Learning by Doing Automation using different sensors in Regular Laboratory

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Abstract : The popularity if using microcontrollers has been increasing vastly in recent years due to much higher affordability and simplicity. Sensors became an integral part in our daily life. This paper presents a low-cost solution of using and implementing different sensors. The microcontrollers named "Arduino" which controls different sensors and Actuators by which different parameters can be monitored. Based on the change of the curriculum, various projects are assigned in laboratory for performance evaluation. The students are monitored and guided for doing despite the regular curriculum. This learning-by-doing(LbD) increased their concentration level towards the lab. The performance of the students had increased better when compared to the traditional experiment-oriented laboratory.

***IndexTerms* - Sensor, Arduino, Ultrasonic sensor, Accelerometer sensor, Infrared sensor.**

I. INTRODUCTION

In any major system, whether it may be a mechanical system or an electronic system "Measurement" is an important subsystem. Sensors, actuators, transducers and signal processing devices comprises a measurement system. Sensor is a device that produces a measurable response to a change in a physical condition. Transducer transforms the output of the sensor to an electrical output. These devices and elements are not limited to measuring systems; they are used in systems which perform specific tasks, to communicate with the real world. The communication can be like reading the status of a signal form a switch or to trigger a particular output to light up an LED. According to Instrument Society of America, "a sensor is a device that provides usable output in response to a specified quantity which is measured." 'To perceive' is the original meaning derived for the word sensor. A sensor provides an output signal that can be measured and/or recorded corresponding to the changes and events in a physical stimulus. Here, the output signal can be any measurable signal and is generally an electrical quantity [1]. Sensors are devices that perform input function in a system as they 'sense' the changes in a quantity. For, example a sensor mercury thermometer the quantity to be measured is heat or temperature. The measured heat or temperature is converted to a readable value on the calibrated glass tube, based on expansion and contraction of mercury.

II.CRITERIA TO CHOOSE A SENSOR

The features that are considered while choosing a sensor are

- **Type of Sensing:** The parameter that is being sensed like displacement or velocity.
- **Operating Principle:** Principle of operation of sensor.
- **Power Consumption:** While defining the total power of the system then the power consumed by the sensor will play an important role.
- **Accuracy:** It plays key role while selecting a sensor.
- **Environmental Conditions:** The conditions in which the sensor is being used will be a factor in choosing the quality of a sensor.
- **Cost:** Sensor cost is depended on the cost of application.
- **Resolution and Range:** The smallest value that can be sensed and the limit of measurement are important.
- **Calibration and Repeatability:** Change of values with time and ability to repeat measurements under similar conditions.

III.CLASSIFICATION OF SENSORS

The scheme of classifying sensors can range from very simple to very complex. The stimulus that is being sensed is an important factor in this classification.

Some of the stimuli are

- **Acoustic:** Wave, spectrum and wave velocity.
- **Electric:** Current, charge, potential, electric field, permittivity and conductivity.
- **Magnetic:** Magnetic field, magnetic flux and permeability.
- **Thermal:** Temperature, specific heat and thermal conductivity.
- **Mechanical:** Position, acceleration, force, pressure, stress, strain, mass, density, momentum, torque, shape, orientation, roughness, stiffness, compliance, crystalline and structural.
- **Optical:** Wave, wave velocity, refractive index, reflectivity, absorption and emissivity.

Electrical Transducers are classified according to their structures, application area, method of energy conversion, output signal nature etc. They are classified into five different types i) Active & Passive Transducers, ii) Analog & Digital Transducers, iii) Primary & Secondary Transducers, iv) Transducer & Inverse Transducer and v) Bases on Transduction Principle. Transducer converts non-electrical quantity into electrical quantity. Whereas inverse transducer converts electrical quantity into non-electrical quantity. Active Transducers are self-generating type of transducers. These transducers do not require external power supply for their operation. Passive transducers do not generate any electrical signal by themselves. They require external source of power for their operation. Analog transducers convert the input quantity into a analog output which is a continuous function of time. While digital transducers produce an electrical output in the form of pulses. Some transducers consist of mechanical device along with the electrical device. In such transducers mechanical device acts as a primary transducer and converts physical quantity into mechanical signal. The electrical device then converts mechanical signal produced by primary transducer into an electrical signal. Therefore, electrical device acts as a secondary transducer.

