Chapter 43
Autonomous Vehicles

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ABSTRACT

The first car was invented in 1870 by Siegfried Marcus. Actually, it was just a wagon with an engine but without a steering wheel and without brakes. Instead, it was controlled by the legs of the driver. Converting traditional vehicles into autonomous vehicles was not just one step. The first step was just 28 years after the invention of cars, that is to say 1898. This step's concept was moving a vehicle by a remote controller. Since this first step and as computers have been becoming advanced and sophisticated, many functions of modern vehicles have been converted to be entirely automatic with no need of even remote controlling. Changing gears was one of the first actions that could be done automatically without an involvement of the driver, so such cars got the title of "automatic cars"; however, nowadays there are vehicles that can completely travel by themselves although they are not yet allowed to travel on public roads in most of the world. Such vehicles are called "autonomous vehicles" or "driverless cars".

INTRODUCTION

The first car was invented in 1870 by Siegfried Marcus (Guarnieri, 2011). Actually it was just a wagon with an engine but without a steering wheel and without brakes. Instead, it was controlled by the legs of the driver.

Converting traditional vehicles into autonomous vehicles was not just one step. The first step was just 28 years after the invention of cars that is to say 1898. This step's concept was moving a vehicle by a remote controller (Nikola, 1898). Since this first step and as computers have been becoming advanced and sophisticated, many functions of modern vehicles have been converted to be entirely automatic with no need of even remote controlling.

Changing gears was one of the first actions that could be done automatically without an involvement of the driver (Anthony, 1908), so such cars got the title of "automatic cars"; however, nowadays there are vehicles that can completely travel by themselves although they are not yet allowed to travel on public roads in most of the world. Such vehicles are called "autonomous vehicles" or "driverless cars".

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BACKGROUND

Autonomous vehicles will noticeably change the worldwide transport market. Autonomous vehicles will improve our quality of life and road safety. The number of traffic accidents will be significantly reduced. In Addition, autonomous vehicles can improve on the parking issues like the ability to park in a remote location in a rural fringe of the city. These vehicles will be more fuel efficient and their insurance will be cheaper. Also, people with disabilities can greatly benefit from this technology and military autonomous vehicles can prevent injuries and deaths in combat.

There are many practical obstacles and law difficulties that should be discussed. There were several car accidents where autonomous vehicles were involved (Wiseman & Grinberg, 2016a), (Wiseman & Grinberg, 2016b), (Wiseman & Grinberg, 2016c), (Wiseman & Grinberg, 2018). Until now two of these accidents were very tragic resulting in the death of a person.

There are several companies along with several government branches (especially military branches) that develop autonomous vehicles. Many of their products will be available for use in the coming years.

There is a need for more research until a car will be able to safely take us to our destination, without being involved in an accident and without having to drive or be there at all. Where is our car on the scale of autonomy and advanced safety? The international automotive organization SAE International (Society of Automotive Engineers) has defined six different levels of autonomous driving, or independent, in vehicles (SAE, 2014). This scale is quite acceptable in the autonomous vehicle industry. These six levels are divided into two groups: The three low levels require the driver to be active at least in part. In the high three levels, there may be situations where the driver is not required to drive at all. These six levels are listed herein below:

Level 0: No Driving Automation. The driver is in charge of all driving activities in other words a vehicle which is not autonomic at all.

Level 1: Driver Assistance. One autonomic system is operating in the vehicle. For example, Electronic Stability Control (ESC) (Lie, Tingvall, Krafft & Kullgren, 2006), Adaptive Cruise Control (ACC) (Van Arem, Van Driel & Visser, 2006), Emergency Brake Assist (EBA) (Page, Foret-Bruno & Cuny, 2005). The autonomic system acts by itself as a help for the driver. However, the autonomic system is not used for driving, but only helps the driver when necessary, as an emergency device.

Level 2: Partial Driving Automation. A vehicle in which two or more autonomic systems work together, capable of simultaneously handling two tasks. For example both steers the vehicle and operate the braking system. The main limitation of this level is that in any given moment, the driver must analyze the conditions of the road and respond accordingly. Thus, even if the car is of level 2, the technology still needs the driver to be aware of the circumstances and to respond immediately to any scenario because the autonomic system cannot prevent some of the potential accidents.

