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Design of Image Processing Techniques for Smart Real-Time Tracking System during Health Emergencies

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Abstract: *Currently, in the period of autonomous era, every sector is involving in the adoption of systems that are spontaneous and efficient. In the sector of autonomous vehicles, safety and health of the people who are seated inside the vehicle are majorly concerned. But, the dream of complete autonomous vehicle is far. The automobile industry focuses more on surviving the accidents by making use of available tools and technologies. One such idea is discussed in this paper, which can improve the road safety by establishing better connectivity between the emergency departments and the vehicle. Under the on-road emergency condition, the proposed methodology mainly deals with, 1) Emergency message communication. 2) Automatic road side parking. In order to accomplish the above-mentioned tasks, it requires the use of sensors (Ultrasonic, Infrared and passive infrared), communication module (GPRS/GSM) operated by main (Raspberry pi) and sub-control-units (Arduino), where the main control unit supervises sub control unit and the sub control unit performs the specified tasks, as defined by the main control unit. The proposed system is developed and analyzed for a prototype car, which will be discussed further.*
The paper also depicts some of the popular image processing techniques such as SVM classifier, CLAHE, histograms that can be implemented in the emergency automatic parking system to analyze the emergency situation more constructively.

Key Word*: Main control unit (Raspberry pi), sub-control unit (Arduino), stationary obstacles, moving obstacles, communication module (GPRS), Automatic road-side parking system, on-road emergency communication, toothed wheel, axle, SVM classifier, CLAHE, and histograms.*

I. Introduction

According to World Health Organization, a specialized agency of the United Nations, the number of road traffic deaths worldwide hit 1.35million every year. The Latest studies show human error to account more than 90% to road fatalities leaving high improvement opportunities for technologies which can survive or avoid road-accidents. As a result, the automobile industry focuses more on surviving the road accidents. Over the past decades, passive safety systems – like pre-tensioned seatbelts, airbags and energy-absorbing deformation zones – have made a major contribution to road safety by reducing the consequences of accidents. However, passive safety technology is reaching a level of maturity, so further room for improvement is limited. Any further development can be made both effective and economic is only through active safety. Considering the driver's health during driving will be one of the main points of real time road safety, if at any health emergency condition, developed safety system can protect road-accidents and also driver's life.

II. Scope and Objectives

The main objective of the project is to enhance the chances of survival of the driver under on-road emergency conditions with the available technologies for improved road safety.

Scopes of our project are:

1. Under emergency condition, nearby emergency sectors (such as hospital and police station) and relatives are conveyed with an emergency message.
2. Live location of the vehicle is also tracked and communicated with the same message.
3. During health emergency, since the driver is not in the state of driving, automatic road-side parking system is implemented which gets activated on his command.

III. Methodology

The two main functions of the system are, 1) to communicate the emergency message and 2) to auto-park on the driver's command. To achieve these tasks, it requires a suitable control system with appropriate elements all synchronized accordingly. Since the system is excited during an emergency condition, it has to perform both the functions swiftly, smoothly and simultaneously. It becomes difficult for one control unit to handle the situation as the two functions are totally different both method wise and equipment wise. Therefore, the system is operated with main and sub control units. The use of sub-control unit for emergency message communication increases the performance and reliability of the main control unit. The subcontrol unit works under the supervision of main control unit which tells it what to communicate (Location or emergency message), how to communicate (call or SMS) and based on the communication status (successful call or disconnected call) - when to re-communicate.

