LOW COST LINE FOLLOWER OBSTACLE DETECTOR AND DTMF TONE ROBOT

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Abstract- *Classical mobile robot control systems are not suitable for use in industrial environments. The high cost of such systems, both to acquire and maintain them, prohibits their adoption. This thesis proposes a new mobile robot architecture and investigates the motion control subsystem of that architecture. This motion control subsystem is based on following a marked path using visual servoing techniques to reduce computational overhead. Two pieces of information are extracted from each frame: the horizontal position of the path, relative to the centre of the image, and the gradient of the path. These pieces of information are then passed into a proportional steering system, which uses them to steer towards the path. The use of marked paths rather than a model of the environment ensures that the downtime, caused by changes to the environment, is minimised. The lack of a model of the robot should allow the control system to easily be ported to different robot hardware.*

Index Terms- Low cost line follower robot, obstacle avoidance robot, DTMF mode robot.

I. INTRODUCTION

A robot is a mechanical or virtual artificial agent, usually an electro-mechanical machine that is guided by a computer program or electronic circuitry. Robots can be autonomous or semi-autonomous and range from humanoids such as Honda's Advanced Step in Innovative Mobility (ASIMO) and TOSY's TOSY Ping Pong Playing Robot (TOPIO) to industrial robots, medical operating robots, patent assist robots, dog therapy robots, collectively programmed swarm robots, UAV drones such as General Atomics MQ-1 Predator, and even microscopic nano robots. By mimicking a lifelike appearance or automating movements, a robot may convey a sense of intelligence or thought of its own.

The branch of technology that deals with the design, construction, operation, and application of robots,[2] as well as computer systems for their control, sensory feedback, and information processing is robotics. These technologies deal with automated machines that can take the place of humans in dangerous environments or manufacturing processes, or resemble humans in appearance, behavior, and/or cognition. Many of today's robots are inspired by nature contributing to the field of bio-inspired robotics. These robots have also created a newer branch of robotics: soft robotics.
Robots have replaced humans in performing repetitive and dangerous tasks which humans prefer not to do, or are unable to do because of size limitations, or which take place in extreme environments such as outer space or the bottom of the sea.
There are concerns about the increasing use of robots and their role in society. Robots are blamed for rising unemployment as they replace workers in increasing numbers of functions. The use of robots in military combat raises ethical concerns. The possibilities of robot autonomy and potential repercussions have been addressed in fiction and may be a realistic concern in the future.

II. STUDIES AND FINDINGS

Line Follower:
In the industry carriers are required to carry products from one manufacturing plant to another which are usually in different buildings or separate blocks. Conventionally, carts or trucks were used with human drivers. Unreliability and inefficiency in this part of the assembly line formed the weakest link. The project is to automate this sector, using carts to follow a line instead of laying railway tracks which are both costly and an inconvenience.

The first idea was to use optical imaging (CCD cameras) to see the line. This was later given up due to various reasons including complexity and unavailability of components. Later a choice was made to use an array of sensors which solved most of the problems pertaining to complexity. The resistor values used in the sensor array were experimentally determined rather than theoretical mathematical design calculations. This was done as the data sheets of the proximity sensor was not available anywhere and most of the parameters had to be determined experimentally. The L293D chip is used as it was a much better option than forming an H-Bridge out of discrete transistors, which would make the design unstable and prone to risk of damage. The PIC microcontroller was used as it is the only device I have a full practical knowledge about, and most of all a RISC processor which are better suited for realtime operations. Thus the midrange devices were chosen. The part 16F873 was used as it has 2 CCP modules which I could use in PWM mode thus simplifying the software routines which I'd otherwise had to write to generate the PWM control for the motors. A priority encoder was used to reduce the number of I/O lines used, which reduces it to 5 which otherwise would require 7 and a lot of additional complexity in software which only results is sluggish operation and inefficiency. Extra hardware was added to let the robot know if it is on a surface or not. This helps it from not running off a table or preserving battery if manually lifted off the floor.

