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Accelerometer based Robot control using Renesas Microcontroller

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Abstract: *Tracking and attacking enemies at distant places is very much difficult for the soldiers. There may be a chance of loss of lives of the soldier during war and emergency situations. So the idea is to replace a real soldier with robot soldier completely controlled with a wireless network. The objective of this paper is to minimize human fatalities in terrorist attack. For this we design a robot that can monitor enemy remotely when required. It can silently enter into enemy area and send us all the information through its tiny camera, that can be mounted on top of it. For this purpose Renesas microcontroller was used to perform the control actions as per requirement.*

Keywords: *Renesas, Robot, Wireless*

I. Introduction

Today, almost all the military organizations take the help of military robots to carry out many risky jobs that cannot be handled manually by soldier. We have also seen a great development in military robots when compare to military robots in earlier time. Military robots are autonomous robots or remote-controlled devices designed for military applications. Such systems are currently being researched by a number of militaries.

Broadly defined, military robots date back to World War II and the Cold War in the form of the German Goliath tracked mines and the Soviet teletanks. The MQ-1 Predator drone was when "CIA officers began to see the first practical returns on their decade-old fantasy of using aerial robots to collect intelligence."

The use of robots in warfare, although traditionally a topic for science fiction, is being researched as a possible future means of fighting wars. Already several military robots have been developed by various armies.

The field of artillery has also seen some promising research with an experimental weapons system named "Dragon Fire II" which automates the loading and ballistics calculations required for accurate predicted fire, providing a 12 second response time to fire support requests. However, weapons of warfare have one limitation in becoming fully autonomous: they require human input at certain intervention points to ensure that targets are not within restricted fire areas as defined by Geneva Conventions for the laws of war.

There have been some developments towards developing autonomous fighter jets and bombers. The use of autonomous fighters and bombers to destroy enemy targets is especially promising because of the lack of training required for robotic pilots, autonomous planes are capable of performing manoeuvres which could not otherwise be done with human pilots (due to high amount of G-Force), plane designs do not require a life support system, and a loss of a plane does not mean a loss of a pilot. However, the largest drawback to robotics is their inability to accommodate for non-standard conditions. Advances in artificial intelligence in the near future may help to rectify this.

II. Literature Survey

We aim to develop a model which will be efficiently used to minimize terrorist causality.
Being able to achieve reliable long distance communication with user-friendly robot control is an important open area of research to robotics.

2.1 Robot control

Programming and control of a robot through the use of the robot teach pendant is a tedious and time-consuming task that requires technical expertise. Therefore, new and more intuitive ways for robot programming and control are required. The goal is to develop methodologies that help users to control and program a robot, with a high-level of abstraction from the robot specific language.

In the robotics field, several research efforts have been made to create user-friendly teach pendants, implementing intuitive user interfaces such as color touch screens, a 3D joystick (ABB Robotics). But, neither of these techniques is efficient to control the robot as they do not give accurate results and have slow response time.

In the last few years the robot manufacturers have made great efforts towards creating "Human Machine Interfacing Device" -recognizing human gestures, recurring to vision-based systems [1], [2] or using finger gesture recognition systems based on active tracking mechanisms [3].

Using data glove is a better idea over camera as the user has flexibility of moving around freely within a radius limited by the range of wireless connecting the glove to the computer, unlike the vision based technique where the user has to stay in position before the camera [4]. The cause of light, electric or magnetic fields or any other interruption does not affect the performance of the glove [5].

So Accelerometer based gesture recognition has become increasingly popular over the last decade compared to vision based technique. The low- moderate cost and relative small size of the accelerometers make it an effective tool to detect and recognize human body gestures.

2.2 Communication

Wired communication is not suitable to transmit data over long distances as wiring itself is a problem. The next option is to adopt wireless communication which includes Bluetooth, WI-Fi, and ZigBee. Table 1 gives us the comparison between all the 3 kinds of techniques.

Category	Wi-Fi	Bluetooth	ZigBee
Distance	50m	10m	50-1600m
Extension	Depend on the existing network	None	Automatic
Power Supply	Hours	Days	Years
Complexity	Very Complicated	Complicated	Simple
Transmission Speed	1-54Mbps	1Mbps	250Kbps
Frequency Range	2.4GHz	2.4GHz	868MHz, 916MHz, 2.4GHz
Network Nodes	50	8	65535
Linking Time	Up to 3s	Up to 10s	30ms
Ease of Use	Hard	Normal	Easy

Table.1: Comparison between Wi-Fi, Bluetooth and ZigBee.

