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Autonomous Vehicles as Safety and Security Agents in Real-Life Environments

Ahmed Abdulhakim Al-Absi*

Associate Professor, Department of Smart Computing, Kyungdong University, Korea
absiahmed@kduniv.ac.kr

Abstract

Safety and security are the topmost priority in every environment. With the aid of Artificial Intelligence (AI), many objects are becoming more intelligent, conscious, and curious of their surroundings. The recent scientific breakthroughs in autonomous vehicular designs and development; powered by AI, network of sensors and the rapid increase of Internet of Things (IoTs) could be utilized in maintaining safety and security in our environments. AI based on deep learning architectures and models, such as Deep Neural Networks (DNNs), is being applied worldwide in the automotive design fields like computer vision, natural language processing, sensor fusion, object recognition and autonomous driving projects. These features are well known for their identification, detective and tracking abilities. With the embedment of sensors, cameras, GPS, RADAR, LIDAR, and on-board computers in many of these autonomous vehicles being developed, these vehicles can properly map their positions and proximity to everything around them. In this paper, we explored in detail several ways in which these enormous features embedded in these autonomous vehicles, such as the network of sensors fusion, computer vision and natural image processing, natural language processing, and activity aware capabilities of these automobiles, could be tapped and utilized in safeguarding our lives and environment.

Keywords: *AI, security, autonomous driving, AI cybersecurity, AV.*

1. Introduction

The concept of autonomous vehicles (driverless or self-driving cars) has seen considerable progress in recent years. Figure 1 shows the five levels of AV [1]. In 2002, Google declared that they had successfully completed more than 300,000 unmanned-driving miles (about 500,000 km) without accident, deploying more than a dozen cars on the road at a time and were starting to test them with single drivers [2]. At the end of May 2014, Google released a new prototype of its self-driving cars, with no steering wheel, gas pedal, or brake pedal, and was completely autonomous [3]. According to Google's accident report while testing the cars, a total of 14 collisions ware recorded, which were mainly caused by other human drivers and it was of recent (2016), that they recorded a crash due to the car's software failure [4]. Other companies and research organizations like

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Corresponding Author: absiahmed@kduniv.ac.kr
Tel: +82 336390108, Fax: +82 1021785226
Associate Professor, Department of Smart Computing, Kyungdong University, Korea

Tesla Motors, Toyota, Audi, Hyundai Motor Company, Volvo, Mercedes-Benz, General Motors, etc. have also developed working prototype autonomous vehicles [5], with several countries in Europe, UK and America permitting the testing of these cars and are also planning to operate transport systems based on them [6].

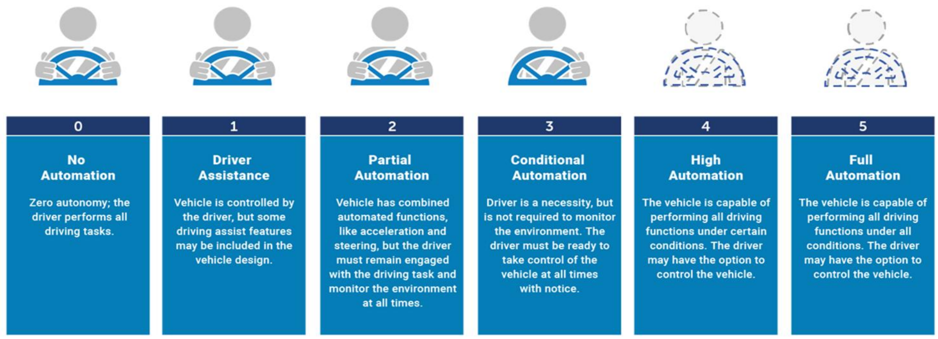

Figure 1. Autonomous vehicle levels

These vehicles are an applied use of increasingly sophisticated artificial intelligence and robotics capabilities [7]. AI is already pervasive in our world, and it is contributing hugely in our everyday lives and is going to bring major shifts in society through developments in self-driving cars, medical image analysis, better medical diagnosis, and personalized medicine. It will also be the backbone of many of the most innovative apps and services of tomorrow [8]. The backbone of recent breakthroughs in AI is deep learning. Because of the robustness of deep learning, there is no need to re-design already designed models because they have the ability to automatically learn to be optimal for any task at hand and also robust to natural variations in the data automatically learned [9]. Deep learning also has generalization approach because, the same neural network approach can be used for many different applications and data types, and its performance improves with more data, methods are massively parallelizable and new tasks can be easily accomplished [9].

