Potential Impacts of the Advent of Fully Autonomous Driving and Foreseeable Hindrances against Widespread Adoption of Robot Cars

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Abstract

This publication brings to light the potential impacts of the advent of fully autonomous driving on the society in terms of positivities and otherwise. Almost every newly deployed technology has unintended downsides and consequences, this paper presents some of the prognosticated disadvantages of autonomous driving. It also explains the obstacles that might inhibit a widespread adoption of robotic vehicles/self-driving cars in the mainstream of driving, also making suggestions on how some of them can be surmounted. The study throws up some advantages of widespread adoption of self-driving cars such as improved mobility and safety, better traffic flow and environmental sustainability, efficient fuel and land use, increased human productivity and comfort; amongst other benefits.

Index terms— autonomous driving, robot cars, self-driving vehicles, technology.

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1 Keywords: autonomous driving, robot cars, self-driving vehicles, technology.

he phenomenon of autonomous vehicles/robot cars is one subject that arouses great interest and enthusiasm in people, our ears tingle whenever the phantom mechanism is being discussed. Many find it difficult to comprehend how machines will perform the complex, much attention-requiring and safety-critical chore of driving. But technically-oriented optimists know that this lofty aspiration is within reach. The world has waited for so long to see the day cars will be able to drive themselves, the hitherto seemingly grandiose idea has now dawned on mankind; autonomous driving is finally here and it is going to change everything! Autonomous vehicles or robot cars are intelligent agents that navigate themselves in road environments without human inputs, by taking in percepts on the current state of the world around them with the aid of highly advanced and sophisticated sensory systems. A fully autonomous vehicle can function without human control and does not require any human intervention. Autonomous vehicles can sense their local environment, classify different kinds of objects that they detect, can interpret sensory information to identify appropriate navigation paths whilst obeying transportation rules. They employ a different range of mechanisms to perceive their surroundings including radar, laser light, GPS, LIDAR; to mention but a few. Highly sophisticated control systems interpret sensory percepts so as to determine the most appropriate navigation routes, as well as obstacles, pedestrians, other agents and important traffic signs. They therefore must have control systems that are capable of interpreting sensory information to determine and distinguish between objects in their sight, with a view to making the right decision and taking the right course.

Autonomous cars have been something of a hot topic in recent years, with Google blazing the trail. Google has driven its fleet of experimental robot cars over millions of kilometers without serious incident. They have premiered amongst other inventions, a low-speed electric prototype to fine-tune city driving -with no steering wheel or brakes whatsoever. Outside Google; Toyota, Honda, and Ford all have their own self-driving car projects, although none of them are nearly as advanced as Google's. As a matter of fact, many automakers have dismissed the idea of fully autonomous cars out of hand as too challenging, focusing instead on Advanced Driver Assist features. Goggle, for its part has outlined an aggressive timeline to commercialization, hoping to partner with automakers to release autonomous vehicles, running Google software and manufactured by third parties before the close of the decade.

But to what extent will fully autonomous driving go mainstream upon its advent? What are the foreseeable impacts on our lives and society in general?

2 Introduction

How well will it be accepted by consumers considering some genuine skeptical concerns of safety? Will all the current human-driven cars be eventually phased out like the typewriters of those days? Do we have the necessary key infrastructure to support self-driving cars? Will they be affordable? These are some of the questions agitating the minds of both the enthusiasts and skeptics alike of autonomous driving. These questions and perhaps some more must be answered for the world to fully berth on the shores of autonomous driving.

3 II.

4 Potential Benefits of Widespread Adoption of Self-Driving Cars

Experts have predicted the advantageous impacts which the advent and eventual widespread adoption of robotic vehicle technologies will have on the society, businesses, and our way of life. Some of these potential benefits are discussed below:

Increased Mobility: A considerable percentage of the world's population is advertently or otherwise constrained from driving. Those who fall within this demography include: people who are disadvantaged in physicality as a result of advancement in age or disability, those who cannot have access to driver's permit as a result of statutory or monetary inadequacies, children and teenagers who are restricted by age; to mention but a few. Autonomous driving has one of the advantageous prospects of providing these groups with the means of independent mobility, will enable easier access to essential social services, and ultimately reduce their social isolation and give them a sense of societal belonging (Trommer, Kickhofer, Kuhnimof, Lenz & Phleps, 2016).

