

SELF-DRIVING TRANSPORTATION SYSTEM FOR ECO-CAMPUS

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ABSTRACT

In large campuses such as UMS and NTU, students need to move at long distances. The transportation of choice has been public transportation. The most common is in the form of buses. Buses need bus stops at strategic locations and only travel at intervals. Although buses are the most eco-friendly among all the transportation systems within a campus, alternative technologies had been studied to improve it further. Self-driving technologies are the most promising. Combined with sharing technologies such as Uber share, self-driving cars offer the most promising solution. Self-driving technologies are already under active development. Campus application should be the first choice for deployment. Campus environment is a private environment so is well controlled. The maps and network infrastructures are well established so will allow reliable self-driving technologies to be used within the campus only. It is therefore surprising that there are few trials involving self-driving transportation systems in a campus environment. There are various possibilities but all these should be overcome in order to have a truly eco-friendly environment within the campus. Electrical shared self-driving cars allow eco-friendly mass transportation of people because electricity is a clean energy. Sharing allows full utilisation of the vehicles unlike other modes of transportation. Mobile apps and GPS allow pickup of passengers at any safe place instead of just at designated places. Because self-driving cars have no drivers, small vehicles may be used economically without the added costs of an extra non-paying passenger and salary of the driver for each vehicle. The lack of any driver also makes it safer for the students especially female students. Although there are still issues of safety among current self-driving technologies as had been shown by the accidents suffered by Tesla cars running on even semi-autonomous modes, safety within the campus should be much better and there is no need for full certification from the transportation authorities. Operating within the campus environment allow operators to operate without the strict licencing requirements of the public transportation environment. Safety can still be ensured by restricting the operation of the self-driving vehicles within clearly marked roads in the campus, enforcing safe speed limits such as the 50 km/hr imposed by Google and restricting operations in clear weather and daytime only. With remote operators and emergency buttons, even the semi-autonomous modes that are within the capabilities of current hardware, self-driving ride-sharing cars should be possible.

Keywords: self-driving; transportation system; eco-campus

1. INTRODUCTION

Self-driving technologies are actively pursued now. They are in the trial stages already. Most of these trials are for public transportation systems. Campus-wide self-driven transportation is less frequent. Those that are available are currently are too experimental to be seriously

considered for adoption in the next few years. Established companies such as Uber, Google and Tesla had not considered campus-wide self-driven cars as much as the more risky and difficult public transportation.

Campus-wide transportation system is best served by self-driven cars. If these cars are electric cars, they will be eco-friendly as well. The system will improve the productivity and safety of students in the campus. Students do not need to travel far to bus stops and can still work while inside the driver-less cars. There will be less time waiting at the bus stops and it will mean safer environments for female students. Without the driver, the safety of students is enhanced because there were cases of assaults by bus drivers while increasing the efficiency of mass transportation of passengers because the driver's place can be taken by another passenger. By implementing ride-sharing apps, efficiency can be enhanced further. Safety can be assured by limiting the passengers to registered campus inhabitants and recorded surveillance put in place. The surveillance data can be used to protect passengers as well as the areas of the campus where the cars pass by against reckless drivers and unwanted vehicles and people inside the campus.

These companies had missed a great opportunity in developing and promoting the sure advantages of shared self-driven cars. The reasons could be lack of understanding of the potentials of the self-driving cars especially when matched with car sharing technologies. This convergence was only realised in 2016 when a successful ride-sharing enterprise, Uber, joined the self-driving revolution that had been tested by Google for years and limited autonomy versions were actually commissioned by Tesla for public use. The result had been accidents that led to one confirmed death. These accidents would not have caused any death or major injury if self-driven cars were restricted to known roads such as those that are around a university campus. More companies had positioned the self-driving technologies for sharing. Similarly, these companies could have made a mistake in the lack of trials in well-known environments such as within a university campus. These companies had missed the opportunity to promote the self-driving technology to students and staff in the universities while fine tuning the technology for safer driving.

2. LITERATURE REVIEW

Google started its trials as early as 2011 (Guizzo, 2011). It was based on Toyota Prius. Sebastian Thrun and Chris Urmson were convinced that smarter vehicles could help make transportation safer and more efficient: cars would drive closer to each because they could react faster than humans to avoid accidents, potentially saving thousands of lives. They were most worried about legal and liability issues but made no attempt to operate in private compounds such as a university campus.