IV. EASE OF STUDY

A. Arduino UNO

The board in Fig.1 is a microcontroller board based on the ATmega328 named as Arduino Uno [2]. The board consists of 14 digital I/O pins, 6 analog inputs, a 16MHz ceramic resonator, a power jack, a USB connection, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.

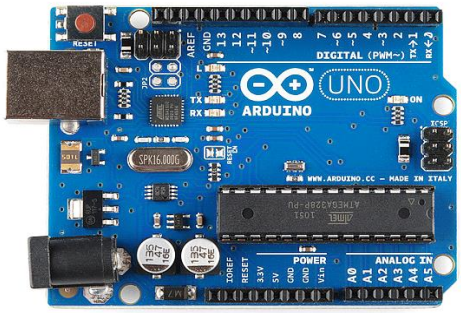


Fig.1 Arduino UNO

B.IR sensors

The **IR Object Detection** sensor module is quiet easy to make. This sensor circuit below in Fig.2 is a low cost - low range infrared object detection module that you can easily make at home using IR LED's. The Maximum input Voltage is 5 Volts [3].

Fig.2 IR Sensors

L293D is a typical Motor driver or Motor Driver IC shown in Fig.3 allows DC motor to drive on either direction [4]. L293D is a 16-pin IC which can control a set of two DC motors simultaneously in any direction. A direct current, or DC, motor is the mostcommon type of motor. DC motors normally have just two leads, one positive and one negative. If you connect these two leads directly to a battery, the motor will rotate. If you switch the leads, the motor will rotate in the opposite direction. For precise control of angular or linear position, velocity and acceleration line actuator or rotary a servomotor is used. For position feedback a suitable motor is coupled to a sensor. To use along with servomotors, it requires a relatively sophisticated controller. Servomotors don't seem to be a selected category of motor though the term servo motor is usually accustomed word to a motor appropriate to be used in a very closed-loop system. Chassis consists of an enclosed vehicle frame that supports a manmade object in its construction and use, can even give protection for a few internal components.

Fig.3 L293D Motor Driver

C.The Ultrasonic Sensor

The Fig.4 shown below is the ultra sonic sensor it has two openings on its front. One opening transmits ultrasonic waves and the other receives them. One acts as a speaker whereas other acts as a microphone. This sensor calculates the time taken for the echo to reflect back of the ultrasonic waves which has been transmitted by itself. The distance to an object is determined by the time difference between sending and receiving the sound pulse by this sensor [5].

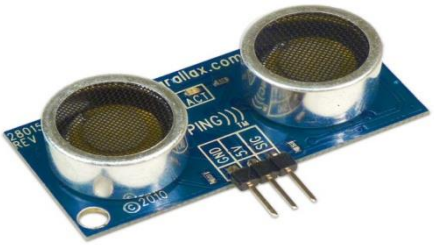


Fig.4 Ultrasonic Sensor

D.AdXL335 Accelerometer

The ADXL335 is a 3-axis accelerometer small, low power, thin, and with signal conditioned output voltages. It measures acceleration with a minimum full-scale range of ±3 g. In tilt-sensing applications it measures the static acceleration of gravity. And dynamic acceleration resulting from motion, shock or vibration. The user selects the bandwidth of the accelerometer using the CX, CY and CZ capacitors at the XOUT, YOUT and ZOUT pins [6]. Bandwidths can be selected to suit the application, with a range of 0.5 Hz to 1600 Hz for the X and Y axes, and a range of 0.5 Hz to 550 Hz for the Z axis. The ADXL335 is available in a small, low profile, 4 mm ×4 mm × 1.45 mm, 16-lead, plastic lead frame chip scale package. The Fig.5 shows the required ADXL35 accelerometer.