Level 3: Conditional Driving Automation. In some conditions the driver is not required to monitor the driving; however, there are limitations in this level; in other words the car cannot be driven without human intervention under any conditions. For example it can be automatically driven only on highways. Accordingly, when the vehicle goes, a human driver must supervisor it, because if emergency circumstances come about, the human driver will intervene so as to avoid any potential accident if the car cannot handle the circumstances.

Level 4: High Driving Automation. The vehicle will be able under certain circumstances to operate fully autonomously and to protect its passengers from accidents. An autonomous vehicle at this level does not require a human driver to be ready to respond in an emergency, but only if the defined circumstances are kept.

Level 5: Full Driving Automation. There is no restriction to certain circumstances, nor is there a need for a human driver for supervision in emergency circumstances.

MOTIVATION

Approximately 94-95 percent of road accidents are caused by human errors (NHTSA, 2015), (Freeman, 2016). These errors are usually taken place because of smartphone use, fatigue or distraction because of any other reason (Kaplan, Guvensan, Yavuz & Karalurt, 2015). An autonomous vehicle will prevent the vast majority of them. In addition, an autonomous vehicle will always conduct itself as it has been programmed. Therefore, if a programming failure is detected that has not been occurred in all tests, it will be possible to issue an update how to correct this failure. This update will instruct all autonomous cars how to conduct themselves in a similar case (Koopman & Wagner, 2016). In this way, every autonomous car will be trained by the experience of all autonomous cars as opposed to a human driver trained only by his own experience.

Autonomous cars will be of great help for people with disabilities (Bradshaw-Martin, & Easton, 2014). For example, people with severe visual impairments can safely travel in an autonomous car. In addition, people with an exhausting job or drunk people will be able to travel in such a car without driving. Moreover, autonomous vehicles will release also people in good physical shape from the burden of driving and will let them do other activities during their travels like work, rest or just enjoy the view (Litman, 2017).

Another issue is air pollution which will be moderated as well. Such smart junctions, whose traffic is routed on the basis of allocation of slots to pass the junction, will significantly reduce traffic jams and other delays (Fayazi, 2017). Such junctions are expected to have an important impact on the road system of each city. The travel and waiting times will be considerably shorter (Zohdy, Kamalanathsharma & Rakha, 2012). Fuel consumption will be decreased and the traffic will flow more freely, with less stoppings and accelerations, which will significantly reduce air pollution (Talebpour & Mahmassani, 2016). In addition, autonomous vehicles will be driven in a more conservative manner; therefore autonomous vehicles will consume substantially less gas and energy while travelling, compared to a traditional vehicle driven by a human, because a substantial amount of gas is consumed when driving at speed that is too high for the vehicle, accelerating excessively or unnecessary braking. Autonomous vehicles will eliminate these undesirable ways of driving; meaning less gas is consumed resulting in less air pollution.

Autonomous vehicles will put an end to the bother of hectic parking systems (Wiseman, 2017a), (Wiseman, 2017b). Furthermore, autonomous vehicles will change the land uses in the metropolitan areas anywhere (Brett, 2016). Many large parking lots will be shifted into alternative uses. (Shoup, 1997) argues that nearly a third of the central area in major cities in the US is reserved for parking. Autonomous vehicles can improve on the parking problems because of several main value-added aspects:

- Unlike traditional vehicles, autonomous vehicle will be able to drop off passengers in almost any spot in any city and then instead of cruising for a free parking (Inci, 2015), the autonomous vehicle will park itself in a remote parking lot in a rural fringe of the city where low-cost land is more readily available (Tayade & Patil, 2016); therefore there will be no necessity, for instance, for an enormous parking lot near airports as opposed to the situation that exists nowadays.
- An autonomous vehicle can park itself in a tighter fitting parking slot without scrapping nearby vehicles (Grinberg & Wiseman, 2013), (Grinberg & Wiseman, 2007). In (Bertoncello & Wee, 2015), it has been estimated that the size of a typical parking lot can be reduced by 15% because of the tighter fitting parking slots of autonomous vehicles. Therefore, autonomous cars will enable to build the parking lots in a more compact manner.
- An autonomous vehicle will be parked by the computer software (Filatov & Serykh, 2016); therefore, there will be no more occurrences of drivers parking their vehicles in an angle in a perpendicular parking; nor will there be drivers parking their cars in other ways that occupy more than one parking slot. In addition, the parking slots will be allocated according to the vehicle size and as a result the parking slots will not be any longer at the size of the largest potential vehicle (Li & Shao, 2015).