When it comes to robot communication the technique adopted should be such that it can cover wide distance and provide good battery backup. When these aspects are considered ZigBee is a better option than the others.

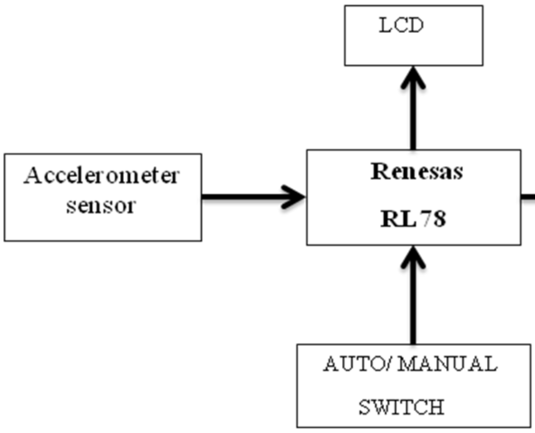
ZigBee is targeted at the applications that require a low data rate, long battery life. It operates over same 2.4GHz frequency range as Wi-Fi and Bluetooth. Unlike those technologies though, ZigBee transmits at much lower data rates, it's made for sending simple commands such as turning on a TV, rotating left etc., or small bits of data. Thanks to the low data rates, ZigBee tends to use far less power than other networking technologies. ZigBee's standard utilizes mesh networking, which allows ZigBee devices to automatically connect with and transmit data through one another without having to go through a central gateway like a router. ZigBee uses IEEE 802.15.4 standard to allow wireless PAN (Personal Area Network) in home. It uses digital radio waves to transfer information between electric devices. It uses transistors in its electronic devices. The electronic devices communicate from a central computer that sends and receives data. It is more reliable, supports larger network and is more fully featured than other networking technologies.

In this paper we use accelerometer based gesture recognition technique to control robot and ZigBee networking technology to communicate.

2.3 Design

The block diagram of the Accelerometer controlled system using Zigbee-communication is shown in Figure 1.

Transmitter End:



Receiver End:

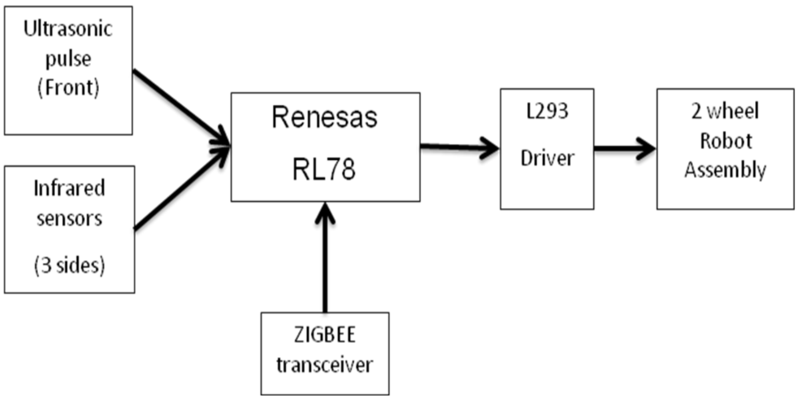


Figure 1: Block diagram of receiver and transmitter end of an accelerometer based robot motion and speed control with obstacle detection.

The brain of the robot is the transmitter i.e., Renesas microcontroller which acts as a master controller by giving commands to the slave controller. The second Renesas controller which acts as a slave controller is responsible for executing all the commands received from the master and also generating PWM pulse for the speed control. Based on the input codes given by the master, the slave i.e., the robot will behave as follows

- Moves in forward direction,
- Moves in reverse direction,
- Speed control in both directions,
- It can take a left or right turn while moving forward or in reverse direction,
- Instant reverse or stopping when obstacle is detected.

III. HARDWARE REQUIREMENTS

3.1 Accelerometer Sensor

The ADXL335 is a small, thin, low power, complete 3-axis accelerometer with signal conditioned voltage outputs. The product measures acceleration with a minimum full-scale range of ±3 *g*. It can measure the static acceleration of gravity in tilt-sensing applications, as well as dynamic acceleration resulting from motion, shock, or vibration.