In the latest news reports, the National Highway Traffic Safety Administration of U.S.A. had shown that Tesla's autopilot mode is safer than humans (Boudette, 2017) (Randall, 2017). Tesla's autopilot is already able to achieve level 5, fully autonomous mode according to the SAE International J3016 standard, published in 2014 (SAE International, 2014). However Tesla still consider this Autopilot is still in the beta phase. Tesla will remove the beta level only if the "Autopilot is approximately 10 times safer than the US vehicle average" in Tesla's Master Plan written by Elon Musk, Tesla's current CEO (Musk, 2016).

Tesla has chosen a noble aim in deploying partial autonomy rather than waiting until Autopilot is fully certified by the authorities (Musk, 2016). Tesla expected that it will take 10 billion km for worldwide regulatory approval. Tesla's current learning rate is 5 km per day.

Google takes a different approach. Christopher Urmson, who directs the car project at Google, reported that (Markoff, 2016) Google engineers are convinced that it might not be possible to have a human driver to quickly snap back to handle split-second crisis so had taken the human driver completely out of the loop.

Google had spun out its self-driving car project into Waymo company in December 2016 (Kovach, 2017). Google cars' accident reports are no longer available. The last report is in November 2016 (Google, 2016) reported Google's first accident free month since January 2016 where it reported 3.8 million km of autonomous mode, 2.2 million km of manual mode (Waymo, 2016). Waymo is not required to publish monthly public reports but the company is required to report any accident involving a Waymo self-driving vehicle to the DMV and the report is published on the California DMV's website (State of California Department of Motor Vehicles, 2017).

Of special note are the trials conducted by Uber (Hawkins, 2016), a successful ride-hailing company although Google had filed a patent on autonomous ride-hailing cars (Patentyogi, 2017) (Colijn, et al., 2016). Waymo is also reported to collaborate with Fiat Chrysler for a semi-autonomous version of the Chrysler Pacifica minivan which is what Tesla already has with their cars. Since Uber is the latest to test its self-driving cars in a more challenging environment in Pittsburgh (Knight, 2016) it showed the most problems. Pittsburgh's roads are narrow and winding with many pedestrians and cyclists. Pittsburgh's climate can have frequent rain and snow unlike California and Nevada where Google's Waymo operates. That is why Uber self-driving cars operate in semi-autonomous modes just like Tesla in the trial runs.

Ride-hailing is different from ride-sharing, which is vital in order to improve the efficiency of mass transportation (Burns, 2017) (Alonso-Moraa, et al., 2017). Elon Musk (Musk, 2016) had seen the need for sharing in order to reduce the cost of ownership because most cars are only in use for 5% to 10% of the day but its software is not ready. Uberpool (Uber, 2017) is a ride-sharing apps that is available in selected cities only.

Other companies had shown interest in commissioning self-driving services. Grab has joined with nuTonomy to provide self-drive taxis in Singapore (Lee, 2016) for a year. It had a collision with a lorry on the 18th of October, 2016 as reported by the Straits Times (Kok, 2016) but intends to expand its operations in other cities (Ackerman, 2016). The State of California Department of Motor Vehicles has issued licenses for autonomous vehicles, by December 8, 2016, to the following companies: Volkswagen Group of America, Mercedes Benz, Google, Delphi Automotive, Tesla Motors, Bosch, Nissan, GM Cruise LLC, BMW, Honda, Ford, Zoox, Inc., Drive.ai, Inc., Faraday & Future Inc., Baidu USA LLC, Wheego Electric Cars Inc., Valeo North America, Inc., NextEV USA, Inc., Telenav, Inc. and NVIDIA Corporation (The State of California Department of Motor Vehicles , 2017).

To accomplish self-driving ability, supercomputers are needed. Tesla has been using Nvidia chipset, the latest of which is Drive PX2 (NVIDIA, 2017). Other suppliers are providing chipsets for self-driving cars (Tilley, 2016). NXP Semiconductors has offered Bluebox (NXP, 2017) and Qualcomm offers the Snapdragon 602A and 802A chips that integrate processors with cellular modems. Intel and AMD also offer their processors.

3. METHODOLOGY

A survey will be conducted on the suitability of the various options that may lead to the development of autonomous self-driving ride-sharing service. The companies are restricted to the most likely to succeed, namely Google, Tesla and Uber. They will be compared based on their safety record in autonomous mode, sensors available for the car, estimated cost, maximum speed, maximum capacity and availability of ride-sharing. Data for Google crashes are collected from a website (Silk, 2017). The data is also for vehicles in the U.S.A. and values are converted to km from miles. Google was allowed to mapped the test route and decide under which weather conditions the car could operate unlike the latest NHTSA (Boudette, 2017) (Randall, 2017). Crash data for Uber self-driving cars are not available but the type of cars are included.