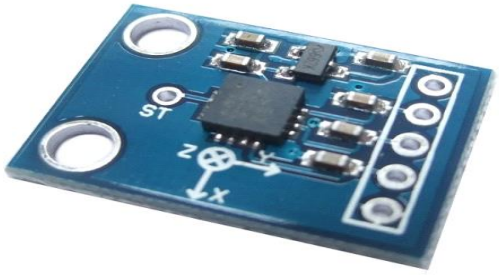


Fig.5 ADXL335 Accelerometer

These wireless transmitters work with 433MHz receivers. They can easily fit into a breadboard and work well with microcontrollers to create a very simple wireless data link. Since these are only transmitters, they will only work communicating data one-way, two pairs (of different frequencies) are needed to act as a transmitter/receiver pair. Fig.6 shows the required 433 MHz RF transmitter and Receiver [7].

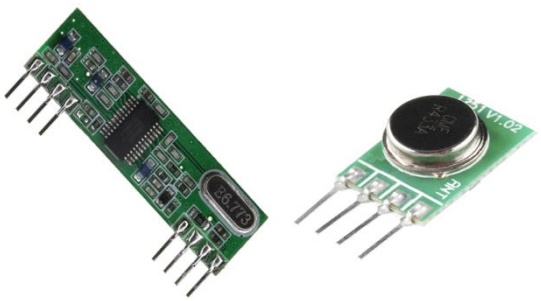


Fig.6 433 MHz RF transmitter and Receiver

These wireless receivers work with 434MHz transmitters. They can easily fit into a breadboard and work well with microcontrollers to create a very simple wireless data link. Since these are only receivers, they will only work communicating data one-way, two pairs (of different frequencies) are needed to act as a transmitter/receiver pair.

IV.CASE STUDIES

A. Monitoring rechargeable battery condition using Arduino.

The rechargeable batteries are generally charged with a normal charger without any monitoring system. As there is nothing to monitor its charging level or its temperature the batteries may lose their efficiency and get spoiled on rapid use. To avoid such disaster battery condition has to be monitored. This is done by monitoring its temperature and charging accordingly.

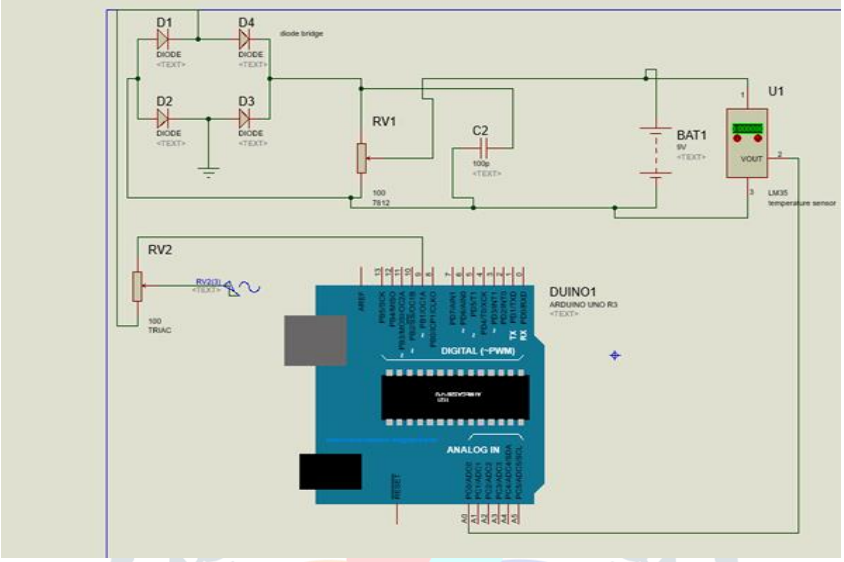


Fig.7 Monitoring rechargeable battery condition using Arduino

The circuit shown in Fig.7 is switched on and current starts flowing for the battery to get charged. During the charging period battery gets heated up. Increase in heat is sensed by the temperature sensor LM35 which is sent to Arduino. When temperature is greater than normal, supply automatically gets switched off as gate to the TRIAC becomes low. This change can be seen by connecting a voltmeter to the output of the supply. Voltmeter reads the output voltage to the battery when charging. When discharging voltmeter reads the battery voltage. If battery is disconnected it reads the value of capacitor when discharging. By charging the battery in this way we can improve the battery performance and even prevent the damage due to overheat setup for Monitoring rechargeable battery condition using Arduino.