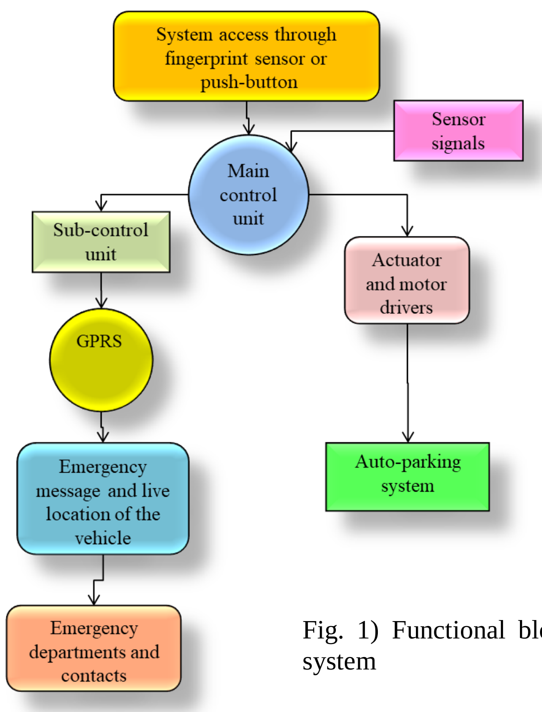

Fig. 1) Functional block diagram of the designed system

The main control unit handles the below tasks,

1. Initiation of the system on driver's command through the push-button.
2. Bringing the vehicle to rest if it is in the moving state.
3. Continuous evaluation of the sensor status using proper feedback loops.
4. Control of vehicle motion using actuators and motor drivers.
5. The above two are the complementary functions for the operation of Automatic road-side parking.

6. Sub-control unit supervision.

Tasks performed by the sub-control unit are,
1. Extraction of vehicle live location through GPS module.
2. Communication of emergency message and live location using GPRS module (through serial communication technique) under the supervision of main control unit.

III. Equipment

As discussed in the previous section, the system is designed to perform the two major functions of emergency communication and automatic road-side parking. Implementing both these technologies for a real-life car requires lot of R & D work (as the car itself is a complex system). So, the safety system shown in this paper can be analyzed using a car prototype which works on the simple techniques such as acceleration and deceleration using DC motor and steering through stepper motor. With this prototype car shown in figure 2 the safety system proposed in this paper can be studied and tested for its working, later on which it can be advanced by syncing with the ECU of the real-life car that increases its performance. The equipment used and their functions with respect to the project are explained below,

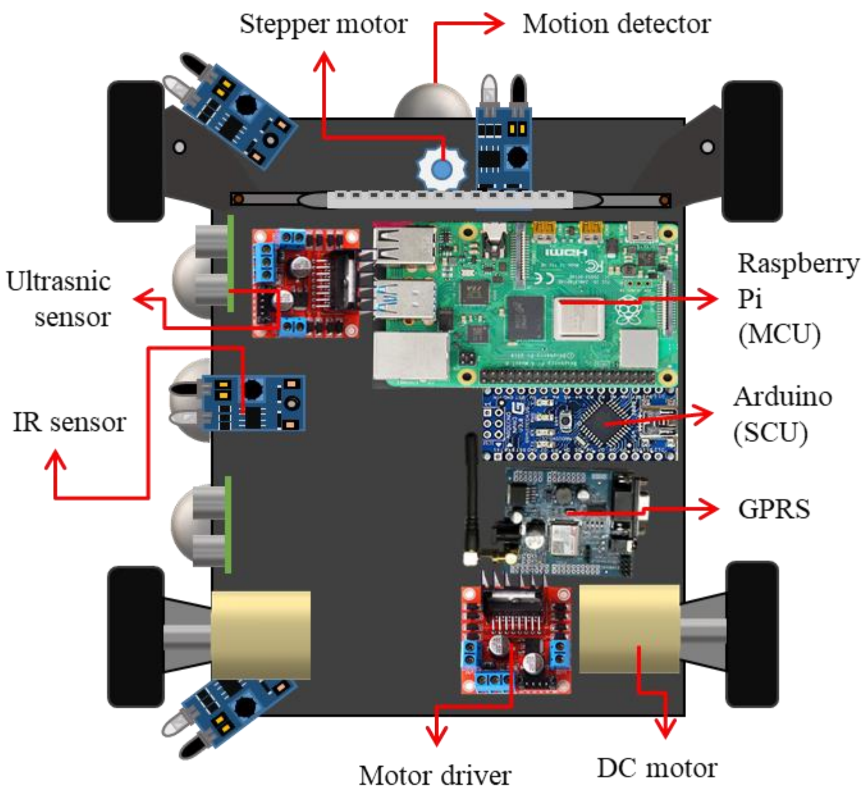

Fig. 2) Car prototype with equipment.

