International Journal of Applied Sciences & Engineering (IJASE) 1(1): April, 2013: 1-8

Design of Accelerometer Based Robot Motion and Speed Control with Obstacle Detection

Swetha N.

Department of Industrial Automation and Robotics, Visvesvaraya Technological University, SIT, Mangalore, India

Email:swethan.peu@gmail.com

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 fighters against terrorist 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

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 sense environmental data captured and tell it what to do next 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.

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 or using finger gesture recognition systems based on active tracking mechanisms.

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. The cause of light, electric or magnetic fields or any other interruption does not affect the performance of the glove. The movement data glove helps users to interface with the practical world. 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, WiFi, and ZigBeee. Table 1 gives us the comparison between all the 3 kinds of techniques.

Table 1: Comparison between WiFi, Bluetooth and ZigBee.

Category	WiFi	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

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.

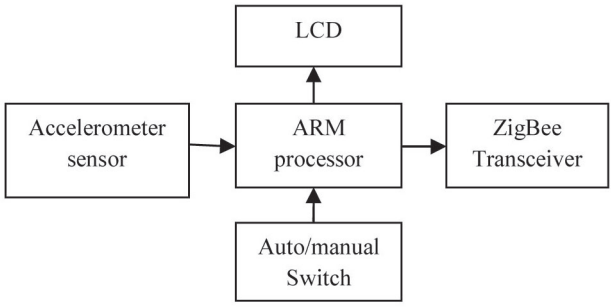
ZigBee is targeted at the applications that require a low data rate, long battery life. It operates over same 2.4GHz frequency range as WiFi and Bluetooth. Unlike those technologies though, ZigBee transmits at much lower data rates, it's made for sending simple commands such as turning on a TV, rotating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

System Overview

The block diagram of the Accelerometer controlled system using RF-communication is shown in Figure 1. The accelerometer is placed in the hands of the user, which controls the direction of the system with the movements of the accelerometer.

Transmitter Side



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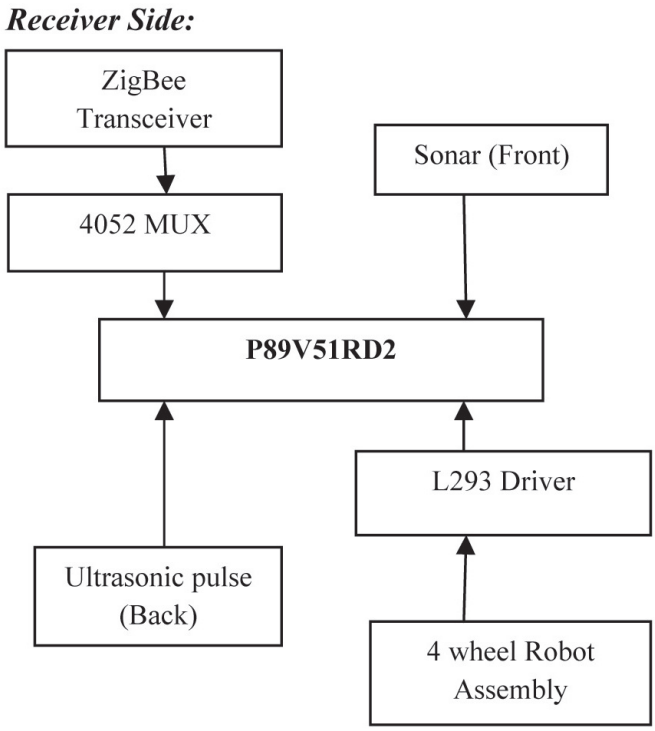

Figure 1: Block diagram of accelerometer based robot motion and speed control with obstacle detection

The entire setup consists of two parts, a transmitter and a receiver and works 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.

When the accelerometer sensor is attached to the human arm it can detect even a small tilt in the arm and the corresponding readings are communicated to the robot through ZigBee for its navigation.

In the auto mode the robot takes a predefined path and the obstacles in the path can be identified with the help of ultrasonic sensors.

Hardware Requirements

A. Accelerometer Sensor

An accelerometer is an electromechanical device which measures acceleration. A moving body possesses an inertia which tends to resist change in velocity. It is this resistance to change in velocity that is the source of the force exerted by the moving body.

Accelerometers are available that can measure acceleration in one, two, or three orthogonal axes. They are typically used in one of three modes:

- As an inertial measurement of velocity and position;
- As a sensor of inclination, tilt, or orientation in 2 or 3 dimensions, as referenced from the acceleration of gravity (1 g = 9.8m/s^2);
- As a vibration or impact (shock) sensor.

There are considerable advantages to using an analog accelerometer as opposed to an inclinometer such as a liquid tilt sensor – inclinometers tend to output binary information (indicating a state of on or off), thus it is only possible to detect when the tilt has exceeded some thresholding angle.

The accelerometer used here is the 3-Axis accelerometer with an easy analog interface and running at a supply voltage of 3.3V, which makes it ideal for handheld battery powered electronics.

B. ARM LPC 2103

The LPC 2103 microcontrollers is based on a 16-bit/32-bit ARM7TDMI-S CPU with real-time emulation.

