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A Study on the Design of Virtual Engine Sound of Eco-Friendly Vehicle

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Abstract

In the development of means of transportation, human beings who walk, ride or ride carriages are now enjoying the benefits of many means of transportation, including bicycles, airplanes, trains, buses, and cars. In the case of automobiles among various means of transportation, there is an advantage that an individual can conveniently move while possessing it. To solve air polution problems at the same time, eco-friendly automobiles such as low-noise, low-pollution, and high-efficiency automobiles have emerged. However, in the case of eco-friendly vehicleJ, engine noise at low speeds is a noise that is unlike existing vehicles and poses a threat to the safety of pedestrians. In this study, virtual engine system has been developed to prevent engine accidents caused by low- The pedestrians are aware of the fact that the vehicle is approaching.

Keywords: *Virtual engine sound, Engine sound, Waveform synthesis, Frequency analysis*

1. Introduction

In the development of means of transportation, human beings who walk, ride or ride carriages are now enjoying the benefits of many means of transportation, including bicycles, airplanes, trains, buses, and cars. In the case of automobiles among various means of transportation, there is an advantage that an individual can conveniently move while possessing it. According to a survey by the Ministry of Land, Transport and Maritime Affairs, the number of registered automobiles in Korea is estimated to be 21 million as of December 2015. [1] Even if you exclude special vehicles such as taxis, buses, and construction vehicles, you will know that you own one car per household. In less than half a century, the number of cars has surged and environmental pollution, air pollution and energy depletion. [2] To solve these problems at the same time, eco-friendly automobiles such as low-noise, low-pollution, and high-efficiency automobiles have emerged.

However, in the case of eco-friendly vehicles, engine noise at low speeds is a noise that is unlike existing vehicles and poses a threat to the safety of pedestrians. Paiiicularly in the case of narrow roads and alleys, the visibility of pedestrians is limited, leading to traffic accidents easily. To solve this problem, Virtual Engine Sound System (VESS), which is a virtual engine system, has been developed. [3] Virtual engine system has been developed to prevent engine accidents caused by low- The pedestrians are aware of the fact that the vehicle is approaching.

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In this paper, we propose a virtual engine sound generation model using vehicle engine, RPM, and velocity considering the hearing characteristics of pedestrians. The composition of the paper is as follows. In Section 2, we examine the existing vehicle engine. In Section 3, we show the proposed method. In Section 4, we conclude.

2. Existing Vehicle Engines

Before today's energy and environmental pollution problems, automobiles are divided into three categories. Class 3 is divided into gasoline engine, diesel engine, and LP gas engine. These three fuels are determined by the process of extraction from crude oil. There are a lot of parts that make up an engine of an automobile, but the parts with major parts can be divided into three parts by crank case, cylinder block and cylinder head. The crankcase has a crankshaft that changes the reciprocating motion of the piston into rotational motion, and the cylinder block is actually the skeleton of the engine in which the piston moves. Finally, the cylinder head has an intake valve and an exhaust valve that open and close according to the movement of the piston, a spark plug for a gasoline engine, and a fuel injection nozzle for a diesel engine. The engine is operated in a four-stroke cycle in the form shown in Figure 3-1 below and is divided into intake stroke, compression stroke, combustion stroke, and exhaust stroke. [4-5]