Infrared sensor

An infrared (IR) sensor is an opto-electronic device that emits infrared (IR) radiation and reacts to the IR radiation reflected from the obstacle in front of it (within its operation range), thereby detecting the obstacle. It mainly consists of IR LED (as transmitter), photo-diode (as receiver), operational amplifier (differential amplifier, to give digital output), voltage dividers (resistors) and potentiometer (to adjust the operational range of the sensor). The IR sensor serve as obstacle detector for the stationary objects (such as trees, milestones, curb and other parked cars) in the designed auto-parking system, it gives 5V digital high output to the main controller when an obstacle is encountered within its operation range.

Passive infrared sensor or motion detector

Passive Infrared sensor is an opto-electronic device that detects moving objects by sensing the changes in the infrared radiation (emitted by the moving body) impinged on the photosensitive surface of the sensor. It mainly consists of photo-sensitive surface, Fresnel lens (to concentrate the incoming radiation on photosensitive surface), differential amplifier and two potentiometers (one to adjust the sensitivity i.e., sensing distance of the sensor and another to adjust the time delay of the output). The PIR sensor detects things in motion (such as moving car and walking person) in the auto-parking system designed, it gives 3.3V digital high output to the main controller when a moving obstacle is encountered within its operation range and holds its output up to the delay time adjusted.

Ultrasonic sensor

Similar to IR sensor, Ultrasonic sensor consists of a transmitter and a receiver but transmits and receives ultrasonic waves. It mainly consists of crystal oscillator (to generate ultrasonic waves), trigger terminal and echo terminal. Both trigger and echo terminals are connected to the main control unit. When the ultrasonic sensor is triggered by sending a digital high pulse from the main controller to the trigger terminal, it emits ultrasonic wave from the transmitter that hits and bounces back from the obstacle, the reflected wave when received by the receiver makes echo terminal high. The distance between sensor and the obstacle can be obtained from the expression shown below,

Distance = Speed of sound × Td × 0.5

Where, Td is the time difference between the transmission and reception of the wave. Hence, the sensor not only detects, but also gives the distance at which the obstacle (sensed by the infrared sensor) is present. In this project, ultrasonic sensor is useful while parallel parking in order to align the vehicle model along the axis of the road (explained in the working part).

Permanent magnet stepper motor

Permanent magnet stepper motor is an electric device that converts train of pulses into mechanical rotation in discrete steps. It consists of rotor made up of permanent magnet material (i.e., ferromagnetic material) and wound stator. The rotor is of cylindrical or salient pole type with even number of alternate North and South poles. Similarly, stator also consists of even number of laminated poles which are wound for alternate North and South polarities. When an end terminal of the stator winding (i.e., one of the stator poles) is supplied with a DC pulse, a rotor pole of opposite polarity aligns itself along that pole which is excited, through the rotor rotation. This is due to the Lorentz force of attraction and repulsion between the stator and rotor poles. The stepper motor in this project is used to steer the prototype car, in order to achieve this the front axle rod is toothed and the stepper motor shaft is mounted with toothed wheel, the steering apparatus is assembled as shown below in Fig 3a). When the stepper motor is rotated clockwise, the car prototype tuns right as shown in Fig. 3b) and when the stepper motor is rotated anti-clockwise, the car prototype tuns left as shown in Fig. 3c)

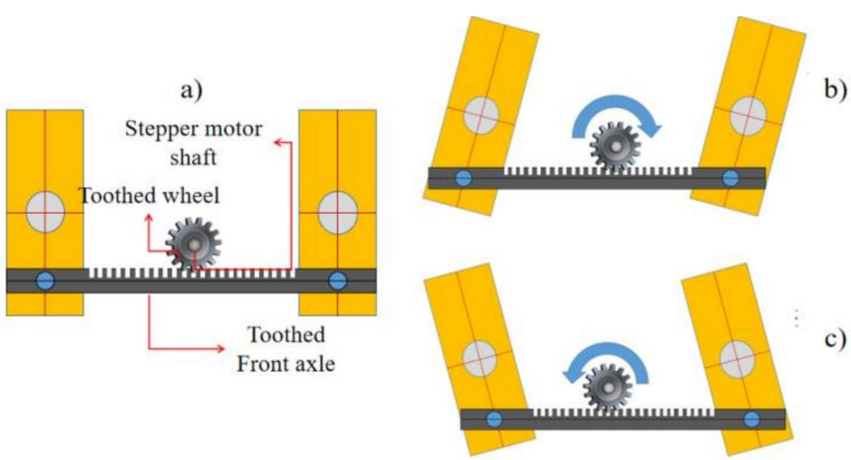

Fig. 3) Steering action using stepper motor.

