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Adaptive Car Safety System

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***Abstract*—**Car accident is one of the major causes of death in many countries. Many researchers have attempted to design and develop techniques to increase car safety in the past recent years. In spite of all the efforts, it is still challenging to design a system adaptive to the driver rather than the automotive characteristics. In this paper, the adaptive car safety system is explained which attempts to find a balance.

***Keywords*—**Analog to Digital Converter (ADC), Adaptive Car Safety System, Multi-Media Card (MMC).

I. Introduction

IN our twentieth century, transportation is one of the greatest industries. Many experts are currently working on different projects to increase the safety of automobiles and decrease the number of accidents on the roads. Based on the statistics, approximately 27,000 civilians are killed in car accidents in some developing countries each year [12-17]. In 2008, the number of accidents which result in death increases by 15%. In other words, 80 people are killed in car accident each day. Consequently, the next generations of cars are improved so that the number of accident decreases. Innovative ideas have emerged and implemented in order to reduce the risk of car accidents.

During the past recent years, some alarm systems and intelligent control apparatus have been designed and developed in order to increase the safety of automobiles.

For instance, the car-to-car anti collision system [15] uses vehicle to vehicle 5.8-GHz frequency band communication and gives a proper signal to the driver before an accident occurs. The system was well verified, however, it is unable to act mechanically in order to stop the car from an accident. It does not consider a limitation for the speed of the car and it needs some extra apparatus for the communication purposes between the automobiles.

In [15], communication is dependent to the information provided by other cars which are equipped with the same apparatus. Due to the lack of communication between the car which is not equipped with such a gadget and other cars, the driver of the car with communication capability may be mislead or at least he may underestimate the potential risk of accident.

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In another attempt, Linköping University and Volvo Car Corporation [16] have collaborated and developed a system which is capable of reducing the risk of severe and fatal traffic injuries by five percent. This is done by taking the benefit of a radar communication system and a computer. Their implementation only avoids the tailgating accidents; however, these types of accidents are not generally measured as the major cause of death. Other possible problems may occur when a rear car wants to overtake the car in front. In this case, the misleading anti-collision signals might avoid the overtaking process. Also, the target-monitoring sensor utilized for the regular traffic increases the complexity of the whole system and therefore reduces its popularity for being widely used.

However, lack of evaluation mechanism for the driver of the car is clearly observed in all of the implementations. Also, the ability of the driver in controlling dangerous and unpredictable situations is not tested as a critical parameter.

In other words, speed control of the vehicle only relies on the capabilities of the vehicle instead of skills of the driver. By increasing the flexibility of the safety system, this problem is overcome in our implementation.

II. Description of Adaptive Car Safety System

As one can see in the system diagram (Fig. 1), the preprocessing stage receives four inputs: the first two inputs are velocities which were read through the timer counter of the microcontroller. Acceleration in X direction has been implemented by variable resistors and a heavy weight attached to it and it is read by the analog to digital converter (ADC) of the microcontroller. The deviation of the weight results in the deviation of the variable resistor and corresponds to the acceleration in X direction. The same procedure is repeated for Y direction as well. The next input (role angle) is estimated by using a shaft encoder which has been attached to the role. In the preprocessing stage, the information is changed in a way that can be read by other components of the system. In order to determine the threshold for maximum speed of a car, an artificial neural network is utilized. Since the behavior of the system changes according to the location of the car (city, town, road, street, etc.), the weights of the network are loaded corresponding to the location. Detection of the location is determined by measuring the changes of the role angle, acceleration, and GPS system coordinates.

After loading the weights of the neural network, the network is activated. Inputs of the network which have been prepared in the preprocessing stage are delivered. The network estimates the maximum allowable speed based on the provided knowledge and delivers this threshold to the speed control system. The current coordinates of the car are compared with coordinates of dangerous locations on the map. These locations are of high risk of collision and accident.

If vehicle is less than, say, half a kilometer away from a dangerous location, this state is reported to the speed control system so that proper action is taken. The speed control system receives inputs from other parts as well. This includes the level of the driver's pressure on the gas pedal. The system sends commands to the stepper motor to change the volume of gas pumped into the engine of the vehicle.

