Autonomous Vehicles – challenges and opportunities

by Emma Allen

Introduction:

Vehicles were invented over one hundred years ago to improve the transport of people and goods from one place to another. In the past hundred years the purpose hasn't changed, however increased safety, comfort and efficiency makes them almost unrecognisable today from the early vehicles of the 19th century. In the last century autonomous vehicles only existed in people's imaginations, creating timeless characters on screen from Herbie [1] in 1968 to Johnny Cab [2] in 1990.

In the United States human choices are responsible for 94 per cent of all accidents [3]. What if this could be lowered? The discussion about autonomous vehicles is not new, but it is becoming increasingly important around the world, for instance the United Kingdom's government has an ambition to have "self-driving cars on UK roads by 2021" [4]. Before this occurs there are many challenges facing the auto industry and society: What does it mean for businesses? Who is responsible in a crash? Will they really be safer? Just because we could do it, should we?

This essay will focus on the challenges that society and technology will face from the use of autonomous vehicles on public roads along with the opportunities. The essay will use the Society of Automotive Engineers (SAE) levels of automation [5] as follows:

- Level 0: no automation; the driver performs all tasks
- Level 1: driver assistance; the vehicle is controlled by the driver, but driver assist features may be present, the majority of cars on the road today have some driver assist features, such as cruise control, blind spot detection or park assist.
- Level 2: partial automation; the vehicle has combined automated functions, but the driver must always remain engaged and monitor the environment, Tesla autopilot provides this level of automation.
- Level 3: conditional automation; driver must always be ready to take control of the vehicle but is not required to monitor the environment, the next Audi A8 claims to deliver autonomous driving at level 3 although in some countries, such as the UK, it is illegal to utilise this functionality.
- Level 4: high automation; the vehicle can perform all driving functions under specific conditions. The driver has the option to control the vehicle, this is considered by many as autonomous driving.
- Level 5: fully autonomous; the vehicle can perform all functions in all conditions and the driver may have the option to control the vehicle, but no driver is required at this level, there may be no need for a steering wheel.

Furthermore, this essay will define a vehicle as "a machine used for transporting people or goods on land" [6]

Technological challenges:

For a car to be autonomous, the car requires sensors to collect information about the road and a central processing unit to analyse all the data and make decisions appropriately. The sensors needed will include lidars, radars, cameras, GPS and ultrasound [7]; these sensors will be used to recognise the vehicles' surroundings and measure the distance between the vehicle and nearby objects so the central processing unit can evaluate them and respond accordingly (see figure 1). This technology already exists, for instance GPS systems and cameras for park assist appear in many level 1 cars, although for level 2 and above there are many problems with consistently identifying objects, for example, rain, snow, road works, complex city driving and other obstacles can prevent the vehicle from carrying out the correct driving action.

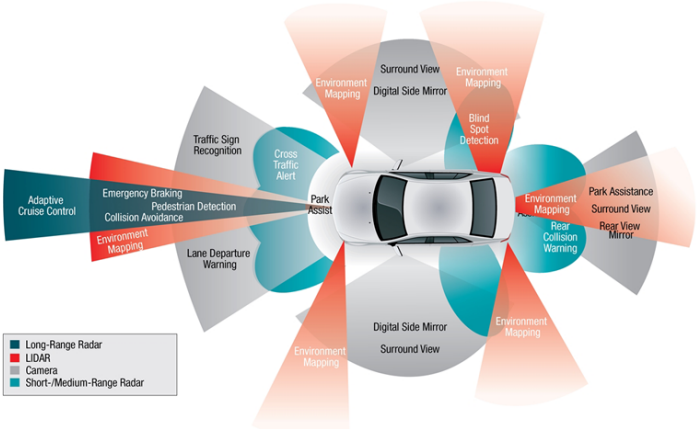

Figure 1.0. Typical Sensors in Autonomous vehicles
Source: Machine Design

The next big challenge is the software and algorithms; it will be very difficult to write a program to identify every possible situation; the vehicle may need the ability to learn to respond to events it has not been specifically programmed for, essentially be artificially intelligent. To work efficiently the vehicles will have to be able to communicate with each other (vehicle to vehicle (V-to-V) communication) via a network or directly via temporary connections between vehicles in close proximity. This means that vehicles will constantly transmit information on direction and their speed during journeys, for example a car driving into a traffic jam would be deaccelerating and sending signals. All vehicles behind would detect these signals and decrease their speed or alert the driver to do so. It is believed that the technology could reduce crashes in situations that do not involve human drivers.