SOLUTIONS AND RECOMMENDATIONS

Traffic lights were invented at 1868 (Wang, 2016) and they have been turning out to be more sophisticated and computer controlled (Fang, 2016). The new generation of traffic lights is called "intelligent traffic lights" and it contains digital electronic units derived from common computers (Wiseman, 2016a), (Wiseman, 2016b). The traffic lights are a common sight in the streets of our cities. They use up space in the streets, need a maintenance team and consume electricity power; however, the traffic lights will probably disappear. Autonomous vehicles equipped with sensors will be able to communicate with each other (Wiseman, Schwan & Widener, 2005). Moreover, they will be able to maintain a safe distance between them with the purpose of going across junctions without using traffic lights. Similarly to the model of air traffic control systems, computerized junctions can route traffic on the basis of time slot allocation, as a result the traffic lights can be replaced by a computerized communication system (Tachet, 2016). When an autonomous vehicle approaches a junction, an access request to the junction will automatically be sent from the autonomous vehicle to a traffic management system. This system will receive the request and assign it a unique time slot to pass the junction.

Likewise, Autonomous vehicles will be able to coordinate their way of driving, so they can move in platoon with fixed intervals (Tsugawa, Kato, & Aoki, 2011), by employing Lidar and ultrasonic rangefinders (Wiseman, 2018) with the intention of distance reduction between them, without any risk of collisions. These platoons will reduce traffic congestion on roads, will increase the energy efficiency of driving and will reduce the air pollution generated by vehicles (Fernandes & Nunes, 2012).

DIFFICULTIES AND OBSTRUCTIONS

The Luddites (Jones, 2013) were a movement of English workers in the beginning of the 19th century who protested, sometimes even by violence measures like destroying machines, against the changes brought about by the Industrial Revolution, which they saw as a threat to their livelihood. Similarly, Autonomous vehicles can cause mass joblessness in the automotive industry. Professional drivers like taxi drivers or truck drivers will not be required anymore. Likewise the Luddites, some unhappy professional drivers attacked autonomous vehicles in California (Wong, 2018). This joblessness will also occur in the garage industry. When 95 percent of the vehicular accidents are eliminated, a much small number of garages will be required and a large amount of automobile mechanics will be fired and will not be able to find a new job. Significantly lower rate of vehicular accidents will also cause less damage to road infrastructure, bringing about some reduction in need for workers in the road maintenance sector.

Another issue that can be challenging is cyber criminalism or cyber terrorism (Petit, & Shladover, 2015). In the future, almost all if not entirely all the vehicles will be exclusively controlled by computers. If the software is not perfect and some flaws make the software vulnerable, smart hackers might be capable to unlawfully interfere with the vehicle software, so they will be able to harm the vehicle or even worse harm the vehicle occupants. In addition, a new version of car thefts may possibly be a fleet of autonomous vehicles thefts.

The trouble of traffic congestion is very acute in many cities and highways (Wiseman, 2017c), (Wiseman, 2017d), (Wiseman, 2017e). The autonomous vehicles will add many cars to the already congested roads, because of several reasons:

