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Embedded System For Driver Assistance & Autopilot Technology

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Abstract: **Among the many reasons that can be accounted for the increasing number of accidents; major one is the latency in the reaction of the driver. Recent studies show that one third of the number of fatal or serious accidents are associated with excessive or inappropriate speed, inattentiveness and faulty judgement of the driver. Thus technologies have been developed which would aid the driver for better response to the incoming vehicle or obstacles or any sort of anomaly. The objective of this project is to provide a solution to these minor negligence of the driver which can become a grave danger to himself and others on the road. This project provides a modest combination of multi sensors featuring lane change assistance, obstacle detection and speed control of the vehicle. These features are collectively put under the auto pilot mode which is at the driver's disposal.**

***Index Terms:*—Embedded Systems Autonomous Vehicle, Sensorial Fusion, Atmega16**

I. INTRODUCTION

In today's fast paced world, everyone wants to get everything done swiftly. In conformity with that, speedy movement from one place to another is the requirement. Amidst that the negative consequences of it are unrecognized. There is a fine line between being cautious and incautious/rash which is more than often forgotten by the drivers. Consequently, to steer clear of the adversity, an embedded system needs to be developed. The system provides driver with essential information about their vicinity and automate difficult or repetitive tasks in the hope of an overall increase in safety. Essentially, they compensate for the weakest link: the driver. This system will assist the driver in taking accurate decisions rapidly. Such systems employed provide designed technologies to refrain from collisions with obstacles and alert the driver to the unseen problems or to safeguard the vehicle in general from any calamity. The adaptive technology feature includes automatic lane change, obstacle detection, alert the driver of any incoming obstacle, autopilot mode, etc. Depending on the level of pre-programmed features, categorization of the autonomy of vehicles have been done; ranging from level 0 to level 5 i.e. no automation to full automation. The technology might just be developed to alert the driver or even take full over the control of the vehicle in unfavorable situations.

The following section II gives the background of the project. It also includes the technical specifications of the project.

In the following section III, the papers have been grouped on the basis of the features they incorporate and which sensors have they used to implement them.

Section IV describes the proposed work followed by results in Section V. Section VI concludes and possible areas for further improvement are suggested in section VII.

II. BACKGROUND

A. ADAS

ADAS stands for Advanced Driver Assistance Systems. These are basically systems to help drivers in the driving process. They can be altered depending on the requirement of the car/user. Some of the features like adaptive cruise control, adaptive light control, automatic braking, etc. are already in use. This technology is being taken further by using it autonomous/unmanned vehicles

B. Auto-pilot technology

Auto-pilot refers to a mode in which the vehicle can move on its own and doesn't require driver's full attention. This is mainly built for saving the driver's time in simpler areas like highways where there is not much disturbance and changes in the road dynamics. These include features like adaptive cruise control.

C. Autonomous Vehicle

The vehicles that can perform required tasks even in absence of human guidance are known as autonomous vehicles. In fields like space exploration high degree of autonomy is required where communication and delays are unavoidable. It can travel from one location to the other without navigation assistance. It can sense and keep away from situations that are harmful to any property or itself.

D. Levels of autonomous driving

Five levels of vehicle autonomy have been forged by the Society of Automotive Engineers (SAE) for the purpose of evaluating self-driving vehicles. These levels range from level zero to level five, the level of autonomy of the car increasing from zero to five while the requirement of human intervention decreases.

Level 0: Automated system has no vehicle control, but may issue warnings

Level 1: Driver must be ready to take control at any time. The features that are included under level 1 of automation are Parking Assistance with automated steering, Adaptive Cruise Control, and Lane Keeping Assistance.

Level 2: Only when the automated system fails to respond properly, the driver is obliged to acknowledge and take control. The automated system executes accelerating, braking, and steering. As soon as the driver takes over, the automated system deactivates.

Level 3: In this, the driver can safely turn their attention away from the driving tasks in limited environments such as freeways. But must still be prepared to take control if and when needed.