Speed fixing button sends commands to the speed control system to keep the current velocity of the car constant. If this speed is more than the maximum threshold, system automatically takes part and reduces the speed of the car. In emergency situations where the driver needs to have a full access to the speed (e.g., while overtaking, or other urgent cases), pressing the emergency button gives the driver a permission to increase the speed. However, the number of times that this button is pressed is recorded and can be monitored by the police!

III. Detection of Dangerous Points using GPS

In this project, a Garmin five-meter precision GPS has been utilized [8]. X and Y coordinates of the current location are provided to the controller by the GPS. Therefore, it can easily refer to the location of the car whenever it needs to make a decision. GPS has been connected to the serial port of the micro-controller using RTCM/TEXT protocol, and a speed of 4800 Megabits per second. It also provides velocity, height above sea level (altitude), and other parameters.

Here, GPS has two major benefits: firstly, coordinates provided by GPS, together with changes of the role angle, speed and acceleration help to distinguish between city streets and roads outside city. Secondly, comparison between dangerous points of the map and current coordinates of the car is facilitated. If the car is close to risky locations, speed of the car will be limited. System loads the proper weights into the neural network using the previous information and starts to control the speed of the vehicle. Since the information about 3000 dangerous points takes about 24 kilobytes, the information must be stored in external memory outside the micro-controller.

For this purpose, MMC memory module is utilized. On the other hand, since this search must be performed with a very high speed, the dangerous points have been sorted based on their x-coordinate. Binary search method is used to speed up the process. If such x-coordinate exists, y-coordinate is compared with the current GPS-provided y-coordinate and in case of compatibility; speed control system will be activated to send proper commands to limit the speed.

Since the car speed must be limited well before the predefined dangerous points, measuring the distance to these points is performed using the following equation (1):

$$\text{IF } | D(x,y)-D(x_t,y_t) | < 500 \text{ THEN } \textit{Limit the speed} \quad (1)$$

$D(x,y)$: Current position of the car
$D(x_t,y_t)$: Position of dangerous points

IV. MMC Memory Module of the System

In this project, the current location of the vehicle must be repeatedly checked with locations of risky points on the map. In case of compatibility, proper decisions will be made to limit the speed of the car. In order to store and retrieve the dangerous locations quickly, a relatively large memory size is needed. It must be small dimension and not so expensive. On the other hand, different users must be able to drive the car and guide the controller according to their skills. Therefore, the memory module must provide us with the following important features:

1. High speed of data communication
2. Huge storage capacity
3. Small dimension and size
4. Easy to replace with similar modules
5. Low power consumption
6. Information protection even if power is disconnected from the system
7. Easy to communicate with microcontroller
8. Relatively cheap
9. Strike and tremble resistance and high endurance

Because of the aforementioned features, a Multi-Media Card (MMC) is chosen, Fig. 2. MMC has two modes of operation [6-7]: SPI mode and multi-media mode. The second mode is utilized in applications such as simultaneous reading and writing of voice and image to/from memory. It is used when applications demand a very high speed provided that the processing unit is also very fast. SPI mode has an average speed of communication between the microcontroller and MMC through SPI protocol. Therefore, it is much easier to communicate with MMC and microcontroller in SPI mode. System takes the benefit of the SPI mode to facilitate the process of communication [9-11].

V. Artificial Neural Network

Although computers have improved a lot during the past decades, there are still many problems which are really time-consuming and difficult for computers to solve. In fact, computers can easily solve complex arithmetic operations on very large numbers in a fraction of second. However, computers can not work efficiently when dealing with noisy input, or inputs taken from the surrounding environment, parallel processing on huge amount of data. Also they can not generalize a small pattern to a bigger one. On the other hand, human brain or even an animal can easily distinguish and perceive the environment. Artificial neural network attempts to imitate human brains. It tries to mimic the human brain behavior and experience the environment.

Recent progress in biology has shown that human brain saves information in the form of patterns [4,5,19]. These patterns are so complicated that they give humans the capability to distinguish an individual person among many others. The process of storing information as patterns helps to solve many other computational problems. This process does not necessarily involve a very advanced programming method. Instead, it creates a relatively heavy parallel network and then training it to solve a particular problem [2,4,5]. Neural networks learn the patterns by observing the training input. Then, the network can be utilized to detect such patterns. They can also generalize a concept or practically 'learn' from it.

