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The Future of Autonomous Vehicles

The future of the modern world faces the appearance of different ways of mobility. Huge strive in today's world have gained autonomous vehicles. The paper explains how autonomous vehicles function as well as their advantages and disadvantages. New developments in autonomous vehicles are being accomplished and introduced to the user's demands. Many car companies have developed their own driverless vehicles and detected the problems within them. The major flaw of autonomous vehicles is cyber security because hackers are still able to break into the car's software system and disrupt it. This is a major issue which is still being dealt with. Autonomous vehicles have modernized the mobility of people, which means that people no longer have to come to the vehicle but the vehicle comes to them and are able to share transportation and thus lowering the traffic congestion and cost. Smartphone applications have been developed facilitating the carsharing system. Users consider these cars comfortable and stylish but expect high level of security. Autonomous vehicles enable the elderly, the disabled and physically limited people move much easier. Furthermore, autonomous vehicles reduce pollution and are environmentally friendly. It is anticipated that autonomous vehicles will take over the roads and are the future of transportation. They offer comfort, safety and good driving conditions. Hereafter, this paper represents important characteristics and features of autonomous cars.

Keywords: autonomous vehicles, mobility, cyber security, carsharing, developments, software system

1. INTRODUCTION

Technology advances rapidly. Nowadays, in the streets one may see various types of means of transportation such as cars, buses, the tube, bicycles, motorcycles etc. What really makes the difference inside each category is the type, the brand, the equipment, the drive, the luxury and last but not the least, how much effort you have to put in to keep it going [1-3].

Modern society desires a vehicle which is safe, comfortable, easy to steer and simple to drive. That is why autonomous vehicles are already an emerging field in the world.

2. AUTONOMOUS DRIVING

Let us explain what autonomous vehicles really are. An autonomous vehicle permits the vehicle to manage certain driving points which in a normal car would be controlled by a driver. For example: steering, braking and acceleration, checking and monitoring the driving environment. To perform all these actions autonomous cars, must have certain equipment such as a combination of sensors, controllers, onboard computers, actuators, algorithms, and advanced software. Autonomous cars form and maintain a map of their surrounding with the help of various sensors embedded in the different parts of the vehicle. Sensors pay attention to the nearby vehicles while video cameras detect traffic lights, road signs, pedestrians and track other vehicles on the road. Furthermore, both detect road edges, lane markings and measure distance in relation to other vehicles. Alongside, the vehicle may offer features which are allowing the driver to communicate through their mobile devices with other vehicles and road users, roadways, traffic lights, internet applications and other.

Figure 1: Volvo vs Kangaroo

A line must be drawn between semi-autonomous and full-autonomous vehicles. Semi-autonomous cars allow the driver to perform several actions in the car as opposed to the full-autonomous cars where the car itself performs all the driving actions.

Semi-autonomous cars are present in everyday life (not as merely as regular cars) but full -autonomous cars have a long way to go to become a trivial thing. They are still not accessible to the public.

Autonomous vehicles have their own benefits. There are a variety of conveniences coming with the usage of

this car. Imagine that you have gone to the beach but realized you forgot to bring your sun umbrella or gone to the store and forgot your wallet, the car could be able to bring you the missing items. These cars could make the elderly and the disabled live independently. People's quality of life would increase significantly. The list of quality-of – life improvements is limitless. One cannot talk about autonomous vehicles without mentioning that these cars promise a dramatically lower CO_2 emission.
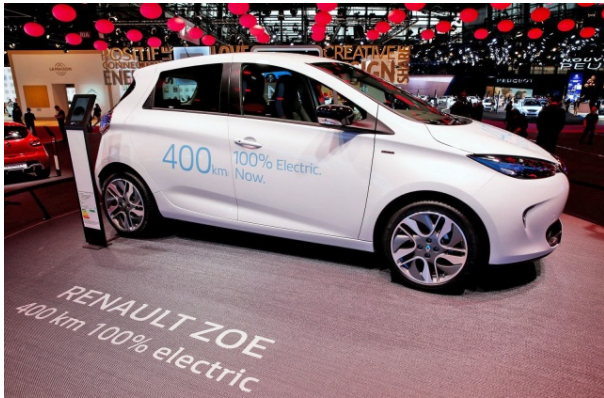

Figure 2: Renault vs Capability

2.1 Autonomous cars vs Car industry

World leaders in car industry have developed their own autonomous cars. It is said that every second car company has developed their own model of autonomous car. One of those companies is Volvo (Fig. 1). The company has carried out a variety of tests on auto-nomous cars. One of those tests deal with how a family accommodates to a self-driving car. The company conducted a test with a four-member family. The goal of the test is to have an insight of how an ordinary person adjusts to the self-driving technology when using a ma-nual beforehand.

