Fuzzy Logic Based Dual Mode Mobile Robot

Nishika Santhakumar[1] Nitya Venugopalan[2] Smruthi S[3] Swati Nair[4] Muruganandham.C[5]
[1,2,3,4]Student [5]Assistant Professor
[1,2,3,4,5]Department of Electronics and Communication Engineering
[1,2,3,4,5]Nehru College of Engineering and Research Centre, Trissur

Abstract— Fuzzy Logic based dual mode mobile robot is a robotic arrangement which can operate in two modes; and it is very helpful in automation applications where we need self-analysis based execution of algorithms. Here the microcontroller is programmed with the most of possibilities and the corresponding actions that need to be taken in the application. In the time of application, the machine takes the readings and the algorithm (which is already programmed in the chip) run on that automatically. Then the solution programmed will get executed. It is a vehicle like arrangement which can move excluding obstacles in a self-reorganization way. Here ultrasonic sensors are used to find obstacles in the moving path and if a sensor finds any block in the way the robot automatically change the path of travelling. The second mode of operation is a line-following movement. Here ir-sensors are used to keep the path in the line given. A microcontroller control and co-ordinate all the parameters and an LCD display interfacing with it shows the readings for our reference. A video camera is mounted on the robot in order to relay sensory data to the control room. A tracking arrangement is also set-up and the information is relayed to PC by means of a ZigBee.

Key words: LCD, Mobile Robot

I. INTRODUCTION

Fuzzy logic is a form of many-valued logic in which the truth values of variables may be any real number between 0 and 1. By contrast, in Boolean logic, the truth values of variables may be 0 or 1. Fuzzy logic has been extended to handle the concept of partial truth, where the truth values may range between completely true and completely false. It is a Superset of conventional (Boolean) logic that has been extended to handle the concept of partial truth. Fuzzy logicdeals with data that is uncertain, imprecise, vague, partially true, or without sharp boundaries. It also allows the inclusion of vague human assessments in computing problems. Truth values are indicated by a value on the range [0.0, 1.0] with 0.0 representing absolute Falseness and 1.0 representing absolute Truth. It uses comparisons to model the brain more closely.

It is a multivalued logic, which allows intermediate values to be defined between conventional evaluations like true/false, yes/no, high/low, etc. Notions like rather tall or very fast can be formulated mathematically and processed by computers, in order to apply a more human-like way of thinking in the programming of computers.

Fuzzy Logic has emerged as a profitable tool for the controlling and steering of of systems and complex industrial processes, as well as for household and entertainment electronics, as well as for other expert systems and applications like the classification of SAR data.

II. EXISTING SYSTEM

A number of methodologies have been proposed for achieving collision avoidance. Some of the more popular methods are based on edge-detection, certainty grids, potential fields, or combinations of these. In edge-detection the goal is to detect the visible edges of an obstacle; the lines connecting these edges represent the obstacle boundaries. This information can be used to decide on an appropriate direction to take for avoiding collision. One of the disadvantages of this approach is the necessity for the robot to stop and execute the algorithm that determines the existence of edges. Since many of these systems employ ultrasonic sensors, other disadvantages related to the shortcomings of these sensors detract from the system's ability to detect edges accurately. Typical problems associated with ultrasonic sensors are specular reflections, external interference from nearby sources, and the poor directionality characteristic of sonic waves. The certainty grid approach, as used in collision avoidance, consists of representing the robot's environment as a two-dimensional grid of cells. To each cell is associated a probability measure of the existence of an obstacle in that cell. The certainty grid is eventually used for planning obstacle-free paths. This technique is often used in the process of acquiring a local scan of the robot's immediate surrounding area, thus requiring that the robot stop periodically. Finally, potential field methods have also been used for mobile robot collision. The method consists of a superposition of attractive and repulsive forces resulting in an optimal direction of travel. Obstacles in the robot's environment exert repulsive forces on the robot and the goal state applies an attractive force. The success of the potential field method is dependent upon predefined environmental models; it thus requires accurate descriptions of obstacle locations in static environments.

