OPEN ACCESS

International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-3 Issue-5, October 2013

Autonomous Remote-Control Car with Lane Detection and Collision Avoidance System

Srudeep Somnaath T K

Abstract— ***According to the United States Census Bureau, there were 10.8 million motor vehicle accidents in the United States alone in the year 2009. Auto collisions are the leading cause of injury-related deaths, around 1.24 million each year, 25% of the total from all causes. It was reported that 35,900 fatalities occurred due to car related accidents. While some of these accidents are not fatal or critical, people who are involved are left with hefty financial expenses and a definite increase in their insurance policy. As per World Health Organization survey in 2000, the financial cost of these crashes was approximately 518 billion dollars. What if all of these auto accidents could be prevented or at least reduced to stop car related deaths and expenses? These statistics triggered a big concern and hence this system was conceived. This system detects the lane and avoids accidents in a significant manner, still very affordable by using cost effective modules. The paper proposes an intelligent collision avoidance system, and also a key algorithm for recognizing navigation and movement controlling. This in turn removes the factor of human error, when it comes to stopping a car in emergency situations. The proposed system will be a combination of software and hardware, both working in a cohesive manner.***

Index Terms— ***Autonomous car, remote control car, lane detection, collision avoidance system, ultrasonic sensor, infrared sensor, ARM 7 TDMI S LPC2129.***

I. INTRODUCTION

In recent years, a lot of research has been done in the area of automated vehicles. A major area of consideration is put in for the safety of the driver. All this research has a common goal - to make driving on today's highways safer and easier. The requirement of making driving easier especially comes into play in lengthy trips on highways or interstates when the driving process itself is not difficult, yet the drivers' full attention is necessary to keep the vehicle on the road. The vehicle collision and its impact emerged as the major problem in the last two decades when the use of the automobile increased to a subsequent number. With the current technology improvements, the accidents can be avoided and maximum protection can be provided to the vehicle occupants and even pedestrians. Today, drivers are more susceptible to accidents than ever. An increase in technology and advances in communication has left drivers (particularly younger drivers) with an unyielding need to use electronic devices while driving, distracting them from focusing on the road. For Example, Blackberry services were disrupted for three days on October 2011. A news article stated that during the duration of those three days, accident rates dropped by an astonishing 40%, with the largest accident decrease among young drivers. This shows that distractions are a major cause of car related accidents. Electronic devices are not the only things that can lead to accidents on the road. Some other examples include being weary from lengthy road trips, talking with other passengers, trying to retrieve dropped items, eating while driving, applying makeup, etc. However, with the implementation of a collision avoidance system this project hopes to save drivers their lives as well as their money. Collision avoidance systems would reduce the number of accidents to a great extent. Accident reduction would also help reduce vehicle-hours of delay. According to the study, around 40 per cent of accidents occur in travel lanes. During congested periods an average accident can induce 500 to 1000 vehicle hours of delay. According to National Highway Traffic Safety Administration some of the collision-avoidance systems could prevent 1.1 million accidents in the United States each year and would save 17,500 lives and $26 billion in accident-related costs. Greyhound Lines have installed systems on its bus fleet, which give collision warnings for the front of the vehicle and lane change warnings for obstructions in the driver's blind spot. As a result, Greyhound's accident rate fell 21 per cent from 1992 to 1993. According to a study the static and dynamic vision of people with age greater than 60 years is less compared to drivers below the age of 60 years. The percentage variations are found to be around 17.17 per cent and 31.14 per cent for static and dynamic vision respectively. The time required for the drivers with age greater than 60 years to react and apply the brakes is found to be 1.35 times that of the drivers with age less than 60 years. Vision enhancement devices and other simple collision avoidance devices could assist the aging drivers by providing them with more amount of time to react for a given situation. This could possibly help reduce collisions. Simple collision avoidance systems that prevent backing collisions which are at low costs could help reduce the number of collisions that are very common in the parking lots. The lane detection system has no necessity to create a general purpose algorithm. Different modules can use very different techniques, each most suitable in different areas, so long as at least one of them is effective at each instant. This is a robust system as it allows highly parallel processing on road detection. If individual modules are not completed in time or fail due to hardware problems on the robot the lane detection system can still operate, albeit with reduced effectiveness, based on the remaining modules.