To operate, the vehicles must be able to perceive its environment, make decisions about where is safe and desirable to move [10], [11]. This fit could only be possible with a combination of deep learning architectures and models. These deep neural network models must work hand in hand with high accuracy and sensitivity. Automated detection and tracking are paramount for reducing monitoring costs and improving event detection in modern security systems. Facial detection through the natural image processing capability of the Autonomous Vehicle (AV) technology can make it feasible to keep humans in the loop or to fully automate detection of events and tracking of subjects it captured and live video streams. Fast, precise AI units with fully dynamic response ensure optimal operation of these systems. Since these vehicles can perceive their surroundings and make critical and complex decisions, this work is aimed at examining ways in which the features of these vehicle could be maximized to help in tackling security and safety problem.

2. Autonomous vehicle sensors

Sensors are among the vital organs required by the AVs to operate. These sensors are Lidar and radar sensors, ultrasonic sensor, GPS, laser sensor, video and camera sensors (Figure 2). Almost all the autonomous vehicles use Light Imaging Detection and Ranging (LiDAR) to detect objects and camera for traffic sign recognition and delineation, influencing the overall mission planning; when the LiDAR detects an obstacle on the road, the mission is re-planned to avoid that object. LiDAR and camera are the only sensors based on light, capable of 3D representation and “reading”, which make LiDAR and camera essential for proper functioning of AVs [12]. However, Musk has argued that a RADAR system and passive optical sensors can be used to achieve the same goal as Google's LIDAR system. Musk applied 12 long-range ultrasonic sensors on Tesla vehicles, which provides a 360-degree projection around the vehicle. Also, they integrated one forward-facing RADAR system in each vehicle and putting these components together helps power Tesla's Autopilot system. The RADAR system sends out signals in form of periodic radio waves that bounce off objects in the cars proximity unlike the Google's LIDAR system described above [13], [14]. The pros of radio waves are that they are reliable in harsh climatic conditions and can be transmitted through heavy dust, rain, snow, and fog.