B. Line Follower Robot using ARDUINO

Robot is a mechanical or virtual artificial agent, usually an electro mechanical machine that is guided by a computer program or electronic circuitry, and thus a type of an embedded system. By mimicking a lifelike appearance or automating movements, a robot may convey a sense of intelligence or thought of its own. The line following robot, operates as the name specifies. It is programmed to follow a dark line on a white background and detect turns or deviations and modify the motors appropriately. The optical sensor is an array of commercially available IR reflective type sensors. The core of the robot is the PIC 16F873 microcontroller. The speed control of the motors is achieved by the two PWM modules in the micro coulomb. The direction control is provided by 2 I/O pins. The H-Bridge motor driving/control chip takes these signals and translates it into current direction entering the motor armature. The motors require separate supply for operation. The sensor used here is an array of 7 IR Led-phototransistor pairs arranged in the form of an inverted V. The control has 6 modes of operation, turn left/right, move left/right, and drift left/right. The actual action is caused by controlling the direction/speed of the two motors (the two back wheels), thus causing a turn. In this project two IR detector modules particularly, left detector and right detector are used. Once each left and right detector senses white colour then mechanism move forward. Left detector comes on black line then mechanism flip left aspect. so the total system that's being developed is shown in Fig.9.

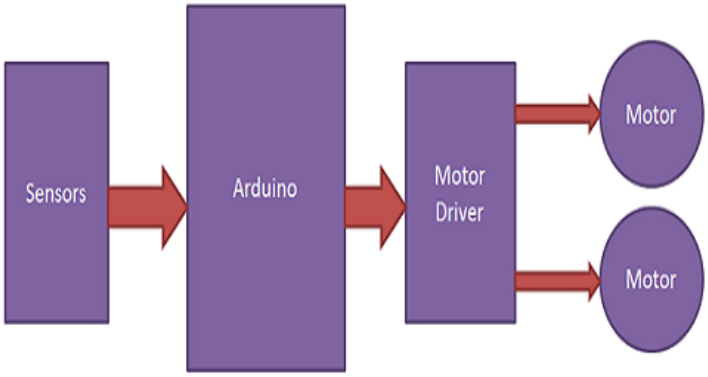


Fig.8 Block Diagram for Line Follower Robot using ARDUINO

If right detector sense black line then mechanism flip right aspect untill both device comes at white surface. Once white surface comes mechanism starts moving on for- ward again. If sensors return on black line, mechanism stops [8].

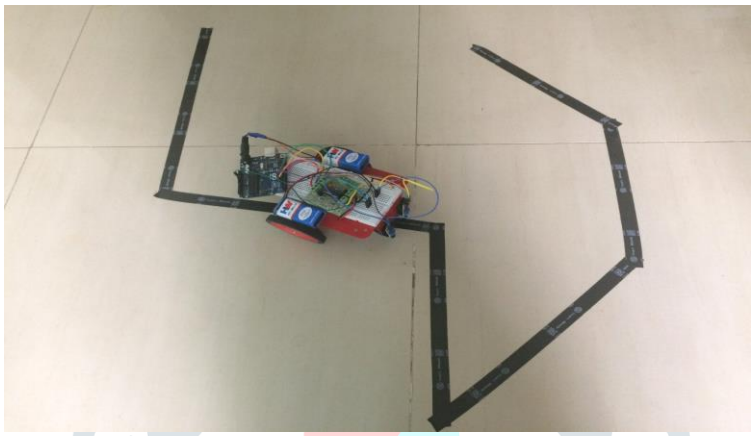


Fig.9 Hardware setup of Line Follower Robot using ARDUINO

The black line can have a lesser reflectivity value (black absorbs light) than the lighter surface around it. This low value of reflectivity is that the parameter used to detect the position of the line by the robot. The higher value of reflectivity are the surface round the line.

