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DIGITALIZATION IN MODERN TRANSPORT OF PASSENGERS AND FREIGHT

Abstract. This paper will present trends in the development of self-driving cars. Successful digitization of traffic conditions is one of the most important parts in this process. Solutions and successes of many companies that work intensively on self-driving cars and their testing to passenger safety in traffic is described. The paper also provides information on progress in the field of freight transport. Further development of digitization and robotization of passenger and cargo transport is no longer a matter of the future but of the present. This applies to land and water and air traffic at the same time. Within a few years, electric cars will be sold at the same price as traditional ones. Electric cars will become cheaper, because the cost of battery production is falling.

Keywords. self-driving car, sensor, data processing, robot taxi, car sharing, public passenger transport, freight transport

Introduction

In the modern world, more than 60 companies develop and produce electric and self-driving cars. Solutions for freight transport, by land, sea and air, are also presented on the transport market. Digitization of traffic and environment conditions are basis of successful development of driving algorithms. This paper presents some of the successes, but also the problems that scientists and researchers need to solve.

The Hyundai Ionik 5 with 30 sensors is a self-driving car

Hyundai Motor Group and Aptiv have set up a joint venture called Motional 2020 to build self-driving cars, while a car-sharing company called Lyft has also contracted to launch its robotic taxi service in 2023. For that purpose, a self-driving car based on the electric car Hyundai Ionik 5 (Figure 1) was built [1-3].The vehicle body has more than 30 built-in radars, cameras and sensors, so the electronics can monitor the entire vehicle environment, and even a learning-capable control unit. However, the controls and dashboards will remain in the passenger compartment as passengers are expected to to sit behind the wheel even while the electronics are driving.

Figure 1. Ionic5 details

A self-driving car is difficult to navigate in the Chinese rush hour

AutoX (Figure 2) is one of the first autonomous vehicle development companies to receive permission from the government to begin testing its vehicles on public roads in California, without the driver behind the wheel. In July 2020, more than 60 companies tested their self-driving cars, but most of them could only put vehicles into traffic with the driver behind the wheel for safety reasons [4-7].

Figure 2 AutoX

According to information from May 2021 from the Department of Motor Vehicles (DMV), the number of companies that can test without a driver is only eight, and that number is increasing compared to last year. Among them are well-known names such as AutoX, Waymo Nuro, Baidu, Poni.ai, or Zook, while Honda, Toyota, Apple or Tesla with 49 other companies are currently only authorized to drive vehicles with a safety driver.

AutoX launched its autonomous taxi cars with drivers in Shanghai in August 2020, then launched RoboTaxi without drivers and remote control in Shenzhen in January 2021, and in July introduced the Gen5 self-driving taxi system, equipped with Nvidia Drive GPUs capable of to cope with traffic jams. The system can perform more than 2,000 trillion operations per second (TOPS) of AI compute performance, the car covers the environment with 28 cameras and 6 lidars, and the equipment also includes 4D radar. Gen5 offers level four of autonomy, and thanks to a large number of sensors, it completely eliminates the problem of blind spots, and it is safe for use by self-driving cars even in the most populated areas.

Such a neighborhood is common in several large cities in China. In the evening, the so-called urban villages are full of residents who return home or travel to other parts of the city on scooters, bicycles or even on foot, often passing through traffic jams. AutoX has released footage of one of their cars driving itself through chaotic traffic conditions, successfully overcame obstacles created by people walking the road or a dog running between vehicles [8-12].

The implementation of full autonomous driving is expected in the future. It requires software improvements, a lot of expensive equipment and as much practice as possible. Security is a top priority, which could be achieved with the highest possible level of computing power for data processing and the necessary redundancy.

Problem with Tesla self-driving car

The National Highway Traffic Safety Administration (NHTSA), organization within the United States Department of Transportation, has launched an investigation about accidents caused by self-driving Tesla cars, models Y, X, S and 3, which were sold in the period from 2014 to 2021. 17 people were injured, and one person died, because the vehicles collided with the emergency vehicles of the police, ambulance and firefighters (*Figure 3*). Although the investigation has just begun, based on the technology of self-driving vehicles, it is possible to determine what is behind this dangerous phenomenon.