II. RELATED WORK

M. Ragul, V. Venkatesh, [1] implemented a vehicle navigation system using RFID technology. The RFID reader is installed in the vehicle and reads the tags which are placed along its route.

Manuscript published on 30 October 2013.
***Correspondence Author(s)**
Mr. Srudeep Somnaath T K, Electronics and Communication Engineering, School of Engineering and Technology, Jain University, Bangalore, India.

Whenever a vehicle reaches a service station it sends a message to the workers. Upon receiving a message, the workers can collect the respective service station goods using RFID. If the wrong goods are taken out of the vehicle, the buzzer gets activated. The obstacle detection can be done by ultrasonic sensors. If any obstacle in the route is detected, the message is sent to the control station of the industry using the GSM module. Ms. Mohini Pande, Mr. Dishant Vyas, Ms. Roopakiran Yeluri, et al, [2] implemented an autonomous vehicle based on neural network for navigation in any environments. The conceptual high-level design of a low cost neural network based autonomous vehicle is presented. When going to the destination if there is any obstacle it will be observed by the IR transmitter and receiver and make the vehicle to rotate to the destination position. Once the vehicle reaches the destination the Buzzer switches on. The microcontroller processes the information acquired from the sensors and sends commands accordingly through neural network. The network works offline with tangent-sigmoid as activation function for neurons and is implemented in real time with piecewise linear approximation of tangent-sigmoid function. Shival Dubey, Abdul Wahid Ansari, [3] proposed an electromagnetic anti-collision device in order to avoid vehicular head to head or back collision by estimating the distance between the two vehicles running extreme traffic condition. It incorporates distance finding between two vehicles using ultrasonic range finder. In order to avoid vehicle collision or road accidents, this system will work in two stages, a range finder will continuously track the distance between two vehicles moving and sends it to the ECM using these inputs if it finds the vehicle in the vicinity of the other it will automatically actuate the sensor strip for electromagnetic induction. S. Saravanan, T. Kavitha, [4] implemented an autonomous mobile vehicle which allows the vehicle to reach the desired destination using tracking and obstacle detection schemes. Using Radio Frequency Identification (RFID) technology the vehicle is navigated from source to destination. The obstacle detection is carried out using ultrasonic sensor. If any obstacles are detected, the information is sent to the operator who navigates the vehicle through Global System for Mobile communication (GSM). On the whole, the system suits well for industrial goods transportation. Sameer Darekar, Atul Chikane, Rutujit Diwate, et al, [5] proposed this paper to implement a multi tracking system using the following two technologies, firstly GSM(Global System for Mobile) and GPS(Global Positioning System). The system will provide solution for tracking and tracing of multiple movable objects at a same time via GPS and controlling its subsystem parts via GSM network using SMS, so the name Multi-Tracking System. The current location of the object and other add-on features is obtained. Abid khan, Ravi Mishra, [6] implemented a tracking unit that uses the global positioning system(GPS) to determine the precise location of any object to which it is attached and using GSM modem this information can be transmit to remote user. The location of the object can be reported by SMS message. Software for the system is developed to read, process, analyze and store the incoming SMS messages. If a password is sent by the owner, it stops the vehicle or does some other task as per the user requirement; it can provide real time control. It can provide monitoring system for inter-cities transportation vehicles and in real time traffic surveillance. The purpose of this system is to design a new system which is integrated with GPS - GSM to provide features such as location information, real time tracking using SMS, track bus driver activity and communication is instantaneous thus the running report can be received quickly. It is an integrated system hence tracking of vehicles is easier once the system is implemented in all the vehicles. S.Ramesh, Ravi Ranjan, Ranjeet Mukherjee, et al, [7] proposed a vehicle collision avoidance system using wireless sensor networks and laser sensor. Vehicle collision avoidance system can be identified by using laser rays with the laser transmitter and laser receiver. Laser transmitter is connected to the laser sensor. Can controller is connected to the all sides of the nodes and send the information wirelessly and transmit the message to the LCD output on the driver side. Laser receiver is connected to the CAN controller.