Vehicles will also need to communicate with the infrastructure (V-to-I communication) in order to be aware of speed limits, traffic updates and route optimisation; many of these features are already available. Several level 1 cars currently on the market can read road signs, satellite navigation systems are plugged into traffic monitoring networks and can alter routes when traffic is heavy along a preferred route. These features will probably need further investment to make them more reliable and capable of handling larger data flows. This will require significant investment from governments. Parts of the UK are being upgraded to “smart motorways” [8] which use technology to actively manage the flow of traffic. This could well be the first step in creating the environment for autonomous vehicles. The next steps to provide both V-to-V and V-to-I communication will be installing 5G. Highways England is exploring improving Wi-Fi[9] and 5G connectivity, as part of the governments ambition to have “self-driving car on UK roads by 2021” [4]. For real time V-to-V communication, LTE-V (Long term evolution- vehicles) communication technology is being compared to WLAN 802.11p in various situations by Audi on the A9 autobahn in Germany, allowing the industry to specify the requirements for standardisation of future 5G communication [10]. One potential side effect of this is that autonomous vehicles could collect a large amount of data. The data could be used to create personalised services and products but could also be used for monitoring our movements and lifestyle, our cars could become spies and there is hence an ethical dimension about data, its ownership and use.

This software also brings with it the risk of hacking, perhaps making autonomous vehicles the perfect tool for terrorists. Issues like, kidnapping, or deliberately causing an accident could occur. This is a new problem for the auto industry, although these are issues that are being debated in the wider world with companies such as Apple and Google being central to the debate, coincidentally both are entering the field of autonomous vehicles. To prevent these problems the auto industry will have to invest heavily in cybersecurity.

Impacts on Economics and business:

According to a study done by Morgan Stanley Research in 2013 [11] in the United States $1.3 trillion could be saved with autonomous vehicles, these savings are mainly from reduced fuel consumption, improved productivity of the vehicle’s occupants, and a reduction in accidents and their related costs.

A clear benefit of autonomous driving is the time people can gain. In 2016 drivers in the United States spent an average of 50.6 minutes a day driving [12]. With a level 5 autonomous vehicle, people would no longer need to drive, consequently people would be able to sleep, read or learn a new skill.

Autonomous vehicles could give mobility to those unable to drive a car, increasing independence for the elderly, disabled and the young thus providing more social and economic opportunities. It is likely that the car manufacturers or third parties will provide cars for single journeys or periods of time, like the service provided by Drivenow [13] or taxis; this could result in car ownership decreasing. Therefore, less space will be needed for car parking this will be particularly useful in big cities, allowing more space for playgrounds, parks and sportsground.

As the traditional business model of car manufacturers changes there will be less emphasis on hardware and more emphasis on software. Increasingly traditional car manufacturers are not the only players, companies like Google, Apple and others are also entering the field with electric vehicles, the other revolution in personal transport. Car manufacturers must be willing to adapt and develop a new business model; although the new data and computing power within the car will allow the vehicle to become an entertainment hub the ultimate purpose of the vehicle is to transport people and their goods, this will remain the same.

As with any new technology, autonomous driving may lead to job losses, the most probable being truck and taxi drivers. The Merged American Community Survey, using data from 2010 to 2014 predicted that more than four million jobs could be lost [14]. However, many jobs could be created in different sectors, such as software development and engineering as well as cybersecurity and the data management sector; autonomous vehicles will produce a massive amount of data which will need to be managed and protected. Other sectors that could benefit are entertainment and marketing; the time wasted driving could be replaced by entertainment services.

Law and government challenges:

The arrival of autonomous vehicles poses many legal questions, in particular who is responsible in an accident? In level 5 vehicles the driver has no control and many people are suggesting that the manufacturers, designers and software developers may face liability [16]. There will also be the world where level 5 automation interacts with levels 1 to 4, another potential flashpoint when blame is being apportioned after an accident. If the autonomous vehicle is to be self-learning it may be impossible to know whether the vehicle's actions are because of what it independently learned or its original programming. This raises the question can you blame the manufacturer if the vehicle learnt to do it?