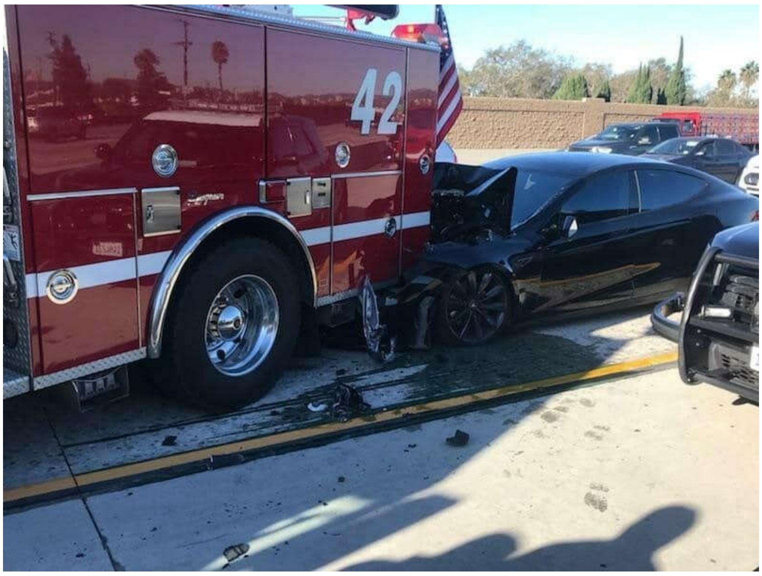

Figure 3. Tesla's collision with a fire truck

In general, self-driving vehicles identify what might be in their environment in two ways: by radar and by cameras. Both technologies require additional programming as well as artificial intelligence to safely "see" a vehicle or object. The operation of the radar is clear: the device emits waves that bounce off surrounding objects, and based on waves arrival, the radar identifies an object and where is it located. In the case of moving objects, it is considered that the wavelength of the bounced signal is extended, if the vehicle moves away from us or the wavelength is decreased when the object is approaching (this is the Doppler effect in physics). The computer can easily process this data, taking in consideration its own movement.

When approaching or passing by objects that are stationary, the same phenomenon occurs, which is why autopilots could activate emergency brakes even when they are not necessary. That is why radars are used in combination with cameras.

The cameras detect dots, i.e. pixels of red, green and blue light, and the computer determines what kind of object it can be, based on the obtained data. Technology is partly manually developed, by defining whether a particular shape belongs to a car, pedestrian or bicycle. In addition, the system is characterized by self-learning automation, which requires to a huge number of repetitions, which will let the machine decide more safely on the maneuver.

However, Tesla company has already completely abandoned the use of radar, because the cameras and artificial intelligence behind them are excellent in recognizing objects that enter the car's environment.

Researchers believe that this is the Achilles' heel of the system. It is extremely difficult to process the data due to the red-blue flashing lights of ambulances and police cars. This blinking light makes the system blind for a moment, when it fails to find appropriate patterns for possible objects and how to react to them. Accidents usually happened at night, when the effect of flashing lights was much greater.

According to experts, this problem can be solved if artificial intelligence learns to interpret flashing lights, as well as work under different lighting conditions. The reuse of radar or the introduction of laser radar (Lidar – laser imaging, detection, and ranging) next to the camera system is also being considered [13-19].

Robot-taxi by Google

Google’s Waymo is launching its taxi service with self-driving cars in San Francisco. In test mode, people selected by the company, can travel with Jaguar I-Pace SUVs.