The company has also tested its autonomous cars in Australia where encountered a strange problem. It discovered that the kangaroos were very confusing to its cars. In earlier tests the vehicles' detection system was exposed to other big animals such as moose, deer, elk, and caribou. Kangaroo's movement was the oddity to the system. Namely, kangaroos jump very high which, to the detection system, seems that the animal is far but when it lands it looks much closer [4-7]. Nevertheless, solving this problem was just a part of the autonomous vehicle's development process.

Another example of autonomous vehicle was given by Renault. The company tested the autonomous vehicle's capability to avoid obstacles just as well as a professional driver. Humans are known to be amazing drivers. Thus, the system was inspired by the drivers' ability to avoid obstacles and created a benchmark for the technology the vehicle should be performing.

The test of avoidance capability was performed on Renault's autonomous prototype Zoe (Fig. 2). The company claims that avoiding objects on the road is the necessary feature of every autonomous car system.

Every company which produces autonomous vehicles is aware of the problem and is creating their own ways of tackling it [8-10].

2.2 Users and use of the new mobility concepts – carsharing and "core application"

Mobility matters and is a fundamental need of every human being. We are constantly on the move to meet our friends and family, travel on holiday or simply go to the store. There are long established means of transportation in everyday life such as bicycles, manual cars, buses, trams etc. Autonomous vehicles represent a new mobility concept [11-20]. As explained above, the driver has little or no action to perform. People most often like to experience a convenient, affordable, and unremarkable journey.

Car companies have recognized these desires. For example, Volkswagen has developed a shuttle-on – demand (MOIA) which was proven to be highly efficient and flexible. This electric vehicle can be booked by a customer via smartphone app by simply entering their location and destination and the MOIA vehicle comes at a virtual stop up until 250 meters away from the customer and the app navigates the customer to the vehicle [21-30]. This concept of mobility promotes sharing a journey with other people who are traveling in the same direction and thus preventing traffic conges-tion, saving the environment by having fewer cars on the roads and reducing traffic. This way of transpor-tation is known as carsharing. Carsharing (Fig. 3) existed long before autonomous cars started to emerge, but the difference is that the user no longer must come to the vehicle, but the vehicle comes to the user [1]. Any person who has a valid driver's license can register to the application and use this service upon payment of the registration fee. The concept is simple.

Figure 3: Carsharing

2.3 Digitalization of the everyday world as a basic precondition for new mobility concept

One cannot argue that new technologies are based and managed through software, digital platforms, and applications. The same thing is applied to new mobility concepts such as carsharing. Mobile applications are inevitable if a person desires to access carsharing vehicles. These apps give the user an insight of the available vehicles and their locations. Next, users decide whether they are willing to go to the vehicle for which they are given no more than 30 minutes. Then, the app books a vehicle and shows the route to it.

To use this mobility concept a person must be technically furnished. That is, to own a smartphone and

be a little bit technology savvy, just enough to know how to use the app. However, people's hardware and software skills are increasing and almost every person in modern society has at least some knowledge about it. In today's digitalized world this is a must.

Well known app for carsharing *Car2Go* (Fig. 4) made a survey in 2014 and discovered that the users find the digitalization of mobility quite useful. Users say that cars are available at any time and can use them spontaneously. These facts may explain the rapid success of flexible carsharing.

3. SAFETY AND CYBER SECURITY ISSUES IN SELF-DRIVING ROBOTIC CARS

When a vehicle is produced there are different issues which must be taken into consideration, for example: interior, exterior, equipment, performance, design but most of all safety. Whether it is a traditional, manual car or a self-driving car safety is the prime thing which must not be neglected. People know autonomous cars will soon replace traditional cars and become a common mean of transportation on the road. Computer operating system which controls the process of driving and receives remote instructions is emerging.

Several questions rise about this latest technology. The first: "How safe are these cars for the traffic circumstances?" The second: "Since this car uses a specially developed software, may that software be broken into by hackers?" Owning a self-driving car sounds tempting but what happens when a curious hacker breaks into your car's computer system and starts controlling it? There still exist certain matters needed to be discerned [31-40].