The advantage of neural networks lies in revealing linear and nonlinear relationships between data and learning from the modeled information. Classical linear methods perform very poor when their inputs have non-linear characteristics.

The implemented system has many inputs and a single control signal to limit the car speed. The inputs and output do not have a clear logical relationship. Therefore, it is best to realize this part of the system using a neural network. A multi-layer perceptron (MLP) has been chosen based on trail and error and due to its error backpropagation learning mechanism. Characteristics of the implemented MLP are as follows:

1. Four input neurons
2. Twelve neurons for the hidden layer
3. Twelve neurons for the output layer (each neuron represents a certain maximum speed).
4. Two different learning rates for output layer and hidden layer.
5. Sigmoid activation function.

The following error diagram (Fig. 3) shows different results after testing the network using two different learning rates for output layer and hidden layer.

VI. Conclusion

The experimental results show that our implemented system compared with other anti-collision and car safety systems adapt with the car and the driver to control the speed of the car. An adaptive MLP (multi-layer perceptron) cooperates with other decision making modules to control the speed of car by controlling the amount of gas which is pumped into the engine.

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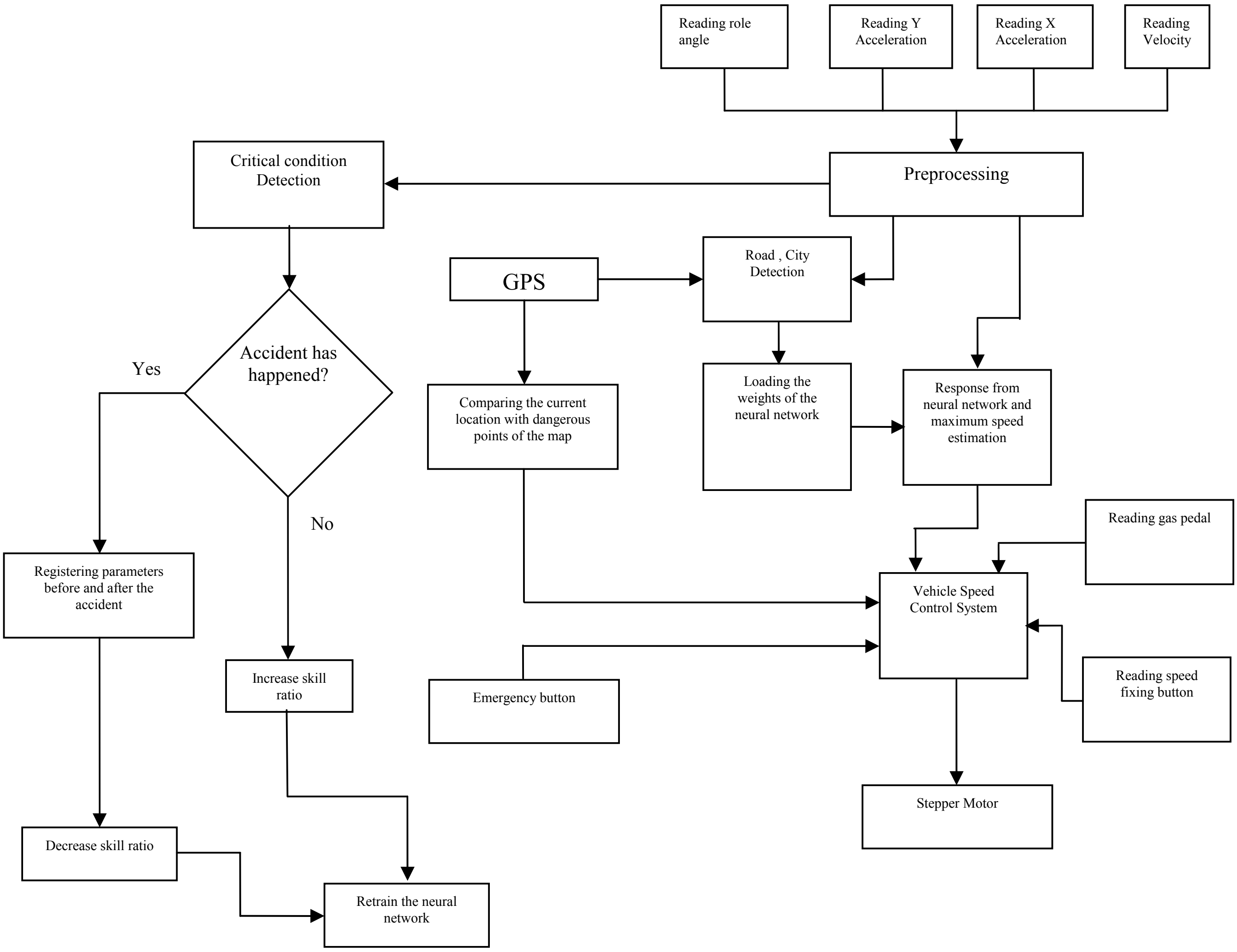