Rajarajan.R, Abdul Rahuman.S, Harish Bharath.M.A, [8] implemented this dissertation in which an ultrasonic sensor is used to sense the object in front of the vehicle and gives the signal to the micro controller unit to avoid crashing. Based on the signal received from the ultrasonic sensor, the micro controller unit sends a signal to the braking unit to brake as per braking and throttle control logic fed in to the micro controller. The function of this system is to avoid the vehicle collision and brake by means of actuators, distance measuring sensors and electronic control module. Liu Huan, Wang Dahu, Zhang Tong, et al, [9] presented a research paper on remote control vehicle; it created a wireless remote controlled car with a crash detection system. The car moves forward/reverse, left/right, and stops as the user desires. The user can also accelerate/decelerate using a joystick. The design allows for easy control of the toy car, and the ultrasonic sensors attached to the car body prevents any possible crashes into obstacles. P. Saravanan, M. Anbuselvi, [10] proposed the paper on ACC for collision detection and prevention using RTOS provides enhancements in the present adaptive cruise control system, which in addition to collision detection provides a comprehensive solution to avoid collision without the driver's intervention. This system with the help of sensors will constantly monitor the lane in which it is travelling. The system after detecting a moving vehicle in front (which moves slower than the set cruise speed of our car) will try to switch to the adjacent lane, if unoccupied. This judgment (of whether a lane is occupied or not) is done with the help of proximity sensors attached on either side of the vehicle. In the new lane, the car will accelerate to the set cruise speed and after overtaking the vehicle, it will again switch back to the previously occupied lane, all of which is done without any human (driver) intervention.

III. STATEMENT OF THE PROBLEM

The basic idea of the project stemmed from a rather playful interest in programming a microcontroller to perform some common function automatically. The design of the car is such that it would autonomously navigate a track made of parallel lines which were meant to mimic the roads that actual full-sized cars encounter. Given that there has been some societal interest in the development of automatic driving car technology, designing a low complexity system with this functionality would be an exciting and practical project to pursue.

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

A Line-Following Car, as shown in figure 1, uses photo sensors to guide the vehicle along a single line track. Also the Autonomous Self-Parking Car introduced us to a cost effective, tractable proximity distance sensor component which is incorporated into the design as a way to detect the lanes.

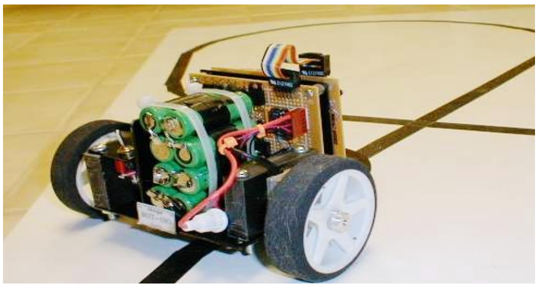

Fig. 1. Line Following Robot

A collision avoidance system was introduced in our design by using a distance measurement technique. There were a lot of techniques available to find the distance but the one technique which was fast, effective and cheap is by using the ultrasonic sensor. With the distance which we obtain from the sensor, the reaction of the car to avoid the obstacle is programmed.

The main objective of problem is to design autonomous vehicle which can be started automatically and drive automatically without changing lanes and avoid forward collisions. The car will be replaced by a microcontroller ARM 7 TDMI S LPC2129 which will drive the car automatically. Proximity infrared sensors and ultrasonic sensors will help in detecting changes in the lane and to avoid forward collisions. When the vehicle drives itself outside the lane without indication, the vehicle will stop and it will shift itself accordingly on the road by using infrared sensors. GSM technology is used to remotely control the car by sending GSM commands from the owner to turn the car on or off.