As mentioned before, people are amazing drivers, but it is inevitable that people also cause many car crashes which are a result of reckless driving. Less damaging, wrong or poorly calculated decisions contribute to traffic jams which bring to traffic halt. Considering all these facts self-driving cars could be a better and safer solution.

The advantages of autonomous cars are various. For instance, human drivers tend to cause accidents due to different reasons. Many people use their mobile phones while driving, some drive for long distances and get tired, others over-speed because they are in a hurry and some of them just do not respect the traffic and road safety rules. These limitations do not fall under autonomous cars. These cars can detect obstacles and thus avoiding them. Sensitive sensors (Fig. 5) can notice the obstacle much earlier than the human driver would, especially in the dark roads [1]. Furthermore, autonomous cars can recognize the presence of other cars on the road and estimate the size and speed of the oncoming car so any collision would be less likely.

One must argue only one thing about this type of car-cyber security. As we already know autonomous cars have specially developed software which, just like any other software, may be broken into by cyber criminals [41-45]. They can get into the car's operating system and steal passenger's information or perhaps disturb its operation on the road. There are several case scenarios which might happen. It is possible to abduct a person driving the car by attacking the car's operating system. Further, hackers may take over the control of the operating system to cause intentional car crashes in a certain area of interest. The user of the car may be harmed financially if a hacker breaks into the car's operating system and destroys it. A great deal of the user's personal data would be exposed, such as destination, allowing the hacker to redirect the car and potentially rob or assault the user. The dangers are indeed many.

Even though the threats and benefits of this kind of technology are not yet quite clear the developers are doing their best to come up with the plan to keep both the vehicles and their passengers safe.
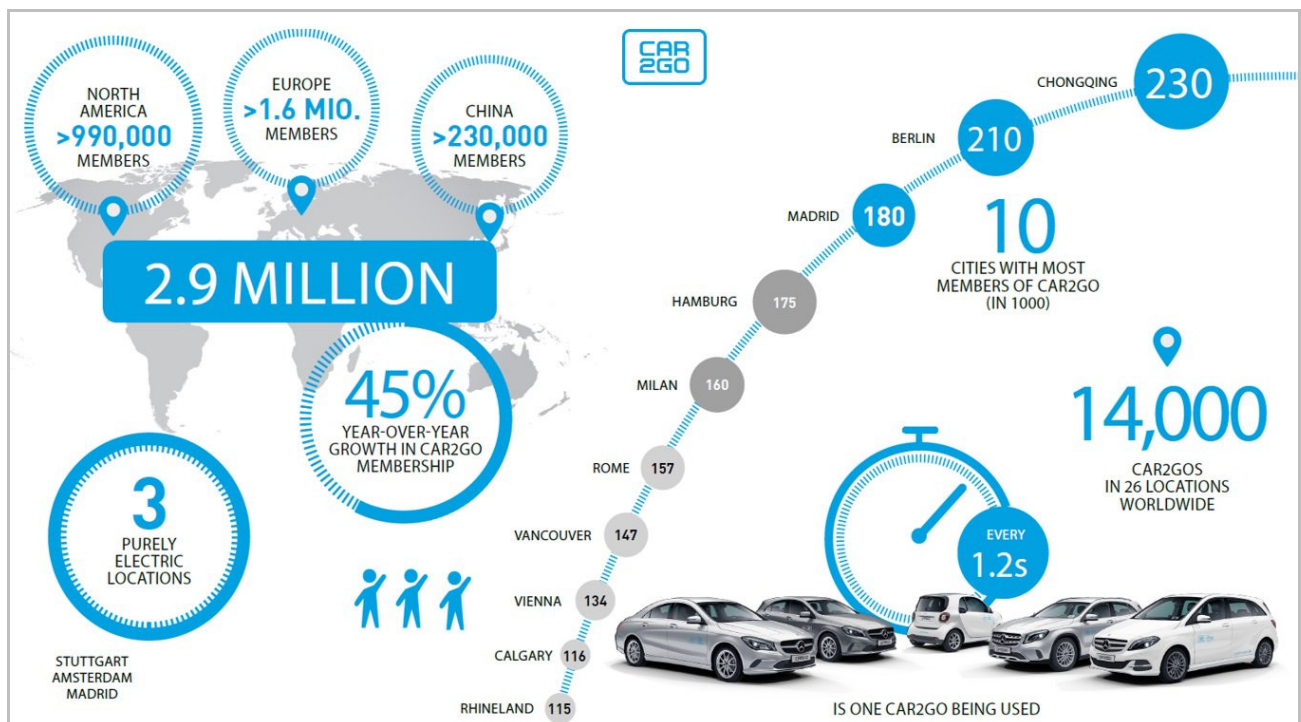

Figure 4: Facts about Car2go

4. CYBER SECURITY DEVELOPMENTS IN SELF-DRIVING ROBOTIC CARS

Since self-driving cars are operating on software and connectivity, they are pretty much vulnerable to the hackers. Autonomous cars are still at their early stages of development and need a lot of improvements especially in terms of security. They require impene0-trable protection. To accomplish this some efforts have already been made.