III. PROPOSED SYSTEM

We have employed fuzzy logic to facilitate the collision-free navigation task for a mobile robot. A fuzzy logic based system has the advantage that it allows human-like intuition and the ability to deal with things other than absolutes. In addition, with the proposed methodology we can relax some of the constraints associated with the methods of collision avoidance mentioned earlier. The computational load of fuzzy inference systems is considerably lighter than those of edge-detection, certainty grids and potential fields. The successful management of uncertain and/or un-modeled data is a proven attribute of fuzzy logic based inference engines. In this work, our objective is to demonstrate the feasibility of this approach for mobile robot sensor-based obstacle avoidance in unknown, semi-structured environments using a minimal hardware system. Fuzzy logic based controllers are expert control systems that smoothly interpolate between rules. Processing of uncertain information and saving of energy using common-sense rules and natural language statements are the basis for fuzzy logic control. The use of sensor data in practical control systems involves several tasks that are usually done by a human in the loop, e.g. an astronaut adjusting the position of a satellite or putting it in the proper orbit, an operator remotely operating a robotic manipulator or vehicle, etc. All such tasks must be performed based on evaluation of the sensor data according to a set of rules/heuristics that the human expert has learned from experience or training. Often, if not most of the time, these rules are not crisp (based on binary logic), i.e. some common-sense or judgmental-type decisions are needed. The class of such problems can be addressed by a set of fuzzy variables and rules which, if done properly, can make expert decisions. Fuzzy logic controllers provide a means of transforming the linguistic control strategy based on expert knowledge into an automatic control strategy. Fuzzy control appears to be very useful for handling problems that are too complex for analysis using conventional quantitative techniques or when the available sources of information provide qualitative, approximate, or uncertain data. The control of mobile robots falls into this class of problems, and in the remainder of the paper we discuss the hardware implementation of a fuzzy logic controller for mobile robot collision avoidance.

IV. BLOCK DIAGRAM

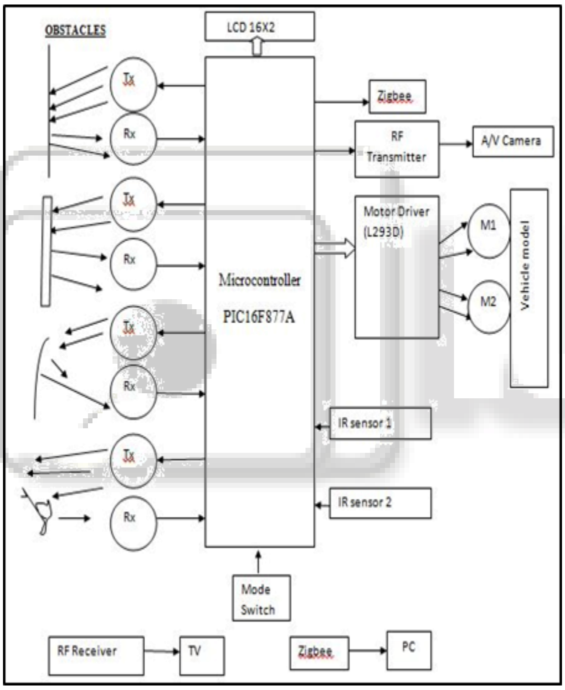

Fig. 1: Block Diagram

A. Power Supply:

It should be light and compact to keep the device functionally portable. It should meet possible current requirements for mechanical components.

B. Microcontroller:

Microcontroller controls individual Braille Cells and Braille Dots. It helps to scroll through text data based on feedback by user. It process text and scrolling information from wireless devices through wireless receiver. Send back acknowledgement and position in text back to wireless device. Emergency messages are stored in particular locations of microcontroller.

C. Motor Driver:

L293D is a dual H-Bridge motor driver integrated circuit (IC). Motor drivers act as current amplifiers since they take a low-current control signal and provide a higher-current signal. This higher current signal is used to drive the motors.

D. Display Unit:

Liquid crystal displays (LCD) is an alphanumeric display and widely used in recent years as compared to LEDs. This is due to the declining prices of LCD, the ability to display numbers, characters and graphics, incorporation of a refreshing controller into the LCD by relieving the CPU of the task of refreshing the LCD and also the ease of programming for characters and graphics.

