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A Study on Autonomous Vehicle Using Sound Information Technology

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Abstract

Autonomous vehicles are cars that operate without driver's manipulation and are different from unmanned vehicles. Autonomous driving is a meaningful research project that is the first step to jump into a dream vehicle in which the driver's seat completely disappears. Recently, however, the speed of research and development has slowed down due to a series of accidents during the trial operation of autonomous vehicles. Autonomous vehicles, which have been studied in the past, are composed of various kinds of object recognition sensors, several special stereoscopic cameras, and graphic recognition devices. Although we are studying various IT technology and object recognition device with automobile production technology, technical loopholes are still being revealed. This is the process of creating a more complete autonomous vehicle, but it should never happen frequently. This paper has experimented and studied the application of sound information to autonomous vehicle technology. It is a sound information recognition technology that uses sound data as information different from sonar equipment using sound waves. sound information technology captures the realization of sound into big data, recognizes the environment by sound, and captures the movement of sound. Each sound entity has its own unique frequency, and the sound environment produced by the sound entitles is important information, and sensing the movement of sound entities may help to complete autonomous vehicles.

Keywords: Autonomous vehicles, Trial operation, IT technology, automobile production technology, sound information technology

1. INTRODUCTION

According to Article 2(1)3 of the Automobile Control Act, autonomous vehicle are defined as "a vehicle that can be operated on its own without the driver or passenger

being manipulated." Autonomous driving cars can be said to be dream cars that do not operate the vehicle but the various advanced equipments mounted on the car operate and move to the destination by themselves. Especially, as the development of digital environment by the development of computer system, the development of information and communication technology, the sensor technology by the advanced science and technology have developed,the dream for autonomous vehicles is becoming a reality now. In recent years, various cases of accidents have been known when driving the autonomous vehicle test, which has become a bigger concern and worry for the world. However, as mankind has overcome the trials, autonomous vehicles are being developed continuously. In particular, IT companies, computer companies, and transportation companies are more actively involved in the autonomous vehicle business, because the core technology of autonomous vehicles is information technology and the beneficiary is the transportation company. Car companies, IT companies and transportation companies are fiercely competing with each other. For autonomous navigation, it is necessary to use GPS, advanced sensor, high-performance camera to interoperate with computer system to recognize, judge and process driving environment information. Autonomous driving technology utilizes IT technology, electronics engineering, mechanical engineering, optical technology, navigation technology, graphic technology, geography, laser technology, and sound engineering as well as automobile production technology. So, many automobile companies, as well as IT companies such as Google and Apple, and science industries are taking the lead in technology development. In Korea, since the late 1990s, research on autonomous vehicles has been conducted through industry-university cooperation research. In this way, the competition of autonomous vehicle technology is getting hotter around the world. However, it is regrettable that there are numerous trial and error in the autonomous vehicle technology that has been accumulated so far and the accident of the driver or the pedestrian is occurring. In this paper, we have studied the application of sound information to autonomous vehicle technology in order to complement autonomous vehicle technology. In existing autonomous vehicle technology, sonar information using sound equipment is utilized, but it is different from that of sound information. The sound information is based on the subject represented by the sound, the environment represented by the sound, and the moving line on which the sound moves. We expect that sound information technology will contribute to the completeness of autonomous vehicles.[1][2]

2. CONCEPT OF AUTONOMOUS VEHICLE

The meaning of autonomy and freedom is different. Autonomy means to act freely while adhering to the basics, and freedom means to act perfectly by itself. Likewise, an autonomous driving car is an automobile which has a driver's seat so that the driver can ride the vehicle, but the car itself judges the situation and operates various systems and moves to the destination. If so, free cars are more developed in autonomous cars and can be said to be totally free-moving cars. That is, there is no driver's seat, and it will be a car that learns by itself from AI and drives passengers to where they want. The dream car, the ultimate goal of our autonomous driving car, is a

free driving car. Developers are testing the functionality of autonomous vehicle technology, which is currently being developed for commercial vehicles, one by one. Cruise control, parking assistance system, rear detection, lane departure, and inter-vehicle distance information system, which are now installed in the new car, can be considered as basic autonomous navigation technology. I have analyzed the developmental stages, principles and techniques of autonomous vehicles.[3][4]

2.1 Development stage of autonomous vehicle

Autonomous vehicles have been proposed and planned with the development of computer environment, information communication technology and various sensor technologies. The concept of autonomous driving began to emerge from the planning of the autonomous driving business in the 1960s. In the mid-and-late 1970s, a rudimentary level of research was initiated while testing lanes in an empty test drive. In this paper, we analyzed the development stages of autonomous vehicles based on 6 stages, which are the US automobile society and engineering society. Stage 0 is a general vehicle without an autonomous driving function, and stage 1 is a step with basic driving assistance functions such as an automatic brake and an automatic transmission.