The ADXL335 is available in a small, low profile, 4 mm × 4 mm × 1.45 mm, and 16-lead. Block diagram of the same is given in Figure 2.

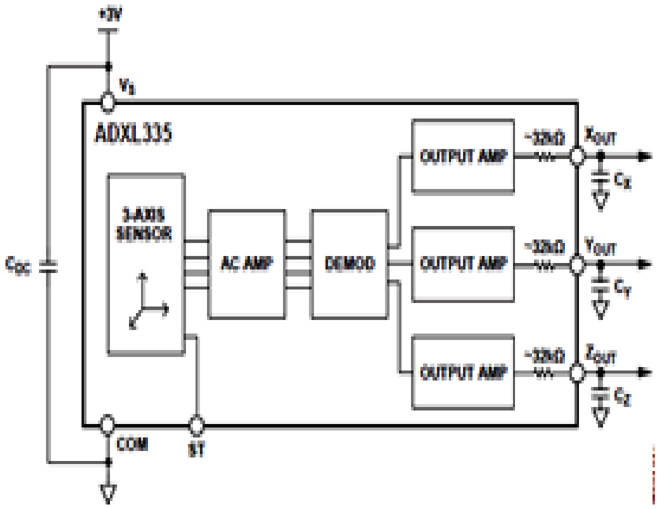


Figure 2: Functional block diagram of ADXL335 accelerometer.

They are typically used in Mobile devices, Gaming systems, Disk drive protection, Image stabilization, Sports and health devices applications.

3.2 Renesas Microcontroller

Renesas is a Japanese semiconductor manufacturer headquartered in Tokyo. It has manufacturing, design and sales operations in around 20 countries. Renesas is one of the world's largest manufacturers of semiconductor systems for mobile phones and automotive applications. It is the world's largest manufacturer of microcontrollers and the second largest manufacturer of application processors. Renesas is also known for LCD drivers, RF ICs, mixed-signal integrated circuits and system-on-a-chip semiconductors.
"Renesas" is an invented name and a contraction of Renaissance Semiconductor for Advanced Solutions.

3.2.1Renesas RL78 16-bit Microcontroller

The Renesas Electronics RL78 is a 16-bit CPU core with CISC architecture for embedded microcontrollers developed and manufactured by Renesas Electronics and introduced in 2011. Renesas Electronics is a developer and manufacturer of semiconductor devices especially microcontrollers, microprocessors, Power MOSFET, IGBTs, opt couplers, SRAMs and SOC devices. The RL78 was the first new MCU core to emerge from the new Renesas Electronics Company from the merger of NEC Electronics and Renesas Technology and incorporated the features of the NEC K0 and Renesas Technology R8C microcontrollers.

The RL78 was developed to address extremely low power but highly integrated microcontroller applications, to this end the core offered a novel low power mode of operation called “snooze mode” where the ADC or serial interface can be programmed to meet specific conditions to wake the device from the extreme low power STOP mode of 0.52uA.