Objectives Of The Study

- The robot must be capable of following a line.
- It should be capable of taking various degrees of turns
- It must be prepared of a situation that it runs into a territory which has no line to follow. (Barren land syndrome)
- The robot must also be capable of following a line even if it has breaks.
- The robot must be insensitive to environmental factors such as lighting and noise.
- It must allow calibration of the line's darkness threshold.
- The robot must be reliable
- Scalability must be a primary concern in the design.
- The color of the line must not be a factor as long as it is darker than the surroundings.

The robot can be further enhanced to let the user decide whether it is a dark line on a white background or a white line on a dark background. The robot can also be programmed to decide what kind of line it is, instead of a user interface. The motor control could be modified to steer a convectional vehicle, and not require a differential steering system. The robot could be modified to be a four wheel drive. Extra sensors could be attached to allow the robot to detect obstacles, and if possible bypass it and get back to the line. In other words, it must be capable predicting the line beyond the obstacle. Speed control could also be incorporated. Position and distance sensing devices could also be built in which can transmit information to a mother station, which would be useful in tracking a lost carrier.

Application:

- Industrial automated equipment carriers
- Entertainment and small household applications.
- Automated cars.
- Tour guides in museums and other similar applications.
- Second wave robotic reconnaissance operations.

Limitations:

- Choice of line is made in the hardware abstraction and cannot be changed by software.
- Calibration is difficult, and it is not easy to set a perfect value.
- The steering mechanism is not easily implemented in huge vehicles and impossible for non-electric vehicles (petrol powered).
- Few curves are not made efficiently, and must be avoided.
- Lack of a four wheel drive, makes it not suitable for a rough terrain.
- Use of IR even though solves a lot of problems pertaining to interference, makes it hard to debug a faulty sensor.
- Lack of speed control makes the robot unstable at times

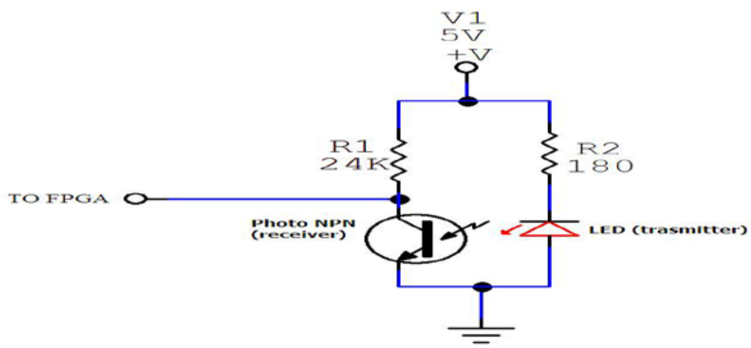
III. Working Of Robot

A. The Sensor Module :

We are providing sensor modules which has 3 pairs of the Transmitter -Reciever and 2modules with one pair each. These Sensors can be utilised and operated to recieve a non electrical data from the environment and to convert it to an electrical signal . This signal can thus further be processed by the brain of our robot . So this is how it works,

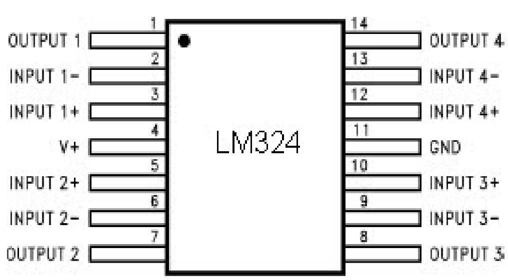
belowe diagram shows the schematic of one part of sensor module . Here the IR LED is connected in forward bias and the ir Reciever is connected in reverse bias.As pe the intensity of light falling on it ,it gives changes in the output .

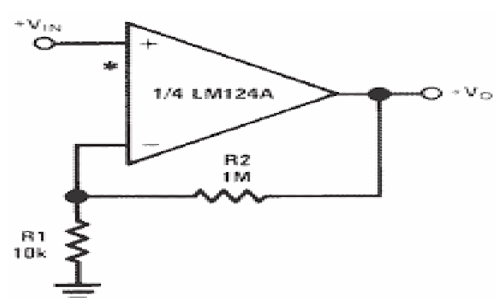
When certain changes in the position of a robot thus there are the changes in the environment around our robot, the changed conditions gives changes in output. Like in obstacle detection mode, a considerable change in the output occurs when there is an obstacle in front of it, than when it is free from obstacles Similarly tor tine tracing mode, a light reflecting back from the surfaces of different colors the sensor gives different outputs. All these properties of sensors are thus used and given to the comparator.