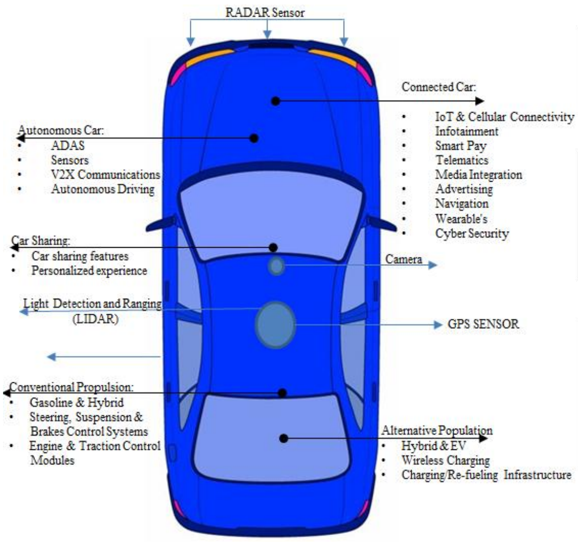

Figure 2. A typical autonomous vehicle with sensors

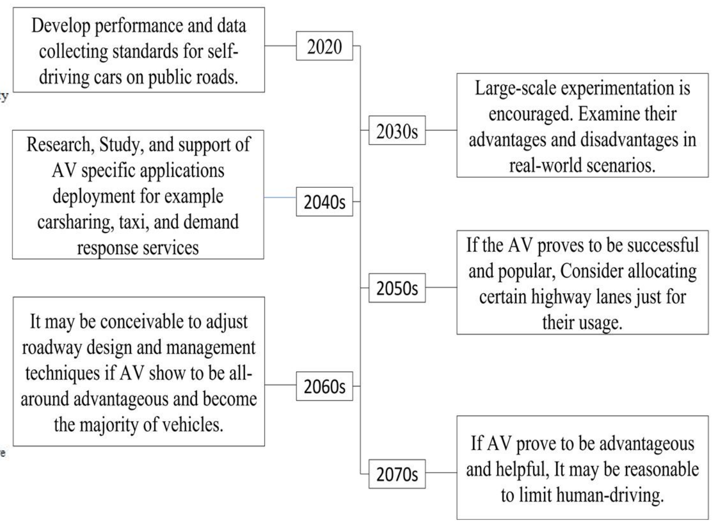

Figure 3. Summarized planning requirement for the autonomous vehicles

3. Artificial intelligence in autonomous driving vehicles

In the past 10 years, autonomous driving has developed rapidly. The autonomous driving system can sense and infer the surrounding environment, make a judgment to reach the destination safely and smoothly, and take actions to control the vehicle accordingly. The rapid development of artificial intelligence technology, especially machine learning, is an important driving factor for the realization of autonomous driving. The enhanced functions of the autonomous driving system using artificial intelligence and machine learning technology mainly include brake assist, intelligent parking, and voice interaction with the infotainment system.

1. Adaptive Cruise Control (ACC). The function includes adjusting the vehicle speed to maintain the optimal distance from the vehicle ahead; estimating the distance between vehicles and accelerating or decelerating to maintain the appropriate distance.

2. Automatic parking or parking assist system. This function refers to moving a vehicle from a driving lane to a parking lot, including identifying markings on the road, surrounding vehicles and available space, and generating a sequence of instructions to perform the action.

3. Car navigation. The feature uses location data provided by Global Navigation Satellite System (GNSS) equipment and the vehicle's position in the perceived environment to find directions to the intended destination.

4. Blind spot/crossroad warning/lane change assist. When the vehicle turns at an intersection or changes lanes, the sensors located at the relevant positions of the vehicle detect vehicles and pedestrians located at the side, rear and front of the vehicle.

5. Collision avoidance or forward collision warning system. Detect potential forward collisions and monitor speed to avoid collisions. The system typically estimates the position and velocity of vehicles ahead,

pedestrians, or objects blocking the road, and responds proactively to a possible collision.

6. Automatic Lane Keeping System (ALKS). Steering to keep the vehicle in the center of its driving lane includes detecting lane markings, predicting the lane trajectory in uncertain driving conditions, and performing vehicle maneuvering actions.

7. Traffic sign recognition. Identify traffic signs on the road, generally all traffic signs such as traffic lights, road signs or signs. This requires camera sensors to detect various signs such as shape, color, symbols and text.

8. Ambient sound detection. Detect and analyze sounds related to the driving environment, such as horns or sirens.

Artificial intelligence is not only used to implement various driving functions, but also proves to be of great benefit in infotainment systems and in-vehicle monitoring. These capabilities are starting to be increasingly integrated into vehicles, from embedded hardware dedicated to speech recognition to personal driving assistants controlled by voice and facial expressions.

- Human-Machine Interface (HMI) [15], which enables the interaction between passengers and the vehicle, such as issuing commands to the driving or entertainment system or receiving information such as the current itinerary.
- In-vehicle monitoring [16]. In-vehicle information is monitored through sensors such as cameras, microphones, temperature sensors, etc., to ensure passenger comfort.
- Vehicle functionality and artificial intelligence technologies are in sync (Table 1).

Table 1. functions artificial intelligence technology and Autonomous vehicle

Vehicle function	Computer Vision			Machine Learning			Control	End to End Method
	Object detection	Image detection	Vehicle localization	Circular Model	Markov Model	Filtering Model		
Road detection	-	X	-	X	-	-	-	X
Traffic sign Recognition	X	X	-	-	-	-	-	X
Object Tracking	X	-	X	X	X	X		X
Voice recognition	-	-	-	X	-	-	-	-
Position	X	X	X	-	-	-	-	X