IV. FUNCTIONAL DESCRIPTION

Shown in figure 2 is the functional block diagram of the system. The modules which are used for the functions are mentioned in the parenthesis.

The microcontroller used is ARM TDMI S LPC2129 32 bit microcontroller. It is used in the system because of its speed of operation i.e. response time, multifunctional port pins, inbuilt ADC, Dual UART ports and many other features. The lane line in the road is detected using infrared sensors. There are two infrared sensors on both sides of the car. It contains a transmitter, an infrared LED, and a receiver, a photo diode, which is used in detecting the grayscale color variation in the road. The distance between the car and the obstacle is measured using the ultrasonic sensor which works on the principle of piezoelectric effect. The device used for displaying the status of the system, such as the distance or the message from the owner, is a LCD display of 16x2 array matrix; each character space is of 5x7 pixels. The vehicle is controlled by external GSM module in the car through a mobile phone. It is used to start and stop the motor of the car. Two DC motors are used for running the vehicle.

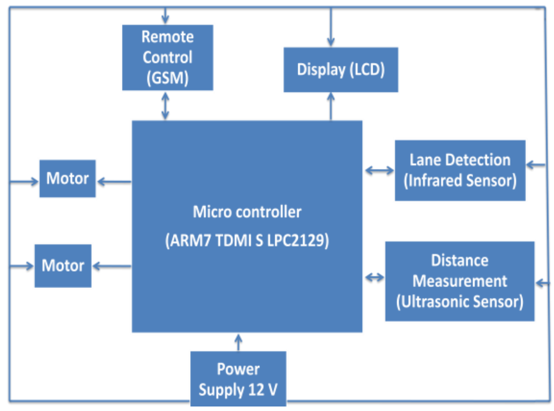

Fig. 2 Functional Block Diagram

V. HARDWARE IMPLEMENTATION

A. ARM7 TDMI S LPC2129

The LPC2129 is based on a 32-bit ARM7TDMI-S CPU with real-time emulation and embedded trace support, together with 256kB of embedded high-speed flash memory. A 128-bit wide memory interface and unique accelerator architecture enable 32-bit code execution at maximum clock rate. For critical code size applications, the alternative 16-bit Thumb mode reduces code by more than 30 percent with minimal per performance penalty. With their compact 64-pin package, low power consumption, various 32-bit timers, 4-channel 10-bit ADC, two advanced CAN channels, PWM channels and 46 fast GPIO lines with up to nine external interrupt pins these microcontrollers are particularly suitable for automotive and industrial control applications, as well as medical systems and fault-tolerant maintenance buses. With a wide range of additional serial communications interfaces, they are also suited for communication gateways and protocol converters as well as many other general-purpose applications.

B. Liquid Crystal Display (LCD)

A 16x2 LCD display is commonly used in various devices and circuits. The reason for preference is that they are economical, easily programmable and have no limitation of displaying special and even custom characters. A 16x2 LCD means it can display 16 characters per line and there are 2 such lines. In the LCD each character is displayed in 5x7 pixel matrix. It has 14 pins. It uses 8 lines for parallel data plus 3 control signals, 2 connections to power, one more for contrast adjustment and two connections for LED back light.

The LCD has two registers, namely, Command or Control register and Data register recognized from the status of the RS pin. The command register stores the command instructions given to the LCD which does a predefined task like initializing it, clearing its screen, setting the cursor position, controlling display etc. The data register stores the data, in ASCII value, to be displayed on the LCD. Data can also be read from the LCD display, by pulling the R/W pin high. As soon as the E pin is pulsed, LCD display reads data at the falling edge of the pulse and executes it, same for the case of transmission.

Published By:
Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP)

LCD display takes a time of 39-43µS to place a character or execute a command. Except for clearing display and to seek cursor to home position it takes 1.53ms to 1.64ms.