Level 4: No driver attention is required, similar to level 3. But outside the known environment, the vehicle enters a safe fallback mode – if the driver does not retake control.

Level 5: No human intervention is required at all, other than setting the destination and starting the system. The automatic system can drive to any location where it is legal to drive and make its own decisions i.e. it is fully automatic.

E. Architecture of a general vehicle

The general architecture consists of all the sensors as the input devices, which collect all the data from the surroundings. This data is sent to processor via serial or parallel buses. The processor produces the output which is then put across via output devices.

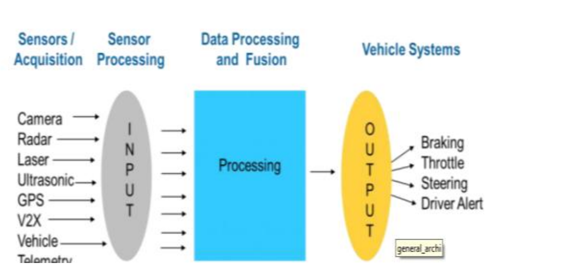

Fig. 1 General architecture

F. Software Specifications

The softwares required for implementation of this project are:

1) Atmel Studio

It is the integrated development platform (IDP) for developing and debugging Atmel, ARM-based and Atmel AVR microcontroller applications. All AVR and Atmel SMART MCUs are supported. It provides an environment to write, build and debug our applications written in C/C++ or assembly code. It also connects seamlessly to Atmel debuggers and development kits.

2) Avrdude

AVRdude stands for AVR Downloader Uploader. It is a program for downloading and uploading the on-chip memories of Atmel's AVR microcontrollers. It is used to program the Flash and EEPROM. It can also program the fuse and lock bits when supported by the serial programming protocol.

G. Hardware Specifications

The hardware requirements of this project are:

1) ATmega16

ATmega16 is an 8-bit high performance microcontroller of Atmel's Mega AVR family with low power consumption. It is based on enhanced RISC (Reduced Instruction Set Computing) architecture. Almost all instructions execute in one machine cycle. The maximum frequency that Atmega16 can work at is 16MHz. It has 16 KB programmable flash memory, static RAM of 1 KB and EEPROM of 512 bytes. It is a 40 pin microcontroller. It has 32 input/output lines which are divided into four 8-bit ports designated as PORTA, PORTB, PORTC and PORTD. It has various in-built peripherals like USART, ADC, Analog Comparator, SPI, JTAG etc. Each I/O pin has an alternative task depending on the in-built peripherals, example: PORTA

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has an alternative task of analog to digital convertor. The following image shows the pin description of ATmega16:

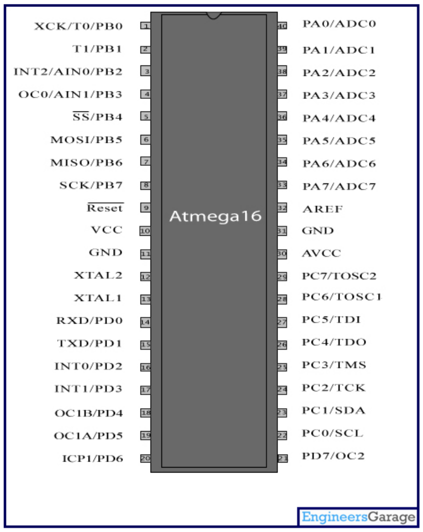

Fig. 2 Pin diagram of ATmega16

2) ATmega8

ATmega8 is a low-power CMOS 8-bit microcontroller which is based on the AVR RISC architecture. Powerful instructions can be executed by ATmega8 in a single clock cycle. Thus, ATmega8 achieves a throughput of around 1 MIPS per MHz, hence allowing the system designer to optimize power consumption versus processing speed with ease. In our project, ATmega8 is used to dump codes onto ATmega16.