GPS module
GPS (Global Positioning System) module extracts from the satellites the location details in the form of latitude and longitude. It is connected to MCU via TX and RX pins through which the location received from the GPS is stored in MCU.

GSM Module
GSM (Global System for Mobile communication) module mainly performs the action of calling or sending emergency message to contact/s using SIM card. It works with the frequency of 800MHz having on-board keyboard interface, serial ports, display interface and supports microphone input and speaker output.

Fingerprint Scanners
A fingerprint scanner or module is a security system based on biometrics, used in order to identify a person through his fingerprint. In the designed system it provides system access security so that only the owner or driver can excite the system under health emergency. It initiates MCU through TX and RX pins (serial communication).
Arduino sub-control unit
Arduino is an 8-bit ATMEGA AVR controller that operates at 16 MHz frequency. It consists of 5 analog pins, 14 digital pins (including PWM), 1 serial port (including TX and RX pins), 2kB RAM and 32 KB ROM (On-chip). In this project, it is used as SCU (Sub-Control Unit) that perform the tasks assigned by the MCU, which is to communicate the location and emergency message with the emergency departments through GSM module. The sub-control unit improves the overall performance of the designed system through the deliberation of tasks.

Raspberry pi main control unit
Raspberry pi (4b) which is used as a main control unit is a strong processor that has 64-bit quad core cortex-A72 (ARM v8) processor, 4GB RAM (Random access memory), 26 General Purpose Input Output (GPIO) Pins, 2 USB (Universal Serial Bus) 3.0 ports, 2 USB 2.0 ports, 2 micro-HDMI ports, Graphical User Interface (GUI) and so on. As explained in the methodology (section III), the raspberry pi has got two main functions in the system proposed, they are auto-parking and communication. The two functions will be performed only if the input from the push-button or fingerprint sensor (which are connected to the GPIO pins) is received. For auto-parking to happen, the sensors are connected to the GPIO pins and configured as input pins using software control. Similarly, the stepper and DC motors are connected to the GPIO pins but they are configured as output pins. Based on the sensors inputs, the raspberry pi decides the situation, and controls stepper and DC motors which are meant for vehicular motion (detailed explanation for auto-parking system is given in section VI). Another main function of the raspberry pi is to supervise the subcontrol unit in order to communicate with the emergency departments. The location details sent by the GPS module are stored in ROM (Read Only Memory), which will be communicated to the emergency departments when the system gets excited.
Raspberry pi module has camera module port to connect a camera externally. The images captured by the camera can be processed through the image processing technique to take suitable decisions about whether the object in-front of the prototype is stationary or dynamic (discussed in section VI and VII).

DC motor
DC motor consists of permanent magnet stator and wound armature. When a current carrying conductor is placed in a uniform magnetic field, it experiences force; this is the principle behind the DC motor operation. In this project, DC motor is used to accelerate or decelerate the car prototype. Other than the above equipment motor drivers and voltage regulators are used which enhances the performance of motors and sensors.

V. On-Road Emergency Communication

The on-road vehicular communication is explained considering the below conditions.

Under normal condition:
While driving, the details of the nearby Emergency departments along with the location are recorded periodically in real time by the MCU.

Under emergency condition:

The designed system is triggered using a fingerprint detector upon which the MCU loads the location details that are stored in real-time into the sub-control unit that communicates the same with the emergency departments. If GPS fails to provide the location data, then the MCU considers the last recorded location details. The Sub-control unit which is connected to the GPRS module will call or message the emergency departments as instructed by the MCU.

Based on call status (successful call or rejected call), the MCU instructs the SCU to go for the next contact which is in the contact list priorly saved in MCU. The process of communication can be looped until the arrival of medical support. The emergency Message consists of location details and the state of emergency.

