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A Study on Fault Diagnosis of Vehicles using the Sound Signal in Audio Signal Processing

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Abstract. The purpose of this paper is to do the advanced prevention for a serious car accident and to diagnose and repair a car trouble by archiving accumulated sounds of car problems. A car informs a driver of several symptoms when a certain part has a problem or it gives notice of a problem. The symptoms are like an abnormal vibration which a driver feels, some symptom which a driver can see, abnormality which a driver smells and a sound when staring a machine.   Among these, a sound plays a role as direct early warning. Also, since a sound is expressed in various ways, it is valuable to use as a diagnostic program by dating. A car diagnostic program through a sound can be given to an owner-driver when a car is released, can do self-diagnosis by installing on a car and can be used with an application in smart environment.

Keywords: Diagnostic, self-diagnosis, Analysis

1 INTRODUCTION

Recently, Korea joints the line of powerful nations for a car and competes with world prominent car brands. In data of current situation of registration for a car in Korea, each car registers population of 2.74 and the number of having a car in Korea is more than 18 million[1]. However, ignorance of an owner-driver regarding a car is more serious than we expected. There are many drivers who just know when the engine oil should be changed and how to put washer fluid and don't open engine room before having a problem. These drivers are embarrassed when their car has a problem and handle this problem poorly. Also, they could be ripped off from repair companies. However, if they have the interest in a car and knowledge of maintenance, they can prevent an accident and tyranny of repair companies. Human has an ability to use five senses, sight, touch, smell, taste and hearing. In case of diagnosing a car problem, the five senses can be actively used and even sixth sense can be used. However, in realistic car diagnostics, there is a diagnostic which uses four senses except for the taste which people should taste. First, by the sight, drivers can diagnose conditions such as an appearance of a car, an amount of engine oil, a battery when a car is parked. Then, sign of gauge can be used to diagnose with naked eyes when a car is in standby or runs. Second, by the touch, drivers can diagnose a condition of a car with the abnormal vibration which drivers feel from the steering wheel and a seat during staring a car or driving[2][3]. Third, by the smell, drivers can diagnose a

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car problem through the smell from a car. However, when drivers smell something, usually, it indicates serious problems in a car. Therefore, drivers should stop a car when they smell. Forth is the diagnosis through hearing, which this paper handles. A car is whole of the most advanced scientific technology which operates as more 25,000 components engage one another. Also, the interest in the sound which the components make is valuable data to diagnose a car problem.

2 STUDY REGARDING CAR DIAGNOSTICS THROUGH THE SOUND

This paper is the study about diagnostics for a car through the sound. For individual, this study needs a lot of time and labor. Therefore, cooperation with repair companies, car manufacturing companies and centers for automotive research is needed. Although each car model is different, basic structure and principle are the same. Therefore, the same part which has a problem makes similar sounds. As a result, the study on the fault diagnosis in accordance with the sound is regardless of a car model. However, in case of using the self-diagnosis program and the application in the smart environment, the voice recognition technology should be introduced. Therefore, the same model should be used to get are exact result of a diagnosis. The best way is that when car manufacturing companies has a plan of a new car, they make fault conditions on purpose, extract sounds and archive the data before releasing a car. In order to install self-sound diagnosis system on a car, the voice recognizer should be installed on a car and programming is needed to analyze the archived sounds of a car. This effort not only contributes to cultural and technical improvement related to a car in one country, but also prevents a loss to a country and rises in economic value by reducing the accident rate because of a car trouble[4][5].
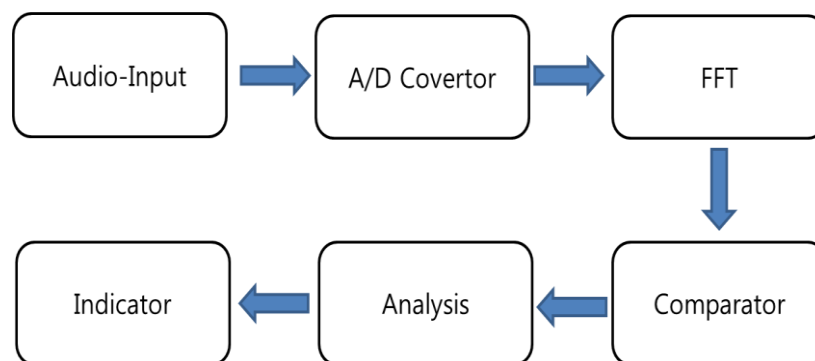

Figure. 1. Diagram about for self Sound check system and Applying smart environment application.

