Design and Implementation of a Real Time Obstacle Avoiding Subsumption Controlled Reactive Robot

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Abstract-- in Reactive robotic system, behaviors serves as the basic building block for robotic actions. A reactive control system tightly couples perception to action without the use of intervening abstract representations or time history. A simple wheeled vehicle is easy in mechanical design, controlling, and the construction part. But it doesn't work efficiently in all kind of surface. On a rough terrain, it performs poorly. The radius of a wheel could pass only a certain height of obstacle. To pass most of the obstacle that it meets, larger wheel radius need to be designed. In this paper the design & implementation of Subsumption based architecture, a reactive control system for real time obstacle avoidance which is compatible with low cost ultrasonic sensor, infrared sensors and fast enough to be implemented using microcontroller based development board is introduced with a legged robot.

Keywords: Microcontroller, ultrasonic sensor, infrared sensor, Subsumption.

I. INTRODUCTION

Many applications of robotics involve robot motion. In particular, an emphasis should be put on obstacle avoidance. Obstacles may as well be expected or not, a natural approach may be to make robots to navigate and avoid obstacles using reactive behavior. [1] The ability to detect and avoid obstacles in real time is an important design requirement for any practical application of robot vehicle.

Therefore, a significant number of solutions have been proposed for this problem. Unfortunately, most of these solutions demand a heavy computational load, which makes them difficult, if not impossible, to implement on low cost, microcontroller based, control structures. So, this paper proposes the reactive robotic system for obstacle avoidance relying on low cost ultrasonic sensor, infrared sensors, and involving a reasonable level of calculations, so that it can be easily used in real time control applications with microcontroller. [4]

A simple wheeled vehicle is easy in mechanical design, controlling, and the construction part. But it doesn't work efficiently in all kind of surface. On a rough terrain, it performs poorly. The radius of a wheel could pass only a certain height of obstacle. To pass most of the obstacle that it meets, larger wheel radius need to be designed. However, this approach is impractical in many cases.

On the other side, legged robots are more capable of moving across rough terrain. That's why the legged locomotion became a research of interest. But the legged robots are much more challenging to control as compared with wheel robots. Each leg consists of at least two motors. Controlling the one motor for left and right and another motor for up and down is difficult. An algorithm for walking must be developed in order the robot to walk. As a result, legged robots movement must be carefully studied and be controlled in such way so that it could stand and walk in a stable fashion.

II. SYSTEM OVERVIEW AND DESIGN

The reactive robot is designed to explore in the environment by detecting obstacles and avoiding collision based on the distance measurement information obtained from the infrared sensors and ultrasonic sensors. This robotic system is real time obstacle avoiding system due to reactive control by using Subsumption based architecture. Infrared sensor senses the obstacle along its path. The Infrared sensors, used for obstacle avoidance, are connected to the controller via analog ports. The input signal is received from sensor circuit and microcontroller is operated according to the received sensor's signal.

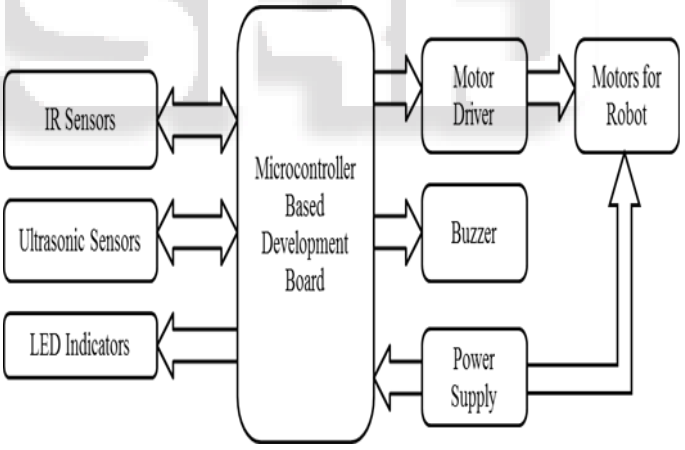

Fig. 1: Block diagram

The block diagram in fig. 1 gives the brief idea about the Real Time Obstacle Avoidance in a Reactive Robot. In this system, the major role is of microcontroller based development board using which robot is controlled to get desired output. The interfacing module is used for programming the microcontroller through personal computer. The obstacles in the limited environment of robot are detected by certain obstacle sensing devices such as IR and Ultrasonic sensors and then sensed signal are given to the microcontroller for particular behavior control of robot.