- Children are a significant portion of the world population; however, they mostly do not own a vehicle; nor do they drive a vehicle. When autonomous cars are available, the children will be able to own a vehicle and to "drive" vehicles. It is hard to predict which portion of the children population will use private cars instead of the public transportation (Fagnant & Kockelman, 2015), but even if a small percentage of the children are added to the already congested roads, it might augment the congestion difficulty.
- Similarly to the children, people with a disability like blindness or other severe disability that nowadays prevents them from driving a vehicle, will be able to use an autonomous vehicle by themselves. Actually, this happening was one of the first motivations for the developing of autonomous cars because such a car will definitely and substantially improves on the disabled quality of life (Madarasz, Heiny, Cromp & Mazur, 1986); however, this improvement will add more vehicles on roads.
- Some people prefer to travel by public transportation because they like to relax while going to their destination. Some of them want to sleep, read or just not arriving in an edgy mood after conflicts with other drivers while driving. The autonomous vehicle will give these people the opportunity to have this rest with no need of public transportation. Traveling by an autonomous vehicle will be usually even a better relaxation because there will be no need for connections i.e. to change from bus to train etc. nor will there be other people in the vehicle. This will make more people to choose the autonomous vehicles.
- More traffic will be added because empty vehicles will go alone in their way to park. Nowadays, drivers make an effort to find a close parking lot, so they will not have to walk a large distance; however, an autonomous vehicle can go by itself to a remote parking lot.

In spite of this added traffic, autonomous vehicles will drive more efficiently, so there are more than a few analyses which have confidence that this efficiently way of driving can counterbalance the added traffic and even obtaining a better traffic flow.

FUTURE RESEARCH DIRECTIONS

The current world population is more than 7.6 billion; however it is expected to reach 10 billion in the year 2056 (Worldometers, 2018). In addition, the standard of living has been increasing in most of the world countries and it is expected that more people will be able to own a car in the coming centuries (Reich, 2010). The reasons mentioned in the previous section for potential excessive congestions when autonomous cars are available will also play a part in the even now congested roads, that is to say many current roads are already congested and even if a major road construction is performed and even a second floor is built in the most congested roads, the problem of traffic congestion will be acute. This concern of congested roads has already stimulated enterprises all over the world to make the first moves toward flying cars.

A flying car will be a private air vehicle which can travel both by air and roads. Many prototypes of such cars like AeroMobil (Becker, 2017), Urban Aeronautics' XHawk (Yoeli, 2002), The Skycar (Pecora, Pecora & Lecce, 2011), The Xplorair (Altran France, 2013) and many more (Frost & Sullivan, 2017) have been built and have been tested; however, the production of these flying cars has not yet started for a widespread use.

The concept is a vehicle that is able to fly and to vertical take-off and land (VTOL). Such a vehicle will be able to go without a road and also several levels of elevation can be attained, as a result there will be a multiple level road without a need to pave even a single mile of road.

Autonomous flying cars will also have the ability to connect and to move in platoons, so they will be able to catch sight of a much larger area, so they will be much safer and more efficient (Wang, Xu, Leng, & Pollin, 2018, June).

The overall consequences of autonomous vehicles are still unknown and the impact on other means of transportation is unclear (Wiseman, 2019a). Also, the impact on transportation infrastructure is undecided (Wiseman, 2019b). When the autonomous vehicles penetrate the transportation market, more information will be available and this information will enable more profound research.

CONCLUSION

Autonomous vehicles are self-guided vehicles that overcome obstacles without any help of a human driver. These vehicles are expected to go on the same road and with the same traffic signs we are currently familiar with. Autonomous vehicles are equipped with several apparatus that enable them to observe their surroundings and decide in real time what action should be taken.

Autonomous vehicles are expected to be safer than vehicle driven by human drivers. Furthermore, autonomous vehicles will release people from the burden of driving and will give them more time to rest, work or do other activities. These vehicles can be operated by children or other incapable persons. In addition, they will be driven in more efficient manner than an average driver. Parking concerns will be enormously affected by autonomous vehicles because autonomous vehicles can park themselves in a remote location and in a tighter fitting parking slot.

There are some concerns like many professional drivers who will lose their jobs and the potential congestions ensued by additional vehicles going empty or going with children; however with a proper preparations the shift to autonomous vehicles can be done smoothly and efficiently.

REFERENCES

Altran France. (2013). *Xplorair: un projet Altran Research - Altran France*. Avialable online at: https://www.youtube.com/watch?v=_v4FNXvF9kQ

Anthony, J. S. (1908). *Automatic speed-changing gear*. U.S. Patent No. 907,711. Washington, DC: U.S. Patent and Trademark Office.