Table-1 Development stage of autonomous vehicle

Stage	Stage 0	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5
main point	General vehicle driving	Driving with automatic brake and automatic transmission function	Partial autonomous driving / Lane keeping Cruising Obstacle detection	Semi-autonomous driving / In special situations Driver intervention	Completed autonomous driving / Driver intervention Unnecessary state	Completed autonomous driving / Boarding the driver Unnecessary state

Stage 2 is a partial autonomous driving stage that requires the driver to supervise at all times, and is equipped with functions such as lane keeping, cruise control, and obstacle detection. Stage 3 is a conditional autonomous driving stage, which we can often refer to as an autonomous driving car, and it is a step of controlling the safety functions of the vehicle itself by analyzing the driving environment and the situation by using various sensors, radar, and special cameras. Since each system is a testing phase, the driver must always be prepared for an unexpected situation. Stage 4 is a highly autonomous driving condition that requires little involvement of the driver. There is little opportunity for the driver to drive, but the driver must be in the driver's seat for departure, parking, or vehicle management. Finally, Stage 5 is a free driving car without a driver's seat that is completely autonomous. Departing, parking vehicle management, artificial intelligence and various systems are steps to move. You can send your car back to your home or you can just send a car to your acquaintance.[5][6]

2.2 Principle of autonomous vehicle

Companies and engineers in many fields are constantly challenging and trying to realize autonomous vehicles. The current stage of development can be seen in step 2 through 3 of the developmental stages described in 2.1. Autonomous vehicles require various technologies to move on their own. so, many experts develop and integrate technologies in 3 stages. The technology of the autonomous vehicle can be largely incorporated into 3stages: the recognition phase, the judgement phase, and the control phase. The basic technology concept of autonomous driving car is collectively referred to as advanced driver assistance system. In order for autonomous vehicles to be realized, The ADAS(Advanced Driver Assistance System) has been gradually introduced with new technologies. Starting with the automatic breaking system and automatic transmission system at the initial stage, It is moving toward the completion of autonomous vehicles with the introduction of ACC(Adaptive Cruse Control) technology that keeps the distance between cars automatically, lane keeping support system, lane departure warning system, rear side warning system, and so on. These progressive technologies have become a great basis for the development of autonomous vehicle technology. The first cognitive step is the most important technology in autonomous vehicles. This is because it is necessary to recognize the surrounding situation and collect information to make judgement and control. In the cognitive step, it collects information quickly and hand it over to the judgement step. The equipment that can perform this role well is LIDAR(Light Detection and Ranging), a key technology called the eye of autonomous vehicles, this includes sonic equipment, 3D cameras, radar equipment and remote laser systems. LIDAR is a kind of advanced sensor for automobiles, and it is an important system that enables autonomous vehicles to recognize, judge and control the environment and information in 3D quickly and accurately. [7][8][9]

Table-2 Development stage of autonomous vehicle ADAS system

stage	Contens	Applied technology
Recognition	It is the start of autonomous navigation technology as information input step. Distance to the car ahead, lane to drive, intersection, curve section, signs, unexpected situation, detection of interpersonal objects	LiDAR system GPS and 3D stereoscopic camera, laser, radar equipment, sound equipment, etc.
Judgment	It is a step to establish the driving strategy by analyzing the input information in the recognition step.	SLAM system Location tracking and mapping Computer Vision: Object Recognition
Control	It is a step to start full-scale driving based on the driving strategy established at the judgment stage.	Steering technology for direction setting Acceleration and deceleration technology Various signal display and defensive driving

LIDAR's principle is to measure the distance between a person or thing and an automobile by calculating the time the sensor fires millions of laser beams per second and then the light returns to the sensor. In the second judgement step, the driving strategy is established based on the information inputted in the recognition step. After analyzing the surrounding environment of the car, it analyzes the image and establishes a driving strategy suitable for the driving environment and the destination. The most common technique for judging is SLAM(Simultaneous Localization and Mapping). SLAM is a field of robot mapping, and based on quick positioning and mapping, the location of the moving vehicle is shifted to the map and the driving direction is instantly set through sensors and equipment installed in the vehicle. We also use equipment called computer vision to recognize various objects.[10][11][12]