For instance, AV producers have introduced programs where they invite hackers to hack their cars so they could discover car flaws and make any necessary changes to boost the security. This kind of system testing allows the car producers to identify, analyse and correct any vulnerabilities in their systems.

There are two well-known examples of hacking the autonomous vehicles. The first one is hacking Jeep Grand Cherokee. Researches wanted to demonstrate that they were able to take over the control of the car remotely. They first hacked into the car's multimedia system via Wi-Fi connection which enabled them to change the radio station, the volume and even track the car via its GPS navigation system [4]. The discovering that the car was easily hacked led to recalling a lot of autonomous cars from the streets until the solution to this problem is found.

Second example is Tesla X. Namely, Chinese researches exposed vulnerabilities of this model. They were able to remotely take over the control of the car's brakes, open the trunk and the doors but also take control of the radio. The researchers managed to hack the vehicle through Wi-Fi and mobile connections with the help of malware sent to the car's web browser. Fortunately, having the problem detected the researchers managed to fix it within two weeks.

Furthermore, to prevent hacking the autonomous vehicle system blockchain solutions for cyber security have been introduced. According to this, autonomous cars will be made "hack proof". This technology is primarily used in applications where data security is crucial. This kind of system uses cryptography and advanced algorithms to verify security data which means that the network used by the vehicle has top security and cannot be easily disrupted.

Autonomous vehicles are still pretty much a novelty and require further developments in particularly in the field of cyber security [3]. In previous years cyber security was something yet to be understood but nowadays it is quickly becoming a hot topic for autonomous vehicles producers.

5. USERS AND USAGE CONDITIONS

Autonomous vehicles are expected to become a trivia in lives of human beings. Until that happens producers must take into consideration people's needs and preferences [18]. Whether a person will or will not adopt the usage of autonomous cars widely depends on how they feel while driving the car and how safe are they while driving. Any company which produces AVs must meet users' expectations and coax them to transfer from manual to autonomous cars.

The advantages of AVs for the users are many. They will liberate those who dislike driving, make life easier for those who are not able to drive, the car can act as an important aid to people who are disabled visually or physically. Moreover, elderly people would be enabled to move more quickly but not less important for parents distracted by young children.

It should be anticipated that people will change their perspective of vehicles and eventually not notice the difference between driven and driverless cars. Users will realize that mobility is very important and driven cars will eventually be dropped.
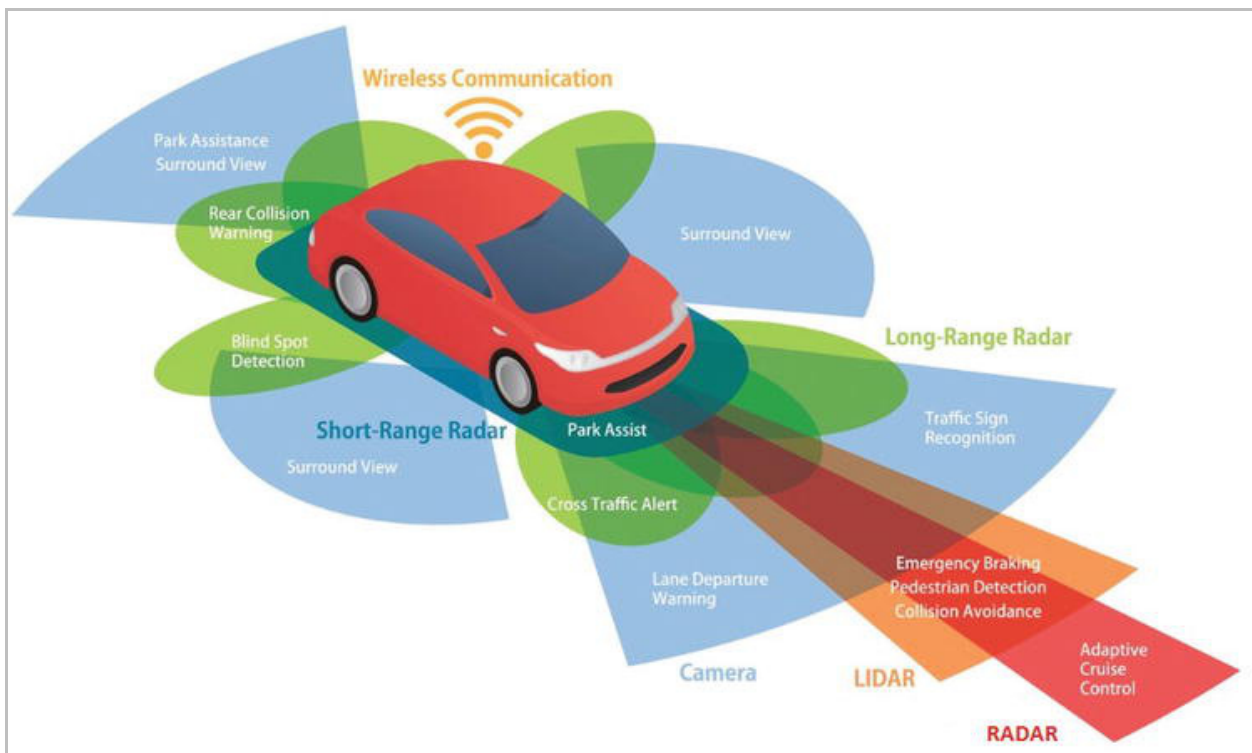