E. Zigbee Unit:

The CC250 RF module is a transceiver module used for creating a local area network. ZigBee is a low cost, low power, wireless mesh network standard targeted at wide development of long battery life devices in wireless control and monitoring applications. The ZigBee operates on the standard ISM band of 2.4 GHz and hence it modulates and demodulates all the data into this 2.4GHz range.

F. Ir Sensors:

An IR LED, also known as IR transmitter, is a special purpose LED that transmits infrared rays in the rage of 750 nm wavelength. Such LEDs are usually made of gallium arsenide or aluminium gallium arsenide.

G. RF Transmitter And Receiver:

An RF (Radio Frequency) module is a small electronic device used to transmit/receive radio signals between two devices. This is a means of making wireless communication possible. For many applications the medium of choice is RF since line of sight is not required.

H. A/V Camera:

- Low radiation, safe
- Built-in microphone for audio monitoring
- Including adaptive bracket, easy installation
- Specification:
- Night vision enabled
- Transmit distance up to 200ft

V. CIRCUIT DESCRIPTION

The microcontroller is interfaced with four ultrasonic sensors (HC SR04) which provide sensory data, the motor driver IC (L293D) which are used to drive the two DC motors which drive and steer the robot, the IR sensors for the robot to work in line following mode and the 16*2 Liquid Crystal Display. The ultrasonic sensors and the motor driver are connected to Port B of the microcontroller. The control pins of the LCD are connected to Port C and the data pins are connected to Port D. The IR sensor pairs are also connected to Port B.

The IR sensors comprise two IR LEDs and photodiodes, connected to comparator LM 358. The LED is a Passive Infrared (PIR LED) that continuously emits infrared radiations which are reflected by all surfaces except black. The sensor is a photodiode which converts light energy into electrical energy. The voltage produced at the photodiode is input to the comparator and the path, which is devoid of reflections, is chosen.

The IR sensors comprise two IR LEDs and photodiodes, connected to comparator LM 358. The LED is a Passive Infrared (PIR LED) that continuously emits infrared radiations which are reflected by all surfaces except black. The sensor is a photodiode which converts light energy into electrical energy. The voltage produced at the photodiode is input to the comparator and the path, which is devoid of reflections, is chosen.

The ultrasonic sensors sends the sensory data to the microcontroller and this information is used to drive the motor left or right through the motor driver. A single motor driver IC can drive two motors using the two H-bridges inside it. Thus it has 4 input pins. It has two voltage pins, one rated at 5V for the IC to work, and the other delivers the 12V required for the motors to work.

Here two microcontrollers are used – one master and one slave. One ultrasonic sensor is interfaced with the master and the other with the slave. This is done as the ultrasonic sensors require 16 bit timers. Only TIMER1 of PIC16F877A is a 16 bit timer, TIMER0 and TIMER2 are 8 bit timers. If the sensors are made to share the timer, then ambiguity and mistakes may take place in the determination of distance.
Selection of the mode is done by means of a switch connected to Port E.

The battery charging circuit consists of a transformer, bridge rectifier, capacitors and a 5V voltage regulator. The power supply circuit consists of two fixed voltage regulators – 7805 and 7812.

The circuit further consists of a Zigbee module for communication with the PC. The module sends information regarding the direction of propagation of the robot while it is in the autonomous mode. This information can be viewed in a PC.

The robot also contains an A/V camera. The mounted camera sends video information to a remote TV, thus enabling surveillance of the terrain under navigation.

Sl.No	Name of the Component	Specification	No.
1	PIC Microcontroller	16F877A	2
2	Ultrasonic Sensor	HCSR04	4
3	16*2 LCD Display	LM016L	1
5	Battery	Lead acid battery	1
6	IR Sensor Pair		2
7	Motor Driver IC	12V	1
8	PCB	PCB	1
9	DC Motor	30 rpm	2
10	Crystal Oscillator	4 MHz	1
11	Diode	IN4001	4
12	Voltage Regulator	LM7805 LM7809	1 1
13	ZigBee Module	CC2500	2