To complement the study on the self-driving cars, a survey of the sensors used in the cars are shown to indicate the potential for autonomous driving for the cars. For the software parts, advancement in mapping and ride-sharing apps will be compared in order to show the future of the self-driving technology. The source of the sensors for Tesla is at its website (Tesla, 2017). The source of the sensors for Google is at a website (Guizzo, 2011) which may be out of date. The source of the sensors for Uber is at a website (Protin, 2016).

4. OBSERVATIONS

The crash rate as shown in Table 1 shows that crashes due to the autonomous mode should be much less than manual modes. The summary of sensors in Table 2 proded by all self-driving cars should be equivalent. LIDAR is the most effective but too expensive but Tesla had shown that LIDAR is not essential if backed up by other sensors. As ssummarised in Table 3, fatalities only occurred to Tesla because drivers are overconfident with the ability of the Tesla’s Autopilot and they all occurred at high speed. By operating at speeds less than 50 km/hr as it should be in a university campus environment, fatalities can be avoided.

Table 1: Crash rate

Company	Car	Mode	Duration	Area	Crash rate per million km
Tesla	i)Model S ii)Model X	Autonomous	2014-2016	U.S.A.	0.5
Tesla	i)Model S ii)Model X	Manual	2014-2016	U.S.A.	0.8
Google	i)Lexus RX450h SUV ii)Prototype	Autonomous	2009- April 2016	California; Austin, Texas	0.4
Uber	i)Volvo XC90 SUV ii)Ford Fusion	Autonomous Taxi	14 December 2016	San Francisco; Pittsburgh	
Utonomy		Autonomous Taxi	25 August 2016	One-north district, Singapore	

Table 2: Sensors

Company	Car					Others
		LIDAR	RADAR	ULTRASOUND	CAMERA	
Tesla	i) Model S ii) Model X	0	1	12	8	
Google	i) Lexus RX450h SUV ii) Prototype	1	4	0	1	1. Inertial 2. Wheel encoders
Uber	i)Volvo XC90 SUV ii)Ford Fusion	1	2	0	20	1. 7 lasers 2. Inertial
Utonomy		1	?	?	>1	

Table 3 : Supercomputers

Supercomputer	Car	Speed	Power	SAE Level
NVIDIA PX2	Tesla, More than 80	16 Tera Floating Point Operations/s	250 Watts	4
NXP Bluebox	More than 4	90 billion instructions/s	40 Watts	4
INTEL	BMW, Mobileye			?

Table 4 : List of self-drive fatalities

Car	Location	Date
Tesla Model S	Williston, Florida, U.S.A.	7 May 2016
Tesla Model S	Handan, China	20 Jan 2016

5. POSSIBLE IMPROVEMENTS

Despite the vast improvement in safety, there are still issues with full autonomy. The processing power is still not enough. It is possible to solve the issues of operating in semi-autonomous mode that is available but with remote monitoring. Passengers are also given red buttons in case of emergencies to stop the vehicles and contact the remote operators. Remote operators should be available to take over when required or requested by passengers. It will make operating in well controlled areas that are well mapped and marked much safer.

6. CONCLUSION

Autonomous vehicles had been proven safer than manual vehicles. This data comes from vehicles that are capable of being ridden manually when the need arises. This mode of operation is called semi-autonomous which requires a human driver. None of the self-driving systems tested for full autonomy because they are still in the testing stage and the providers

of these systems are not confident that their vehicles can be driven autonomously. Despite the tremendous reduction in crashes and therefore fatalities that result from adopting fully autonomous vehicles, the liability imposed on the providers of these systems made them extremely cautious. Licensing authorities agree with the manufacturers. Although it is impossible to provide a system that will not have any fatality that can be attributed to the self-driving system, the huge reduction in road traffic accidents and fatalities is a worthwhile cause. The sensors and hardware to control the cars appear to be adequate. The super-computers that run the software are deemed sufficient for semi-autonomous for economical use because they can be upgraded or added at any time, at more cost to the manufacturers. There is no problem with hardware. The biggest stumbling block is software. Current software is only reliable in well-known and controlled situations. The trials were therefore conducted in cities. The fatalities that occurred to Tesla autonomous modes were outside these established environments. Based on the trials so far, it is safe to conclude that self-driving ride sharing semi-autonomous cars would have less crashes due to itself, and would have no fatalities inside a well-controlled environment such as a university campus. Full autonomy will take some more time but with remote monitoring in low speed and well known conditions, such as in a university campus, it should be safe.

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