LCD displays have two RAMs, naming DDRAM and CGRAM. DDRAM registers in which position which character in the ASCII chart would be displayed. Each byte of DDRAM represents each unique position on the LCD display. The LCD controller reads the information from the DDRAM and displays it on the LCD screen. CGRAM allows user to define their custom characters.

C. Global System for Mobile Communication (GSM)

GSM is a digital mobile telephony system. GSM digitizes and compresses data, then sends it down a channel with two other streams of user data, each in its own time slot. It operates at either the 900 MHz or 1800 MHz frequency band.

The GSM module SIM 300, used in this system, is interfaced with the microcontroller ARM LPC2129. The GSM module is used communicate with the microcontroller through UART. To communicate over the UART, we use three basic signals which are - RXD (receive), TXD (transmit), GND (common ground). In this scheme RTS and CTS signals of serial port interface of GSM Modem are connected with each other. The transmit signal of serial port of microcontroller is connected with transmit signal (TxD) of the serial interface of GSM Modem while receive signal of microcontroller serial port is connected with receive signal (RxD) of serial interface of GSM Modem. A voltage converter MAX232 is employed to convert the RS232 logic data of GSM Module to TTL logic so that it can be processed by the microcontroller. The SMS message in text mode can contain only 140 characters at the most. It depends upon the amount of information collected by the base station.

To send commands from the microcontroller to the number stored a set of pre registered commands called AT commands are used. AT commands allow giving instructions to both mobile devices and ordinary landline telephones. The commands are sent to the phone's modem, which can be a GSM modem or PC modem.

D. Ultrasonic Sensor

Ultrasonic sensors (also known as transceivers when they both send and receive) work on a principle similar to radar or sonar which evaluate attributes of a target by interpreting the echoes from radio or sound waves respectively. Ultrasonic sensors generate high frequency sound waves and evaluate the echo which is received back by the sensor. Sensors calculate the time interval between sending the signal and receiving the echo to determine the distance to an object.

Ultrasonic wavelengths are on the same order of magnitude as visible light. Ultrasonic is a sound wave transmitted at a frequency greater than 18,000Hz or beyond the normal hearing range of humans. Systems typically use a transducer which generates sound waves in the ultrasonic range, above 18,000 hertz, by turning electrical energy into sound, then upon receiving the echo turn the sound waves into electrical energy which can be measured. The voltage obtained is converted to appropriate distance using ADC and is displayed in the LCD.

E. Infrared (IR) Sensor

An infrared sensor is an electronic device that emits and/or detects infrared radiation (which is below the optical spectrum) in order to sense some aspect of its surroundings. Infrared sensors can measure the heat of an object, as well as detect motion.

The basic principle of IR sensor is based on an IR emitter and an IR receiver. IR emitter will emit infrared continuously when power is supplied to it. On the other hand, the IR receiver will be connected and perform the task of a voltage divider. The lower the intensity of IR light cause higher resistance between collector-emitter terminals of transistor, and limiting current from collector to emitter. This change of resistance will decrease the voltage at the output of voltage divider. Hence, if there is a low intensity of IR light on the receiver, the output voltage decreases. After comparing the received voltage with the threshold voltage, the output of the IR sensor is receiver and further action is determined by the software.

F. Power Supply

A transformer can be defined as a static device which helps in the transformation of electric power in one circuit to electric power of the same frequency in another circuit. In this circuit, the voltage is lowered from 230V to 12V. The full wave bridge rectifier is a type of single phase rectifier which uses four individual rectifying diodes connected in a closed loop bridge configuration to produce the desired DC output. It gives greater mean DC value (0.637 Vmax) with less superimposed ripple while the output waveform is twice that of the frequency of the input supply frequency. The average DC output level is increased even higher by connecting a smoothing capacitor across the output of the bridge circuit as shown in figure 3.