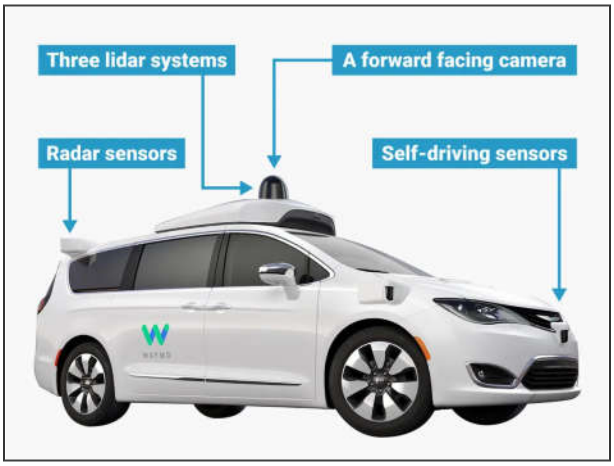

Figure 4. Waymo robot taxi

The ride can be ordered by anyone who uses the application. Since this is still a trial run, developers from the headquarters manually select a passenger – which means they may not be able to "catch" a taxi. Whoever is lucky enough to be selected gets a ride in one of the all-electric SUVs of the Jaguar on streets full of trams and cyclists. During testing for safety reasons, there is a man on each driver's seat, who follows the movement of the car with his hands on his knees. Compared to rivals, Waymo is moving faster on the road, but they are still far from the desired results. Problems occur with curbs, stopping and parking next to other cars, which often take up two parking spaces, or coping with different traffic jams during the day.

The Waymo robot taxi (Figure 4) has previously been tested in Phoenix suburbs, easier to drive and with less traffic jams, so the experience in the San Francisco metropolitan area will allow faster development [20-23].

The company started the development of self-driving cars in 2009 and has already performed testing in more than 10 American states. The test drives also included the company's freight service. San Francisco is one of the largest freight trucking markets in the United States. Uber and Lyft companies are also present in and around the city, and Cruise Company, which also uses autonomous vehicles, has received a freight license. Also present is Ford Motors, which plans to provide a robot taxi service in the city in partnership with Lyft.

The first fully electric self-propelled cargo ship completed an initial voyage

Yara Birkeland is not the first self-propelled cargo ship (*Figure 5*) – e.g. The Finns have been operating an autonomous ferry since 2018 – but this is the first fully electric and autonomous container ship, with zero emissions of harmful gases.

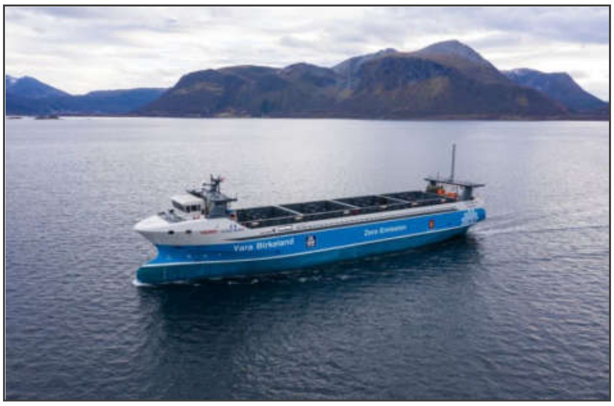

Figure 5. Yara Birkeland – self-propelled cargo ship

The initial voyage of the ship was scheduled for 2020, but the project was postponed due to the corona virus epidemic and errors discovered during production. During 2021, the first voyage of this ship without a human crew is planned, between two Norwegian cities, Heroya and Brevik. The movement will be monitored from three data processing centers. According to the data of the International Maritime Organization, out of the total emission of greenhouse gases, 2.5 to 3 percent falls on sea traffic, which is why the company's goal was to develop a fully electric ship. In Norway, most of the electricity is produced in hydropower plants (88%), followed by wind turbines (10%), while the least in thermal (coal-fired) power plants (only 2%).The project for the construction of this vessel was launched in 2017. Yara Birkeland is a ship capable of carrying 103 containers, a top speed of 13 knots (24 km/h) and has batteries with a capacity of 7 MWh. At full capacity, this unmanned environmentally friendly ship will reduce NOx and CO_2 emissions by reducing diesel-powered truck transport by around 40,000 journeys per year. In the beginning, people will perform unloading and loading, but it is planned that later all operations related to the ship – loading, mooring, departure, etc. performed automatically. This requires, among other things, the construction of self-propelled cranes and loading vehicles [24].