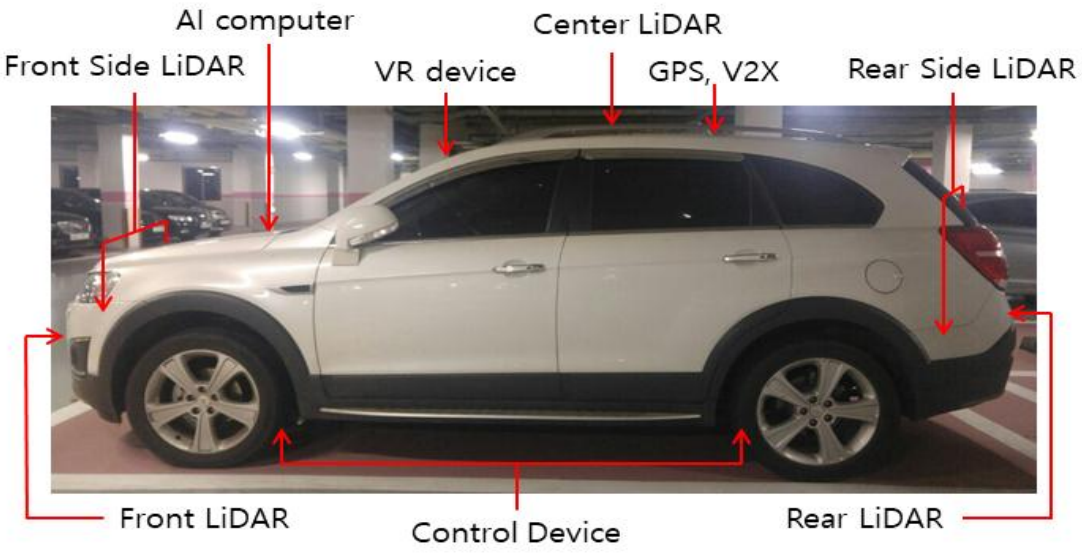


Figure 1. Principle of autonomous vehicle

In the third control step, the engine is started based on the driving plan established at the judgment step, the traveling is started, the direction and the speed are controlled, and the traveling is started in earnest. The control stage, which is a full-fledged driving stage of an autonomous driving car, is a step of controlling the vehicle while communicating with each other quickly and accurately. Since the control stage is a direct driving stage and there is a possibility of accidents, the safety measures must be thoroughly established. The autonomous driving vehicle LIDAR mounting position is forward, rearward, both sides of the front and rear sides, and the upper center of the vehicle. In this way, the LIDAR system mounted on a car detects nearby vehicles, lanes, and objects, and sends various kinds of information to artificial intelligence computers. VR Devices captures stereoscopic images, and GPS connects with communication base stations through satellites and performs precise position tracking by forming ultra-precise maps using Wi-Fi. The V2X uses mobile communication

networks to communicate between vehicles and vehicles and to supplement blind spots. The information obtained from LIDAR, VR, V2X is sent to the AI computer, which establishes the driving strategy and commands the control system to operate the autonomous vehicle safely.

2.3 The technology of the autonomous vehicle

Autonomous vehicles must be able to recognize all the surrounding objects and situations on behalf of the driver and drive safely. Such tasks can be performed while applying advanced sensors and high-performance graphics processing devices to recognize objects around them. The advanced sensor calculates the distance between the car and the object, the car and the car, the distance between the car and the person, and obtains the calculated data like the human eye and the ear. The graphics processing unit draws the surrounding environment of the vehicle with information obtained from several 2D and 3D stereoscopic cameras, and collects the data acquired through the advanced sensor so that the autonomous vehicle can move safely. Advanced sensors and graphics processing units also help to understand the meaning of various safety signs or to identify moving objects and act as a driver.

2.3.1 LIDAR technology

The LIDAR system consists of a 3D camera, radar, and sonic equipment, and serves as an eye for autonomous vehicles. The LIDAR system is a core technology for autonomous vehicles. LIDAR is an abbreviation of 'Light Detection And Ranging' or 'Laser Imaging, Detection and Ranging'. It performs 'detection and range measurement using light' and 'laser detection and range measurement'. In other words, it emits pulses of light or laser to the target and collects various information by measuring the time and intensity of return. The information LIDAR collects senses distance, direction, speed as well as temperature, substance composition and concentration. LIDAR creates a 3D map of the collected information in real time through a point cloud.

2.2.2 Deep learning technology

NVIDIA, an autonomous vehicle research company in Bell Labs, is developing a system for autonomous operation with a deep learning technology using spiral neural networks. Deep learning technology is artificial intelligence based technology which is called another conscious system other than human. It is a technology that enables a computer to think, learn, speak, and act on its own like a person. Deep learning techniques applied to autonomous vehicles use spiral neural networks among artificial neural networks derived from techniques for classifying and managing data. Autonomous vehicles also evolve by learning various information data, knowing their location, recognizing their surroundings, learning and upgrading their objects.

2.2.3 Connected Car technology

Connected car technology is a broad-based technology for autonomous vehicles, literally a networked vehicle. It is a technology in which IT technology is concentrated and connected to the Internet, mobile, other cars around my car, and furthermore, all the information with the driver is shared and operated. Autonomous vehicles are not possible without 5G network technology because they must be designed so that the vehicle can run on the driver's behalf. Beyond the 2G, 3G, and 4G era, the 5G era will be a key platform that will drive the fourth industrial revolution and will be an important platform in autonomous vehicles. As such, it is essential to use various advanced sensors based on the 5G environment. It is based on the Internet, and the automobile has to interact, judge and act on myriad objects, people, environment and situations. As well as the front car and the rear car, the side car and all the cars around it will travel on the road sharing information. Connected car technology not only stops driving, but it also incorporates IOT technology to operate household electrical appliances in the house and connect AI secretary to office work.

3. ACCIDENT CASES AND LEGAL REGULATIONS AND CONTROVERSIES OF AUTONOMOUS CARS

In Korea, there have not been any accidents during the trial operation of autonomous vehicles. However, there is a great possibility of legal disputes because the legislation such as specific types of autonomous vehicles, safety standards and basis of responsibility for accidents are slower than advanced countries like USA and Europe. In order to prevent such concerns, legal regulations should be urgently set up. It is worried that the delay of legalization will lead to disputes and it will be a stumbling block to the development of autonomous vehicle development technology, which may lead to a lagging behind as an automobile powerhouse in the world.[13][14][15]