C. Object Avoider Robot using Ultrasonic Sensor and Servo Motor

The word robotics is used to collectively define a field in engineering that covers the mimicking of various human characteristics. It must be able to perform certain tasks, which are set for it. The desired task must be achieved within some given limitations. The obstacle detection is primary requirement of this autonomous robot. The robot gets the information from surrounding area through mounted sensors on the robot. Some sensing devices used for obstacle detection like bump sensor, infrared sensor, ultrasonic sensor etc. Ultrasonic sensor is most suitable for obstacle detection and it is of low cost and has high ranging capability. A servomotor connected to ultrasonic sensor allows the sensor to look around.

The obstacle rejection robotic vehicle uses ultrasonic sensors for its movement. The ultrasonic device is connected before a the robot that is so connected to a servomotor. Whenever the robot goes on the specified path the ultrasonic device transmits the ultrasonic waves unendingly from its device head. Whenever associate obstacle comes earlier than it the ultrasonic waves are mirrored back from associate object which info is passed to the system. The system controls the motors left, right, back, front, supported ultrasonic signals. Due to its various applications and low cost ultrasonic robots have become more essential.

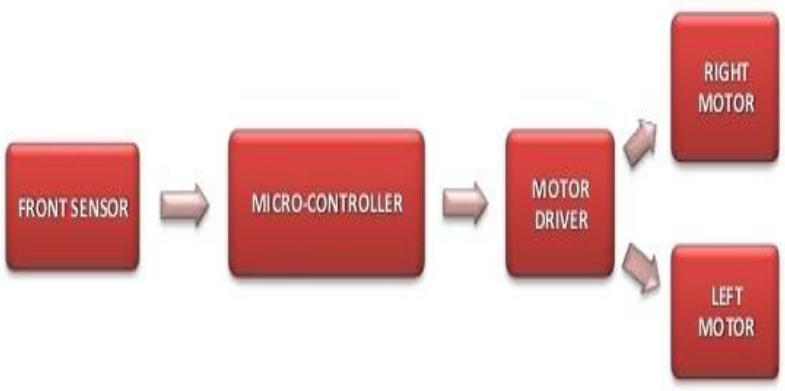


Fig.10 Block Diagram for Object Avoider Robot using Ultrasonic Sensor and Servo Motor

First connect the metal chassis to the DC motor with the help of chassis. Later connect the bread board at the start of the metal chassis . Place the arduino and L293D motor driver with double side tape to the metal chassis. Now connect the motor pins to the L293D motor driver. The motor driver pins are connected to the digital pins. Connect the 5V and ground of the arduino to the breadboard.Ultrasound sensor has 4 pins Vcc,Ground,Trig pin,Echo pin. The echo pin and trig pin goes to the 2 pin and 3 pin of the arduino board. The Ground and Vcc of L293D motor driver goes to the negative and positive of the bread board. Connect the ultrasound sensor at the top of the servo motor and the servo motor is connected to the bread board with the angle of the servo motor placed at 90 degrees. Coming to servo motor which has three pins Vcc, Ground,Signal pin. The Signal pin goes to 9th pin of the arduino and Vcc and the ground goes to 6v supply given extrenally.Supply to the motor driver is given with the help of battery. First connect the battery to the required motor, arduino and servomotor. The motor starts moving in forward direction and goes as per the program. Thus the whole system that is being developed is shown in Fig.11.
When an obstacle comes in front of the robot the ultra-sound detects the signal and transmits it to the receiver which is the echo and trig pin of the ultrasound, sound sensor. The ultrasound sensor when detects an obstacle the servo motor goes from 90 degrees position to the 180 degrees position and later goes to 0 degrees position.