B. The Comparator

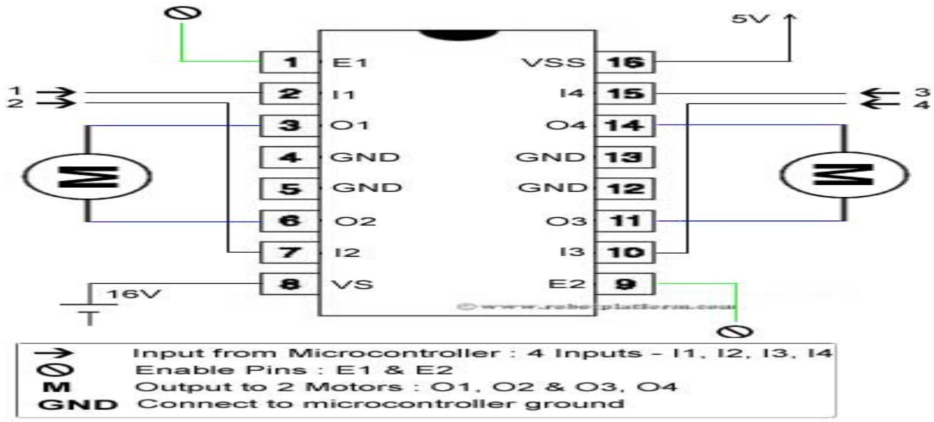
Sensors cannot itself provide output, which can solely be used as a reference to the con Also every IR Receiver provides a dilferent ouupun even for the same conditions and is Analog in nature Thus a fundamental signal conditioner is necessary to a into identifiable This job is done using a comparator IC LM124. IC LM 124 has a comparator init, so it can compare 4 sensor outputs at a time. As shown above, one input of the comparator has given to the variable pot connected to the supply voltage, which will provide the reference comparator input so the output of the sensor is compared with the reference voltage and the respective HIGH and Low output is given out.





C. The Motor Driver:

When driving the motor, motors draw large currents from the source, which is in Amperes Thus connecting the loads directly to the control circuitry is totally impractical Thus to control the motors from the robot driving loads are needed to be isolated from it. also the high current to drive the motors has to be provided from some other source. These needs can be fulfilled by a DRIVER CIRCUITRY.



In our Robot, we basics for driving the motors. he schematic diagram of a common motor L293D driver circuit above. Each Motor Drives as follows:

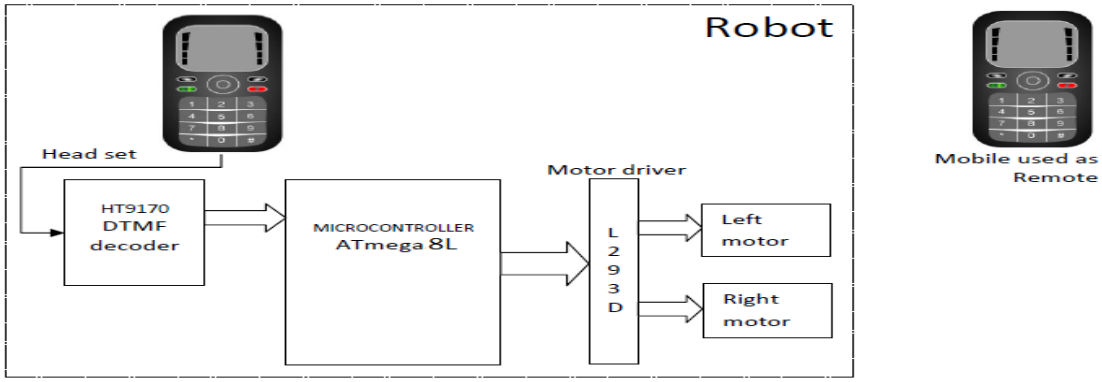
- When both i/p are HIGH-Motor Halts
- When both i/p are Low-Motor Halts
- When i/p 1 is HIGH and i/ p 2 is Low-Motor moves in forward direction
- When i/p1 is Low and i/p 2 is HIGH-Motor moves in reverse direction

In our Robot, we're using on Motor Driver IC for each motor by shorting out the terminals of both terminals ofics. This helps to provide high load current to the motors without the IC getting damaged.