Becker, E. P. (2017). The future of flying is near. *Tribology & Lubrication Technology*, *73*(8), 96.

Bertoncello, M., & Wee, D. (2015). Ten ways autonomous driving could redefine the automotive world. McKinsey & Company.

Bradshaw-Martin, H., & Easton, C. (2014). Autonomous or 'driverless' cars and disability: a legal and ethical analysis. *European Journal of Current Legal Issues, 20*(3).

Brett, J. A. (2016). *Thinking local about self-driving cars: a local framework for autonomous vehicle development in the united states* (MSc Thesis). Urban Design and Planning, University of Washington.

Fagnant, D. J., & Kockelman, K. (2015). Preparing a nation for autonomous vehicles: Opportunities, barriers and policy recommendations. *Transportation Research Part A, Policy and Practice*, *77*, 167–181. doi:10.1016/j.tra.2015.04.003

Fang, J. (2016). Intelligent traffic light controller design using FPGA digest of technical papers. In *Proceedings of IEEE International Conference on Consumer Electronics (ICCE 2016)*, (pp. 449-452). IEEE.

Fayazi, S. A., Vahidi, A., & Luckow, A. (2017, May). Optimal scheduling of autonomous vehicle arrivals at intelligent intersections via MILP. In *Proceedings of American Control Conference (ACC 2017)*, (pp. 4920-4925). 10.23919/ACC.2017.7963717

Fernandes, P., & Nunes, U. (2012). Platooning with IVC-enabled autonomous vehicles: Strategies to mitigate communication delays, improve safety and traffic flow. *IEEE Transactions on Intelligent Transportation Systems*, *13*(1), 91–106. doi:10.1109/TITS.2011.2179936

Filatov, D. M., & Serykh, E. V. (2016, May). Intellegence autonomous parking control system of four-wheeled vehicle. In *Proceedings of IEEE International Conference on Soft Computing and Measurements (SCM 2016)*, (pp. 154-156). 10.1109/SCM.2016.7519713

Flinn, E. D. (2003). Revolutionary X-Hawk hovers near success. *Aerospace America*, *41*(7), 26–28.

Freeman, D. (2016). Self-Driving Cars Could Save Millions Of Lives — But There's A Catch. *HuffPost*. Available online at: https://www.huffingtonpost.com/entry/the-moral-imperative-thats-driving-the-robot-revolution_us_56c22168e4b0c3c550521f64

Frost & Sullivan. (2017). *Future of Flying Cars, 2017–2035*. Available online at: http://www.frost.com/sublib/frost-content.do?sheetName=report-overview&sheetGroup=K16A-01-00-00-00&viewName=virtual-brochure&repid=K16A-01-00-00-00

Grinberg, I., & Wiseman, Y. (2007, August). Scalable parallel collision detection simulation. Proceedings of Signal and Image Processing, 7, 380-385.

Grinberg, I., & Wiseman, Y. (2013). Scalable parallel simulator for vehicular collision detection. International Journal of Vehicle Systems Modelling and Testing. *Inderscience Publications*, *8*(2), 119–144.

Guarnieri, M. (2011). When Cars Went Electric, Part 2. *IEEE Industrial Electronics Magazine*, *5*(2), 46–53. doi:10.1109/MIE.2011.941122

Inci, E. (2015). A review of the economics of parking. *Economics of Transportation*, *4*(1-2), 50–63. doi:10.1016/j.ecotra.2014.11.001

Jones, S. E. (2013). Against technology: From the Luddites to neo-Luddism. Routledge.