3.1 Accident cases

At around 10 pm on March 18, 2018, autonomous vehicle in the Tempe area of Arizona was hit by a pedestrian. Uber's autonomous driving test vehicle collided with a woman who pulled a bicycle and walked on a driveway, not a pedestrian crossing. The driver in the driver's seat was also in charge of the autonomous driving, but he could not prevent the accident. According to a police investigation, it was found that the accident would have been an accident, even if it was a car that people drive directly. On the contrary, autonomous vehicles are judged to be radar, which is a machine, so some people judge that they have caused an accident even though they could have been avoided if they were driving. Among those opinions, those who expressed concerns about the safety of autonomous vehicles were once again raising the issue of stability of autonomous vehicles when the first pedestrian was killed by autonomous vehicles. Due to this accident, the Uber side expressed sympathy to the bereaved family and suspended the autonomous driving car. In the meantime,

accidents involving autonomous vehicles have frequently occurred in large and small forms at the trial run. Among them, Google's autonomous-driving car accident that occurred in February 2016, trying to avoid sand bags, is being recorded as the first accident that caused the autonomous-driving car to provide its cause. It was a minor accident with no casualties, but it raised questions about the safety of autonomous vehicles. In May 2016, the Tesla Model S fatal accident was recorded as the first death in an autonomous car driven by the US Road Traffic Safety Administration. According to the US road network and Tesla's announcement, the container trailer is turning left across the road, the sensor of the autonomous vehicle could not distinguish the white side of the high-cargo container from the sky, and the autonomous vehicle was in the lower part of the trailer. It was said that the vehicle could pass through the space and slipped under the car. Both the autopilot function of the model S and the driver are said to have not stepped on the brakes. Concerns over the completeness of self-driving cars are also emerging as a result of the fact that the autonomous vehicle, which was the first test vehicle in Singapore, caused a light contact accident and Uber-taxi was signalling a violation. US and Japanese companies have been braking to develop autonomous vehicles after the Uber traffic accident. US local governments, including Boston, have asked each company to stop driving their autonomous vehicles, and Toyota of Japan has decided to stop all autonomous driving test runs in the United States.

3.2 Legal regulation

When new technologies emerge, it is essential that new legal provisions be created. Autonomous vehicles also require legal judgment to clearly define the responsibility of the accident. Especially in terms of automotive technology that is directly linked to human safety. Countries around the world are making new laws to speed up the autonomous automobile age, and they are also revising existing regulations that are a stumbling block. If a drunk driver is sitting in the driver's seat of an autonomous drive vehicle and a major accident occurs due to a malfunction of the autonomous drive vehicle, is it the responsibility of the car maker or the driver? In Korea, when autonomous vehicles are commercialized until 2020, there will be legal problems that have not been experienced in the past. In the United States, California, in the fourth stage, which does not require driver intervention, a provision is made to ask the manufacturer for safety responsibility, and instead, a plan is being sought to obtain a license for autonomous vehicles. In the case of Germany, it may be a reflection of the development of the automobile industry, but the suggestion that it is necessary to clarify the legal regulations based on the level of technological development of autonomous vehicles is getting stronger.

3.3 The Controversy of Autonomous Vehicles

Since autonomous vehicles are technologies that are exposed to various accident risks in the process of moving people and moving the streets, concerns about safety responsibility and social controversy are raised. Above all, concerns about safety are

raised, and concerns about car and driver liability are high when an accident occurs. I also looked at the trolley dilemma and job problems.

3.3.1 Safety

Google, a leader in developing autonomous vehicles, is confident in the development of autonomous vehicles with a view that humans are far more dangerous than autonomous vehicles. According to Google, traffic accidents are actually caused by negligence on the part of drivers, violations of safety regulations, drinking and sleepiness, and pedestrians are frequently crossing. However, since it is composed of autonomous driving car and computer system and operates by interaction through information communication, vulnerability to hacking poses a serious safety hazard. It is reported that there is an automobile theft case through the hacking of the black box and the accident recorder of the automobile although it is not the case of the autonomous vehicle, so a complete safety device for hacking should be preceded. In addition, there are concerns that cracking, illegal access to the computer, bugs such as malfunction of the computer, and the like may cause the autonomous vehicle to cause an accident.

3.3.2 Responsibility of the accident

When an autonomous driving vehicle on which a driver is driving causes an accident in the autonomous driving mode, there is a high possibility that conflicts will arise between the driver and the autonomous vehicle. In the test phase, it will be applied differently depending on the development stage of the autonomous vehicle, but it is considered that the subject of the accident will be the autonomous vehicle in the stage 4 or more. In this case, there may be a dispute with the insurance company, and auto insurers will have to scrutinize the insurance rider for autonomous vehicles. In addition, there is a problem depending on whether the manufacturer of the autonomous vehicle causing the accident is regarded as a deficiency of the autonomous vehicle model or the driving ability problem of each autonomous vehicle object. If an autonomous vehicle is commercialized, if such a problem is not solved, it is expected that a lot of lawsuits and workshops between the driver, the automobile manufacturer and the insurance company will occur.

3.3.3 Trolley dilemma

The trolley dilemma applies the logic proposed by the English philosopher Philippe Putt to autonomous vehicles. If the car goes straight ahead, it will hit five people. If you turn one direction, you will hit only one person. If you go straight ahead, you will hit five people. If you turn right, you will fall to the cliff and you will fall victim to only one driver. It may be controversial whether the program should be programmed to do so. From a mechanical point of view, it would be a real problem to study how to hit the obstacle rather than control direction and speed by thinking about the

number of lives.

3.3.4 Job loss

When autonomous vehicles are commercialized in earnest, there is a concern that the jobs of drivers in public transportation, courier service, and lorry drivers may decrease or disappear. In addition, there is no guarantee of employment for a driver's license school or a test staff. In order to prevent such a situation, it is necessary to prepare an alternative in which the occupational group related to driving and the autonomous vehicle business can coexist. In India, which already has a high unemployment rate, it has been declared to prohibit the development of autonomous vehicles. Some people think that the driver job is not merely a driver, but rather a service business, and there will be a separate group of assistant service drivers.