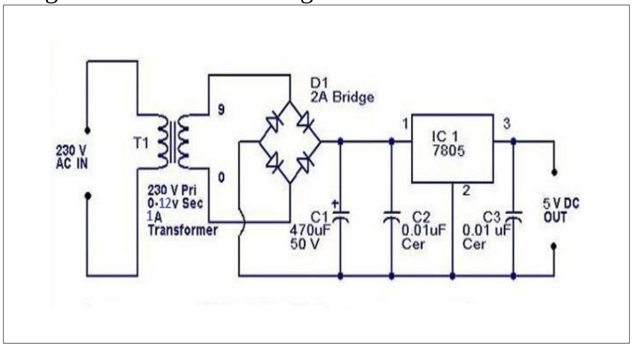

Fig. 2. Power Supply Design

VI. SOFTWARE IMPLEMENTATION

Keil µVision3 IDE is the software that is run on computers to program microcontrollers. One of the supported microcontrollers is ARM 7 LPC2129. An integrated development environment (IDE) provides a single integrated environment to develop a code. The µVision IDE from Keil combines project management, make facilities, source code editing, program debugging, and complete simulation in one powerful environment. Application development for the prototype was done on a desktop computer (PC), using the high level language C. After the executable binary code has been created by the cross development tools in the Keil uVision3 IDE, the binary code is uploaded into the target board. The ARM microcontroller is programmed without being removed from the circuit as it supports in-circuit or in-system programming.

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-3 Issue-5, October 2013

A special programming interface called SPI (Serial Programming Interface) is used to transfer the code from the PC to the microcontroller. Flash magic software was used to dump the hex code obtained from Keil IDE into the microcontroller using the SPI interface. A baud rate of 9600 was used for communication.

VII. RESULTS

The system has been tested as a prototype by using all the modules as mentioned in the functional description. These modules used are assembled in a single board as shown in figure 4. They can be placed far apart as per the requirement, the only extension being the length of the wires. An external battery can be used in place of the 12V transformer to attain portability of the system. Following are the result cases for each input parameters of the prototype:

A. GSM

1. Only if the owner sends any message, the microcontroller responds.
2. If the owner sends the message “ON”, the motors are turned ON by the microcontroller and the car moves forward. The LCD shows the ON condition.
3. If the owner sends the message “OF” (the program accepts two characters from the message), the motors are turned “OFF” by the microcontroller and the car stops. The LCD shows that the motors are turned off.
4. If the owner sends any other message then the microcontroller gives an error message back to the owner. The LCD also shows the error message.
5. If any other number sends any message, the microcontroller does not respond.

B. Ultrasonic Sensor

1. If the distance detected between the car and any obstacle is more than 6.45 meters, the car keeps moving. The distance between the car and any obstacle is showed in the LCD.
2. If the distance detected between the car and any obstacle is within 6.45 meter range (the range can be set), the car stops. The left wheel starts first to overtake the obstacle. Then the right wheel starts for the car to move normally. The suitable time gap is given to overtake the obstacle.

C. Infrared Sensor

1. The infrared sensor has a range of within 3cm and it gives best results for greyscale range.
2. If there is any reflective surface, like white colour surface, within the 3cm range the IR radiation is reflected and the car stops with a suitable delay. This is because the IR radiation is reflected back to the IR detector. After the delay the motor starts.
3. If any non-reflective surface, like black colour surface, is placed within 3cm range, the car keeps moving.

