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The prospects for self-driving vehicles

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Summary

Vehicle automation is being driven by technology push. The difficulties in achieving wide adoption of driverless vehicles are very considerable. The benefits to users and to road authorities seem quite limited.

Technology push

There has been much interest in recent years in self-driving vehicles, also known as autonomous vehicles (AVs), the impetus coming from technology entrepreneurs who see the possibilities to earn large returns. However, the technical task has proved more challenging than anticipated, and the prospects for widespread deployment of self-driving vehicles are not clear.

A variety of technological advances in combination allow the human driver to be dispensed with, at least under specified conditions. The human is replaced by a robot driver - a robotic replacement for the functions exercised by an experienced and safe human driver.

There are a number of technological components that go to make the robot driver. The robot must sense its surroundings using video cameras, usually plus radar and often plus lidar, which uses the reflection of laser light to detect objects. It must know where it is located in relation to the features of the road network, requiring satnav location and high-definition three-dimensional digital maps, which need frequent updating. Fast software programming is required to fuse all images, using inexpensive hardware with minimum power requirements. Unlike a factory robot, the robot driver cannot be pre-programmed to deal with all situations that might arise, so the robot must learn on the job by utilising artificial intelligence.

Approaches to automation

There has been extensive development of automated technology both by new entrants to the road vehicle sector and by established manufacturers. There are broadly two approaches. The *evolutionary approach* adds individual features to reduce the driving task, such as cruise control, lane keeping, lane changing and valet parking. These can be seen as further advances in the sequence of developments that have delivered established technologies such as automatic gearchange and automatic emergency braking. The potential problem is that as the tasks required of the driver are reduced, the driver's attention may wander or may become occupied by unrelated tasks, with the risk that the driver may not be able to respond sufficiently quickly to take control in circumstances where the robot driver cannot cope – such as sudden reduced visibility or a difficult-to-identify obstruction.

This problem of achieving a safe handover to the human driver has prompted the *revolutionary approach* to automation in which the vehicle is designed not to need a human driver at all. If purpose-built, it may omit the steering wheel and other controls; where a conventional vehicle is adapted, conventional controls are normally redundant. Waymo, a subsidiary of the parent company of Google, is probably the most advanced in developing vehicle automation, operating a driverless taxi service – a 'robotaxi' - in the Phoenix, Arizona, area, without safety backup drivers in the vehicle. However, the road, traffic and weather conditions in that location are particularly favourable, and it remains to be seen to what extent such a service could be extended to more demanding situations. More generally, the concept is that of an autonomous vehicle able to function without a driver within a defined geographical area where conditions are suitable. It would be more demanding to go beyond that to replace the human driver under all conditions, although this is the ultimate objective of the proponents of the technology.

Waymo/Google has developed driverless technology because it has the expertise and judges the potential as likely to be rewarding. It would make the technology available to car manufactures but does not plan to manufacture vehicles itself. In this respect it resembles Google's sponsorship of the Android mobile operating system, which is available to all manufacturers of mobile phones. There are a number of other enterprises pursing driverless technology, mostly involving tech start-ups supported either by car manufacturers, who see this as potentially an essential technology, or by deep-pocketed businesses that seek a commercial opportunity.

Benefits of automation

The practical benefits of vehicle automation remain unclear. Proponents argue for safety benefits, especially in the United States where 36,000 people were killed in motor vehicle crashes in 2019. Given that human error and risky behaviour is responsible for 90% or more of fatalities, it would seem a reasonable expectation that robots could do better than fallible drivers. On the other hand, robots suffer from their own shortcomings, tending to be less effective at perceptions involving high variability or alternative interpretations. In particular, robots would find it difficult to engage in the kind of visual negotiation that occurs between human drivers to settle which gives way when space is tight. Moreover, the driving performance of a robot would need to be very similar to that of a human driver to ensure public acceptability. A robotic driver that proceeded particularly cautiously to meet safety requirements would be unattractive to purchasers of AVs. So the robot driver would need to learn how to drive like a human.

Fatalities involving AVs, although rare, naturally attract attention. It seems likely the public will expect an AV to perform substantially better than a regular car, but by how much is an important question. In any event, it will be difficult to demonstrate the safety performance of AVs in practice. For instance, in Britain there is one fatality per 140 million miles driven, so if AVs are to do better than a human driver, fatalities will be exceedingly rare events. Besides, achieving and demonstrating cybersecurity will be crucial for AVs since a hack of a fast-moving vehicle would be dangerous.

Those who urge high safety standards at the outset of AV deployment stress concerns about the public acceptability of new technology. Against that is the argument that the best can be the enemy of the good, meaning that any automation that reduces crashes should be deployed as it becomes available, with the expectation that safety performance will improve over time. Automation should indeed improve safety over time, yet there are many other measures that would reduce deaths and injuries, for example the Vision Zero approach, which are almost certainly more cost-effective than vehicle automation.

Another claimed benefit is that automation might increase the capacity of existing roads by allowing vehicles to move with shorter headways, that is, with a smaller distance between them than the recommended two-second gap on fast roads. The more precise control exercised by a robot might also smooth traffic flows and allow the use of narrower lanes. However, such increases in capacity seem likely to be possible only on roads dedicated to AVs since the presence of conventional vehicles, not to mention cyclists and pedestrians, would require standard spacing to be maintained. In any event, any increase in capacity would be expected to attract additional traffic, so that congestion relief would not be expected. Automation that allowed an increase in road capacity might be of interest to a road authority, but not to vehicle owners who would bear the cost of the necessary technology.

More generally, because AVs would be capable of operating empty, for example when returning to base after dropping off the occupant, they could add to traffic and hence to congestion. Conventional taxis operate without a passenger while seeking a fare, of course, but privately owned vehicles without occupants would be a new source of traffic and may require regulation if congestion is not to worsen.

Prospects for automated vehicles

The prospects for widespread vehicle automation on existing roads with mixed traffic seem very uncertain. The driving task on motorways might be lessened in good visibility and in the absence of road works, but the driver would need to be immediately available to take control in adverse situations; one approach is to monitor driver attentiveness, for instance checking that hands are on the wheel and alerting the driver if attention wanders. There are low-speed environments that might accommodate driverless vehicles, including campuses, business parks and other planned developments with extensive road space. Yet it is hard to see robotic vehicles negotiating historic towns and cities with complex layouts, often narrow streets, extensive kerbside parked cars, cyclists and pedestrians.

This urban impediment to automation is particularly relevant to robotic taxis that could be attractive to ride-hailing operators such as Uber, to avoid the cost of the human driver and spread the extra capital cost of the robot through intensive use. On the other hand, there would be the potential cost of ownership of fleets of automated taxis, which contrasts with the asset-light business model of ride-hailing operators where drivers own their own vehicles. Moreover, it is likely that a robotaxi operator would need to exercise oversight of each vehicle to deal remotely with incidents and navigate obstructions, which would add to costs. It is certainly possible that the relatively unskilled human taxi driver is a lower cost option than the robotaxi.

Commercial roll out of robotaxis and privately-owned AVs may need local permits to comply with the requirements of particular cities, which would limit the rate of deployment of the technology and the returns to investors. In contrast, the evolutionary approach to vehicle automation allows additional facilities to aid the driver to be offered across the whole vehicle fleet, subject to satisfying national safety regulators, provided the attractions to purchasers justify the incremental cost. This is the usual way that the auto industry has developed its products, so that the evolutionary business model may be more attractive commercially than the revolutionary approach, even if the eventual outcome is not entirely driverless travel.

After more than a decade of development of autonomous vehicles, the early excitement and optimism have been followed by some disillusion as the problems of achieving an acceptably safe product have been recognised. The recent decline in the value of venture capital investments suggests that finance to support further development of the technology may be harder to come by. Accordingly, it would be premature to predict the eventual outcome, both timing and scope for wide deployment. It is not impossible, as enthusiasts for the technology assert, that children born today will not need to learn to drive a car. However, it seems unlikely that automation would increase the average speed of travel on the existing road network, which is constrained by safety and congestion.

The major transport innovations of the past have allowed step-change increases in the speed of travel – the railway and the modern bicycle in the nineteenth century, the internal combustion engine for road vehicles and the jet engine for aircraft in the twentieth century. These increases in speed permitted increases in access to people and places, opportunities and choices, which were the benefits of harnessing the energy of fossil fuels for mobility. In contrast, vehicles automation will not increase speed and access. The benefits will take the form of improved journey quality. It remains to be seen to what extent purchasers of vehicles will be willing to pay for improved quality.

The UK government has been very supportive of vehicle automation, in particular aiming to put in place a comprehensive legislative regime based on the thorough analysis of the Law Commissions. Yet there is little development of the technology in Britain, so the benefits for both industrial and transport policy do not seem to be great. The top technology priority for transport policy has to be the switch to electric propulsion of surface transport and the decarbonisation of aviation.

Sources

More extensive treatment of vehicle automation can be found in:

David Metz, *Driving Change: Travel in the Twenty-First Century*. Agenda Publishing, 2019.
David Metz, *Good To Go? Decarbonising Travel After the Pandemic*, London Publishing Partnership, 2022.

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