4. PRINCIPLE OF AUTONOMOUS DRIVING VEHICLE WITH SOUND INFORMATION TECHNOLOGY (SIT)

In recent years, there has been a debate over whether Uber, the world's largest vehicle-sharing company in the United States, is responsible for Uber's responsibility as a driver of an autonomous car. LIDAR, which is regarded as the core technology of autonomous vehicles, is using 3D laser stereoscopic cameras as well as 3D laser map reconstruction technology, as well as various sensors using laser beams, as well as sonar information such as sonar equipment. Why did the accident happen? Is the journey for perfection of autonomous vehicles still far? If so, why not integrate sound information technology (SIT) that you have not yet applied? Sound information technology may be thought of as sonar information through the built-in sonar equipment, but sonar information and sound information are different levels of information application techniques. Sonar information is a method of measuring the distance to an object by measuring ultrasonic waves and returning to the object by the returning sound waves. It is used to measure the presence or distance to an object. However, the principle of an autonomous driving vehicle applying sound information is a vehicle that informs, accumulates, and compares the sound of the received audio frequency band and carries autonomously as if a person hears and judges a sound. The sound information is applied to the reality of the sound, the environment of the sound, and the movement of the sound.[16][17]18]

4.1 Collecting sound through autonomous vehicles

Recently, as shown in Uber's autonomous vehicle accident, high-tech sensor, communication environment, computer system mounting and information exchange mechanism are improving the completeness of autonomous vehicles, but accidents are still happening at the trial driving stage. I have studied sound information technology to contribute to the perfection of autonomous driving car. The sound information has a perspective on the environment represented by the sound and the environment

represented by the sound, the copper line represented by the sound, in other words, the distance, speed and direction of the sound. The most important thing is to make the sound realization sound information, and it is necessary to accumulate big data through learning using AI. Beyond the step of distinguishing the substance of sound, it is necessary to distinguish the environment in which the sound represents. The sound environment will be the sound information made up of the realities of sound. And lastly, sound entities move in the sound environment, and information that grasps the distance and movement such as approaching or moving away from autonomous vehicle is needed. Such sound information should be learned as it continues to accumulate and be developed to such a level that the autonomous vehicle can respond to the sound like a personality and react immediately. I expect that sound information technology will contribute to the completeness of autonomous vehicles.

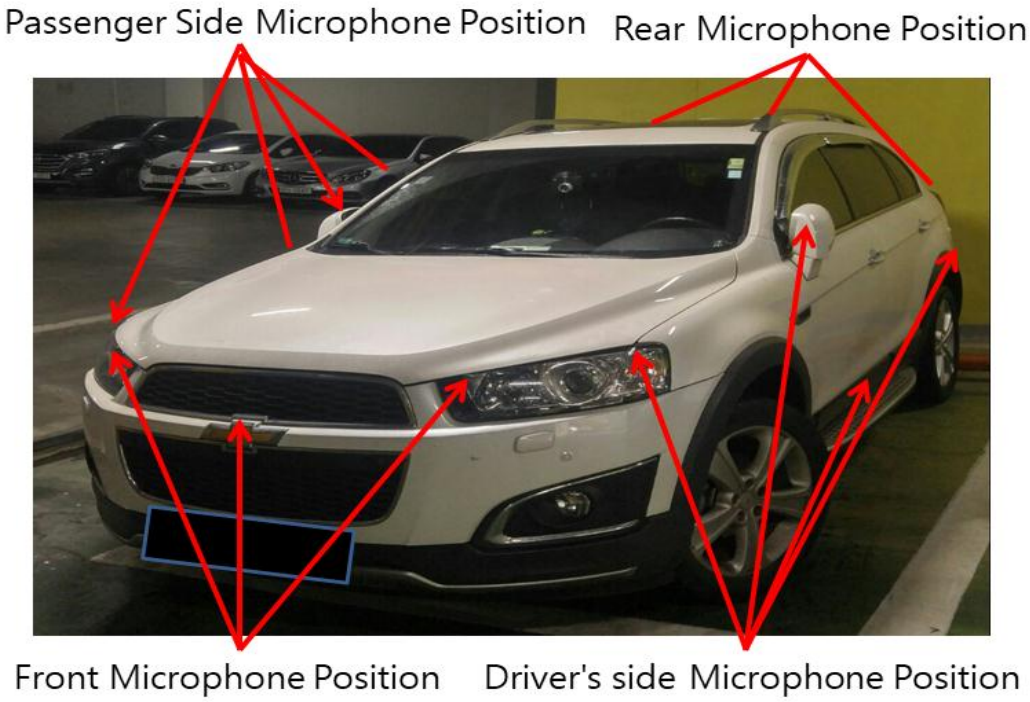


Figure 2. Microphone layout for collecting sound information

In order to apply the sound information, the sound must first be collected. It is important that high-performance miniature microphones for sound collection are embedded in the edge elements of the car and attached precisely to avoid wind resistance. There is a way to incorporate a microphone inside the car headlight. The right and left sides can also find ways to embed the microphone in a wall mirror or embed it in a turn signal lamp. The rear panel also incorporates a microphone built into the taillight or rear camera. It is possible to obtain more effective sound information by interfacing with the microphone in various positions built in the front and rear black boxes.