3) IR sensors

The IR Sensor single is a general purpose proximity sensor. The sensor consists of an IR emitter and IR receiver pair. The highly precise IR receiver always detects an IR signal. The module consists of comparator IC. The output of sensor is low if it isn't IR frequency that is being received else high. The on-board LED indicator helps the user for checking status of the sensor without using any additional hardware. It is a low power consumption sensor. Its output is digital in nature. The sensitivity of the IR Sensor is tuned using the potentiometer. The output pin goes low when even though the IR LED is continuously transmitting, cause of absence of an obstacle, nothing is reflected back to the IR receiver. The result, LED is off. When an obstacle encountered, obstacle surface reflects IR signal, driving the output of the comparator low. Resulting in high output pin, hence LED, turned ON.

4) Ultrasonic sensors An Ultrasonic sensor is a device that can measure the distance to an object by using sound waves. It works on the basic principle of science, reflection. It measures distance by sending out a sound wave at a specific frequency (ultrasonic) and waiting for that sound wave to bounce back. It records the elapsed time between the sound wave being generated and the sound wave echoing. This makes the calculation of the distance between sonar and the obstacle possible. The basic formula of speed, distance and time can be rearranged for calculating this distance. The speed of sound through air is about 344 m/s, multiplied with time will give us the double the distance i.e. the distance travelled in a round trip. It includes the 'trip' from the sonar sensor to the object and the 'trip' from the object to the Ultrasonic sensor (after the sound wave bounced off the object). To find the distance to the object, simply divide the round-trip distance in half.

5) LCD A liquid-crystal display (LCD) is a flat-panel display or other electronically modulated optical device that uses the light-modulating properties of liquid crystals. The LCD screen is more energy-efficient and can be disposed of more safely than a CRT can. It can be easily powered using batteries due to low electrical power consumption.

6) DC motor The DC motor is a device that converts electrical energy into mechanical energy. It is made of a rotating armature in the form of an electromagnet. A rotary switch known as commutator reversing the direction of the electric current twice every cycle to flow through the armature so that the poles of the electromagnet push and pull against the permanent magnets on the outside of the motor. The armature electromagnet behaves like the poles of the permanent magnets, since using the poles, the commutator reversing the polarity of the armature electromagnet. During that instant switch of polarity, inertia actuates the classical motor going in the proper direction.

) Accelerometer The accelerometer we are using is ADXL335 which is a small, thin, low power, complete 3-axis accelerometer with signal conditioned voltage outputs. It has a measurement range of ±3 g minimum. The output signals are analog voltages that are proportional to acceleration. The accelerometer can measure the static acceleration of gravity in tilt-sensing applications as well as dynamic acceleration resulting from motion, shock, or vibration.

III. LITERATURE REVIEW

Research work related to aiding the driver and easing the driver experience have been taken up by many researchers. Car companies like Jaguar, Land Rover and Hyundai have shown good interest with respect to this research for making driving a safer experience for their customers [20], [21]. One of the features of Google has even been granted a patent for pothole detection system [22] which uses two sensors — GPS and a vertical accelerometer — to automatically document nasty bumps in the road. Moreover, Microsoft has developed systems like TrafficSense [23] and Nericell [24] which include similar features.

This literature review includes papers which were openly available and are published from the period of 2010 to 2016 and employs a combination of diverse combination of sensors. One of the major reasons in the vehicular fatalities is over speeding. This clubbed with the faulty judgment result in even more adverse mishaps. Accident avoidance can also be done by sending the coordinates in case of collision via GSM to a preset number. To ease the process of finding the apparent cause of the accident a visual and audio memory backup will be created [2]. This memory can help the manufacturer improve his vehicle. But this won't account for the over speeding of the driver. Therefore under such conditions, the driver needs to be forced to speed down.
Simple execution of speed control is done by giving commands (setting different speeds) to the DC motor which is connected to a microcontroller using remote control by the use of RF transmitter and receiver [1]. In this the speed of the wheel can be controlled from a distance. This can be improvised further by installing the wireless setup inside the vehicle itself and using ZigBee transceiver [6], and controlling the speed sitting in the vehicle itself. Another wireless technology that can be used to implement such a system is CAN [5].