Improved Safety: Perhaps the most significant potential benefit of the full advent of autonomous driving is the promising prospect of reducing road crashes and ultimately improving safety. Statistics have it that nearly 1.2 million people die globally in car accidents every year, and 50,000 are maimed. It is also a widely held belief that over 90% of road crashes are caused by human errors. Car accidents have been largely attributed to human distractions while driving, drunk driving, overtaking miscalculations and impatience, recklessness and other aggressive driving behaviors. Advocates and experts therefore aver that since driver error contributes to more than 90% of traffic accidents, autonomous driving will reduce road mishaps by 90% (Litman, 2017).

Better Traffic Flow and Road Utilization: It is widely anticipated that autonomous driving will help better facilitate the concepts of ridesharing and platooning. Carpooling and ridesharing companies are set to leverage the potential possibilities of robot/self driving cars, with a view to promoting their businesses. It is expected that with the transition from manually driven cars to a widespread adoption of autonomous vehiclesbased carpooling and ridesharing, there will be decreasing need to own a car, and as such the number of cars on roads is set to reduce, thereby promoting a better traffic. Autonomous vehicles are also expected to be able to travel closer together, engendering a better utilization of road capacity and dissipation of traffic congestions (Litman 2017;Trommer et al.).

Environmental Sustainability and Fuel Efficiency: With a widespread adoption of autonomous vehicles and the appurtenant improvement in traffic flow and reduction in the number of cars on roads, a decrease in energy/fuel consumption and hence resultant emission of harmful hydrocarbons into the atmosphere will naturally follow. Robotic cars are also expected to be able to accelerate and brake more smoothly than human drivers can do, thereby facilitating fuel efficiency **??**Trommer et al.). Add to this the fact that the future self-driving cars are set to exploit other sources of energies -such as electricitywhich are more environmental-friendly, this will invariably reduce pollution. Lighter vehicles are also anticipated to come on board as road crashes reduce, thereby facilitating an improvement in the energy efficiency of the cars **??**Trommer et al.).

Land Use Efficiency: Another potential impact widespread adoption of autonomous vehicles will have on our geographical landscape is a reduction in the need for motorable roads and parking lots in highly developed and urban areas. In the US alone, about 5.7 billion square feet of land is dedicated to parking, and it is estimated that about 105 million parking spaces exist. It is instructive to add that most of these lots in big cities of the world are often superfluous. As robotic vehicles go mainstream and cars reduce on our roads, the redundant lands can be freed up for other uses such as, recreational parks, housing, retail and business outlets, and what have you. Additionally, car dealerships, mechanic workshops, gas stations, will all become reclaimed territories at the long run.

5 Better Human Productivity and Comfort:

The behind-thewheel commute time -especially for long distance trips -can be boring, physically demanding and strenuous. Add to this the fact that quality man hours are lost during driving in traffic and while embarking on long journeys. A wide spread adoption of self-driving cars will obviously address these issues. As prospective users travel in autonomous vehicles, they will have more time for work and rest. They can therefore choose to either channel gained time into productivity or relaxation. Moreover, travelers will enjoy more comfort as they are relieved of driving and navigational chores of steering and braking. Additionally, the increasing digitalization in modern vehicles and advancements in infotainment systems can improve the overall travel experience and comfort **??**Trommer et al.).

New Business Models: It is difficult to comprehensively and accurately predict the effects that the advent of autonomous vehicles will have on businesses, but one can make a shrewd conjecture of events to come. To start with, the phenomenon of self-driving greatly supports ride sharing, mobility service businesses are set to exploit this. Contemporary liability ordinances will definitely give way for new ones, with the full advent of robotic cars and car sharing. This will surely engender a resultant effect on insurance businesses as new models must be conceptualized to address the "disruptions". As driving becomes more enjoyable and travel time more interesting, air tourism will predictably take a hit as enterprising minds will capitalize on the prospects of land tourism in transit. There will be appurtenant startups to cater to the needs of the nascent self-driving car industry.

Vehicle Cost Savings: A widespread adoption of autonomous vehicles and car sharing platforms will encourage different mobility services to start up as explained previously. These services will tend to progressively discourage individual car ownership, as on the one hand robotic cars might not come readily affordable, and then on the other it is often more economical to patronize commercial transport services. This potential development will help predictably free up scarce resources from savings made that might have been expended on car purchase. Not to mention pecuniary endeavors appurtenant to private vehicle ownership like car insurance premium, fuelling, repairs, maintenance, parking fee, road and similar transport facilities tolls, and other sundry financial undertakings.