2.1 For experimental purposes

By comparing the engine idling sound of SUV and the engine idling sound of the same car which shows symptoms of a problem when a car is parked, the characteristic of the sound is figured out and the possibility of the study on car fault diagnostics using the sound is diagnosed.
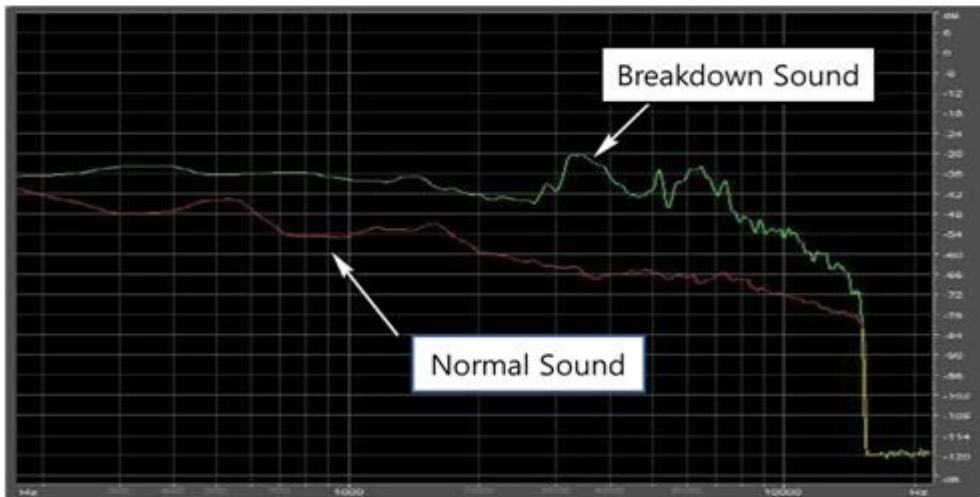
2.2 Experimental methods

Figure. 2. Comparative and analysis spectrum about the Sound of generator failure and normal vehicle.

First, keep data after recording the idling sound of engine when a normal car is parked.

Second, keep data after recording the idling sound of engine of the same car which shows the symptoms of a problem when an abnormal car is parked. The engine idling sound of the normal car is called standard sound and the engine idling sound of the abnormal car is called trouble sound.

Third, by analyzing the standard sound and the trouble sound through an acoustic analysis program, the data of the difference is made.

2.3 Experiments and Results

1) Trouble Symptom: repeating revolution sound of metal-scratching was getting worse and suddenly a steering wheel and a brake pedal didn't work. Therefore, it could almost encounter a big accident.

2) Cause of Trouble: bad condition of looseness of a belt, trouble of a generator because of a decrepit and damaged problem

3) Solution: the belt and the generator were changed and the looseness of the belt was checked.
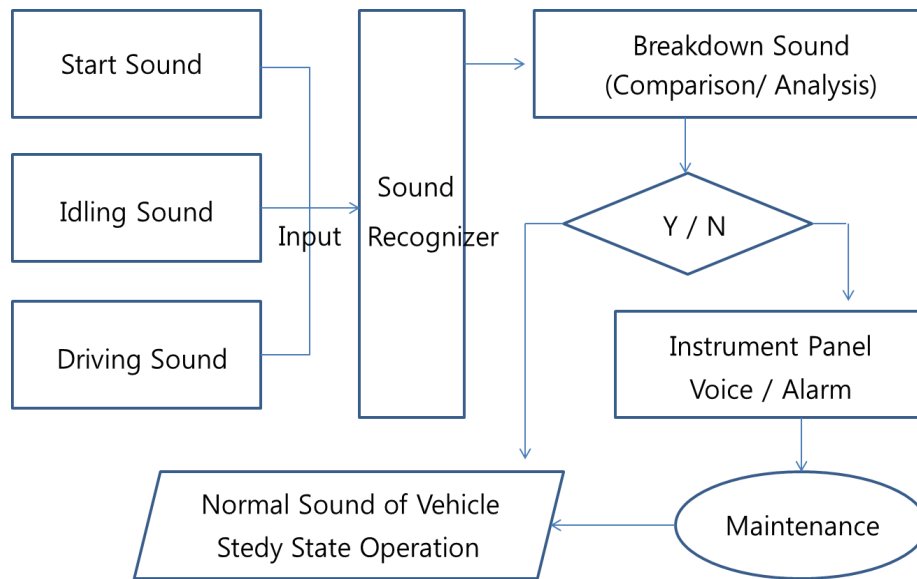
Figure. 3. Self-diagnostic flow chart of the vehicle through the sound.