VI. Software Details

Embedded systems are systems which perform a specific or a pre-defined task. It is the combinations of hardware and software. It is nothing but a computer inside a product. It is a programmable hardware design nothing but an electronic chip. A general-purpose definition of embedded systems is that they are devices used to control, monitor or assist the operation of equipment, machinery or plant. "Embedded" reflects the fact that they are an integral part of the system. In many cases their embedded may be such that their presence is far from obvious to the casual observer and even the equipment for some time before being able to conclude that an embedded control system was involved in its functioning. At the other extreme a general-purpose computer may be used to control the operation of a large complex processing plant, and its presence will be obvious. All embedded systems are or include computers or microprocessors. Some of these computers are however very simple systems as compared with a personal computer. The very simplest embedded systems are capable of performing only single functions to meet single functions to meet a single predetermined purpose. In more complex systems an application program that enables the embedded system to be used for a particular purpose in a specific application determines the functioning of the embedded systems. The ability to have programs means that the same embedded system can be used for a variety of different purpose. In some cases a microprocessor may be designed in such way that application software for a particular purpose can be added to the basic software in a second process, after which it is not possible to make further changes. The applications software on such processors is sometimes referred to as firmware. The simplest devices consist of a single microprocessor (often called a "chip"), which may itself be packaged with other chips in a hybrid systems or Application Specific Integrated Circuit (ASIC).

Its input comes from a detector or sensor and its output goes to a switch or an activator which (for example) may start or stop the operation of a machine or, operating a value, may control the flow of fuel to an engine.

VII. Project Outcome

The fuzzy control scheme allowed for the robot to quickly respond to obstacles it could detect in its environment using the data from the four ultrasonic sensors. Fuzzy logic affords a certain level of simplicity in the design of a system. It is a novel approach to dealing with high levels of uncertainty in real-world environments. The omni-directional wheels were used to develop a robot capable of omni-directional movement. The second mode which is a line following mode allows us to use the robot for a fixed path. The use of the camera allows the user to observe the path which the robot is using and the tracking mechanism depicts the pathway taken by the robot.

VIII. Conclusion

Thus a dual mode mobile robot using the concepts of fuzzy logic was created. In one mode, therobot acts as an anti-collision robot and traverses the environment avoiding all the obstacles. This autonomous mode is implemented using fuzzy logic and makes use of four ultrasonic sensors and two PIC microcontrollers. In the second mode the robot acts as a line-following robot. It is designed to follow the black line and it uses two pairs of ir-led and photodiode.

This robot has the ability to traverse unstructured and undetermined environment. It is also equipped with a video camera which relays sensory information to control room, which is basically a television. The robot is also programmed to relay the information of the path it undertakes to a remote PC. This is done by using wireless serial communication and is implemented using ZigBee.

IX. FUTURE SCOPE

This project has various future extensions and a wide variety of applications.

- The project can be implemented on a servo motor so that it can scan a full 180 degrees.
- Various types of sensors can be added so that data could be taken at multiple ranges.
- Velocity and position feedback can be used in order to permit straight line drive capability and smoother path traversal.
- To eliminate the problems with motor control the circuitry can be modified to deliver more power and torque.
- The use of tracking mechanism software allows noting the path the robot has taken. This data can be plotted to get a pathway using Matlab. This allows the user to map an obstacle free path.
- This feature allows the use of the robot in case of a collapsed building where a debris-free path is to be located.
- The IR sensors may be replaced by TSOP series sensors, which sends and receives waves that are modulated at a specific frequency, thus avoiding problems caused by ambient light.

REFERENCES

[1] William Martin, “Autonomous Robot Obstacle Avoidance using a Fuzzy Control Scheme”, Dec 4, 2009
[2] Neng-Sheng Pai, Hung-HuiHsiesh and Yi-Chung Lai, “Implementation of Obstacle-Avoidance Control for an Autonomous Omni-Directional Mobile Robot”, ISSN 1424-8220, October 2012
[3] Angelo Martinez, Eddie Tunstel1, and Mo Jamshidi, “Fuzzy Logic Based Collision Avoidance For a Mobile Robot”, Robotica, 12(6) 521-527
[4] David H, Humberto M, “Fuzzy Mobile-Robot Positioning in Intelligent Spaceds using Wireless Sensor Networks”, Sensors 2011, 11,10820-10839
[5] Green, W.E, “Optic-Flow-Based Collision Avoidance, IEEE Robot, Autom, Mag 2008, 15, 96-103