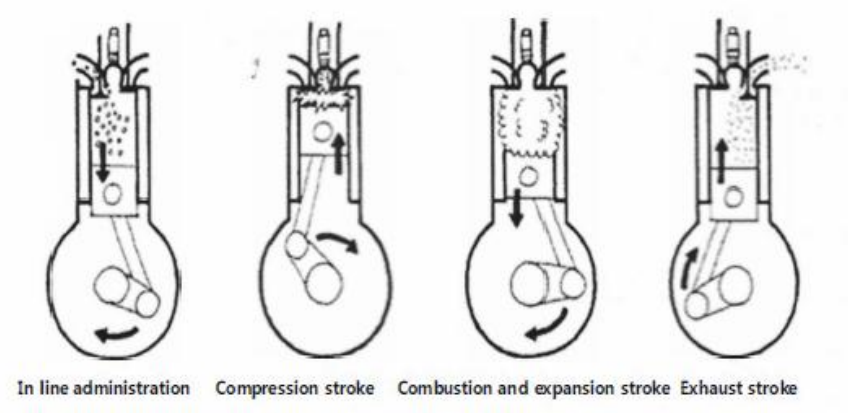

Figure 1. Structure and Operation Principle of 4-stroke cycle engine

3. Proposed Method

In this paper, we propose to make a customized virtual engine sound according to the change of engine type, RPM, and Velocity to create a virtual engine sound considering the hearing characteristics of the pedestrian. Figure 2 is a block diagram of the proposed method. We divide the original engine sound signal and design the engine sound considering each characteristic. After that, it generates the engine sound according to the change of RPM and Velocity in the engine model made by convoluting it. In addition, we propose a method of producing a virtual engine sound that is effective on the hearing characteristics of the pedestrian through the auditory perception of the pedestrian.

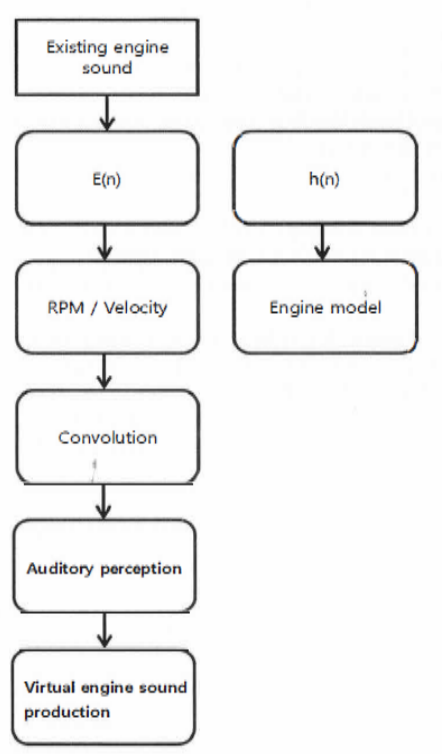

Figure 2. Block diagram of virtual engine sound production

Next, Figure 3 was recorded using SONY-PCM050 equipment for every 1000, 1500, 2000 RPM of diesel engine (Hyundai Tucson 2009 model year) and gasoline car (Kia Forte 2010 model engine sound), and using Adobe Audition CC program, (Red), the window in the car (yellow), and the sound source (green) produced by the proposed method.

As a result of the analysis, frequency energy was measured higher in the 60 ~ 100Hz band. However, it was confirmed that the energy drop was more rapid as the frequency band was increased. Also, it is found that the frequency component of the engine sound produced by the proposed method is higher than that of the conventional engine sound. In addition, when the gasoline / diesel engine is analyzed, the resonance frequency of the gasoline engine is more prominent than the resonance frequency of 1000, 2000RPM at 1500RPM. In the case of 2000RPM, the first resonance frequency dB value is smaller than 1500RPM, The harmonics came out noticeably. In the case of diesel, the resonance frequency energy at the position of 35Hz was large, and the dB value was about 6dB larger than that of the gasoline engine and several harmonics were generated. Based on the experimental results, it was concluded that diesel could feel engine sound even though low RPM is more weighty than gasoline. The analysis of psychoacoustic characteristics shows that the sharpness characteristic of sharpness is different according to the gasoline and diesel engine sounds, and similar characteristics are obtained according to RPM. By analyzing auditory characteristics, it is possible to listen mainly to the band that includes the fundamental frequency as a whole, regardless of the fuel characteristics, and the other band has a flat result. If the fuel characteristics are analyzed and analyzed, the diesel engine sound is more physically felt in the low frequency range than the gasoline, and depending on the RPM, the diesel engine sound is easier to feel the band including the fundamental frequency than the gasoline Results were obtained.