By analyzing spectrum of normal sound and abnormal sound, the definite difference is shown. The engine sound of the normal car is soft, rhythmical and middle-low tone like the waveform at the bottom of spectrum in Fig.2. However, the engine sound when having a problem of the belt and the generator was friction sound in 3,000Hz~8,000Hz like an upward waveform. Like waveform analysis in this experiment, by making data of common waveform analysis according to the trouble situation of the same type, the possibility of commercialization of the car fault diagnostics program was confirmed. The possibility of commercialization can be explained with flowchart in Fig.3. By comparing and analyzing starting sound, engine sound and driving sound with the existing data of trouble sound through the sound recognizer, and warning with an indicator light, alarm or voice, drivers can do preventive maintenance. Therefore, they can prevent the accident caused of trouble of a car.

2.4 Data of the breakdown sound

Table 1 is an example which collects data of diverse studied sounds related to a car trouble. The sound of the normal car is standard and the trouble sound is divided into the trouble sound when a car is parked and the trouble sound when a car runs. Also, the trouble sound when a car is parked is classified into idling and starting and the trouble sound when a car runs is divided into an engine part and others. With fault diagnosis details, the trouble sound is well described by Korean language which is a phonetic word.

Table 1. Trouble diagnosis details and solution plan through the sounds which occur at the Vehicle.

Problem	Generative Sound	Diagnostic contents	Solution Plan

Part				
Drive	**Engine Part**	"gi gig~,gi gig~"	Coolant, Engine oillack, Engine Overheat	Coolant, Engine oil Supple
		"ggik-,ggik-"	Radiator trouble, Engine Overheat	Radiator part, Replacement
		"ggiggik,ggiggik"	Gasket damage, Engine oil concern	Gasket Replacement
		"garrik,garrik"	Coolant, Water Pump Trouble	Water pump bearing Service
		"shik~,shik~"	Radiator hose damage, Engine Overheat	Hose, Coolant Supplement
		"kooluck,kooluck"	Coolant Thermostat(80°) trouble Engine O.H	Thermostat Exchange
		"fafa-, fafa-"	Water percolates,Spark plug Failure	Dehumidification, Exchange
		"fafafafak,fafafafak"	Ignition system fail, Incomplete combustion	Ignition system, Check SVC
		"shue~, shweek"	Suction or Exhaust trouble, Engine concern	Hose orGasket Exchange
		"dulkulk,dulkulk"	Abnormality of a drive shaft which take charge the drive train ratting because of water and humidity	After eliminate humidity, check and change the rusty or broken part.
		"woowoong~"	Shortage of oil at each part(engine , transmission, break)	oil supplement & exchange
		"dalgrak, dalgrak"	Injection of foreign substance in engine room and faulty of fastener condition.	Eliminate foreign substance, check the fastener condition
	Etc, Part Situation Variables	Brake"bbee~ ik"	Brakepad or brake shoeAbrasion phenom	Brake pad, shoeExchange
		Brake"gruc, gruck"	Transform of brake disc .hardening of pad, foreign substance.	Check the brake and take action.
		Gear "gga, ggang"	Fricative because of gear shift abrasion.	Check gear shift, change and supplement the oil.
		Handle"ddagurak"	Damage of steering gear due to shock, radical control.	Check and repair the steering gear box.
		handle"ddugguck"	Occur when we turn the handle .Faulty of fastener and abrasion .	Check the steering system
		Bumpy"bbeegguk"	Damage of shock absorber because of shock from uneven ground.	SuspensionCheck, change the shock absorber.
		Bumpy"ddooduk"	Loosening connector of suspension, greases , shortage of oil.	suspension systemCheck
		curve"ggiggiggigik"	Damage of tire wheel packing and bearing.	drive shaftCheck, change the abnormality part.
		Tire"jjalggakjjalgak"	Run a nail into tire , or injection foreign substance into hubcap.	Repair at the near garage.
		Accel,"tungtung"	Damage of drive shaft, gear, bearing, joint.	Check the drive shaft.
		Accel"gu~woong"	Sound due to break down of gearing and abrasion of transmission gear.	Check the transmission and subsynchronous.
		Accel"jjeejikjjeejik"	Slag of fan belt tension and overage phenomenon.	Control the tension and change the fan belt.
		Accel"dudook du"	Metal trouble because of the abrasion of crankshaft of	Check&repair transmission engine oil