The over speeding on roads can be detected using Doppler Effect, this will be installed on the sides of the road along with a camera. This camera would help detect the number plates of the over speeding vehicles using theories of digital image processing (DIP). These number plates would then be sent to the nearest toll gate so that the person is fined for exceeding the speed limit [3]. Another way to keep a check on the over speeding vehicles can be done using IR diodes, by placing them on roadsides at a known distance and calculating speed from knowing the time taken for a vehicle covering that specific distance [17].
Directly controlling the speed of vehicles on road is a tough task, hence another way to limit the speed of the vehicle is by informing the driver from time to time depending on the different areas he enters. This can be done using the global positioning system (GPS). This GPS will be used to find the exact zone and the speed limit allowed there [4], thus keep the driver informed. This information can also be given to the driver by a RF transmitter [7], [13] or RFID [9] that is installed on road side, marking that zone and a receiver that is installed on the vehicle.

The speed control can be taken one step further by actually controlling the vehicle speed by controlling the acceleration pedal position [8]. But this is can turn out to be faulty in traffic prone areas. Along with speed control obstacle detection is also important, which needs to be in all directions. A modest way of implementing this using ultrasonic sensors [10]. Alternatively, camera can also be used, which for further processing would use concepts of DIP [11] or machine learning [14]. Alongside the reasons already mitigated, another possible reason for collisions is inattentive driver/ driver drowsiness, which can also be taken care of by using eye blink sensor [12].

A combination of the zonal speed control using RF and GSM collision avoidance can mitigate and also take care of consequences just in case [15]. Another combination to

implement the same is by using GPS for the zone information and GSM to cater to accidents if any, immediately [16].
Additionally, all the existing driver assisting features like Automatic cruise control, etc. can be combined with zonal speed control using RFID [18] making it safer for the driver. This can be taken a notch higher by installing various gas detectors in the car to keep a check on the various leaks that may occur [19].

IV. PROPOSED SOLUTION

The advanced driver assistance system is what we are trying to replicate with our own terms. The main purpose of this project is to develop a low cost version of autonomous system of level 2. Level 2 means partial automation or combined autonomous functions. In this, the system is capable of driving the vehicle by itself under certain conditions, but the driver might need to supervise what the vehicle does. Level 2 contains a combination of functions as the name suggests. Features that will be majorly incorporated are obstacle detection, lane change assistance, and speed control. The project of driver assistance cannot be completely drawn in a prototype form since the vehicle that we use is small and there cannot be any driver instructions given to the vehicle in any form. Hence the prototype seems is more or less autonomous.

Our prototype consists of an accelerometer which provides the system with acceleration with which our system is moving on the track. Acceleration is how quickly something can speed up or slow down. We require this system to know if our vehicle is deaccelerating or accelerating. We are here trying to use the information of the accelerometer and display on the screen which will be seen by the driver who can take necessary steps just in case.