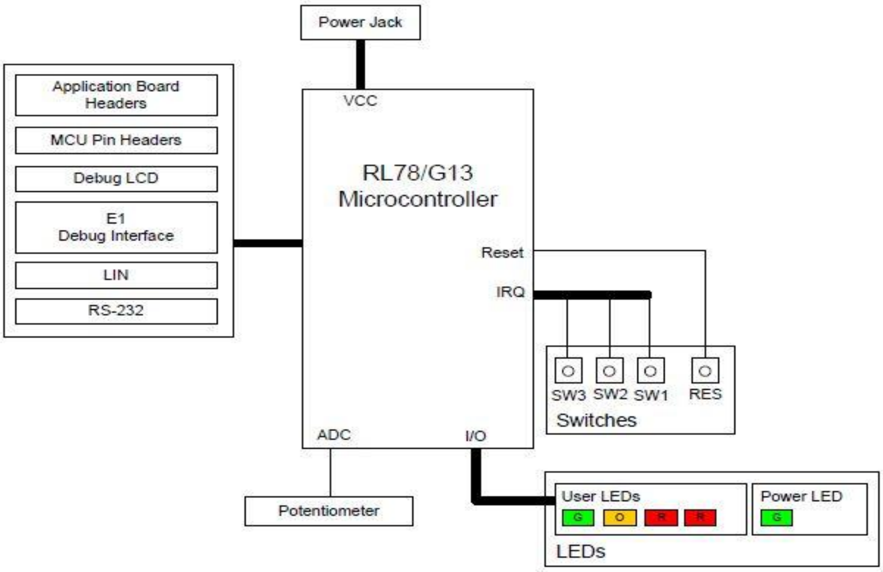


Figure 3 Block diagram of Renesas Microcontroller

3.3 Ultrasonic Motion Sensor

Figure 4 gives the clear idea of the GH-311 ultrasonic Motion sensor which provides precise, non-contact distance measurements from about 2 mm (0.8 inches) to 3 meters (3.3 yards) but with the sensing angle not greater than 15°.

The GH-311 sensor works by transmitting an ultrasonic (well above human hearing range) burst and providing an output pulse that corresponds to the time required for the burst echo to return to the sensor. By measuring the echo pulse width, the distance to target can easily be calculated.

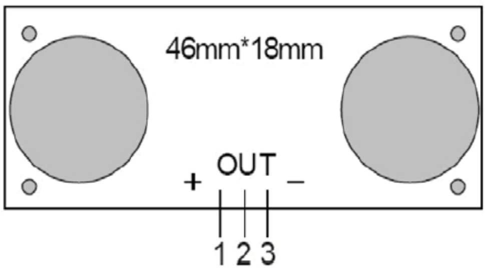


Fig 4: External connection schematic of GH-311 ultrasonic motion sensor.

The GH-311 sensor has a male 3-pin header used to supply ground, power (+5 VDC) and signal. It can be used to detect the move of human or object. Suitable for indoor and outdoor burglar-proof application, vehicle burglary-proof application, ATM surveillance camera, warehouse surveillance camera, and safety warning applications in dangerous site where high voltage and high temperature exist.

3.4 IR Transmitter & Receiver

To monitor the density of the traffic, we will be keeping a few sets of IR transmitter and receiver sensors on the side of the roads. On side IR transmitter will be placed & right opposite to the IR transmitter, an IR receiver will be kept. This set of IR transmitter & receiver will be kept on roads at different intervals.

The IR transmitters are connected to supply, so that they will transmit high signal all the time. The IR receivers are connected to the comparator circuit, to get digital signals. A low power operational amplifier LM324 IC has been used to develop a comparator circuit.

Two set of LM324 IC has been used in this project. The circuit diagram of the comparator is shown below:

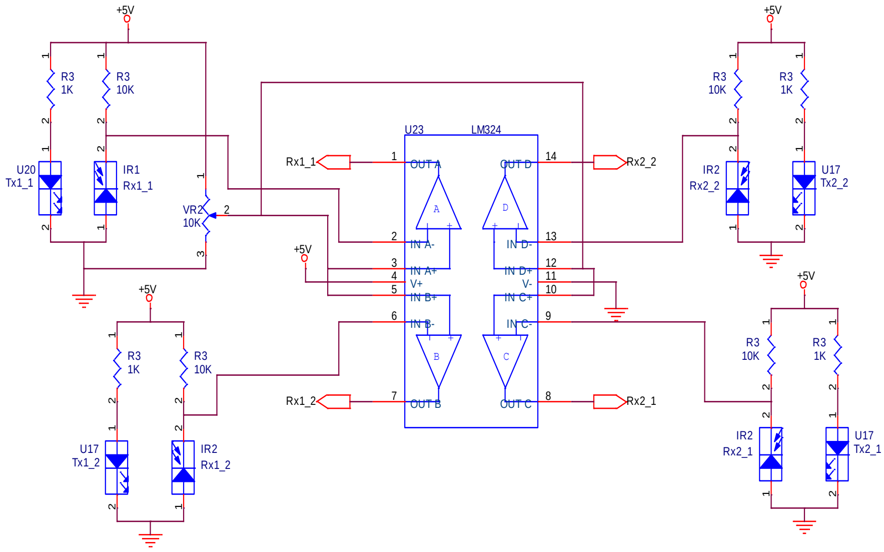


Figure5: Internal circuitry of IR sensors

3.4.1 Types of Infra-Red Sensors

Infra-red sensors are broadly classified into two types:

Thermal infrared sensors – These use infrared energy as heat. Their photo sensitivity is independent of wavelength. Thermal detectors do not require cooling; however, they have slow response times and low detection capability.