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			connecting rod.	change
		Accel"chulkuck"	Damage of rubber mounting which fixed engine and transmission.	Check the mounting part and repair.
		Accel"burreeruruk" --> "budadadang"	Fall out the exhaust system and decline of engine output which leak gas because of abnormalityof exhaust manifolds, muffler.	Check and repair the exhaust manifolds
		Turn "gururuck"	Damage and abrasion constant velocity joint which deliver the change of speed to wheel.	Check the constant velocity joint.
		Step on the clutch "ssheeik, ssheeik"	Damage the releasebearing which block the engine power.	Check the release bearing
		Gear chang "ggieeikggieeik"	Pilot bearing connected with main axis, release lever, abrasion of shift lever, asynchronism phenomenon of synchromesh	Check the gearbox.
		Airconditioner "ggiggiggi~"	Breakdown of bearing ,airconditioner belt and compressor rotating unit.	Check the air conditioner part.
Stop	Starting	"ggigik~ ggigik~ " "ggiririck, ggiririck"	Discordance of ring gear of fly wheel and starter motor or battery consume.	Exchange or recharge the battery and check the starter part.
		"ggiggiggi","ggieik"	Damage of pulley part which connected drive belt.	Check and repair the drive belt part.
		"baaaang, baaang"	Blockage of muffler and exhaust manifold in winter.	Check and repair the exhaust part.
		"ddagddagddag"	Abnormality of lubrication system and valve clearance because of shortage of warm up in winter.	Check, repair the lubrication or valve system.
		"ddagakddagak"	Abnormality of valve clearance and abrasion of CAM axis.	Check the CAM axis , rocker arm and valve clearance.
	Idling	Regular Fricative sound	Occurance when abnormality of moving component according to engine rotation especially timing belt.	Check the timing belt and drive part.
		"faduck,faduck"	Annealing or slagging of timing belt and drive belt. Drive belt : increase noise when it accelerate. Timing belt : decrease noise when it accelerate.	Check the timing belt and drive part. Check the tighten condition.
		"shwoo~ shwoo~~"	Unusual suction phenomenon of air into the intake system or more	Checktheintake system related parts, repair

3 CONCLUSION

Owner-drivers misunderstand. They think that a car is durable goods like a building. However, a car is also consumable. It is consumer goods which people should maintain to use for a long time[7]. Since a car is mutual combination of mechanism and a moveable machine which operates by meshing, the sound is generated. However, there is difference between the normal car sound and the abnormal car sound. The sound makes it possible to do the fastest diagnosis among human's senses. Because drivers are always sensitive to the sound, they can recognize the strange symptom early. Recognizing early can prevent a trouble in advance, which can be serious later, and it is confirmed that the sound is the excellent data for the car fault diagnostics. As generation which each adult has one car, owner-drivers should have interest in not only

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purchasing and driving a car, but also using car economically by maintaining and diagnosing in advance to prevent a fault. For this, government or car manufacturing companies should give diagnosis archive using the sound to owner-drivers and the application is need to be made in the smart environment. Therefore, I suggest that the car manufacturing companies collect sounds by making situations before releasing a new car, and analyze what the sounds indicate and make data. Then, they make a car diagnostic program and give it to drivers. Besides, as we are living in the smart environment, the plan which grafts the car fault diagnostic sound onto the application is suggested. Then, by introducing sound recognition technology on a car, the system which informs drivers of warning by collecting, analyzing and diagnosing is considered. This is what automobile companies should have for their benefit, responsibility and obligation.

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