Experts predict that autonomous navigation has a future, but there are still many problems to be solved: development of communication between self-propelled cargo ships, development of automated fault diagnosis and self-repair of ships and creation of legal frameworks for their participation in international maritime traffic. Yara Birkeland sails without a permit along the Norwegian coast, but if he entered foreign territorial waters, he would find himself faced with the regulations of other countries (Figure 6).

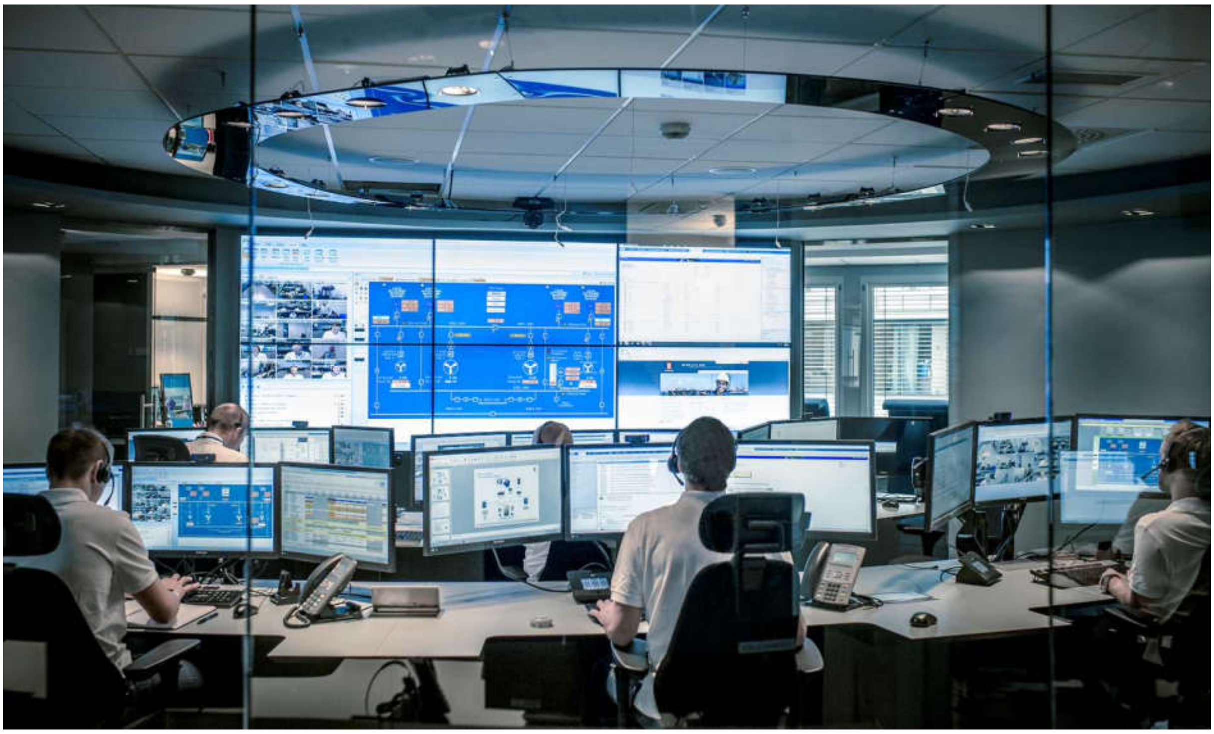

Figure 6. Yara control center

Conclusions

Further development of digitization and robotization of passenger and cargo transport is no longer a matter of the future but of the present. This applies to land, water and air traffic at the same time. Within a few years, electric cars will be sold at the same price as traditional ones. The EU market is now the largest, but in China, many companies want to produce an electric and smart vehicle.

Electric cars will become cheaper, because the cost of battery production is falling. The price of lithium-ion batteries fell 89% between 2010 and 2020, to an average price of $ 137 per kilowatt-hour. A further decline of 58% is expected for this decade. The revolution of electric and self-driving cars is happening.

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