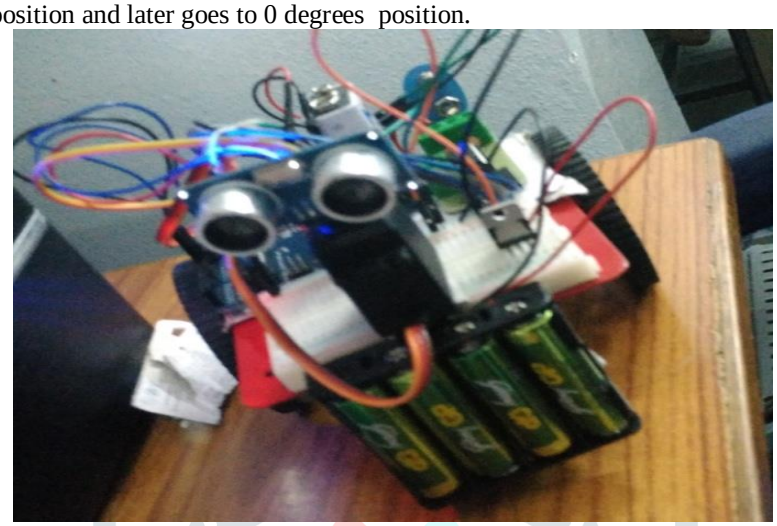


Fig.11 Hardware setup of Object Avoider Robot using Ultrasonic Sensor and Servo Motor

Due to the motion of the sensor the ultrasound sensor detects the objects all around. It checks for the left distance to that of the right distance. The greater the left distance to that of the right distance robot moves to the left distance and vice versa. The movement of the robot depends on the time delay given in the program. Later the robot moves in the forward direction.

D. Gesture Control Robot using ARDUINO

A Gesture Controlled robot is a kind of robot which can be controlled by hand gestures not by old buttons. A small transmitting device is to be carried in hand which included an acceleration meter. This will transmit an appropriate command to the robot so that it can do whatever is needed. The transmitting device included a ADC for analog to digital conversion and an encoder IC(HT12E) which is use to encode the four bit data and then it will transmit by an RF Transmitter module. At the receiving end an RF Receiver module receiver's the encoded data and decode it by and decoder IC (HT12D). This data is then processed by a microcontroller and finally motor driver to control the motors.
Fix the wheels on the chassis. Mount the DC motors on the rear wheels and use dummy wheels for the front. Mount the L293D IC on the board and place it on the chassis place the Arduino on the chassis and connect L293D. When the input supplied are opposite then the motor rotates. as an example, low, could rotate the motor in dextrorotatory, high in anti-clockwise. If all the inputs are same then motor doesn't rotate. during this case it absolutely was discovered that the robot can move forward if pin nine of Arduino is high, pin eight is low (for left motor),pin ten is high, pin seven is low(for right motor). equally for moving back the combination is high, low, low, high. The robo can go right if left motor is moving and right is stopped by giving same inputs [9]. Similarly for left. Thus the whole system that is being developed is shown in Fig.13.