VI. Automatic Road-Side Parking System

Under on road health emergency condition, since the driver may not be in the state of driving, it requires a safety system to take control over the car on command of the driver and park along the road-side, this system is called as emergency automatic road-side parking system. Well, it's not that simple, as under real life situations there exist other cars moving on the same road or parked along the road side, pedestrians, trees etc. These situations can be tackled by the use of appropriate sensors with proper feedback loops and suitable algorithm. Under real life on-road condition, there exists only two types of obstacles for the car of interest, 1) Stationary obstacles such as curb, street lights, trees, other parked vehicles, house compounds etc. 2) Moving obstacles such as other cars in motion, pedestrians etc. Fortunately, the stationary obstacle are always found at the road side and has negligible probability of their existence at the middle of the road, this forms one of the main part of automatic road-side parking algorithm. The auto-parking system proposed in this paper is designed considering all the consequences and contingencies mentioned above. This sub-system uses IR and PIR sensors (explained in section IV) to sense the obstacle and to make a decision whether it is moving or not. If the obstacle sensed is in the moving state, then there is a highest probability that the car is not at the road-side. Under this condition both IR and PIR will be active. Once when the car is at the road side, the PIR sensor would be simply redundant and only IR sensor will be active as there are only stationary objects. Ultrasonic sensor is used to know the distance at which the obstacle is sensed. Two ultrasonic sensors are used; one near the front wheel and another near rear wheel as shown in figure 2). In order to align the car along the axis of the road, the obstacle distance detected by the two ultrasonic sensors should be the same; the prototype car is turned using stepper motor accordingly. The algorithm of automatic road side parking system is as follows,

1. The car will come to rest during emergency condition.
2. The car now has to move to the left side of the road to park.
3. The sensor outputs (both infrared sensor and motion detector) are continuously monitored through GPIO pins of the controller until the car is parked safely to the left side of the road.
4. Upon the input given by any of the sensor, the car will stop and analyze the GPIO inputs.
5. If the sensor outputs are low, the car will move further to park itself at the road side.
6. Else if only IR sensor outputs exist, it is clear that the car is at the road side (as there are no moving objects detected).
7. If the car is at the left most side of the road, then it will align itself along the axis of the road.
8. Then the car will check for space to park, if sufficient space is detected, then the car will park (or it will parallel park, considering the case of sufficient space existing in between two already parked vehicles or obstacles).
9. Else if no available space detected, the car will park on the current location along the road side.

VII. Design of Image Processing Techniques

Recent developments in the computer technology and artificial intelligence have made the hardware sectors dwell smart and accurate in their applications. The algorithms and training models not only improve the performance of the designed model but it also makes the model learn from the past and present experience to predict the future. These technologies require sufficient expertise in the concepts like mathematics (especially, linear algebra), and statistics. In the present scenario of automobile security system, the image processing techniques like CLAHE, histogram equalization, image classifiers like Convolutional Neural Network (CNN) and Support Vector Machine (SVM) will be powerful and the same are discussed below,

Contrast limited adaptive histogram equalization (CLAHE) is used for improve the visibility level of foggy image or video. Using CLAHE technique the proposed model can work efficiently regardless of the external weather conditions, day or night. Histogram equalization is a method in image processing of contrast adjustment using the image's histogram. This method usually increases the global contrast of many images, especially when the image is represented by a narrow range of intensity values. Through this adjustment, the intensities can be better distributed on the histogram utilizing the full range of intensities evenly. This allows for areas of lower local contrast to gain a higher contrast. Histogram equalization accomplishes this by effectively spreading out the highly populated intensity values which use to degrade image contrast.

The method is useful in images with backgrounds and foregrounds that are both bright or both dark. In particular, the method can lead to better views of bone structure in x-ray images, and to better detail in photographs that are either over or under-exposed. A key advantage of the method is that it is a fairly straightforward technique adaptive to the input image and an invertible operator. So, in theory, if the histogram equalization function is known, then the original histogram can be recovered. The calculation is not computationally intensive. A disadvantage of the method is that it is indiscriminate. It may increase the contrast of background noise, while decreasing the usable signal.

In machine learning, support-vector machines (SVMs, also support-vector networks) are supervised learning models with associated learning algorithms that analyze data for classification and regression analysis.

Given a set of training examples, each marked as belonging to one of two categories, an SVM training algorithm builds a model that assigns new examples to one category or the other, making it a non-probabilistic binary linear classifier (although methods such as Platt scaling exist to use SVM in a probabilistic classification setting). SVM maps training examples to points in space so as to maximize the width of the gap between the two categories. New examples are then mapped into that same space and predicted to belong to a category based on which side of the gap they fall.

In addition to performing linear classification, SVMs can efficiently perform a non-linear classification using what is called the kernel trick, implicitly mapping their inputs into high-dimensional feature spaces.