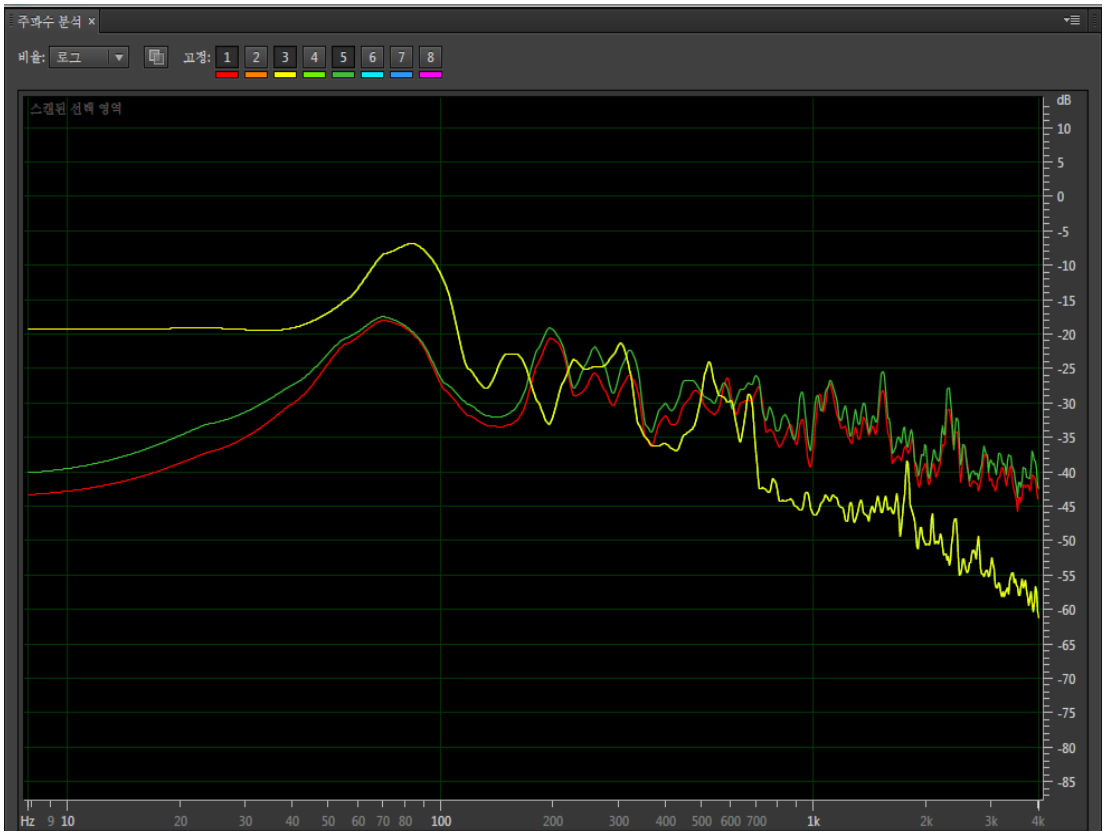

Figure 3. Virtual Engine sound spectrogram

4. Conclusions

As the economy develops over time, various technologies are being announced. Among them, battery technology is a technology that carries a big issue among many technologies. In the battery technology, the substitution of automobile fuel is not only as much as the automatic driving technology but also the car which uses the electric fuel is being introduced in Korea as well as abroad. The first step of the study was to analyze the acoustic characteristics of fuel (gasoline, diesel, gasoline). For this purpose, the actual engine sound of the vehicle according to the fuel was collected and engine structure and acoustic modeling work were performed. As a second step, we measured and worked on the acoustic characteristics of how the actual engine sound sounds physically in the audience. As a third step, I examined the psychological stimulation of the engine sound through the psychological perspective rather than physical viewpoint.

By analyzing the series of processes above, engine structure and acoustic modeling are invited to develop basic virtual engine sounds through physical acoustic characteristics, and finally developed to feel the engine sound psychologically, I have come up with a plan to develop it so that it can feel rich in the enemy.

The engine noise can be noisy according to the driver, but if you use it advantageously, you can check the problem in advance for the purpose of managing the vehicle. Furthermore, it can be a way to reduce the speed of driving. It is expected that various engine sounds will be improved and developed through the analysis presented in this study.

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