Kaplan, S., Guvensan, M. A., Yavuz, A. G., & Karalurt, Y. (2015). Driver behavior analysis for safe driving: A survey. *IEEE Transactions on Intelligent Transportation Systems*, *16*(6), 3017–3032. doi:10.1109/TITS.2015.2462084

Koopman, P., & Wagner, M. (2016). Challenges in autonomous vehicle testing and validation. *SAE International Journal of Transportation Safety*, *4*(1), 15–24. doi:10.4271/2016-01-0128

Li, B., & Shao, Z. (2015). A unified motion planning method for parking an autonomous vehicle in the presence of irregularly placed obstacles. *Knowledge-Based Systems*, *86*, 11–20. doi:10.1016/j.knosys.2015.04.016

Lie, A., Tingvall, C., Krafft, M., & Kullgren, A. (2006). The effectiveness of electronic stability control (ESC) in reducing real life crashes and injuries. *Traffic Injury Prevention*, *7*(1), 38–43. doi:10.1080/15389580500346838 PMID:16484031

Litman, T. (2017). *Autonomous vehicle implementation predictions*. Victoria Transport Policy Institute.

Madarasz, R., Heiny, L., Cromp, R., & Mazur, N. (1986). The design of an autonomous vehicle for the disabled. *IEEE Journal on Robotics and Automation*, *2*(3), 117–126. doi:10.1109/JRA.1986.1087052

NHTSA - National Highway Traffic Safety Administration. (2015). *Critical Reasons for Crashes Investigated in the National Motor Vehicle Crash Causation Survey*. NHTSA's National Center for Statistics and Analysis, United States Department of Transportation, DOT HS 812 115. Available online at: https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812115

Nikola, T. (1898). *U.S. Patent No. 613,809.* Washington, DC: U.S. Patent and Trademark Office.

Page, Y., Foret-Bruno, J. Y., & Cuny, S. (2005). Are expected and observed effectiveness of emergency brake assist in preventing road injury accidents consistent? *Proceedings of the 19th International Technical Conference on the Enhanced Safety of Vehicles (ESV Conference).*

Pecora, R., Pecora, M., & Lecce, L. (2011, September). Flutter certification of SKYCAR aircraft: Rational analysis and flight tests. *Proceedings of the 3rd CEAS Air&Space Conference*.

Petit, J., & Shladover, S. E. (2015). Potential cyberattacks on automated vehicles. *IEEE Transactions on Intelligent Transportation Systems*, *16*(2), 546–556.

Reich, R. B. (2010). The Work of Nations: Preparing Ourselves for 21st Century Capitalis. Vintage Books.

SAE. (2014). Definitions for Terms Related to On-Road Motor Vehicle Automated Driving Systems-J3016. In Society of Automotive Engineers: On-Road Automated Vehicle Standards Committee. SAE (Society of Automotive Engineers) Pub. Inc.

Shoup, D. C. (1997). The high cost of free parking. *Journal of Planning Education and Research*, *17*(1), 3–20. doi:10.1177/0739456X9701700102

Tachet, R., Santi, P., Sobolevsky, S., Reyes-Castro, L. I., Frazzoli, E., Helbing, D., & Ratti, C. (2016). Revisiting street intersections using slot-based systems. *PLoS One*, *11*(3), e0149607. doi:10.1371/journal.pone.0149607 PMID:26982532

Talebpour, A., & Mahmassani, H. S. (2016). Influence of connected and autonomous vehicles on traffic flow stability and throughput. *Transportation Research Part C, Emerging Technologies*, *71*, 143–163. doi:10.1016/j.trc.2016.07.007

Tayade, Y., & Patil, M. D. (2016). Advance Prediction of Parking Space Availability and Other Facilities for Car Parks in Smart Cities. *International Research Journal of Engineering and Technology*, *3*(5), 2225–2228.

Tsugawa, S., Kato, S., & Aoki, K. (2011). An automated truck platoon for energy saving. *Proceedings of 2011 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, 4109-4114. 10.1109/IROS.2011.6094549

Van Arem, B., Van Driel, C. J., & Visser, R. (2006). The impact of cooperative adaptive cruise control on traffic-flow characteristics. *IEEE Transactions on Intelligent Transportation Systems*, *7*(4), 429–436. doi:10.1109/TITS.2006.884615

Wang, M. Y., Ding, H. W., Zhao, Y. F., Liang, Z. G., & Zhu, L. Z. (2016). The Application of the Exhaustive Polling Theory in Intelligent Traffic System. In *MATEC Web of Conferences* (*Vol. 44*, paper 02013). EDP Sciences. 10.1051/matecconf/20164402013

Wang, Q., Xu, C., Leng, S., & Pollin, S. (2018, June). When Autonomous Drones Meet Driverless Cars. *Proceedings of the 16th ACM Annual International Conference on Mobile Systems, Applications, and Services*, 514.