D. The Mobile Control

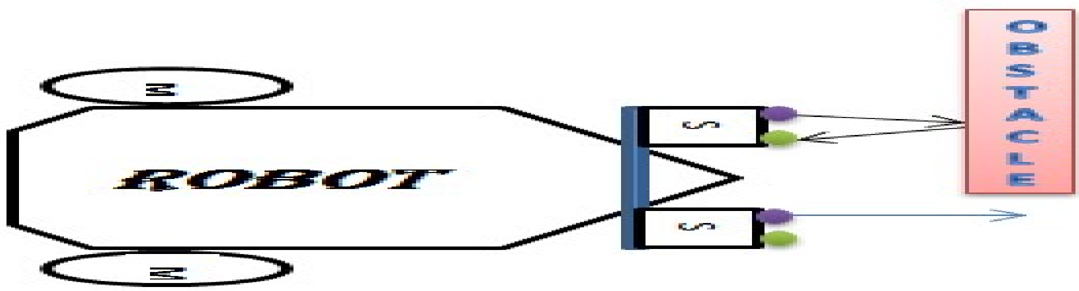
To control the robot using a cell phone, we're using the DTMF (Dual Tone Multiple Frequencies) tones to do so. These are the irritating tones we hear in a call when some keys are pressed mistakenly. Each keys on dial pad produces different frequencies and are distinct from each of them.

The robot, is controlled by a mobile phone that makes call to the mobile phone attached to the robot in the course of the call, if any button is pressed control corresponding to the button pressed is heard at the other end of the call. This tone is called dual tone multi frequency tone (DTMF) IC HT9170 receives this DTMF tone with the help of phone stacked in the Robot. The mobile that makes a call to the mobile phone stacked in the robot acts as a remote. So this simple robotic project does not require the construction of the receiver and transmitter unit. DTMF signaling is used for telephone signaling over the line in the voice frequency band to the call switching centre. The version of DTMF used for telephone dialing is known as touch tone. DTMF assigns a specific frequency (consisting of two separate tones) to each key that it can easily be identified by the electronic circuit. The signal generated by the DTMF encoder is the direct algebraic submission, in real time of the amplitudes of two sine (cosines) waves of different frequencies, i.e. pressing 5 will send a tone made by adding 1336Hz and 770Hz to the other end of the mobile.



E.Obstacle Detector:

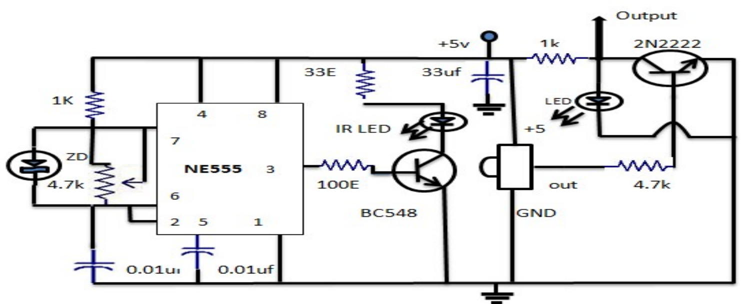
This includes the hardware design of the robot that is motor &wheel placement, body setup. Robot uses two Robotics gear motor & wheel for the movement, Which will help it to move forward, left or right. Robot uses two motor & wheel in the back side and one freewheeling ball is placed at the front which helps it to free movement. The sensor are placed in such a way that they can cover the maximum area in front of the robot and can be capable to detect an obstacle either obstacle is small or big.