6 III. Potential Downsides to the Advent of Self-Driving Cars

Almost every newly deployed technology has unintended consequences. The robotic vehicle technology certainly will not be an exception. A conjecture of the possible undesirable fallouts of the widespread deployment of autonomous driving/robotic cars has been made. Some of the identified potential disadvantages are discussed below:

Loss of Jobs: The impact of the advent of fully autonomous vehicles on global economy and businesses will go both ways in terms of pros and cons. We cannot categorically say yet which one would outweigh the other, but these impacts are likely going to be monumental. The major predictable downside to the widespread adoption of robotic cars on economic activities is the loss of driving-related jobs. Several markets will be disrupted as services appurtenant to human-driven cars will likely reduce or go obsolete (Wikipedia; Schoitsch, 2016). Human taxi drivers will vehemently oppose this as the prognosis is not promising for them. Auto repairers should also feel threatened as there may be less demand for vehicle repairs due to reduced rate of road crashes (Litman, 2017). The entire public transport system will change and workers will become redundant. "Automated cars on demand" will replace bus lines in sparsely populated areas, and traffic police and other transport officials will become surplus to requirements (Schoitsch, 2016).

7 Probable Loss of Privacy:

The robotic vehicle will be a highly automated and autonomous system. It will predictably be predicated on very sophisticated and virile network connections. The advent of self-driving cars is expected to come with vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communications, with a view to facilitating efficiency and safety on the road ahead. These functions will be IP-based and therefore user's activities can be monitored, effectively culminating in privacy intrusion (Schoitsch, 2016). People have particularly expressed their skepticisms about the Google prototype self-driving car, many are of the opinion that riding with Google will be tantamount to riding with big brother! They believe features like GPS tracking and data sharing will leave them under the continuous surveillance of the search engine giant.

Cyber Threats and Security Concerns: Inextricably intertwined to loss of privacy and even more serious fallout of IP-based functions is the threat of cyber crimes and other serious concerns. The very latest cars of these days are often either connected or highly automated, and therefore have multiple access points which can be controlled from outside, having serious safety and security implications (Schoitsch, 2016). Criminal elements may access these network-based autonomous vehicles via hacking, with a view to perpetrating theft or other more serious malicious intentions. For example, terrorists can potentially use self-driving cars in deploying explosives for insurgent attacks (Litman, 2017). The vulnerability of highly connected and automated car systems to cyber abuse (hacking) has been demonstrated in a number of examples. A 2015 article on ”Wired” written by Andy Greenburg and titled, ”Hackers remotely kill jeep on the highway -with me in it,” sufficiently demonstrates the potency of car hacking (Schoitsch, 2016).

Astronomical Costs: While the progressive costs of fabricating robotic cars cannot yet be ascertained, they most likely will not come cheap (Litman, 2017). Most of the highly sophisticated components that will be needed in producing autonomous vehicles like cameras, sensors, and other percepts-gathering devices cost thousands of dollars. The LIDAR turret for example, which is the primary sensing element of a certain Google’s prototype, costs more than $30,000. Selfdriving cars retail prices will certainly reflect these additional costs, as manufacturers will be expected to maintain a reasonable profit margin in production. But we can expect that as autonomous driving goes mainstream, there will be a mass production of some of these expensive components and robotic cars themselves, which will predictably drive down costs at the long run.

Additional Risks: As exciting as the prospects of fully autonomous vehicles may be, they will also come with some additional risks. The most legitimate one being system failure which may engender what has been referred to as ”death by computer”. The robot car is an intelligent agent in its own right, a highly automated computer you might want to call it, there is therefore the plausible risk of it crashing, consequences of which can be cataclysmic. Another real risk associated with selfdriving cars is the unreliability of sensing elements, especially under some unfavourable weather conditions. All of these pose a new threat to safety, as well as technological inadequacies in dealing with complex and uncertain situations. The unfortunate Tesla incident which happened in Autopilot mode corroborates this point. It claimed the life of the human driver who was aboard and did not intervene quickly upon a technological failure in percepts sensing (Schoitsch, 2016).

Increased Budgetary Spending and Misplaced Priority: It has already been established that for autonomous driving to gain widespread adoption and for the ”smart” robotic vehicles to fully fulfill their potentials, we must put in place ”smart” road equipment and facilities. There will be constant communications between the self-driving cars and the ”smart” critical infrastructure. Many of such state-of-the-art facilities will not just be novel, but will also be very expensive. Therefore the execution of such requisite projects will incur humungous funds, and as such has the potential of increasing government’s statutory spending exponentially. In the face of very limited government revenue, and many other programmes and services competing for budgetary allocations, investing in these autonomous driving infrastructure will take its toll on existing plans, and therefore might be seen as an imprudent move and a misplaced priority.