Fig. 1 General diagram of the implemented car safety system

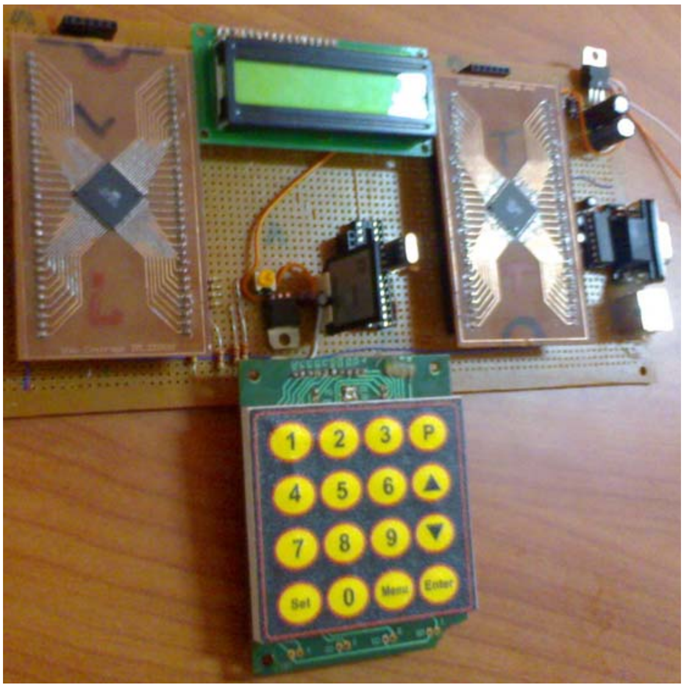

Fig. 2 A photo of the hardware implemented

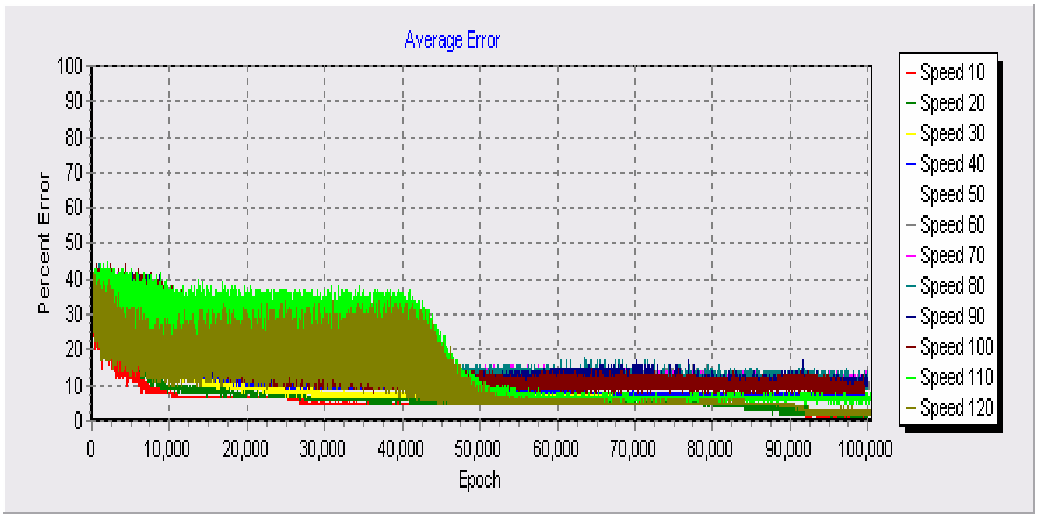

Fig. 3 Average error diagram. Epochs: 100,000, Hidden learning rate: 0.3, Output learning rate: 0.2