4. AI cybersecurity issues in autonomous driving

The development of autonomous driving and the Internet of Vehicles puts forward higher requirements on the computing function and interconnection of vehicles, and also increases the possibility of vehicles being attacked by cyberspace. The cybersecurity risks of autonomous vehicles will have an impact on the safety of passengers, pedestrians, other vehicles, and related infrastructure, and there is an urgent need to study the risk of security vulnerabilities in the application of artificial intelligence. AI cyber threats can be divided into two categories: intentional and unintentional. Intentional threats include malicious exploitation of vulnerabilities in artificial intelligence and machine learning to conduct deliberate attacks and harm. Unintentional threats include unpredictable failures, failures, or other negative consequences caused by deficiencies, poor design, or inherent characteristics of artificial intelligence and machine learning.

4.1 AI cybersecurity challenges in autonomous driving

1. Systematic security verification of artificial intelligence models and data: Data is critical for building and validating AI systems and is at the heart of the learning process of machine learning models. Self-driving vehicles are generally equipped with multiple sensors and collect millions of environmental description data per second. These massive data sets provide basic support for complex and dynamic artificial intelligence models.

2. Supply chain challenges related to AI cybersecurity: Supply chain security is a top priority for cybersecurity. In the supply chain of AI components, without proper security policies and adequate policies, the system will be inflexible and there will be potential security holes. Security issues at all stages of the AI life cycle may bring security risks to the automotive supply chain.

3. An end-to-end overall solution that combines artificial intelligence network security with traditional network security: To ensure the safe operation of autonomous vehicles, AI security solutions should be promoted in autonomous vehicles and combined with traditional network security to improve the security of AI systems. The deepening dependence of autonomous driving on artificial intelligence technology not only provides an impetus for attackers to carry out cyber-attacks targeting artificial intelligence algorithms, but also the consequences of successful cyber-attacks are becoming more and more serious.

4. AI-related incident handling and vulnerability discovery capabilities: While many enterprise cybersecurity teams are aware of the cybersecurity implications of autonomous vehicle components and systems, it is often only when a security incident occurs, or a vulnerability is discovered that the real importance of security is realized. Although there has been a lot of publicity about security breaches, cybersecurity awareness is still weak, especially when it comes to security breaches related to artificial intelligence systems.

5. Lack of AI cybersecurity capabilities and expertise in the automotive industry: Due to the lack of expertise in AI cybersecurity by developers and system designers, security testing and code analysis of AI components were not performed during the development process, and cybersecurity policies were not formulated in advance during the application process, which led attackers to easily Self-driving vehicle AI components are targeted for attack. Therefore, artificial intelligence security problems usually adopt the method of post-event remediation, and mainly in the form of security plug-ins, which also creates good conditions for the occurrence of security vulnerabilities. Even if the artificial intelligence system considers safety issues in the design and development process, due to the variability of artificial intelligence systems, its additional equipment, software and functions will continue to change. Make adjustments to security configurations to assess potential security threats to AI systems. Most people have not received the corresponding training, so they cannot recognize the impact of changes in artificial intelligence software requirements on security, and they are not even aware of the security risks in some designs and choices of software, resulting in errors and omissions in the development stage. Resulting in the vulnerability of artificial intelligence software to be exploited. The lack of a management system that supports and encourages developers and designers to acquire AI security awareness through education and training is the most important issue for AI cybersecurity in the automotive industry. Businesses may lack the resources to provide AI security training, developers may focus primarily on software features and neglect cybersecurity, or developers may be aware of cybersecurity issues but constrained by budget and time constraints. Therefore, it is imperative that project leaders receive proper AI safety education and training, which can go a long way to ensure that decisions that undermine the safety of autonomous vehicles are not made.

The planning requirements for AV can be summarized as showing in Figure 3.

5. Conclusion

In this paper, we proposed autonomous vehicles as safety and security agents in real-life environments. The advancement of AV systems is driving innovation in many areas of technology. However, this increasing pace of innovation poses challenges for automakers as well as suppliers of equipment, materials, components, and manufacturing equipment. Automotive technical intelligence and intellectual property administration will assist automobile manufacturers and suppliers to protect their market position and identify additional sources of income by setting competitive standards and patent licensing negotiations and compensation.

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