The perception of the robot stimulates a particular behavior, which decides motion of the robot. Actuators are driven by motor driver. The robotic motion is based on sensed data about the limited environment, obstacles and other parameters. The LEDs and Buzzer are used for indicating

occurrences of certain events. The microcontroller and motors are powered by power supply.

A. SYSTEM HARDWARE

This system uses microcontroller based development board which consists of ATmega2560.

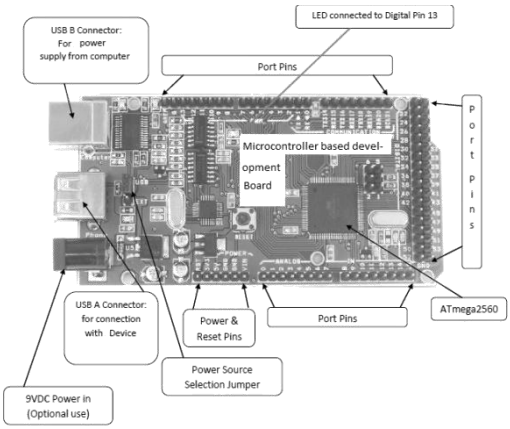

Fig. 2: Microcontroller based board

ATmega2560 based board is interactively programmable controller, which runs at 16MHz provides a wealth of hardware features including a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It has 54 digital input/output pins (of which 14 can be used as PWM outputs), 16 analog inputs, which is sufficient to control no. of servo motor required for legged robot. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC to- DC adapter or battery to get started.

B. INFRA RED SENSOR

The basic concept of IR (infrared) obstacle detection is to transmit the IR signal (radiation) in a direction and a signal is received at the IR receiver when the IR radiation bounces back from a surface of the object.

Here in the figure the object can be anything which has certain shape and size, the IR LED transmits the IR signal on to the object and the signal is reflected back from the surface of the object. The reflected signal is received by an IR receiver, which further given to the board for controlling the actuators of the robot. IR sensors are used when an obstacle is within a certain distance and for most robots which only need to know when an obstacle is right in front of it.

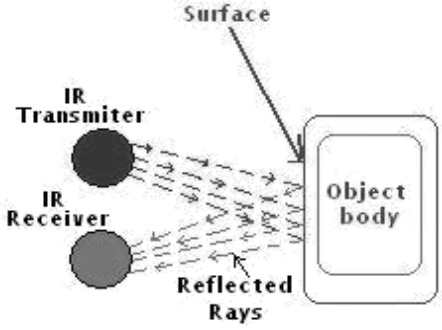

Fig. 3: Infra-Red Sensor

C. ULTRASONIC SENSOR

The ultra-sonic sensors often take the form of a pair of eyes, because it consists of two parts transmitter and receiver. The transmitter emits a sound at a defined frequency and the receiver collects the sound reflected back by obstacles. Distance to objects is calculated by measuring the time taken by the sound to return to the receiver. Ultrasonic sensor is used to detect an obstacle which is at a longer distance and not within the reach of IR sensor.

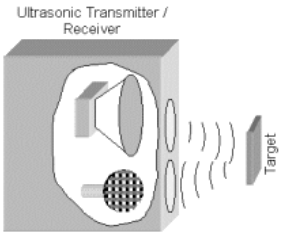

Fig. 4: Ultrasonic Sensor

D. SYSTEM SOFTWARE

The following flowchart shows the flow of the program for the real time obstacle avoiding robots using subsumption based architecture. For programming of the system a software compatible with ATmega2560 is used.

The robot first adjusts itself once it is powered on. The sensors of the robot sense the environment. Then it heads straight towards the goal. While heading towards the goal if any obstacle is detected by the sensors of the robot, it computes the new path which further proceeds towards the goal. If any obstacle is not detected by the sensors of the robot, the robot continues heading straight towards the goal. The robot continues heading towards the goal till it is visible.

