot feature. However, the driver remains aware of the situation and must be ready to take over, if any change in weather or traffic conditions suddenly occurs (Autoglass, 2020).

At level three, the vehicle monitors its surroundings and moves between lanes. Audi A8 in 2017 was the first car to achieve this level of autonomy.

Autonomous cars at level four can fully pilot themselves. They can control the ignition, steering, braking, acceleration, and any parking duties. It will only request assistance by a human driver, if it encounters something that it is unable to read or negotiate (Autoglass, 2020).

The goal is to achieve level five, full automation without the requirement of any intervention by the human driver. Some level five concept cars include- the Volkswagen Group SeDric and the Audi Alcon concept (Autoglass, 2020).

Autonomous vehicle technology development had begun since the 1500's, with da Vinci designing a cart that could move without being pushed or pulled. Then in the 19th century, Robert Whitehead's invention of a torpedo that could propel itself underwater proved to be a game-changer for naval fleets. In addition, cruise control was first commercialized in 1958 and through 2004 – 2013 the U.S. Department of Defense had sponsored a series of challenges that pushed autonomous vehicles forward (Wired, 2016).

Challenges

Challenges begin to surface from level three (conditional automation) development. At level three, when the driver is forced to take over, the risk of collision with surrounding vehicles increases. Unfortunately, this issue is still being examined and a solution is yet to be found.

In addition, level four, operates in limited operational design domains (ODDs) such as highways. In the event of leaving such an area, the vehicle must safely stop the trip by automatically parking itself. No production vehicle is capable of level four and level five. The Toyota Research institute has also claimed that no one is even close to attaining the last level of automation (Yurtsever).

Level four and above driving automation, has many difficulties in predicting environmental variables, weather conditions and surrounding human behaviour in urban environments. Failure in these predictions has led to many accidents. Hyundai Automation crashed due to rain, Google's automation failed to determine the speed of an approaching bus and Tesla's autopilot failed to recognize the white colour of a truck, colliding with it and killing the driver (Yurtsever).

Casualties during testing of autonomous technology undermine the public acceptance of the new era in the transport industry. Many people question the safety of the technology and want to be assured that the technology is fully safe to use. Only 55% of respondents do not feel comfortable in an autonomous vehicle (Geneva Internet Platform, 2020). That is a large proportion of people who are simply not willing to give up their driving.

Another major concern for security is that autonomous vehicles will provide many opportunities for the vehicle to be hacked. Not only could this affect the functionality of the vehicle causing accidents to occur, but it could also mean that data provided on the vehicle can be easily stolen. One example of this is through a malicious app acting as a self-diagnostic app installed on a person's smartphone which is connected to the target vehicle using WiFi. Such a malicious app can transfer data frames of the in-vehicle controller area network (CAN) consisting of an efficient network of electronic control units (ECUs) to the attacker's server. The attacker can then transmit a CAN data frame to force control of a particular ECU (Woo). Once this happens, there could be a distortion of the dashboard, the engine could stop, handle control and acceleration can also be severely affected depending on the ECU targeted.

Security has never been considered in the design of CAN making it very vulnerable for exploits and as a result undermining the security of autonomous vehicles even further.

Furthermore, as mentioned, autonomous vehicles use a broad set of sensors. Lidar uses lasers to measure the distance between objects and the vehicle. Radar detects objects and tracks their speed and direction. These sensors feed data back to the control system to help it make better decisions.

However, lousy weather, heavy traffic and road signs with graffiti can negatively impact the accuracy of sensing capability. Challenges remain in ensuring that the chosen sensors can detect all objects in all weather conditions that may exist.

Radar sensors lack precision in estimating the shape of the objects in the environment. It can be used for distance measurement of large objects like vehicles but lacks the accuracy in detecting pedestrians and static objects. In addition, they have a very limited field of view.

Luckily, Lidar sensors are more accurate than Radar under two hundred metres, however fog and snow have a severely negative impact on its performance. They are also quite large in terms of their size and are not preferable on vehicles because of limited space. Unlike Radar, they offer precise object localization capabilities (Yurtsever).

Cameras have a lower performance than Lidar and Radar, as they are affected by illumination conditions. Event camera sensors record data asynchronously for individual pixels with respect to visual stimulus. The biggest limitations are the pixel size and resolution and as a result it is not effective in detecting changes in the environment.

Another challenge is the understanding of lanes and how they are connected through merges and intersections. Fully automated driving requires a complete, semantic understanding of road structures and the detection of lanes at long ranges.