Reduced Services: Another foreseeable downside to the advent of fully autonomous driving is the issue of reduced services. While it has been argued that the widespread adoption of robotic vehicles will give a certain demography of the human population a sense of societal belonging, mainly those inhibited in terms of physicality like the senior citizens, those with health challenges and the physically challenged; the full scale deployment of robotic cars will also on the flip side take a serious toll on the same class of people. There are several very important services that human drivers do render for these people, like supporting them as they walk to get on human-driven cars, and likewise aiding them to alight at their desired destinations, not to mention often helping them in carrying their stuffs on and off the vehicles; these key services will obviously be negated the moment cars begin to drive themselves in a widespread dimension (Litman, 2017).

8 Induced Frustration and other Social Concerns:

It is virtually impossible for computer science and artificial intelligence to cover all probable nuances and scenarios that might come up in driving. This technological inadequacy will make self-driving cars behave strangely and indiscretionally in certain situations, thus inducing frustration and aggression in human drivers. For example, if a robot car was driving along a highway and it perceived a tree branch poking outward from the bush, because it might not want to flout the traffic law of not crossing a double yellow line, it might come to a full stop instead of simply maneuvering around it. This kind of timid driving would surely irk human drivers behind and might even lead to a collision. There are also concerns that self-driving cars will be taken advantage of and bullied by human drivers, knowing full well that the robots will be programmed to drive conservatively and fully comply with traffic rules and regulations. This may somehow promote reckless driving from humans. Additionally, the culture of drinking might be encouraged, as humans will no longer have to worry about drunk-driving since robot cars now exist that can fully drive them home or wherever safely.

9 IV. Potential Obstacles to Widespread Adoption of Self-Driving Cars

Several factors have been identified as potential inhibitions to widespread adoption of autonomous driving technology. Some of them are comprehensively discussed below:

10 Safety/Privacy

Concerns: Self-driving/autonomous vehicles are computers in their own right. They continually process percepts taken in with their sensors, and in turn generate appropriate actions on their surrounding environment. They do not exist in isolation; they must share information with themselves and the enabling smart infrastructure around. These activities are anticipated to be internet network-based. This makes them potentially vulnerable to malicious and illintentioned attacks. Simulation car hack demonstrated by Andy Greenburg corroborates this possibility (Schoitsch, 2016). Consider also the phenomenon of "death by computer". If computer systems can crash suddenly then there is a likelihood of a smart robotic vehicle having a system failure. There are also concerns about the potential loss of privacy which the highly sophisticated car-to-car, and car-to-infrastructure connections might bring. All of these might discourage full scale adoption of robotic vehicle technology.

Huge Infrastructure Deficit: For the phenomenon of autonomous driving to go widespread, we will need to re-design and re-engineer our current road infrastructure. As explained earlier, fully autonomous vehicles are anticipated to be able to exhibit vehicle-tovehicle, as well as vehicle-to-road facilities communications. If smart autonomous cars are going to fully takeover, our roads must also become smart. This will most certainly incur humongous funds to implement. Already national governments the world all over have other priority items competing for budgetary expenditures. An investment in these smart road facilities might be seen as misplacement of priority. This will not only inhibit the potentials of these self-driving cars to fully express themselves, but also hinder their widespread adoption.

Affordability: Autonomous vehicles will most likely not come cheap, although the incremental costs of manufacturing them are not yet verifiable. They incorporate features like highly sophisticated sensors, computers, and controls; amongst others. These additional vehicle equipment and parts cost tens of thousands of dollars. Also, given that the self-driving cars are safety-critical; these parts must meet very high standards of manufacturing, installation, testing, repair, and maintenance; as aircraft components. As such, robotic vehicle appurtenant parts will most likely be very expensive. This will resultantly have an effect on the overall cost of the vehicle. Vehicular services like repairs and maintenance will expectedly be higher than what currently obtains because of the additional sophistication. These envisaged incremental costs might discourage the purchase of autonomous vehicles and therefore pose as an inhibition against the transition from human driving to widespread autonomous driving.