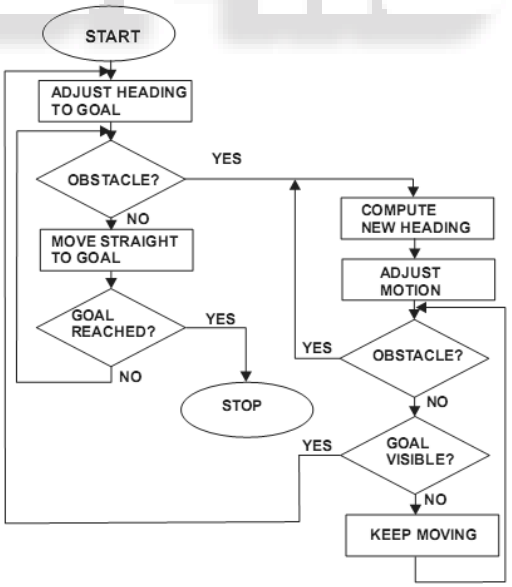

Fig. 5: Microcontroller Based Board

III. SUBSUMPTION BASED CONTROLLING SYSTEM

This robot uses Subsumption architecture, which is type of reactive control system in robotics. This method divides behaviors to many levels, where the higher level behavior have higher priorities too. So it can subsume the lower level ones as shown in Fig. 6 and Fig. 7. [1]

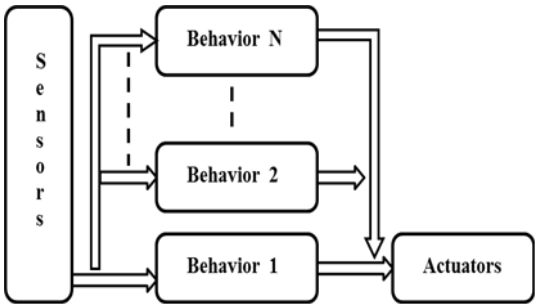

Fig. 6: Subsumption Based Architecture

The term 'subsumption' derives from the idea that higher levels can subsume the lower levels by suppressing their outputs as needed. The advantage of this system is that a robot control systems can be built incrementally, as lower levels continue to function while higher ones are added on. The result, according to Brooks, is a development framework for robotics that offers a large number of advantages concerning robustness, build ability, and testability over the approaches employed in traditional or classical AI. (Brooks, R., 1990) [3]

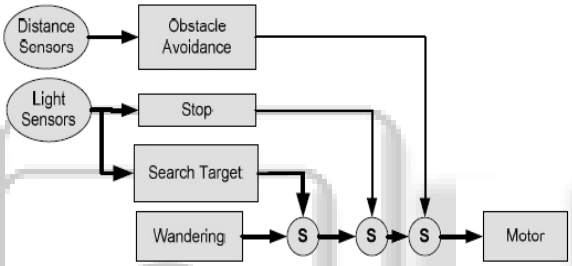

Fig. 7: Subsumption Based Robotic Control

Subsumption architecture is the result of work by professor Rodney Brooks [6] and the Mobile Robotics Group at the MIT Artificial Intelligence Lab. Brooks' subsumption architecture arose from an attempt to escape the confines of traditional robot control methods and provides a way of combining distributed real-time control with sensor-triggered behaviors.

IV. IMPLEMENTATION OF THE SYSTEM

The robot is designed for detecting obstacles and avoiding collision based on the distance measurement information obtained from the sensors using Subsumption architecture, a reactive control system. Sensors senses the obstacle along its path, which are interfaced with the microcontroller based development board which consists of ATmega2560.

The input signal is received from sensor circuit and microcontroller is operated according to the received sensor's signal. The hardware for the project used will be mainly microcontroller to control all the functionalities of the robot, sensors, robotic motion parts, indicators etc. The programming software to program the robot is compatible with ATmega2560 microcontroller based board.

Overall architecture of reactive robot consists of three major parts, perceptual, control and action parts. Perceptual part is composed of sensors, perceptual processes which are processed asynchronously and concurrently, precedence and evidence fusion relations through which a robot perceives the environment. Control part takes charge of invoke mission or mission transition and it controls behavior selection or behavior changing. Finally, action part is given to the actuators of the robot action such as searching and approaching the goal, avoiding obstacles.

V. CONCLUSION

In this paper, study and design of the obstacle avoidance system using subsumption architecture, a reactive control system for real time obstacle avoidance is presented. It is capable to avoid any kind of static obstacles. This system demands very low computational load and can be implemented on low-cost microcontrollers with low cost sensors.

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