Figure 5: Wireless Communication and Sensors in Self-Driving Cars

Car producers believe that there are three things to be accomplished in order that society accepts autonomous vehicles [46-50]. Those are: trust, comfort, and control. It is out of high importance that the user trusts the safety of the vehicle, that it is familiar with their surroundings, journey as well as the user. In other words, the user must be well informed about what is the vehicle doing and its operations. Comfort is something that is always expected. Users will probably anticipate a car which has a premium-feel interior, long lasting, and easy to maintain, flexible seating configurations and a modern dashboard with a screen intuitive to use.

Great conditions for the driver and better control of the vehicle were confirmed with the research carried out by Google on their autonomous vehicles. The research proved that their self-driving Prius and Lexus cars are safer and smoother when controlling themselves rather than a human. Additionally, a dashboard has been developed to help people comprehend what is the vehicle doing. Hereafter, it may be concluded that the driving conditions for the user are impeccable.

6. CONCLUSION

In conclusion, majority of people would like to own such modern, driverless, easy to control, cheap to charge vehicle. Nonetheless, these vehicles will reduce pollution and save the environment due to electric drive. They will reduce accidents, traffic congestion, CO_2 emission, reduce travel time and the list may go further. Considering all the facts, autonomous vehicles represent the future of transportation and hopefully will soon become common in the streets.

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БУДУЋНОСТ САМОВОЗЕЋИХ АУТОМОБИЛА

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Савременог свет у блиској будућности очекује појава различитих начина кретања и врста превоза. Велику популарност у данашњем свету стекли су самовозећи аутомобили. У раду се објашњава како они функционишу, које су њихове предности и недостаци. Развој самовозећих аутомобила прилагођава се захтевима корисника. Многе аутомобилске компаније развијају сопствена возила без возача и истовремено раде на откривању и решавању проблема који би се јавили током вожње. Главна мана самовозећег аутомобила је безбедност његовог софтверског система који је подложан нападу „хакера" чије активности могу да га поремете. Ово је проблем који се још увек решава. Самовозећи аутомобили осавременили су начин кретања људи, омогућили су да људи не морају више да одлазе по своја возила, већ да возило долази до њих. Употреба оваквих возила је довела до појаве нових улсуга, као што је дељење превоза, а самим тим, до смањења загађења и трошкова у саобраћају. Развијене су апликације за паметне телефоне који олакшавају систем дељења аутомобила. Корисници ове аутомобиле сматрају удобним и елегантним, али очекују и висок ниво безбедности. Самовозећи аутомобили омогућују старијим људима, инвалидима и особама са посебним потребама да се крећу много лакше. Даље, самовозећи аутомобили смањују загађење и еколошки су прихватљиви. Очекује се да ће самовозећи аутомобили да преузму путеве и представљаће будућност превоза. Они нуде удобност, безбедност и добре услове вожње. У даљем тексту овај рад представља важне карактеристике самовозећих аутомобила.