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# Design and Implementation of Accelerometer based Robot motion and Speed control with Obstacle detection.

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***Abstract* -** The objective of this paper is to minimize human casualties in terrorist attack such as 26/11. The idea is to design a robot having a wireless camera mounted on it, so that it can monitor enemy remotely when required. It can silently enter into enemy area and send us all the information through its tiny camera eyes. Since human life is always precious, these robots are the replacement of soldiers in war areas. This spy robot can also be used in star hotels, shopping malls, jewelry show rooms, etc where there can be threat from intruders or terrorists.

Keywords – wireless, robots, spy robot.

## 1. INTRODUCTION

The global focus on terrorism and security may have geared up following the 9/11 attacks in the USA. The risk of terrorist attack can perhaps never be eliminated, but sensible steps can be taken to reduce the risk.

Nowadays tracking enemies at different areas are very much difficult for soldiers. There may be a chance of lost of lives of the soldier during war and emergency situations. So the idea is to replace a real soldier with robot soldier.

The word "Robot" was first used in a 1921 play titled R.U.R. Rossum's Universal Robots, by Czechoslovakian writer Karel Capek. Robot is a Czech word meaning "worker."

Merriam-Webster defines robot as "a machine that looks like a human being and perform various complex acts; a device that automatically performs complicated, often repetitive tasks; a mechanism guided by automatic controls." ISO describes a robot as "an automatically controlled reprogrammable, multipurpose manipulator programmable in three or more axes, which may be either fixed in place or mobile for use in industrial automation applications".

These definitions do give us a rough idea about what comprises a robot, which needs to sense the outside world and act accordingly. There are motors, pulleys, gears, gearbox and many more mechanical systems, enabling locomotion. There are sound, light, magnetic field and other sensors that help the robot to collect information about its environment. There are Processors powered by powerful software that help the robot make decisions by sensing environmental data that is captured and also microphones, speakers, displays, etc that help the robot interact with humans.

The main objectives of using robot are:

### A. *Where man dares not venture.*

Robots have traditionally been put to use in environments that are too hazardous for man.

### B. *To rescue pronto.*

Robots also work under precarious conditions, for search and rescue after disasters.

### C. *We even make them go to war.*

Battle robots of various shapes and sizes were deployed to defuse landmines, search for criminals hiding in caves, search for bombs under cars.

## 2. 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.

### A. *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.

### *B. 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.

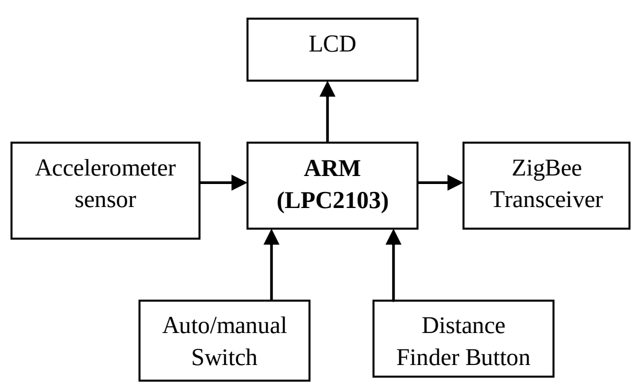
ZigBee is targeted at the applications that require a low data rate, long battery life. It operates over same 2.4GHz frequency range as Wi-Fi and Bluetooth. Unlike those technologies though, ZigBee transmits at much lower data rates, it's made for sending simple commands such as turning on a TV, rotating 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.

## 3. DESIGN

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

***Transmitter End:***



***Receiver End:***

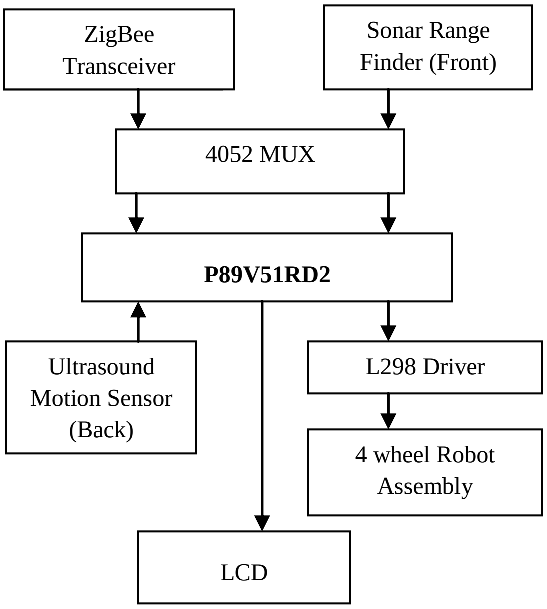



Figure 1: Block diagram of receiver and transmitter end of an accelerometer based robot motion and speed control with obstacle detection.