Circuit Design:
Circuit design mainly consists of two parts-
a) Sensor part
b) Control board part

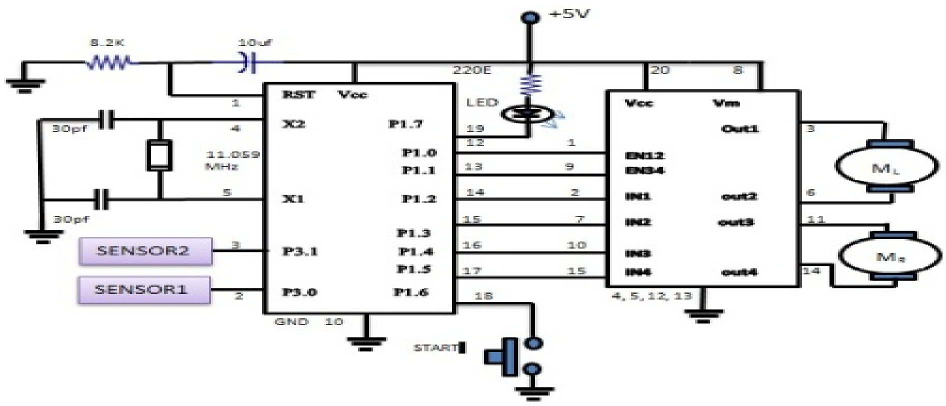
a) Sensor part:-The sensors used in this robot are Infrared sensor, consisting two part infrared signal generator and the IR receiver designed in single PCB. There are two sensors are used as left side sensor and right side sensor and two sensors are used to sense the obstacle on left and right side.

IR Generator :-This is a Monostable multivibrator using NE555 IC generating Infrared Signal of 38KHz frequency for better determination of the object. By using a variable resistance we can adjust the frequency of the IR signal, detector TSOP1738, gives a high ouput.



IR Detector :-IR detector circuit is a circuit which gives a low output in absence of IR signal When some obstacle come in path IR signal reflected back and fall onto the IR detector. In such a way that obstacle are detected.

Motor driver L293D, decide which motor will be in motion or stop in according to the incoming signal from the microcontrollerAT89C2051.



Applications:

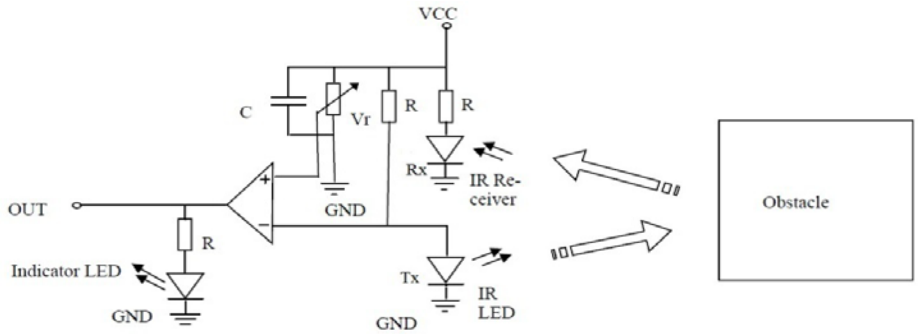
Obstacle avoiding technique is very useful in real life, this technique can also use as a vision belt of blind people by changing the IR sensor by a kinetic sensor ,which is on type of microwave sensor whose sensing range is very high and the output of this sensor vary in according to the object position changes. This technique makes a blind people able to navigate the obstacle easily by placing three vibrato in left, right and the centre of a belt named as VISION BELT and makes a blind people able to walk anywhere.On top of obstacle avoiding robot temperature/pressure sensors can be added to monitor the atmospheric conditions around. This is useful in places where the environment is not suitable for humans.