Many countries have taken steps to create legalisation for testing autonomous vehicles on public roads. In 2017 Germany passed laws allowing companies to test self-driving cars on public roads on condition a licensed driver is behind the wheel to assume control if necessary [17]. California and China have followed in passing laws, China has released national guidelines on road tests and allows autonomous vehicles on the road network on condition the vehicle passes a technical assessment and is equipped with sensors and cameras so the driving position can be monitored [18]. These laws have allowed companies in California such as Cruise and Apple to conduct tests which supply information for further development of V-to-V and V-to-I communication.

If countries do not pass distinct laws, then car manufacturers will move to other countries where these laws exist. For instance in the United Kingdom technology used in the new Audi A8 (a level 3 autonomous vehicle) is prohibited by Regulation 104 of the Road Vehicles Regulations 1986 which states: "No person shall drive or cause or permit any other person to drive, a motor vehicle on a road if he is in such a position that he cannot have proper control of the vehicle or have a full view of the road and traffic ahead." [19]

Fully autonomous driving (level 5) will require national law to be changed as well as international law. The 1968 Vienna convention stipulates that a human driver must always remain in control of the vehicle and is responsible for its behaviour in traffic [20], consequently this will need to be amended in countries which signed it to allow level 5 vehicles on the roads.

Ethics and public perception:

One of the biggest challenges for autonomous vehicles is public perception, if autonomous vehicles are labelled disruptive like genetic engineering, which took years before proper debates were possible, then autonomous vehicles will not progress, showing that resistance in public opinion can bring technology to a standstill. To avoid this from happening industry and government will need to discuss the issues surrounding autonomous vehicles openly and honestly. The current discussion in the media shows that people are aware of the possible dangers but there is

less emphasis on the potential benefits, for instance in 2016 [21] a Tesla on autopilot drove a man 20 miles to hospital, saving his life; an example of autonomous driving giving mobility to those that cannot drive. The problems with cybersecurity could change people's perception, and make some unwilling to embrace the new technology, it is likely there will be a split between those willing to adopt the technology and those that refuse.

A central theme to the development of autonomous vehicles will be ethics; one example of this is the trolley experiment, which is based on a theatrical thought experiment [22]. Should a car swerve towards a couple of people or a large group of bystanders? In 2016 Massachusetts Institute of Technology conducted a moral machine study and found that 50 percent of people would want their driverless car to plough into pedestrians rather than harming passengers, furthermore the majority of people would save the lives of humans over animals and spare the lives of many rather than a few. If level 5 automation occurs and is widespread these kinds of problems could occur at any time and the decision may have to be made by pre-programmed algorithms; ethics may have to be programmed in advance and these moral decisions must be made by people. This could potentially lead to legal issues as it raises the question would the person who programmed the ethics be liable? Unless the programme learns ethics itself, again raising the question is the manufacturer liable? Some of these questions are already being addressed, Germany has created the first ethical rules which states "In the event of unavoidable accident situation, any distinction based on personal features (age, gender, physical or mental constitution) is strictly prohibited. It is also prohibited to offset victims against one another" [23]. This provides a good start and allows German car makers to move forward with their plans however more laws, both national and international will need to be conceded.

Conclusion:

Whatever happens in the future one thing is certain, autonomous vehicles will fundamentally change the way we travel, as people move away from the drivers seat to the passenger seat. What once only appeared on the silver screen as Herbie [1] or Johnny Cab [2] will soon become reality; Ford Motor CEO said that Ford plans to have a "level 4 vehicle in 2021" [24]. The questions we as a society need to address are both ethical and financial. Do we want to invest in the infrastructure for this technology and what are the implications if we do? Ethical issues for instance the liability for accidents and subsequent harm, data usage and others. These issues must have clear solutions before we can derive the benefits such as improved mobility, increased safety, decreased traffic congestion and more free time. These decisions will govern and determine the course which humanity takes as it constructs the future of automobile transport. Ultimately, just because we could do it, should we?

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