Wiseman, Y. (2016). Conceptual Design of Intelligent Traffic Light Controller. *International Journal of Control and Automation*, *9*(7), 251–262. doi:10.14257/ijca.2016.9.7.23

Wiseman, Y. (2016). Traffic Light with Inductive Detector Loops and Diverse Time Periods. *Contemporary Research Trend of IT Convergence Technology*, *4*, 166–170. doi:10.21742/asehl.2016.4.39

Wiseman, Y. (2017). Remote Parking for Autonomous Vehicles. *International Journal of Hybrid Information Technology*, *10*(1), 313–324. doi:10.14257/ijhit.2017.10.1.27

Wiseman, Y. (2017). Self-Driving Car-A Computer will Park for You. *International Journal of Engineering & Technology for Automobile Security*, *1*(1), 9–16. doi:10.21742/ijetas.2017.1.1.02

Wiseman, Y. (2017). Real-time monitoring of traffic congestions. *IEEE International Conference on Electro Information Technology (EIT 2017)*, 501-505. 10.1109/EIT.2017.8053413

Wiseman, Y. (2017). Tool for Online Observing of Traffic Congestions. *International Journal of Control and Automation*, *10*(6), 27–34. doi:10.14257/ijca.2017.10.6.04

Wiseman, Y. (2017). Computerized Traffic Congestion Detection System. *International Journal of Transportation and Logistics Management*, *1*(1), 1–8. doi:10.21742/ijtlm.2017.1.1.01

Wiseman, Y. (2018). Ancillary Ultrasonic Rangefinder for Autonomous Vehicles. *International Journal of Security and its Applications, 12*(5), 49-58.

Wiseman, Y. (2019). Driverless Cars will Make Passenger Rails Obsolete, IEEE. *Technology in Society*, *38*(2), 22–27.

Wiseman, Y. (2019). Driverless Cars will Make Union Stations Obsolete. *The Open Transplantation Journal*, *13*(1), 109–115. doi:10.2174/1874447801913010109

Wiseman, Y., & Grinberg, I. (2016, May). Circumspectly crash of autonomous vehicles. *IEEE International Conference on Electro Information Technology (EIT 2016),* 387-392. 10.1109/EIT.2016.7535271

Wiseman, Y., & Grinberg, I. (2016). Autonomous vehicles should not collide carelessly. *Advanced Science and Technology Letters*, *133*, 223–228.

Wiseman, Y., & Grinberg, I. (2016). When an inescapable accident of autonomous vehicles is looming. *International Journal of Control and Automation*, *9*(6), 297–308. doi:10.14257/ijca.2016.9.6.28

Wiseman, Y., & Grinberg, I. (2018). The Trolley Problem Version of Autonomous Vehicles. The Open Transportation Journal, 12(1). doi:10.2174/18744478018120100105

Wiseman, Y., Schwan, K., & Widener, P. (2005). Efficient end to end data exchange using configurable compression. *Operating Systems Review*, *39*(3), 4–23. doi:10.1145/1075395.1075396

Wong, J. C. (2018). Rage against the machine: self-driving cars attacked by angry Californians. *The Guardian*. Available online at: https://www.theguardian.com/technology/2018/mar/06/california-self-driving-cars-attacked

Worldometers info. (2018). Available online at: https://www.worldometers.info/world-population/

Yoeli, R. (2002). Ducted fan utility vehicles and other flying cars. *2002 Biennial International Powered Lift Conference and Exhibit*, 5995. 10.2514/6.2002-5995

Zohdy, I. H., Kamalanathsharma, R. K., & Rakha, H. (2012, September). Intersection management for autonomous vehicles using iCACC. *Proceedings of 15th International IEEE Conference on Intelligent Transportation Systems (ITSC 2012)*, 1109-1114. 10.1109/ITSC.2012.6338827

ADDITIONAL READING

Blau, M., Akar, G., & Nasar, J. (2018). Driverless vehicles' potential influence on bicyclist facility preferences. *International Journal of Sustainable Transportation*, *12*(9), 665–674. Advance online publication. doi:10.1080/15568318.2018.1425781

Buehler, M., Iagnemma, K., & Singh, S. (Eds.). (2009). *The DARPA urban challenge: autonomous vehicles in city traffic*. Springer-Verlag Berlin Heidelberg. doi:10.1007/978-3-642-03991-1

Lozano-Perez, T. (2012). *Autonomous robot vehicles*. Springer Science & Business Media.