Quantum infrared sensors – These provide higher detection performance and faster response speed. Their photo sensitivity is dependent on wavelength. Quantum detectors have to be cooled so as to obtain accurate measurements. The only exception is for detectors that are used in the near infrared region.

3.4.2 Working Principle

A typical system for detecting infrared radiation using infrared sensors includes the infrared source such as blackbody radiators, tungsten lamps, and silicon carbide. In case of active IR sensors, the sources are infrared lasers and LEDs of specific IR wavelengths. Next is the transmission medium used for infrared transmission, which includes vacuum, the atmosphere, and optical fibers.

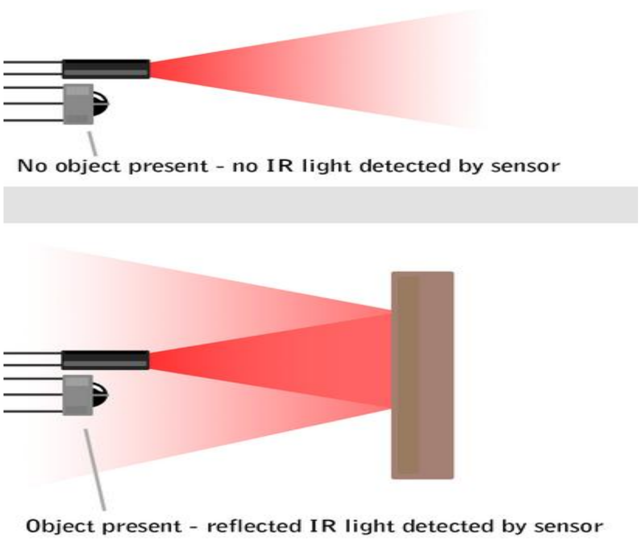


Fig 6: Working principle of IR sensors

IV. SOFTWARE REQUIREMENTS

For the software implementation, we deploy two software packages. First one is the Keil µVision 3.0, second is the Flash magic simulator.

4.1 Keil µ Vision

The debugger accurately simulates on-chip peripherals (I²C, CAN, UART, SPI, Interrupts, I/O Ports, A/D Converter, D/A Converter, and PWM Modules) of 89S52device.

Simulation helps to understand hardware configurations and avoids time wasted on setup problems. With simulation, we can write and test applications before target hardware is available. The system program written in embedded C using Keil IDE software will be stored in Microcontroller. The industry-standard Keil C Compilers, Macro Assemblers, Debuggers, Real-time Kernels, Single- board Computers, and Emulators support all 89S52derivatives. The Keil Development Tools are designed to solve the complex problems facing embedded software developers.

4.2 Flash Magic

It is used to dump the code to microcontroller from PC. Flash Magic is a free, powerful, feature-rich Windows application that allows easy programming of Philips FLASH microcontrollers. Custom applications built for Philips microcontrollers on the Flash Magic platform can be used to create custom end-user firmware programming applications, or generate an in-house production line programming tool.

The Flash Memory In-System Programmer is a tool that allows in-circuit programming of FLASH memories via a serial RS232 link. Computer side software called Flash Magic is executed that accepts the Intel HEX format file generated from compiler Keil to be sent to target microcontroller. It detects the hardware connected to the serial port

V. IMPLEMENTATION

It operates in two modes – manual and auto (predefined) mode. A Wireless camera mounted on the robot will send real time video signals, which could be seen on a remote monitor, and action can be taken accordingly.

5.1Algorithm for Auto mode

Once the controller gives the auto mode command to the robot, the robot uses its ultrasonic sensor to identify any obstacles in its path and navigates accordingly; it also displays the distance from the obstacle using its ALCD.

We can brief the algorithm for this mode as in figure 7.