Not to forget, the study of driving styles is very limited. This requires much more attention and the current scope of understanding is not accurate enough. Each person is different in the way he/she drives the vehicle, and it is difficult to put a certain category or label on a set of people. This kind of approach is more of an estimation rather than a correct classification of every single driving style there can possibly exist. Machine learning algorithms may predict driving patterns in the wrong way, failing to detect the dangers approaching the driver in a particular situation.

The human machine interaction has always been important in alerting the driver of any sudden changes in the system of the vehicle or any other dangers ahead. However, challenges exist in communicating the message effectively to the driver while the car is in autonomy from level three. It has been scientifically proven, that drivers exhibit lower cognitive understanding of the current road situation ahead of them. Drivers get too relaxed when the system takes over control of the vehicle and the instinct of reacting quickly to a sudden dangerous situation imposed on the road is simply not the same.

That automatic instinct of reaction to danger is not as quick as it should be and the transition of the vehicle back to the driver is not fast enough to avoid the danger. Future research should focus on delivering better ways to inform the driver to create an easier transition. The user and the Automated Driving System must always have a mutual understanding [6].

Unfortunately, these autonomous vehicles would also be very expensive. Currently, the installation of LIDAR systems alone costs around 30,000 to 85,000 dollars. That places a large price tag for the average consumer and makes it difficult to introduce it to the global market (Coppola).

Most importantly, the introduction of autonomous vehicles would create massive unemployment in sectors related to traditional driving jobs such as truckers, insurers, taxi drivers and bus drivers (Coppola). Uber has already planned in moving their business model into an automotive one without the need to hire drivers, but to have self-driving cars picking up customers in the future.

Opportunities

Reaching full automation (level five) would create new possibilities, in terms of car design. If accidents can be fully avoided, cars can have a much more lightweight design as the security measures and very robust bodies will no longer be needed. The reduction of incidents on the roads would also allow for smaller investments in the deployment of road signage and traffic police (Coppola).

The car being fully connected to the internet and to the services nearby, can easily locate possible parking areas, reducing the time spent searching for a parking space. The flow of traffic would be more efficient, and more traffic jams would be avoided as smarter routes could be taken. This reduction of congestion and delays would also result in a significant reduction of emissions and energy consumption. Consumers would be impressed with the ability to save more fuel.

Furthermore, many cars today remain unused once the driver leaves the vehicle. However, in the future it will be possible for the car to collect its passengers from any destination and to carry out other duties if requested. For example, an owner might request the car to drive a relative to a certain destination, while the owner carries out his/her own shopping. By the time, the owner would be done with shopping, the car would have already carried out the duties and returned to the owner to pick him/her up (Coppola).

Overall, full automation of vehicles can create substantial economic savings for many organizations and countries in the world. It is estimated that 5.6 trillion dollars would be saved each year (Coppola).

Similarly, the way people can now subscribe to their favourite video or music streaming service, the possibility of subscribing to a transportation service is very likely in the future. People would prefer not to have privately owned cars anymore due to high maintenance costs and instead have an on-demand autonomous vehicle. If autonomous vehicles become in demand, the insurance industry will have to redesign its current pricing structure to cover the decisions of a machine instead of a human (Geneva Internet Platform, 2020).

Level five autonomous vehicles will have incredibly sophisticated systems. High resolution stereo, Lidar, and Radar sensors, and large 4K screens to display information to the passengers. Due to the invention of 5G it will now be easier to transmit data in real time. For V2X communication it will be easier to capture and interpret data to the surrounding environment. Using both sensor technology and radio-based communication, autonomous cars will make decisions in split-seconds based on driving conditions such as traffic congestion and tolls. Cars will be easily able to change the route depending on which one will be better in the current situation (IEEE Spectrum, 2020).

Due to the vast exchange of internet services in vehicles in the future, data collection will become even more prevalent. Users will be able to choose their entertainment preferences such as music preferences or movie preferences to allow the vehicle to recommend its own available in-vehicle infotainment services based on passenger preferences. This would also create opportunities for products to be advertised in cars based on consumer choices as vehicles will become the new living room. Commercial ads would sponsor your streaming TV services, or an ad might pop up before any article or flash across your screen when you approach a certain store. The in-vehicle experience would be more customized to your personalized content. For example, the vehicle might suggest destinations that are worth visiting based on your likes. Around 17,600 minutes are spent on average each year driving. This just shows how valuable advertising can become for future marketers (Forbes, 2018).

Conclusion

The way autonomous vehicles can create a much more sustainable and brighter future for many sounds very promising, however it does have its drawbacks which are still yet to be resolved. However, it is an important step in transportation technology that we must pursue with a vision of eliminating existing challenges. Through the rapid advancement of technology throughout the ages, it is highly possibly that the future of driverless cars is closer than one might imagine.

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