The brain of the robot is the transmitter i.e., 8051 microcontroller which acts as a master controller by giving commands to the slave controller. The ARM 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.

## 4. HARDWARE REQUIREMENTS

### *A. 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.

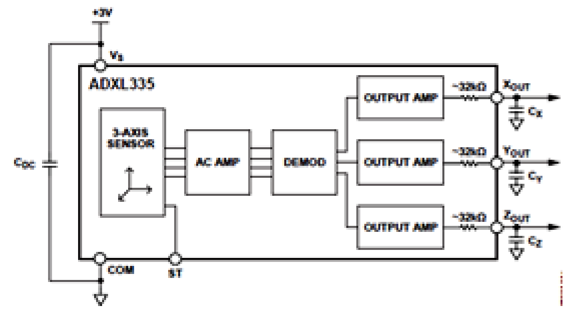



Figure 2: Functional block diagram of ADXL335 accelerometer.

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

### *B. ARM LPC 2103*

Figure 3 shows the LPC 2103 microcontrollers which is based on a 32-bit ARM7TDMI-S CPU with real-time emulation.

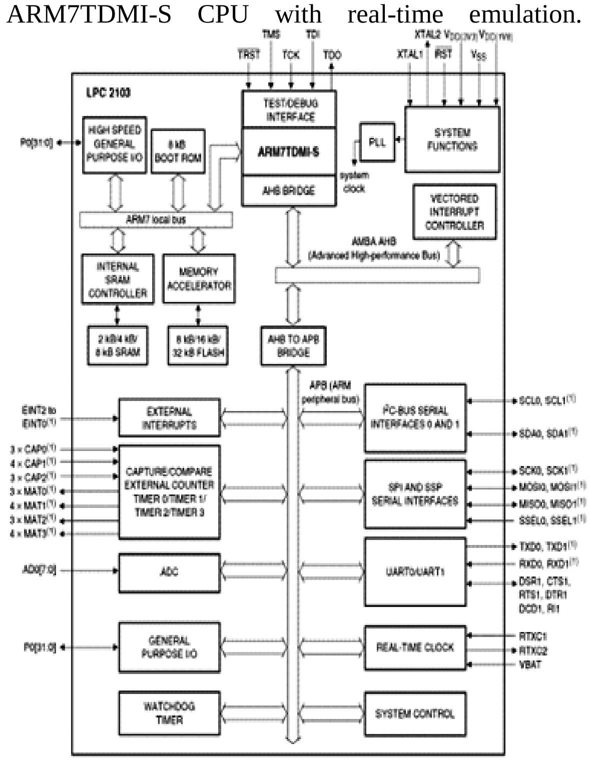



Figure 3: Block diagram of LPC 2103 microcontroller.

A blend of serial communications interfaces ranging from multiple serial interfaces including two UARTs (16C550), two Fast I2C-buses (400 Kbit/s), SPI and SSP with buffering and variable data length capabilities, combined with 2 kB/4 kB/8 kB of on-chip static SRAM, which makes this device very well suited for communication gateways and protocol converters.

Two 32-bit timers/external event counters and two 16-bit timers/external event counters, an improved 10-bit A/D converter providing eight analog inputs, with conversion times as low as 2.44 ms per channel and dedicated result registers to minimize interrupt overhead are some of its features.

PWM features through output match on all timers, and 32 fast GPIO lines with up to nine edge or level sensitive external interrupt pins make these microcontrollers particularly suitable for industrial control and medical systems.

### C. P89V51RD2

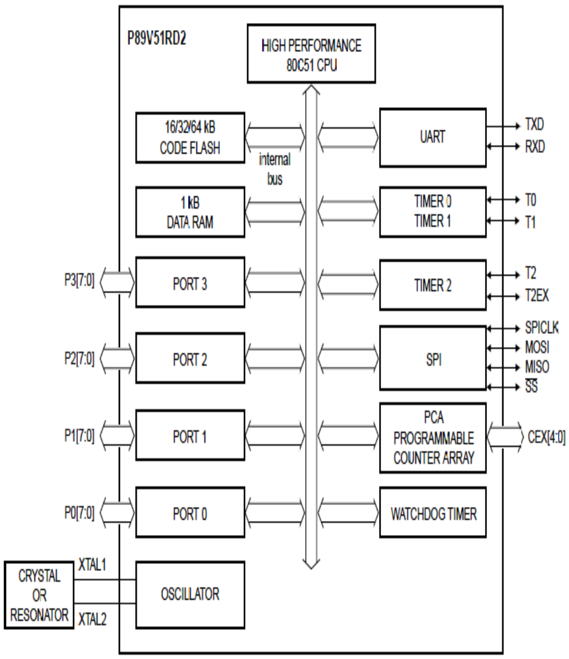



Figure 4: Block diagram of P89V51RD2 microcontroller.

The P89V51RD2 is 80C51 microcontroller with 64 kB flash and 1024 B of data RAM as shown in Figure 4. The flash program memory supports both parallel programming and in serial ISP. It is also capable of IAP, allowing the flash program memory to be reconfigured even while the application is running.

A key feature of the P89V51RD2 is its X2 mode option. The design engineer can choose to run the application with the conventional 80C51 clock rate (12 clocks per machine cycle) or select the X2 mode (six clocks per machine cycle) to achieve twice the throughput at the same clock frequency. It has four 8-bit I/O ports with three high-current port 1 pins (16 mA each). Some other features are:

- Three 16-bit timers/counters;
- Programmable watchdog timer;
- Eight interrupt sources with four priority levels;
- Second DPTR register;
- Low EMI mode (ALE inhibit);
- TTL- and CMOS-compatible logic levels.

### D. Ultrasonic Motion sensor

Figure 5 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.

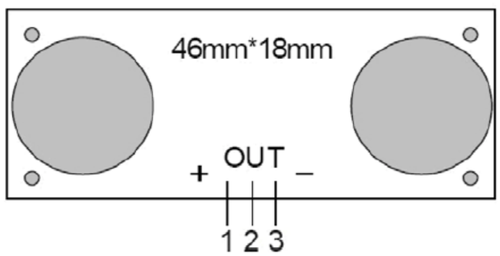



Figure 5: External connection schematic of GH-311 ultrasonic motion sensor.

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.

Features include

- High Sensitivity, Reliability and Stability,
- Extreme-Temp resistant, moisture proof, shock & vibration-proof, etc.

### E. Sonar Range Finder

SONAR, acronym for Sound Navigation and Ranging, a detection system based on the reflection of underwater sound waves, just as radar is based on the reflection of radio waves in the air.

A typical sonar system emits ultrasonic pulses by using a submerged radiating device; it listens with a sensitive microphone, or hydrophone, for reflected pulses from potential obstacles or submarines.

Figure 6 gives the physical view of the LV-MaxSonar®-EZ1™ which detects objects from 0-inches to 254-inches (6.45-meters) and provides sonar range information from 6-inches out to 254-inches with 1-inch resolution. Objects from 0- inches to 6-inches range as 6-inches. With 2.5V - 5.5V power the LV-MaxSonar®- EZ1™ provides very short to long-range detection and ranging, in an incredibly small package.


Figure 6: Sonar Range finder.

## 5. 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.

### A. *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.

### B. *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.

## 6. 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.

### A. *Algorithm 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.

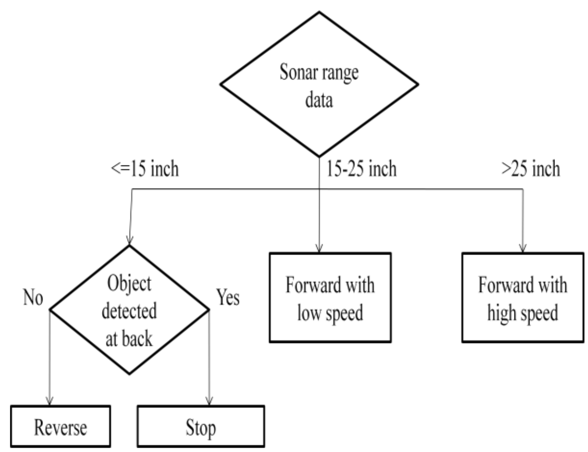



Figure 7: Algorithm for auto mode

### B. *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

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between the robot and obstacle in this mode and the algorithm for the same can be described in figure 8.