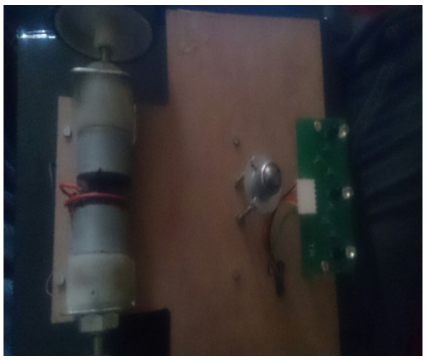
Same technology can be used in various application by modifying the microcontroller program for example

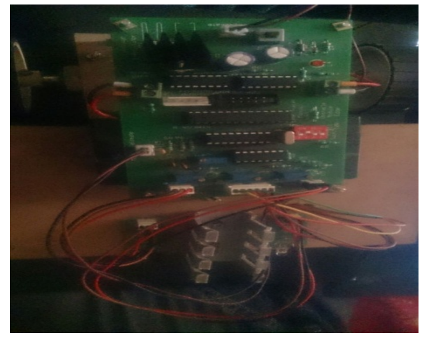
1. Line / Path finder Robot .
2. As automatic vacuum cleaner.
3. With proper programming we can use it as a weight lifter.
4. In Mines

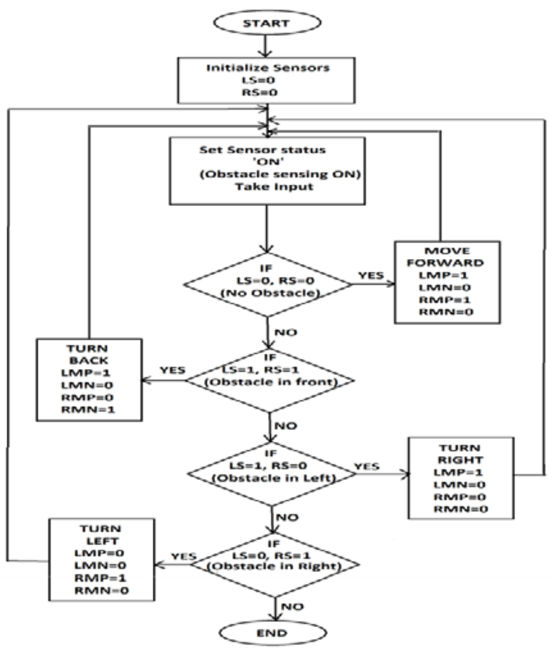
IV. SENSORS AND WORKING OF OBSTACLE DETECTOR

There are varieties of sensor available those can be implemented for detection of obstacle. Some of the very popular sensors are: Infrared sensors, Cameras, which can be used as a part of Computer Vision, Sonar, LIDAR which can directly measure the distance of thousands to hundreds of thousands of points in its field of view [5]. Since reduction of cost is an important factor in the design of robot, we opted Infrared (IR) sensors for our low cost obstacle avoidance robot. IR sensors occupy lower ground in cost as compared other sensors. IR sensors provide the distance of objects directly in front of the sensor beam. This sensor can be used for most indoor applications where no important ambient Infrared light is present. The IR sensor used, basically is of 'always ON' type. The sensor can be divided into two parts: Transmitter and Receiver. Transmitter has an IR LED (Tx), constantly emitting light and hence this sensor is known as always ON type. The second part, Receiver consists of a photodiode (Rx). Transmitter keeps on emitting IR light, when there is any obstacle in the front of sensor, the emitted light get reflected back to the sensor. When reflected IR light beam falls on the photodiode, the voltage drop increases and the cathode's voltage of photodiode goes low depending on the intensity of reflected light beam. This voltage drop can be detected using an Op-Amp (operational Amplifier LM358). From the working principle of Op-Amps, we can notice that the output will go High when the volt at the cathode of diode drops under a certain voltage. So the output will be High when IR light is detected, which is the purpose of the receiver [6]. Detection range of the sensor can adjusted using potentiometer/variable resistor (Vr) present in the sensor. An LED is also mounted for the indication of detection of obstacle. The circuit diagram for an IR senor is shown in Fig.3. Two IR Sensors were attached in front side of robot. Sensors were optimized in such a way that robot can detect the obstacle up to the range of 15cm.