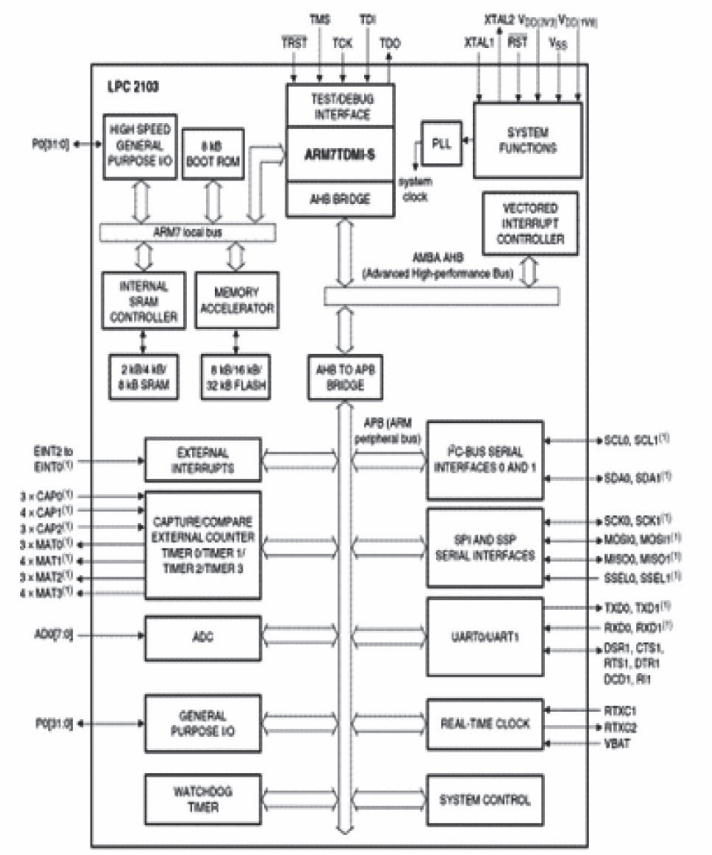

Figure 2: Block diagram of LPC 2103 microcontroller

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, is clearly shown in figure 2 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.

A. 4052 MUX

The UTC 4052 is differential 4-channel analog multiplexer/demultiplexer for application as digitally–controlled analog switches. The device has two binary control inputs and an inhibit input. It feature low ON impedance and very low OFF leakage current. Control of analog signals up to the complete supply voltage range can be achieved.

Some of the features of 4052 MUX are:

- Wide Analog Voltage Range: VDD–VEE = 3V~18V;
- Break-Before-Make Switching Eliminates Channel Overlap;

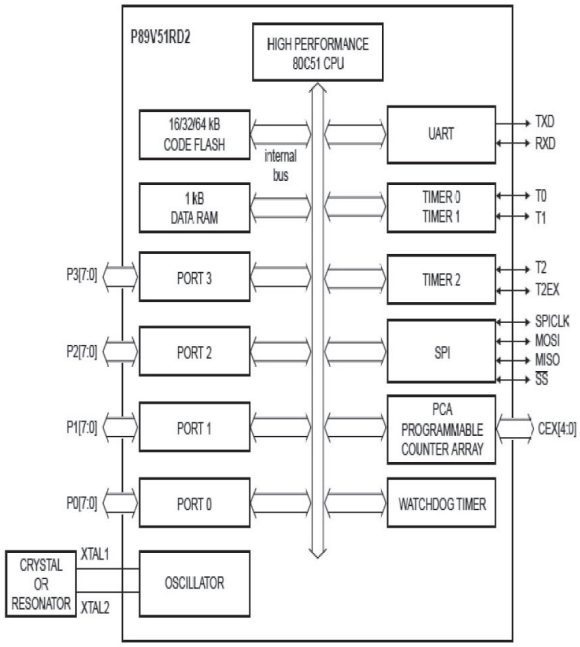

Figure 3: Block diagram of P89V51RD2 microcontroller.

- Linearized Transfer Characteristics;
- Implement an DP4T Switch Effectively;
- Pin to Pin Replacement for CD4052.

The P89V51RD2 is 80C51 microcontroller with 64 kB flash and 1024 B of data RAM. 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.

A. L293 Driver

The Device is a monolithic integrated high voltage, high current four channel driver designed to accept standard DTL or TTL logic levels and drive inductive loads and switching power transistors. To simplify use as two bridges each pair of channels is equipped with an enable input.

A separate supply input is provided for the logic, allowing operation at a lower voltage and internal clamp diodes are included. This device is suitable for use in switching applications at frequencies up to 5 kHz.

The L293D is assembled in a 16 lead plastic package which has 4 center pins connected together and used for heat sinking. The chip is designed to control 2 DC motors. There are 2 Input and 2 output pins for each motor. The behavior of motor for various inputs is shown in Table 2.

Table 2: Behavior of motors

Operation	A	B
Stop	Low	Low
Clockwise	Low	High
Anti-clockwise	High	Low
Stop	high	High

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 (I^2C, 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 89S52 derivatives. 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.

Conclusion

As we all know, these days India is sick off 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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