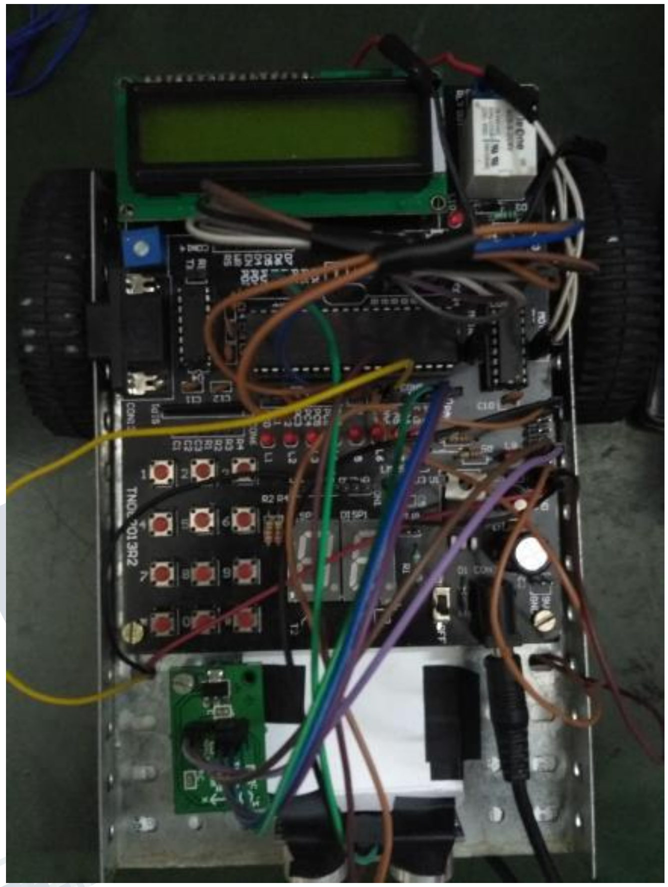

Fig. 3 Prototype Vehicle

This project constitutes a combination of the basic line follower and obstacle avoidance which is achieved using ultrasonic sensors and IR sensors. In order to make our vehicle more user friendly, the obstacle distance and the safe speed will be displayed on a LCD screen. The vehicle will drive on the white lane having black line in the middle. When the IR sensors mounted on the vehicle detect the white line they move forward. To detect the white line the IR sensors will send out the light from the transmitter and wait for the reflected light as the output. Depending on the reflection, the vehicle follows the line.

The ultrasonic sensor serves by sending a trigger signal and waiting for the echo signal to calculate the distance of the any obstacle with the system. Using appropriate calculations the distance is calculated and

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displayed on the screen. According to that information the vehicle will be designed to take steps. Using the output of ultrasonic sensors we fix a limit distance which would be harmful for our prototype if achieved. When the limit is touched the vehicle changes lane. With our project we will try to enhance features by introducing zonal speed control. This would be realized by installing a RF transmitter and receiver in our system and the surrounding to limit the speed of the vehicle when entering into a zone. This will be helpful when the vehicle is entering into a crowded zone for example, the school zone, the market zone etc. But in our prototype we cannot incorporate RF transmitter since its range is too high and we won't be able to show the difference of changing speeds in real time. So to eradicate this problem we have used two black boards, each at the corner of the zones. When the vehicle passes through the zones, the IR receiver installed at the side of the vehicle will detect the black color and the speed will be lowered until it detects the next black board which will be at the end of the zone. In this manner the zones will be speed limited.

V. RESULTS

A. Lane driving

The vehicle will drive on the white lane having black line in the middle. When the IR sensors mounted on the vehicle detect the white line they move forward. To detect the white line the IR sensors will send out the light from the transmitter and wait for the reflected light as the output. When both of our IR sensors sense the reflection, our vehicle moves forward. Black color absorbs all the light falling on it. So when our sensor falls on the black line, the output is null. Hence our vehicle in this manner detects the black line. The black line going in the middle of the road when takes turn right or left, the vehicle should also take a right or left accordingly. When the black line falls on the left IR sensor the left wheel stops moving according to our coded program. Hence when left wheel doesn't move and the right wheel moves, the vehicle turns left. The same mechanism takes place when the right IR sensor is detected black. When both the sensors detect black, our vehicle stops then and there.