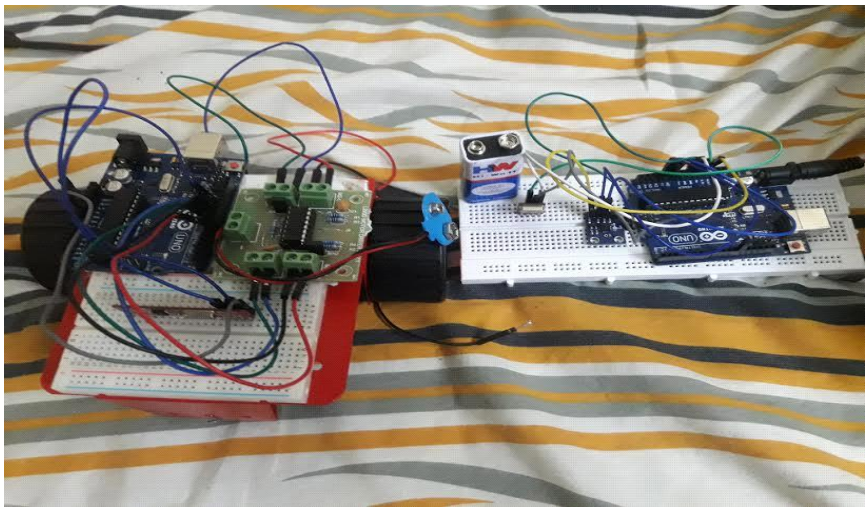


Fig.13 Hardware setup of *Gesture Control Robot using ARDUINO*

E. Car Parking with LEDs Bar Graph

India is facing a new problem nowadays – the problem of parking the car properly which is also resulting lack of sufficient parking spaces. With families getting smaller and the total number of motor vehicles exceeding the total number of heads per family, the parking scenario is woefully falling short of the current requirements in the country. The problem has been further exacerbated by the fact that nowadays even people from low income group are able to own cars. The number of families with cars has become much more than what the country is able to manage. A distance device may be a device able to discover the presence of near objects without any physical contact. A distance device usually emits associate magnetism field or a beam of electromagnetic wave (infrared, for instance), and appears for changes within the field or echo sign.[10]

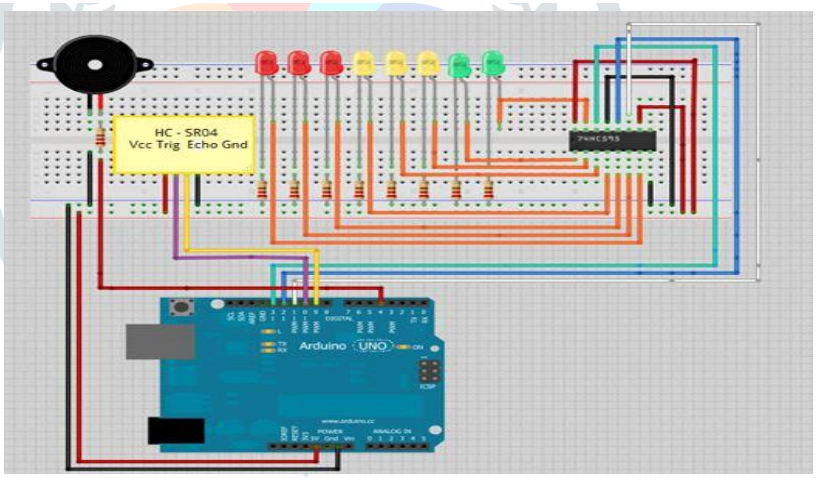
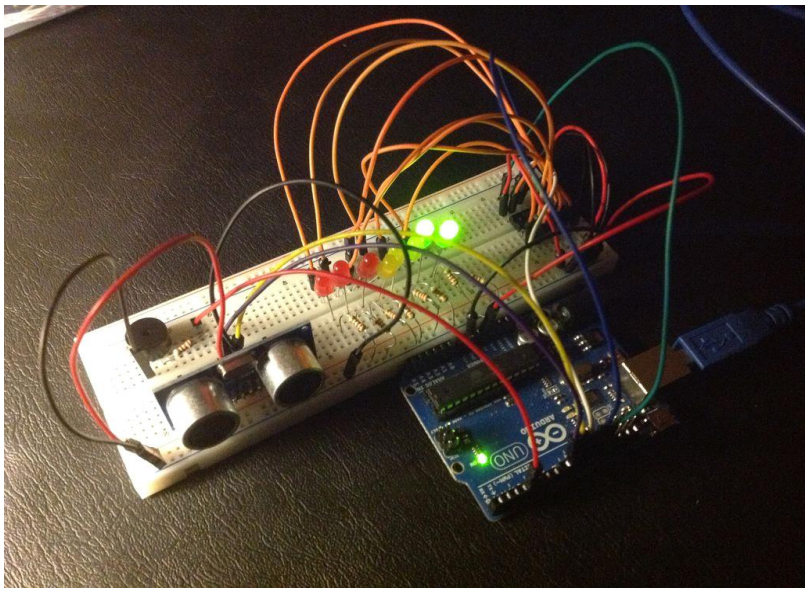


Fig.14 Circuit Diagram of *Car Parking with LEDs*

In this project economical and simple way to park the automobile has been demonstrated. Arduino has been incontestable. Arduino is open-source physical science platform supported easy-to-use hardware and computer code. Arduino boards are able to browse inputs - light-weight on a device, a finger on a button, or a Twitter message - and switch it into output - activating a motor, turning on semiconductor diode, any thing on-line. The Hardware setup is shown in Fig.15.