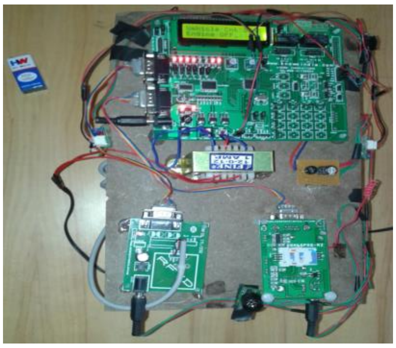

Fig. 3. Prototype Board

TABLE I. RESULT ANALYSIS

Parameter	*Existing Technology*	*Implemented Prototype*
Ultrasonic Sensor	Absent	Present
Infrared Sensor	Absent	Present
GSM Module	Absent	Present
Camera	Present	Absent
Size	Larger	Smaller
Cost	Comparatively High	Comparatively low
Response Time	More than 0.5 seconds	Below 0.5 seconds

VIII. CONCLUSION

The automatic vehicle collision avoidance and lane detection system is an affordable, practical, user friendly and effective solution that will make big impact in today’s fast paced and distractive life style. The alert mechanism that is proposed here will facilitate the vehicle drivers, even of semi-automatic variant, to realize any unusual movement of the vehicle. Lane detection will be an added safety feature which will ensure that the car follows proper lane discipline. Same solution when used in fully automated cars will complement the already available features.

If this product were to be produced commercially, a more sophisticated microcontroller would be used that would eliminate the rounding problems resulting in near perfect distance readings. For real world implementation, the project would need to take into account different situations. For example, it would include movement factors such as velocity, wind, and weather conditions.

The future scope of this system depends on the need of the society. While this system provides basic alert mechanism to the user, additional features could easily be adopted into it, therefore making the project open to further development. Otherwise, this system also functions as a stand-alone device. Additional features like ‘force feedback system’ is possible, which will integrate into the steering and breaking controls. When used in fully automatic cars with cruise control system, the overall safety will be further enhanced.

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

REFERENCES

1. M. Ragul, V. Venkatesh, "Autonomous vehicle transportation using wireless technology", *International Journal of Engineering and Technology (IJET)*, Vol. 5 No. 2, Apr-May 2013
2. Ms. Mohini Pande, Mr. Dishant Vyas, Ms. Roopakiran Yeluri and Prof. (Mrs). Suvarna K.Gaikwad, "Microcontroller based neural network controlled low cost autonomous vehicle", *International Journal of Emerging Trends in Electrical and Electronics (IJETEE)* Vol. 2, Issue 4, April-2013
3. Shival Dubey and Abdul Wahid Ansari, "Design and development of vehicle anti-collision system using electromagnet and ultrasonic sensors", *International Journal on Theoretical and Applied Research in Mechanical Engineering ISSN: 2319 – 3182*, Volume-2, Issue-1, 2013
4. S. Saravanan, T. Kavitha, "Vehicle navigation and obstacle detection system using RFID and GSM", *Journal of Theoretical and Applied Information Technology*, Vol. 38 No.2, 30th April 2012
5. Sameer Darekar, Atul Chikane, Rutujit Diwate, Amol Deshmukh, Prof. Archana Shinde, "Tracking system using GPS and GSM: practical approach", *International Journal of Scientific & Engineering Research* Volume 3, Issue 5, May-2012
6. Abid khan, Ravi Mishra, "GPS – GSM based tracking system", *International Journal of Engineering Trends and Technology-* Volume3 Issue2- 2012
7. S.Ramesh, Ravi Ranjan, Ranjeet Mukherjee, Swarnali Chaudhuri, "Vehicle collision avoidance system using wireless sensor networks", *International Journal of Soft Computing and Engineering (IJSCE)* ISSN: 2231-2307, Volume-2, Issue-5, November 2012
8. Rajarajan.R, Abdul Rahuman.S, Harish Bharath.M.A, "A design and implementation of Collision Avoidance System (CAS) for automobiles using embedded system", *2011 International Conference on Circuits, System and Simulation IPCSIT* vol.7 (2011)
9. Liu Huan, Wang Dahu, Zhang Tong, Huang Kerning," Research on a remote control vehicle", *2010 2nd international Conference on Education Technology and Computer (ICETC)*
10. P. Saravanan, M. Anbuselvi, "Design of an enhanced ACC for collision detection and prevention using RTOS", *2009 International Conference on Advances in Computing, Control, and Telecommunication Technologies*

Published By:
Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP)