# Implementation of Smart car using Fuzzy Rules

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ABSTRACT

Future vehicle must be both driver-friendly and able to adapt to changes in the road's conditions. The system is needed to adapt to both the driver and the circumstance for maximum convenience and safety. In order to solve these problems, this paper proposes an algorithm for developing smart vehicles. In this paper, it is simulated to compare the performance of a normal car with that of the algorithm-implemented vehicle in a potential accident. Through the computer simulation, it proved that the algorithm-implemented vehicle automatically adjusted the mirrors and seat for the maximum comfort and driver's awareness of the circumstance.

**Key Words** : Implementation, Smart car, Fuzzy, Vehicle, Safety

## Ⅰ. Introduction

Future cars require a human-friendly technology. Ubiquitous technologies are certainly needed that vehicles become human -friendly. People could get pleasures to be able to manage vehicles. We must be able to provide status information of a vehicle to a driver to realize ubiquitous functions on a vehicle. If we can transfer the information of vehicles effectively via cellular phones and PDAs, people will know easily the fact that their vehicles are stolen or broken [1-2]. The technology that we propose should be implemented in future cars. We are going to implement intelligence in vehicles. Making it as mentioned above, we think that future-oriented vehicles may be completed. Sensor network combines a number of disciplines of various fields. Sensor network is mixed technology of a sensor technology, communications technology, SoC, and MEMS technology and so on. This technology is a key technology of network and semiconductor industry for next generation. The purpose of this paper is to develop intelligent devices and improve driver's convenience and safety on vehicles [3-6]. We are going to develop a car with an intelligent algorithm which has an electronic control system. This device is connected to TPEG terminal with a wireless Internet. This terminal provides the status of the vehicles to the driver. The driver can know engine temperatures, conditions of exhaust gas, tire and gasoline [7-10]. Traffic accidents break out on the road. Drivers and a road

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do not hold a close relationship. Specially, they occur due to the causes such as insufficient safe facilities, erroneous road design, and uncomfortable mind of drivers. This paper is organized as follows. Section II explains automatic control algorithm which can automatically adjust car seat depending on the driver's height. Section III explains the fuzzy rule algorithms for smart car. Section IV shows that it can automatically adjust car speed when it finds an obstacle, or receives the traffic message broadcasted via a wireless data channel, and describes traffic accident simulation results. Finally, Section V will present our conclusions.

## II. Automatic control algorithm of smart car

A driver must adjust the rearview mirror when they sit in the driver's seat for the first time. This is an essential action to acquire outside information during driving. Driver's seat control is a preparation for recognizing the surrounding circumstances of vehicles. If the seat control is ended, it is not required to control the seat again. However, it will be needed automatic seat control processing certainly if someone among a family drives the vehicle. Therefore, an algorithm for this is as following.

Install a camera in front of a driver and a pressure sensor in the seat.

① If a driver sits in the seat, the pressure sensor acts. According to driver's weight, the seat controlled back and forth. The driver should carry out the following steps to control the distance between handle and chair.

° Step 1: 50cm
° Step 2: +5cm
° Step 3: +10cm
° Step 4: +15cm

Table 1 is automatic control level depending on the body size.

Table 1 Automatic control level

| Automatic seat control | Physical condition | | |
|---|---|---|---|
| | Upper body length 100cm~ 150cm | Weight 40kg ~ 100kg | Lower body length 60cm~150cm |
| Room mirror | level 1<br>level 2<br>level 3<br>level 4 | level 1<br>level 2<br>level 3<br>level 4 | level 1<br>level 2<br>level 3<br>level 4 |
| Rearview mirror | level 1<br>level 2<br>level 3<br>level 4 | level 1<br>level 2<br>level 3<br>level 4 | level 1<br>level 2<br>level 3<br>level 4 |
| Seat control (top and bottom) | level 1<br>level 2<br>level 3<br>level 4 | level 1<br>level 2<br>level 3<br>level 4 | leel 1<br>level 2<br>level 3<br>level 4 |
| Seat control (Back and forth) | level 1<br>level 2<br>level 3<br>level 4 | level 1<br>level 2<br>level 3<br>level 4 | level 1<br>level 2<br>level 3<br>level 4 |

## III. Fuzzy rule algorithm for smart car

For safe driving, a driver must be able to see the road well. Hence, a vehicle has a rearview mirror. Even though there are a number of deluxe cars, there is no vehicle that controls rearview mirror automatically. Drivers need a car to automatically control the rearview mirror, because of the need for a vehicle's safety. The principles for controlling optimum seat and the rearview mirror for driver are as follows.

e=R-Y

Ce=e2-e1

Constrained condition

Y: Optimum safety seat control

R: Reference input (driver average physical condition)

E: Error (reference input - driver's height, weight)

Ce: Change amount of error

E 2: Present error (upper body and lower body)

E 1: The present sampling previous error

Table 2 Safety seat control to consider physical condition

| Quantization step | Range of quantization step to consider driver's physical condition |
|---|---|
| -6 | x<=-60 meters |
| -5 | -60<x<=-40 |
| -4 | -40<x<=-30 |
| -3 | -30<x<=-20 |
| -2 | -20<x<=-10 |
| -1 | -10<x<=0 |
| 0 | 0<x<=10 |
| +1 | 10<x<=20 |
| +2 | 20<x<=30 |
| +3 | 30<x<=40 |
| +4 | 40<x<=50 |
| +5 | 50<x<=60 |
| +6 | x<60 meters |

Table 3 Fuzzy rule for automatic seat control

| | NB | NM | NS | Z | PS | PM | PB |
|---|---|---|---|---|---|---|---|
| NB | NB | NS | NB | NB | NB | NS | NB |
| NM | | | | NM | NM | | |
| NS | | | NM | NS | | | |
| Z | | NS | NS | Z | PS | | |
| PS | | | PS | PS | PM | | |
| PM | | | PM | PM | | | |
| PB | PS | PM | PB | PB | PB | PM | PM |

Table 2 shows the most suitable value for safety seat control to consider driver's height condition. Also, physical condition changes the input value of fuzzy control.

Table 3 is the fuzzy rule to revise for seat coordination.

If the height is the same as the weight and the upper body is longer than the lower body, it will make an error. Also, when the driver's inclination differs from the result of the automatic seat control device, a variation occurs.

In this paper, fuzzy safety seat control rule is as follows.

(RULE 1) IF DPSV IS PB
AND USPC IS NS
THEN OPRG IS PB

(RULE 2) IF DPSV IS PB
AND USPC IS NM
THEN OPRG IS PM

(RULE 3) IF DPSV IS PS
AND USPC IS NS
THEN OPRG IS PS

In above routine, the constrained condition is as follows.

DPSV: Upper body condition and lower body condition error (E)

USPC: Driver's visual height

Driver's inclination: Error change amount (CE)

OPRG: The most suitable seat control

To consider fuzzy control rule and driver's physical condition, it produces the most suitable seat control output (OPRG).

(Rule 1)

[0.3/4, 0.5/5, 1/6] | ^ [0.7/-3, 0.6/-2, 0.8/-1, 0.4/0, 0.1/1]

^ [0.3/4, 0.5/5, 1/6]

= 0.3 ^ 0.7^ [0.3/4, 0.5/5, 1/6]

= [0.3/4, 0.5/5, 1/6]

(Rule 2)

[0.3/4, 0.5/5, 1/6] | ^ [0.3/-6, 0.2/-5, 0.8/-4, 0.5/-3, 0.4/-2,0.2/-1]

^ [0.1/2, 0.5/3, 1.0/4], 0.5/5,0.2/6]

= 0.3 ^0.5^[0.1/2, 0.5/3, 1.0/4, 0.5/5, 0.2/6]

= 0.1/2, 0.3/3, 0.3/5, 0.3/5, 0.2/6

(Rule 3)

[0.3/1, 0.9/2, 0.7/3, 0.3/4] | ^ [0.7/-3, 0.6/-2, 0.8/-1, 0.4/0, 0.1/1] | ^ [0.3/1, 0.9/2, 0.7/3, 0.3/4]

= 0.3, 07^[0.3/1, 0.9/2, 0.7/3, 0.3/4]

= 0.3/1, 0.3/2, 0.3/3, 0.3/4

Non-fuzzification method:

$$U = \frac{\sum(\text{Big set that have membership value of function} \times \text{Its value of function})}{\text{Value of membership function}}$$

## IV. Intelligent prevention technology against traffic accidents

Wireless communication is applied to various application fields. One of them is wireless data channel. It can offer traffic information to a driver. Such application could contribute to reduce the traffic accident. Communication between a vehicle and road side is basically achieved between a RSE (Road Side Equipment) on the road side and OBE (On Board Equipment) on the vehicle.

The RSE transmits a speed limit of a road, danger information, and other information. Vehicles reduce the speed depending on the traffic information transferred to them. This paper is interested in establishing necessary information for communication methods between the road and the car and accident prevention.

Specially, the algorithm is developed to take advantages of information that is transmitted from the road and controls vehicle speed. Speed control of vehicles uses a throttle. The following is the vehicles speed control algorithm.