4.2 Contents of sound information for autonomous vehicles

Sound is also referred to as sound wave, which is a wave that propagates by vibrating an air, liquid, or solid medium, where the object is subjected to an external stimulus or by self-motion. The sound is made up of three elements, tone, volume, and pitch. The tone refers to the sound shape, the volume refers to the sound loudness, and the pitch refers to the level of the sound. Every sound has these three elements. A tone refers to the shape of the sound the sound has, and each object has its own waveform. Volume refers to the size of the sound, also referred to as the sound volume, in units of dB. The pitch is also called the scale and frequency, and its unit is denoted by HZ. These elements of sound create and potentially possess unique sound information of things. Just as the sound of glass, wood or iron is different, the sounds of various tones have the substance of sound. The sounds of high and low scales are combined to create a sound environment. And as the reality of the sound moves away, it gradually hears, and as it approaches, the sound moves louder and louder. The microphone attached to the autonomous driving car will help the autonomous driving by learning and accumulating the sound, the environment, and the movement as sound information.

Table-3 Contents of sound information

Sound information classification	Contents of sound information
The substance of sound	The collected sound is compared with the accumulated sound data and informed by the accumulated sound data.
The environment of sound	The environment of the sound is informed and accumulated as data by converting the data which constitutes a lot of informative and various sound entities.
The movement of sound	When the actual information of the sound and the environmental information of the sound are established, the information of the movement of the sound such as the distance, speed and direction of the sound entities in the environment of sound is informed and accumulated as data.

4.3 Analysis of sound information for autonomous vehicles

In order to apply the sound information technology to autonomous vehicles, the sound collected from the microphone attached to the side of the car was analyzed. The side microphone on the driver's side can collect sound information of the car coming from the opposite side of the center line. The side microphones on the passenger side can collect sound information of the car heading in the same direction. In the sound information of the side, both the realness of the sound and the environment of the sound and the movement of the sound can be grasped. In order to analyze the sound information, we analyze the time duration and the sound volume using the time domain waveform, the reverberation sound characteristic and the energy through the spectrogram, the sound band distribution and the whole frequency characteristics using the spectrum. Analysis of these frequency components uses the FFT concept to obtain the results.[19]20]21]

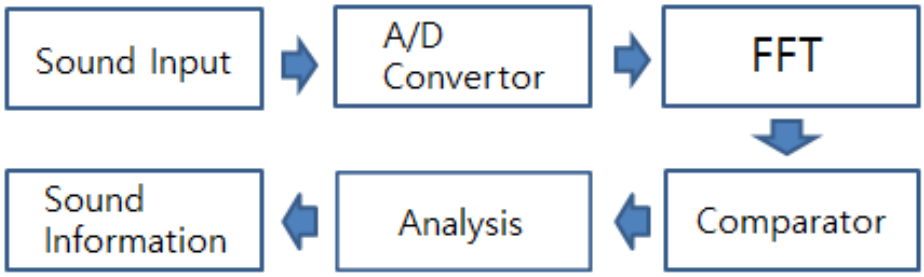


Figure 3. FFT diagram for obtaining sound information

In the waveform analysis, the energy of the time domain components was analyzed to verify the realness of the input sound and the result was obtained.

$$Time\_energy = \frac{1}{N}[\sum_{n=1}^{N}(E_1(n) - E_2(n))^2]$$

Equation (1) is the energy of the time domain.

Eh (n) is the data after the conversion of the input sound, and E2 (n) is the energy value of the sound information.

The similarity of each frequency component was measured by the following equation.

$$Frequency\_energy = \frac{1}{N}[\sum_{n=1}^{N}(FE_1(n) - FE_2(n))^2]$$

The difference of each frequency component was analyzed by the above equation and sound information was measured.

Equation (2) is a formula for converting sound information into data.

The frequency-converted data of the input sound is called FE1 (n), and the FFT converted value of the sound information is called FE2 (n).

The information of each sound was measured by the following equation.

$$D_{LS} = \sqrt{\frac{1}{2\pi}\int_{-\pi}^{\pi}[10\log_{10}\frac{P(\omega)}{\hat{P}(\omega)}]^2 d\omega}$$

e

$P(\omega)$: 원래 신호, $\hat{P}(\omega)$: 만든 신호

Equation (3) is a formula for measuring the spectral difference using Log-spectral distance.