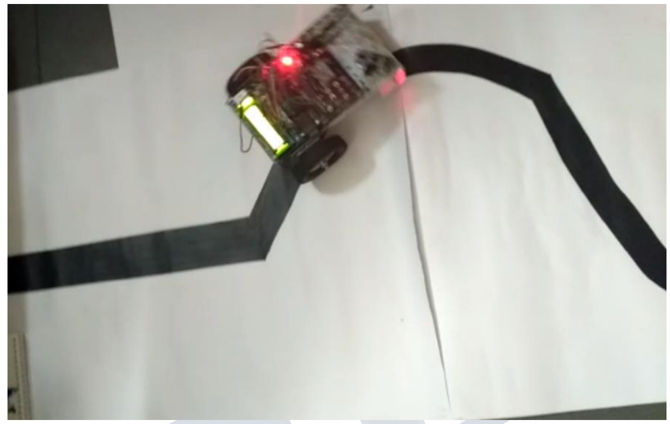

Fig. 4 Line follower robot

B. Obstacle Detection

The ultrasonic sensor works on the principle of reflection. It serves by sending a trigger signal and waiting for the echo signal to calculate the distance of the any obstacle with the system. Using appropriate calculations the distance is calculated and displayed on the screen. When the obstacle is too far there is "no distance" displayed. Using the output of ultrasonic sensors we can fix a limit distance which would be harmful for our prototype if achieved. When the limit is touched the vehicle changes lane and follow the new lane given that lane is free to move into. The data given by ultrasonic sensor and accelerometer, the vehicle will slower the speed or change lane or stop there immediately according to the program.

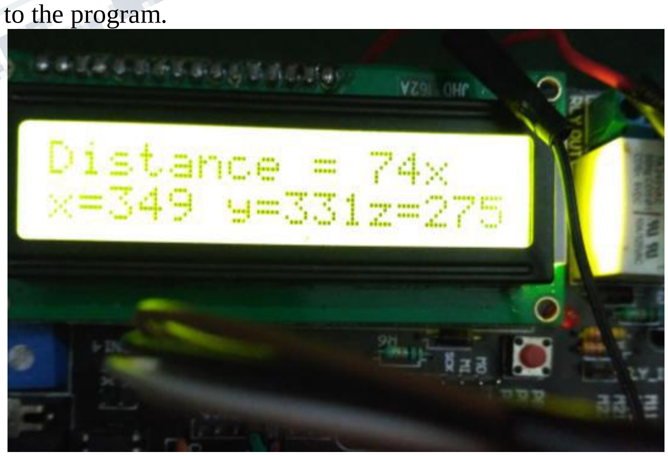

Fig. 5 Ultrasonic sensor and accelerometer readings

C. Speed Control

The zonal speed limit feature that we have used in our system will help the vehicle to curtail the speed in the regions will be crowded at certain point of time. These zones are defined using IR sensors. The speed limit will be set and when the prototype enters the region, the speed will not exceed a certain limit and hence the probability of accidents happening in the crowded areas will deteriorate .The speed will be controlled (if required) by changing the rotation of the wheels. The output to the wheel is in digital form i.e. 1 or 0. So Pulse Width Modulation technique is used convert the digital output to analog one. The duration of pulse is called pulse width and this width can be modulated accordingly to get the desired analog output which will be given to the motor and the rotation can be tamed.

So in our project whenever the vehicle sees an obstacle it will check the distance and when the distance is too small, it changes the lane and follows the lane. When it passes through an area which is crowded, it slows the speed until it is out of the area. Once it is out of the zone, it retains its original speed.

VI. CONCLUSION

The consequences of any collision can be very adverse, thus the proposed solution provides a low cost method of constructing an autonomous vehicle. This vehicle incorporates the features of a level 2 autonomous vehicle. These features include lane change assistance, obstacle detection, cruise control and speed control depending on different zones. Cruise control is implemented on the prototype using a simple line follower. The lane change assistance makes use of obstacle detection and depending on the distance from the obstacle changes the lane. Speed of the prototype is controlled on the basis of the zone it enters like a school zone or a freeway. The entire system is built using very low cost and readily available sensors.

VII. FUTURE SCOPE

The future scope of this project is to include more features like blind spot reduction which can be realized by using more advanced sensors like RADARs, LIDARs, etc.

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