Human Resistance: Resistance to the widespread adoption of autonomous vehicles should also be expected from the segment of the human population constituting people who either like driving or whose source of livelihood depends on it. A considerable percentage of the human population enjoys driving as a hobby, especially over long distances. Such might be unwilling to relinquish steering wheel controls to the vehicle. Also worth considering are driving-related jobs and services. Human taxi drivers and other commercial transport workers will certainly not be looking forward to the advent of robotic vehicles. They will surely oppose it as they now do with Uber; akin to the manner the advent of the railways was initially resisted by coachmen (Schoitsch, 2016).

Legal Framework: Another potential barrier to widespread adoption of self-driving vehicles is statutory inhibition. Some governments in the world might be unwilling to promulgate laws that support autonomous driving. This might be engendered by skepticisms about the safety and guarantee of user privacy in robotic vehicles. For example, some states in the US still do not allow the testing of self-driving vehicles on their roads due to different reasons but most commonly safety. If these automated intelligent vehicles are to go mainstream of driving, national and state governments must first make laws that permit testing, and thereafter eventual use by the public. The sheer robustness of the necessary legal framework might be an encumbrance; as several issues like liability and ethics must be factored in. And then in the highly litigious nations of the world, one can still expect an opposition to these statutory implementations.

Technological Inadequacy: The available stock of autonomous vehicles is not yet perfect. Some of them still require a human driver to be present and alert with a view to taking over in dicey situations. A good number of these self-driving cars function sub-optimal under unfavourable weather conditions. Flash flooding, heavy fog, and deep snow, amongst other natural phenomena; are known to seriously affect the performance of autonomous vehicles' sensing components. Then there is the issue of insufficient adaptation to the gestures and non verbal communications of pedestrians, and dealing with stray animals on the road. Until equipments that can work under any harsh condition are manufactured and algorithms further fine-tuned to address different scenarios that might come up in driving, skepticisms will still be there about the safety and efficiency of the robotic vehicles. As such, the bulk of the general public might be reluctant to jump on the bandwagon of autonomous driving.

11 Ethics and Liability:

The most talked about barriers when analyzing the feasibility of a world filled with self-driving cars are infrastructural and technological inadequacies. But then the twin grey areas of ethics and liability need to be comprehensively discussed and ironed out before the robotic driving technology can fully take off. Some inevitable situations often arise in driving when the human driver has to choose between two or more undesirable outcomes, thereby ensuring the minimal possible damage, how will the inanimate robot car deal with this situation? Conventional rules in human driving have it that the person behind the wheels is fully responsible, and therefore is liable for prosecution in the event of a culpable mishap. But who is going to be responsible when a self-driving car gets involved in a pedestrian-killing incident, the owner of the robot car or the manufacturer?

The debate on this still goes on. These thorny issues must be sorted out first with a view to establishing a robust and viable legal framework that enables fully autonomous driving in our society (Schoitsch, 2016).

12 V. Conclusion and Recommendation

We cannot accurately predict what a future of fully autonomous driving holds for us. We can only make a shrewd conjecture of how a world filled with robot cars will look like. But it is safe to say that its full advent and widespread adoption will monumentally change transportation, businesses, and in general our way of life.

The currently obtainable stock of self-driving cars is not perfect. The first step that must perhaps be taken in the journey to the future of fully autonomous driving is the promulgation of laws that support the testing of autonomous vehicles on our roads, and removal of legal barriers against such. The Vienna and Geneva treaties certainly must be reviewed. This is necessary with a view to improving on what has been achieved so far in autonomous driving technology.

It goes without saying that government at all levels must invest massively in road infrastructure. The decrepit and deplorable roads still obtainable in developing and underdeveloped nations of the world must give way to fantastically motorable roads. Robot cars will never be able to truly fulfill their potentials without impeccable road facilities.

Internet, which will be central to vehicle-tovehicle and vehicle-to-infrastructure communications in robotic driving technology, must be deployed widely and in excellent strength.

Artificial intelligence programmers must finetune their algorithms to adequately cover every nuance and possible scenario that might come up in driving. Similarly, better and more efficient robotic drivingsupporting technologies must evolve, especially in the area of percepts sensing. This is imperative with a view to addressing the current technological inadequacies, thereby alleviating the fears and skepticisms of the general public about the safety and other issues pertaining to self-driving cars.

However, given the inhibitions we identified in this report, we still feel that the future of widespread robotic driving might not come earlier than fifty years from now.

Figure 1:

[Trommer et al. (2016)] *Autonomous Driving -The Impact of Vehicle Automation on Mobility Behaviour*, S Trommer , B Kickhofer , T Kuhnimof , B Lenz , P Phleps . December 2016. Institute for Mobility Research

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