When data are unlabeled, supervised learning is not possible, and an unsupervised learning approach is required, which attempts to find natural clustering of the data to groups, and then map new data to these formed groups. The support-vector clustering algorithm, created by Hava Siegelmann and Vladimir Vapnik, applies the statistics of support vectors, developed in the support vector machines algorithm, to categorize unlabeled data, and is one of the most widely used clustering algorithms in industrial applications.

The image processed with the CLAHE technique can be further polished with the SVM classifier in order to prepare suitable algorithm and training models. The best possible programming language for machine learning (artificial intelligence) and image processing is python. So, suitable libraries (pandas, numpy, scikit learn) has to be imported while programming the raspberry pi (Main Controll Unit). The decisions taken from the sensor input configuration can be optimistic but the use of image processing techniques along with the conventional method elevates the accuracy of the operations.

Another major application of image processing technique is facial expression detection which when implemented will not require the use of finger print module or push button to excite the system, rather it excites the system when uneasiness is detected on driver’s face.

Conclusion

This paper discusses about establishing better connectivity with the emergency sectors under on-road emergency conditions using available technologies. System access security for the proposed safety system is provided through fingerprint detector. As the designed system is complex, the burden on main control unit is decreased by using sub control unit for emergency communication system thereby increasing the system performance. Further, the paper discusses the image processing techniques that gives better results for the emergency automatic roadside parking system. This Project contributes to the improvement of road safety and also it increases the chances of survival of the driver during on road emergency condition.

References

[1] Yunrui Li, Majeed Nader, and John Q. Liu: “In-Vehicle System Design for the European Union Emergency Call”, 2018 IEEE.

[2] Hassan Dawood, and Ping guo, “Automatic Parking Space Detection System”, 2nd International Conference on Multimedia and Image Processing Beijing, China 2017.

[3] Jon Blancou, Joao AAlmeid, Bruno Fernandes, Lu´ıs Silva, Muhammad Alam,Jose Fonseca, Joaquim Ferreira: “eCall++: An Enhanced Emergency Call System for Improved Road Safety”, IEEE Vehicular Networking Conference (VNC) 2016.

[4] Ter-Feng Wu, Pu-Sheng Tsai, Nien-Tsu Hu, and Jen-Yang Chen, "Research and Implementation of Auto Parking System Based on Ultrasonic Sensors", Proceedings of the IEEE International Conference on Advanced Materials for Science and Engineering - Meen, Prior & Lam (Eds) IEEE-ICAMSE 2016.
[5] Ms. Honghong Liu Dr. Gene Yeau-Jian Liao, "Automatic Parking Vehicle System" ASEE's 123rd annual conference & expositions, New Orleans, 2016
[6] Singh, Himal Pratap, Om Prakash Uniyal, and Kireet Joshi. "An Approach to Implement Cost Efficient Space Detection Technology with Lower Complexity for Smart Parking System." Indonesian Journal of Electrical Engineering and Computer Science 2015.
[7] Sahil Jitesh,Antilock Braking System (ABS),Research Paper 2014.
[8] Yusnita, R.; Fariza N; Norazwinawati B, "Intelligent Parking Space Detection System Based on Image Processing," International Journal of Innovation, Management and Technology, June 2012.
[9] Trong-Yen Lee, Chi-Feng Lee, "Microcontroller Based Automatic Parking System", Proceedings of the 2012 International Conference on Machine Learning and Cybernetics, Xian, 15-17 July, 2012
[10] Anastasia Razinkova, Hyun-Chan Chow, Hong-Tae Jeon, "An Intelligent Auto Parking System for Vehicles, International Journal of Fuzzy Logic and Intelligent Systems" 2012.
[11] Feng YANG, lifeng JIAO: "Call Taking, Dispatch Decision Supporting, Vehicle Tracing: Emergency Response Systems under Location Based Services", Third IEEE International Conference on Multimedia and Ubiquitous Engineering, 2009.
[12] Tsung-hua Hsu, Jing-Fu Liu, Pen-Ning Yu, Wang-Shuan Lee and JiaSing Hsu, "Development of an Automatic Parking System for Vehicle", IEEE Vehicle Power and Propulsion Conference (VPPC), Harbin, China September 3-5, 2008.