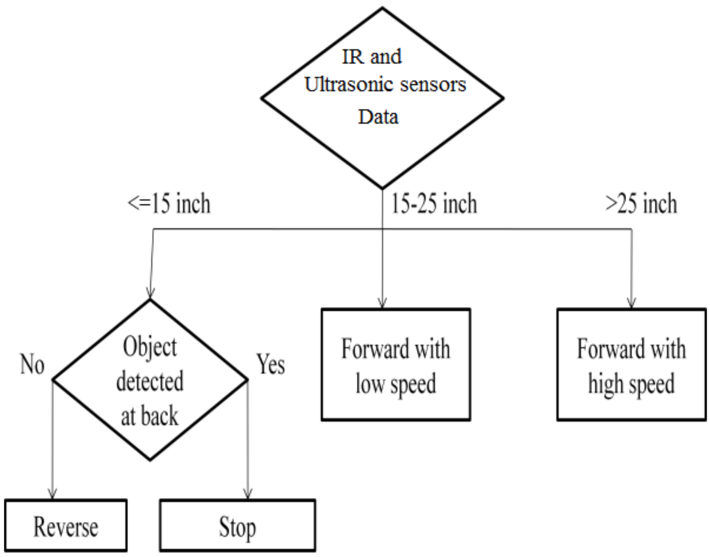


Figure 7: Algorithm for auto mode

5.2 Algorithm for manual mode

In this mode we control the robot movement manually using the accelerometer. Even a small tilt in the accelerometer sensor corresponds to the readings that are communicated to the robot through ZigBee for its navigation. We can request for the distance between the robot and obstacle in this mode and the algorithm for the same can be described in figure 8.

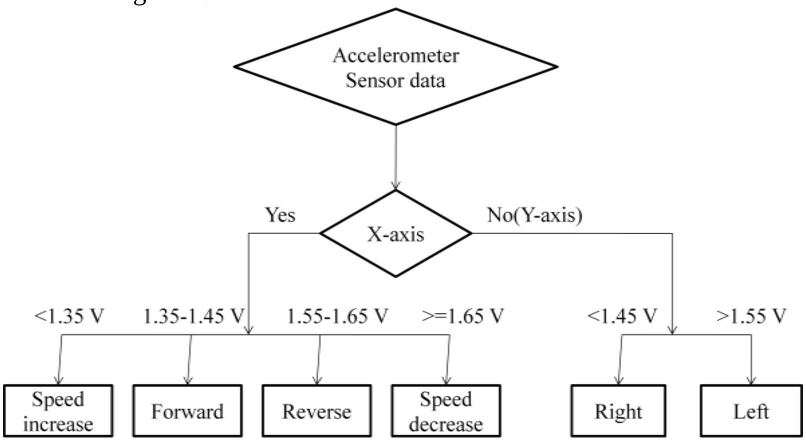


Figure 8: Algorithm for manual mode

5.3 Results

The top view of the robot and controller after the entire setup is shown in Figure 9 and 10.

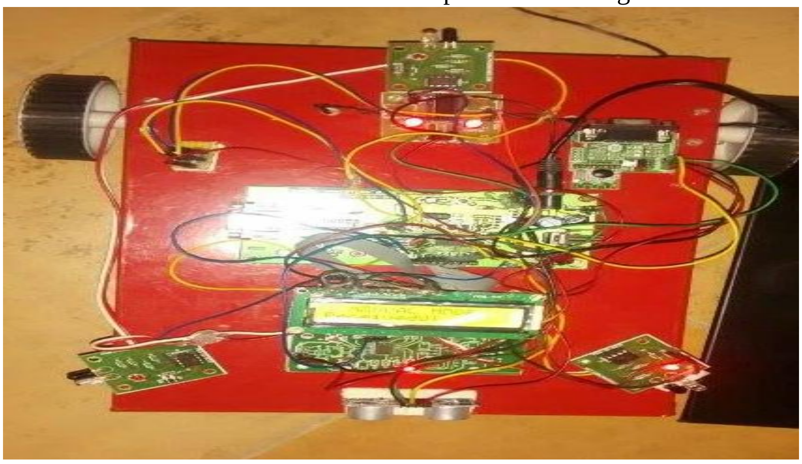


Figure 9: Top view of robot.


Figure 10: Top view of controller.

Here the robot detects the obstacles using ultrasonic sensors and takes the path that is previously defined. When accelerometer is tilted in any of the 4 directions the ALCD displays its corresponding X and Y-axis value in terms of voltage (V) along with the command for the robot to traverse, the robot then moves in the specified path by displaying the distance from the obstacle along with the direction of movement.

VI. CONCLUSION

As we all know, these days our nation is sick of massive terror attacks and bomb explosions. To avoid such disasters technological power must exceed human power. Human life and time are priceless.

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