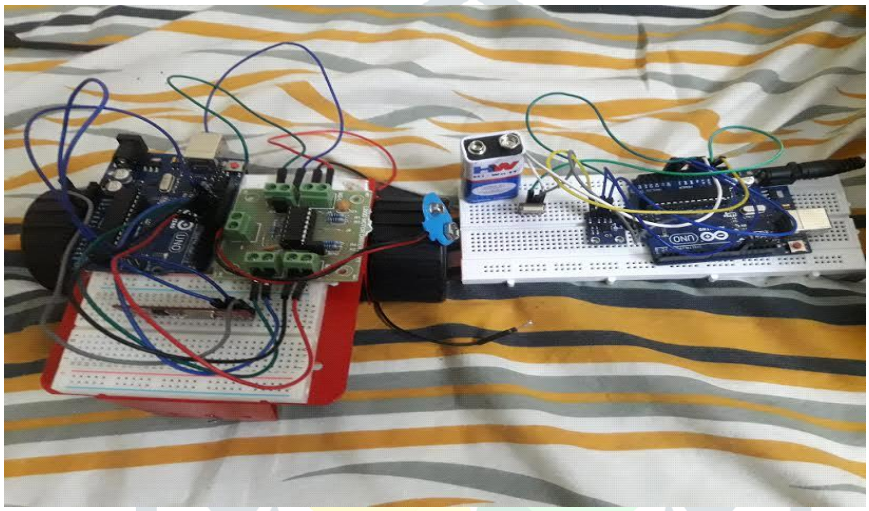


Fig.15 Hardware setup of Car Parking with LEDs Bar Graph

This project is helpful in parking the cars easily. In this project 8 LEDs are connected which glow in such a fashion that it makes a bar graph. This project is done with the help of Ultrasonic sensor which sense the distance of object from it. As the car moves closer to the sensor, the number of leds glowing increases one after the other and also there is a change in the sound pattern of buzzer. As the driver moves closer to the wall, the buzzer starts making frequent sounds indicating to the driver that he is closer to the wall. The more closely the driver moves to the wall, number of leds glowing increase which results in increase in intensity of light.

Thus, from the various cases it is proved that the performance analysis of the students had improved. In fig 16 it shows the Performance index of the batches comparing it with previous traditional laboratory curriculum. The index is based on following criteria's

Student involvement

Moodle Uploading

Continuous Assessment

Quiz

Feedback on Traditional Teaching Vs Learning By doing(LbD)

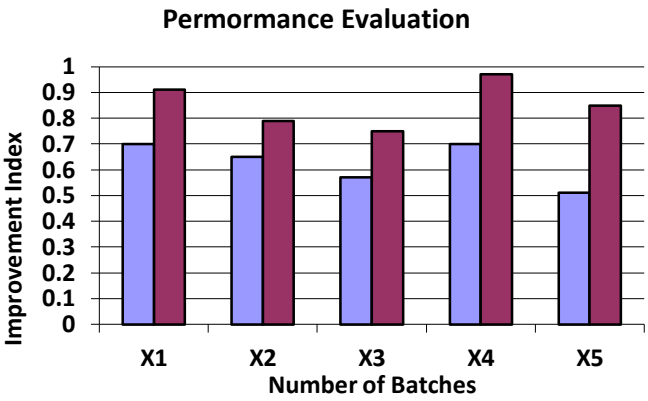


Fig.16 Improvement in performance analysis of different batches compare to the previous year

CONCLUSIONS

Thus, this paper projected on learning about different sensors, experimentally and employing them on their own for a particular application. This made students to involve themselves for the project-oriented problem solving using self-learning in lab, which is different from the traditional laboratory curriculum.

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