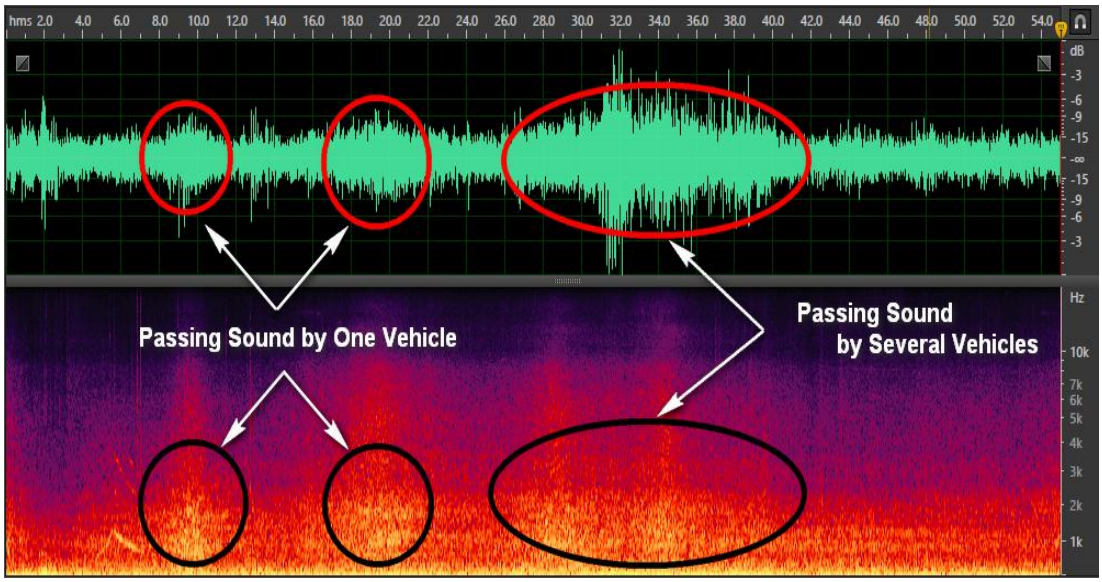


Figure 4. The sound Information on the driver's seat of the autonomous vehicle

Picture 4 shows a time-domain graph and a spectrogram graph of sound collected from a microphone attached to the driver's seat side of the car. The upper line shows the duration and the sound level of cars passing by the side of the driver's seat in the time domain graph. The bottom line is a spectrogram graph that shows the energy of sound in terms of color density and shows the change in sound energy of cars passing to the side of the driver's seat. The two circles on the left side of the graph are slightly distant from the graph of a car passing by, so the energy for sound and duration is expressed weakly. The elliptical circle on the right side is a graph that passes by several cars close together at the same time, and has a wide sound, a long duration, and a strong energy. The sound information is shown differently when passing one by one and when passing several parties.

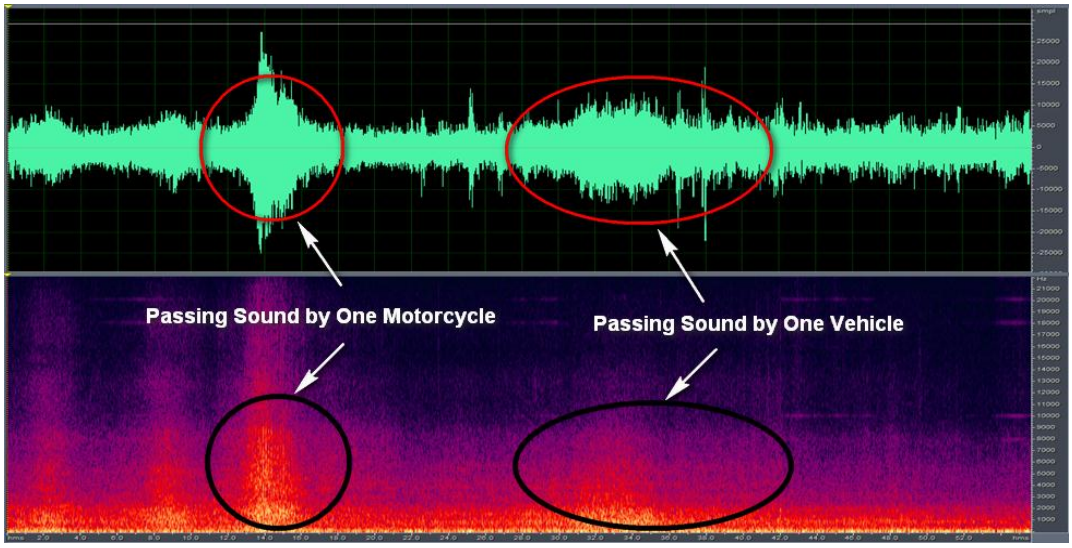
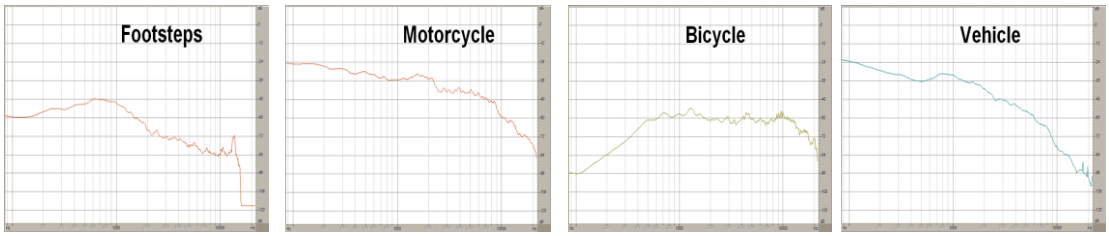


Figure 5. The sound Information on the Passenger seat of the autonomous vehicle

Picture 5 shows a time-domain graph and a spectrogram graph of sound collected from a microphone attached to the side of the passenger's seat. The top line is a time-domain graph that shows the duration of the cars passing through the side of the passenger's seat and the degree of sounding. The bottom line is a spectrogram graph showing the energy of the sound in terms of color density. It is a graph showing the change in the sound energy of cars passing by the side of the passenger seat. The left circle in the graph above is a graph passing by a motorcycle passing over close, and the energy for the sound and duration is strongly expressed. The elliptical circle on the right side is a graph passing over the right side of the car. The sound energy is lower than that of the motorcycle, but the characteristics of long duration and energy are expressed by the sound of the characteristic of the vehicle.



a. Human footsteps b. Motorcycle c. bicycle d. vehicle

Figure 6. The natural frequency of the sound received from the microphone installed in the autonomous vehicle

Figure 6 shows the frequency characteristic of sound entities extracted from a microphone installed on the side of a car using a spectrum graph. People's footsteps,

motorcycle sounds, bicycle sounds, and car sounds have their own unique mean frequencies, so it is well worth the sound information to be applied to autonomous vehicles. The natural frequencies for the sounds of the same object have similar frequency characteristics. If you make the frequency characteristics of the common frequency band as data, it will be good sound information.