Milakis, D., Van Arem, B., & Van Wee, B. (2017). Policy and society related implications of automated driving: A review of literature and directions for future research. *Journal of Intelligent Transport Systems*, *21*(4), 324–348. doi:10.1080/15472450.2017.1291351

Rothenbücher, D., Li, J., Sirkin, D., Mok, B., & Ju, W. (2016, August). Ghost driver: A field study investigating the interaction between pedestrians and driverless vehicles. In *25th IEEE International Symposium on Robot and Human Interactive Communication (RO-MAN 2016)*, pp. 795-802. 10.1109/ROMAN.2016.7745210

Wiseman, Y. (2017). Automatic Alert System for Worn Out Pipes in Autonomous Vehicles. *International Journal of Advanced Science and Technology*, *107*, 73–84. doi:10.14257/ijast.2017.107.06

Wiseman, Y. (2018). In an Era of Autonomous Vehicles, Rails are Obsolete. *International Journal of Control and Automation*, *11*(2), 151–160. doi:10.14257/ijca.2018.11.2.13

Wiseman, Y. (2019). Driverless Cars will Make Passenger Rails Obsolete, IEEE. *Technology in Society*, *38*(2), 22–27.

Zhao, L., Ichise, R., Yoshikawa, T., Naito, T., Kakinami, T., & Sasaki, Y. (2015, June). Ontology-based decision making on uncontrolled intersections and narrow roads. In *IEEE Intelligent Vehicles Symposium (IV 2015)*, pp. 83-88. 10.1109/IVS.2015.7225667

Zhou, M., Qu, X., & Jin, S. (2017). On the impact of cooperative autonomous vehicles in improving freeway merging: A modified intelligent driver model-based approach. *IEEE Transactions on Intelligent Transportation Systems*, *18*(6), 1422–1428.

KEY TERMS AND DEFINITIONS

Absolute Positioning: A system that is able to locate the precise autonomous vehicle position, so the vehicle will be able to know where it should make its turns.

Automated Highway System (AHS): A system that is capable to drive a vehicle in a highway by itself in a pre-determined route. This system can significantly reduce distances currently necessitated between vehicles, so as a result such systems will be able to relief many traffic congestions. Such systems are typically combined with adaptive cruise control and collision avoidance systems and typically used by autonomous vehicles level 3 or higher.

Computer Vision: Systems that are in charge of an autonomous vehicle's ability to observe its surroundings.

Far Infrared Sensors (FIRS): Sensors employed by autonomous vehicles with the purpose of obtaining the heat outline of pedestrians or animals, so as to avoid a collision with them. These sensors can work together with traditional cameras and LIDAR, so as to decide together on the safest choice.

Intelligent Driver Assistance Systems (IDAS): Devices aiming at improving vehicle safety, for example, blind spot monitor or traffic signs recognition.

Internet of Vehicles (IoV): Internet of vehicles is a wireless network used for information exchange between vehicles, infrastructure, pedestrians using the traditional Internet protocols and networks.

Light Detection and Ranging (LIDAR): A laser-based radar used in autonomous vehicles. In nowadays autonomous vehicles, the LIDAR unit is typically located on the vehicle roof with the aim of enabling unimpeded 360-degree view of the autonomous vehicle surroundings.

Platooning: Multiple autonomous vehicles that communicate and change information in order to move and maneuver simultaneously. Commonly the vehicles go in a convoy, so as to increase road capacity.

Vehicle to Infrastructure (V2I): Communication technology enabling information exchange between vehicles and infrastructures.

Vehicle-to-Vehicle (V2V) Communication: Communication technology enabling information exchange between vehicles.