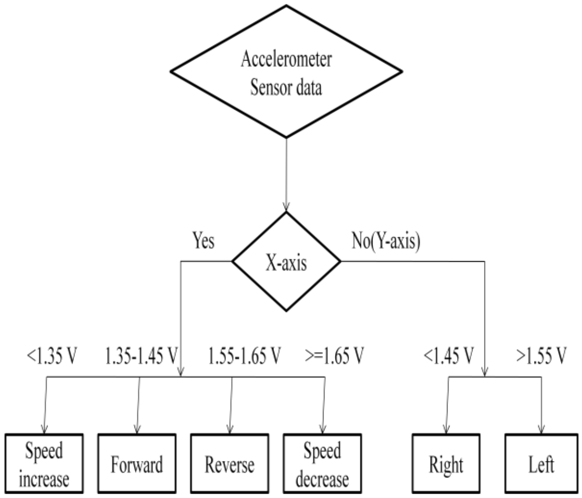


Figure 8: Algorithm for manual mode

### *C. Results*

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

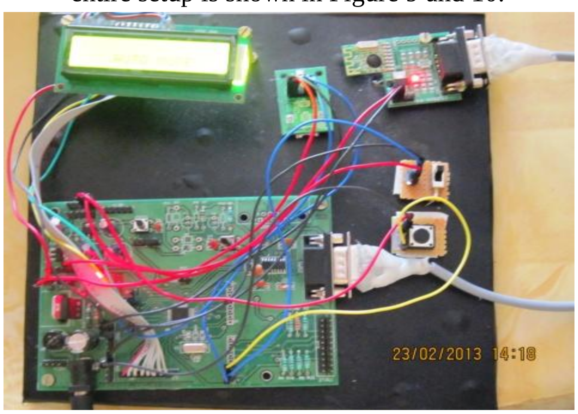


Figure 9: Top view of controller.

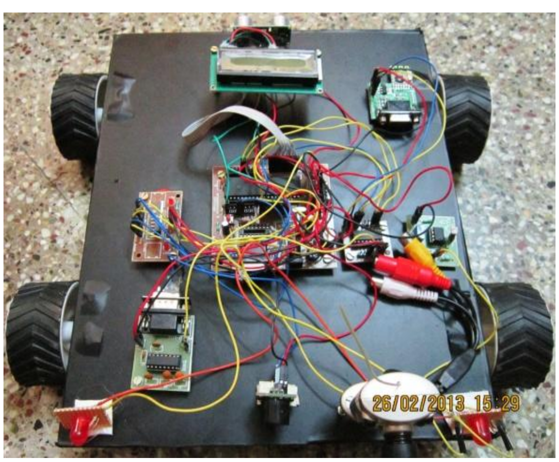


Figure 10: Top view of robot.


Figure 11: ALCD display of the controller and robot when controller is set to auto mode.

Here the robot detects the obstacles using ultrasonic sensors and takes the path that is previously defined.


Figure 12: ALCD display of the controller and robot when transmitter is in manual mode and when tilted ahead.

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.


Figure 13: ALCD display of the transmitter commanding the robot to increase its speed.

In the speed increase state the robot moves fast according to the specified speed.


Figure 14: ALCD display of robot to reduce speed.

The speed increase and decrease commands doesn't work all alone, we also need to specify the direction of movement based on which the robot moves. For example if the command is speed increase followed by left command, then the robot takes quick left turn.

## 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.

So in this paper, we propose a model of a robot based on "Human Machine Interfacing Device" utilizing hand gestures to communicate with embedded systems for tracking of enemies. The 3-axis accelerometer is selected to be the input device of this system, capturing the human arms behaviors. When compared with other common input devices, especially the teach pendant, this approach using, accelerometer is more intuitive and easy to work, besides offering the possibility to control a robot by wireless means. Using this system, a non-expert robot programmer can also control a robot quickly and in a natural way.

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