O Entry alarm to a curve in the road

O Alarm for the speed limit

O Accident alarm and control for invisible area

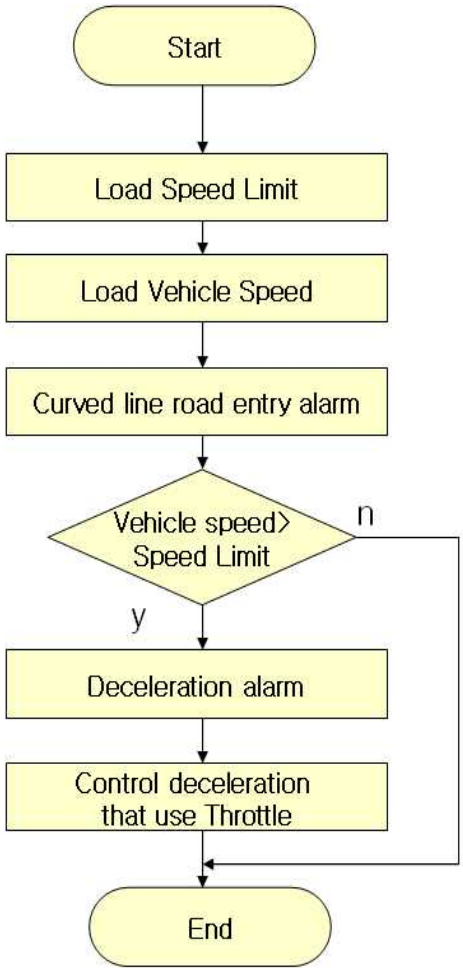


Fig. 1 Communication Flow for Prevention against traffic accident.

Fig. 1 could be explained as follows. It loads the speed limit, to make various controls and alarm information, received by the vehicles at a curve in the road. We propose the system that the sensors on RSE detect the vehicle's speed

violation, and the RSE sends to the car's ECU (Electronic Control Unit) the commands to reduce its speed in rainy day or when a car passes the accident sector. In more detail, the OBE periodically notifies the information, such as the speed limit or the other information, to the car's ECU when the car enters the DSRC (Data Short Range Communication) communication sector. The ECU computes the states of the car such as acceleration based on this information. That is, it drives the throttle actuator and brake actuator to control target car. When a car exits the DSRC sector, the OBE detects the communication ability with RSE and notifies the ECU the information to the ECU through CAN communication system. Then, the ECU controls the throttle actuator and recovers the original car speed, which is set by the driver. The traffic accidents on the icy road are reduced by half on average due to introducing this intelligent road system. Sudden change of weather such as heavy fog and rain is another cause of accidents which endangers the driver's safety. The driver's risk can be reduced very much if they can predict the road conditions in advance, such that the road is wet, icy or in the fog. Fig.1 shows a flowchart to prevent traffic accidents.


Fig. 2 Vehicle structure for prevention against traffic accident.

Fig. 2 could be explained as follows. When an accident occurs or an obstacle is found while a vehicle is driven, the RSE transfers such information. The RSE transfers the information to successive RSE through DSRC (Data Short Range Channel) network. The driver pushes a button to signal when an accident occurs. It could be explained as follows. Vehicles behind can obtain the existence of vehicles ahead by the RSE. Moreover If vehicles in front are in an accident, vehicles are notified of the accident occurrence information. In particular, to develop active intelligent integrated monitoring system to prevent various accidents in existing metropolitan railway service sections, to intelligently monitor the emergency and dangerous status when accidents and disasters are arisen, and to be able to quickly identify and cope with the situation, this paper carried out a simulation, which digitalizes the image information of the surveillance camera, so that the system by itself analyzes locations and patterns of objects and operates the alarm and entrance blocking system or immediately informs the status to security officials when dangerous situations are arisen, and to substitute and compensate vulnerabilities generated caused by manual management.


Fig. 3 Computer simulation result.

This paper simulated the system to primarily search ex-convicts (dangerous people group DB) stored in the database for searching the criminal when a crime was arisen around a railway station. Furthermore, the simulation was developed to search the person with the same clothes color of the criminal at the scene of a crime around the station if the clothes color of the criminal was entered at the site. Fig.3 is the screens executing the program, and the real time video area shows the real time video from the USB camera. The color is selected from 8 colors to search for the real time video, and a screen is divided into 16 areas for each frame of the video to check which color is mostly existed in each divided area, and the result is shown in the search result window. Since there is an option of the one time search and the continuous search, it could be decided whether searching the area where the suspect with the color once or continuously after specifying a color.

## V. Conclusion

Future traffic must be safe. It could be explained as follows. Vehicles behind can know the existence of vehicles ahead by the RSE. If vehicles in front are in an accident, vehicles are notified of the accident occurrence information. Also, people should be joyful to drive a car. Recently, people are interested in smart cars. Every smart car has some electronic equipment so that they can communicate each other. As a result, every car can share information in all places. It will become more convenient for vehicles if they can control smart vehicles using fuzzy rules. This paper proposed an algorithm to automatically control the seat, and notify dangerous traffic conditions.Future vehicle must be both driver-friendly and able to adapt to changes in the road conditions. Moreover, this paper simulated the system to primarily search ex-convicts (dangerous people group DB) stored in the database for searching the criminal when a crime was arisen around a railway station. Furthermore, secondly the simulation was developed to search the person with the same clothes color of the criminal at the scene of a crime around the station if the clothes color of the criminal was entered at the site.

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