4.4 Application of sound information in autonomous vehicles

Let's take a look at the application of sound information technology to autonomous vehicles. The sound data collected from the exterior of the vehicle and the microphones installed in the interior of the vehicle are informed through the sound information system and applied to autonomous vehicles.

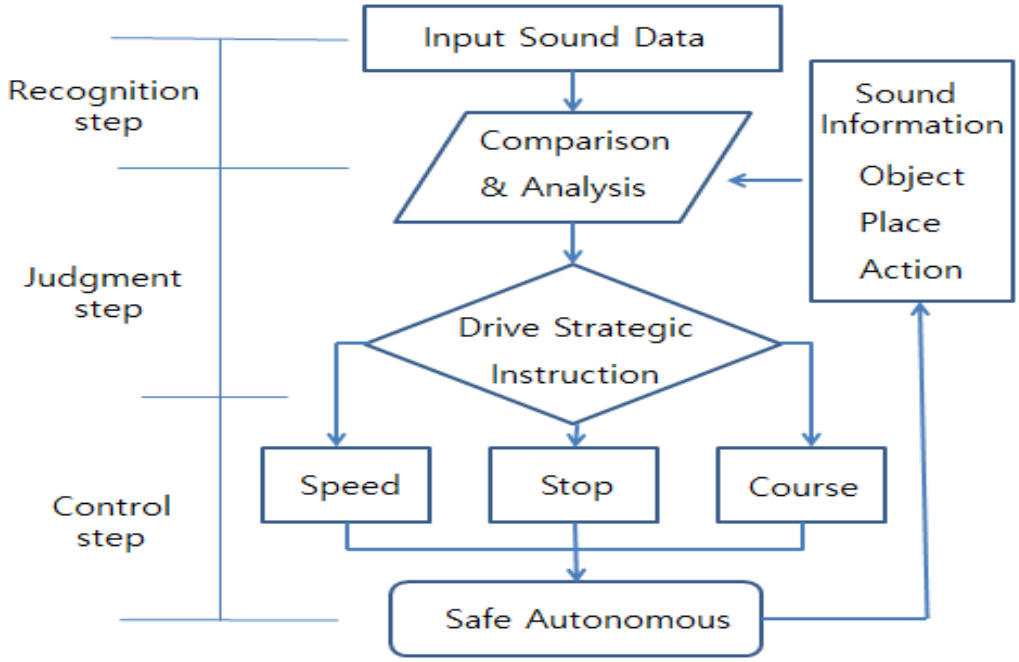


Figure 7. Flow chart of sound information technology application of autonomous driving car

In the sound information system, the input sound is informed through the sound collection, and compared with the existing big data, it is sent to the recognition step, LAIDAR system through precise review. The LAIDAR system sends all information to the SLAM system, which is the judgment stage, together with the information recognized by various advanced sensors and stereoscopic camera equipment. In the SLAM system, objects are recognized on a map and a driving strategy is established by using a location tracking device, a mapping device, and a computer vision. Various mechanisms are operated through the control step according to the driving strategy established at the judgment step, and the autonomous driving vehicle

finally runs on its own. Sound information technology will fuse with conventional sensor technology, special stereoscopic camera, graphic implementation and recognition device, and help safe driving of autonomous vehicles. I have constructed a flow chart for application of sound information technology to improve the function of autonomous vehicle.

5. CONCLUSION

From 2020, the world's autonomous car market will become more competitive. The era of autonomous driving of dreams that I have only seen in movies in the past is right in front of my nose. When an autonomous vehicle is commercialized, the driver's feelings of behavior such as accident, driver's abuse, repulsive driving, etc., such as signal violation and speeding driving, will disappear. In addition, it is possible to obtain the effect of reducing the traffic congestion by eliminating the wrong driving due to driving habits such as drunken driving and sleeping driving. In addition, driving of the elderly and the disabled is also convenient, which is expected to have a positive effect on social welfare. However, on the one hand, autonomous vehicles use various advanced equipment such as computer and IT information, various sensors, etc., and therefore, there is a concern about equipment failure. Especially, there is a great concern about the possibility of hacking a communication network using satellite or the Internet. In addition, legal disputes over whether to consider accidents caused by autonomous vehicles as the responsibility of the car maker or the responsibility of car owners to manage them will also be a concern, which will affect the character of car insurance in the future. However, if the implementation of more secure and secure devices and the security of the complete network is established, autonomous vehicles will be able to enjoy a smart traffic environment. In this paper, we have studied sound information technology as a more reliable and secure device implementation of autonomous vehicles and have been able to derive the possibility. I can see that the sound has the substance and the environmental sound according to the place forms the harmony and actively moves with the sense of distance and speed with three dimensions. As such, there is a unique and diverse information in the sound, so it is expected that it will make a great contribution to autonomous vehicle technology if it is used correctly and appropriately. I hope that sound information technology will be actively applied to the development of autonomous vehicles and help them to come up with the perfect five - stage autonomous vehicle age.

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