Flow chart for obstacle avoidance

V. LIMITATIONS AND FURTHUR USE

This robot has been successfully implemented for many obstacles like wall, chair, vessels, doors etc. but due to use of IR sensor it has certain limitation. We know that black and some other dark colours are good absorbent of light. IR light beams are also not reflected back from these coloured objects resulting into obstacle remaining undetected. Also efficient application of robot is limited only to indoor purposes. Performance of this robot can be improved with the help of Bump sensors, for slow moving robots, Ultrasonic range sensors for large range up to 6m or LASER range finders One of the prevailing fields is the use of camera in robot, Computer vision can be implemented for better performance Differential Drive System: A mobile robot which uses differential drive has separate speed and direction control for the left and right sets of wheels. Such a system is very flexible for a mobile robot because it does not have a minimum turning radius, it can execute a turn around its own centre. Arc turning is achieved by driving the left and right wheels at different speeds. This ensures that the wheel speeds of the robot are lower while turning and faster when moving straight. Turning at high speeds can result in slipping and inaccurate turns, this prevents it from such happening . Further improvements are Certainty Grid and The Virtual Force Field (VFF) Method.

IMPLEMENTATION AND USE OF SOFTWARE

The implementation of obstacle avoidance strategy for robot involves the writing and compilation of program using software AVRStudio (version4). The compiled program from the PC has to be written on microcontroller on PCB or development board of the robot for which a serial communication has to be established. This is done by using a USB to RS232 (FRC)conversion cable, and RS232 port is then connected to the MAX232 present on PCB which converts TT Logic to Binary Logic [7]. Software HID Boot Flash (version1.0.0.1) was used to write program on development board using USB cable. Hence the program through MAX232 is written in microcontroller. Once program has been loaded to the microcontroller the robot can now roam around. During the operation of robot, it continuously takes the input from photodiode of the IR Sensor. The input is compared in the LM358 comparator IC present in the IR Sensor. The output of the comparator is given to the microcontroller. Microcontroller based upon the program takes decision and provides output for controlling the direction of robot. The output has to be sent to the motors but the output signal from microcontroller is not capable to drive the motors hence IC L293D is used for driving motors, it is also known as driver IC. All inputs of it are TTL compatible.

VI. CONCLUSION

By creating the line-following robot, we learned the basics of energy flow and exactly what building a circuit entails. We found out how voltage is potential energy, and how wires can run in series or in parallel depending on how many points the wires share. We understood the purpose of resistors, to transform excess energy into heat, and we discovered the function of transistors, the comparator, variable resistors, photo resistors, headlights, diodes, motors, and light emitting diodes (LEDs). We came to the conclusion that because we used less power than the robot built by David Cook, we could use less resistance. Building the robot consisted of a heavy revision and modification process. For example, knowing that the inside of the robot would be crowded with our circuit and power source, we realized that if the gears were also placed inside the robot, they would be incapable of moving without constant adjustment. Consequentially, we decided to locate the gears outside of the robot, allowing a free range of motion with less friction. Another modification we were forced to make involved the headlight circuit. Because the robot was already crowded, we decided to #electrically glue# the headlights to another breadboard using a soldering iron. However, in the end, we disconnected the headlights from the second breadboard and simply added them to the initial circuit. In the future, if we were to adjust and make further modifications, we would make the wheel size larger and experiment with different gear ratios. After getting a working circuit, we were able to test different configurations and the extent of the the robot's ability to follow a course.

Almost all navigation robot demands the some sort of obstacle detection, hence obstacle avoidance strategy is of utter importance. Obstacle avoidance robot has a vast field of application. They can be used as services robots, for the purpose of household work and so many other indoor applications. Equally they have great importance in scientific exploration and emergency rescue, there may be places that are dangerous for humans or even impossible for humans to reach directly, then we should use robots to help us. In those challenging environments, the robots need to gather information about their surroundings to avoid obstacles. Nowadays, even in ordinary environments, people also require that robots can detect and avoid obstacles. For example, an industrial robot in a factory is expected to avoid workers so that it won't hurt them. In conclusion, obstacle avoidance is widely researched and applied in the world, and it is probable that most robots in the future should have obstacle avoidance function.

The overall picture for the development of intelligent robotics is very positive but more evolutionary that revolutionary, with a steady penetration into the industrial and domestic worlds at affordable prices on the near horizon.

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I perceive this opportunity as a big milestone in my career development. I feel that the skills gained and the knowledge acquired, during the course of project making will help me in attaining further improvement in knowledge and attained desired career objectives.

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