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Implementation and analysis of real time obstacle avoiding subsumption controlled robot

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Abstract: Reactive robots provide more rapid and flexible response than is attainable through traditional methods of robotic control. The subsumption based architecture is reactive control system which it is also referred to as behaviour-based robots. They are instructed to perform through the activation of collection of low-level primitive behaviours. For real time obstacle avoiding robots, a reactive control system is most suitable as it tightly couples perception therefore in this paper design and implementation of subsumption based reactive control system is presented.

Keywords: Obstacle avoidance, Reactive Robot, Subsumption based architecture.

I. INTRODUCTION

A well-known approach towards behavior based artificial intelligence is Brook's subsumption architecture [2], where the programming is done within several layers, each having their own input, output and priority. The output should not depend on results from other layers and all control the robot individual. In many applications of robotics involve robot motion to achieve certain goal while emphasis on the 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.

The reactive behaviors directly map spatial information extracted from sensors into actions. Tasks in the real world require autonomous robots to behave not only in real time and in a reflex way but also in causal reasoning and a temporal order. [3] Legged morphologies have always been considered necessary to achieve robust and autonomous movement towards its goal. [4] Despite effective behaviors and performance demonstrated by tracked vehicles [5] and flexible multi wheeled platforms [6], remain limited due to restricted body movement of robot and obstacle avoidance.

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. Therefore in this paper, the implementation and analysis of real time obstacle avoiding legged robot based on subsumption architecture is presented.

II. SUBSUMPTION BASED ARCHITECTURE

A variety of behavior-based control schemes have been inspired by the success of Brook's [7] [8] with his architecture which is known by the subsumption architecture. In this architecture behaviors are arranged in levels of priority where triggering a higher level behavior suppresses all lower level behaviors. Using the subsumption architecture, a clear layered concept was needed for making this reactive robot, in which every layer has its own input and output connection to the real world.

These behaviors are each achieved separately and then tied together to form the robot control system using subsumption architecture as its advantages are:

1) Concurrent execution of multiple behaviors;
2) Multiple goals can be achieved;
3) Expandable layers, as new behaviors can be added onto existing layers; and
4) Robustness—older, underlying layers maintain core competency beneath overlaying behaviors. [9]

In fig 1, of Subsumption based architecture, the robot has a perception of the world through the sensors.

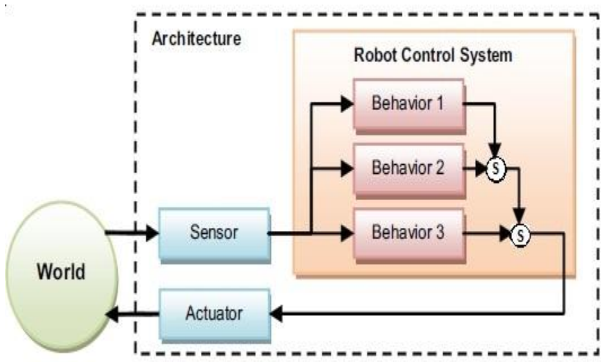

Fig 1: Subsumption based architecture

The behavior based robots need information about the world so they can relate themselves to the environment, just like animals. For this purpose, they rely on sensor devices which transform the world stimuli into electrical signal. These signals are electrical data which represents state of about the world and must be interpreted by the robot to achieve its goals.

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If the sensor information stimulates upper level behavior then the output of the behavior module is connected to the top input of behavior module. If the top input to the behavior module has any value, then the output of the behavior module assumes that value; otherwise, the output of the lower behavior module takes the value of its left input. [10] Where a particular behavior may suppress the lower behavior as shown in the fig 1 with S in the circle.

III. DESIGN OF THE SYSTEM

The real time obstacle avoiding robot is designed to search maximum light source in the environment by using the photocell sensors such as light dependent resistor, which is one of the behaviors of the robot as shown in fig 2. It also detects the obstacles and avoids them during maximum light search based on the distance measurement information obtained from the ultrasonic sensor.

When it detects the obstacles, it suppresses the lower behaviors and avoids the obstacles according to the avoid obstacle behavior. Then robot again observes the environment by suppressing the behaviors avoid obstacle and search maximum light. Once a particular behavior is stimulated by the perception, motors are actuated to perform certain tasks as move to left, right, forward or backward.

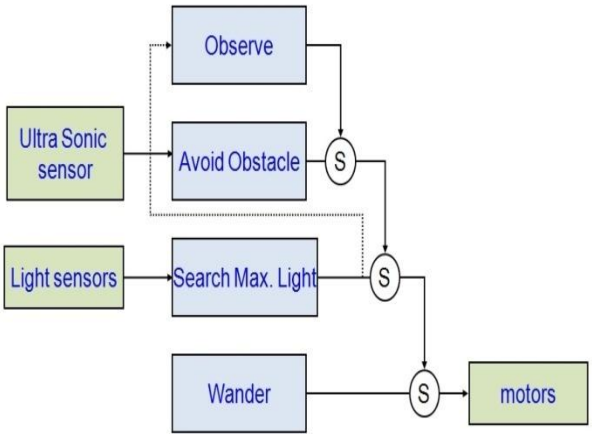

Fig 2: Block diagram

The block diagram in fig 2 gives the brief idea about the subsumption architecture used for the Real Time Obstacle Avoidance in a Reactive Robot. The behaviors shown in the block diagram can be also represented by the finite state machine, where each behavior makes transition from one state to another state with a particular stimulus.

The finite state machine for searching maximum light is mentioned in the fig 3, which makes transition through 5 different states from S1 to S5. State S1 compares the values of right LDR and left LDR with threshold value, if the condition is true it makes transition from S1 to S2 otherwise from S1 to S3. If condition in S3 is satisfied it goes to state S4. When conditions in states S1 and S3 are false then both the states makes transition to the state S5.

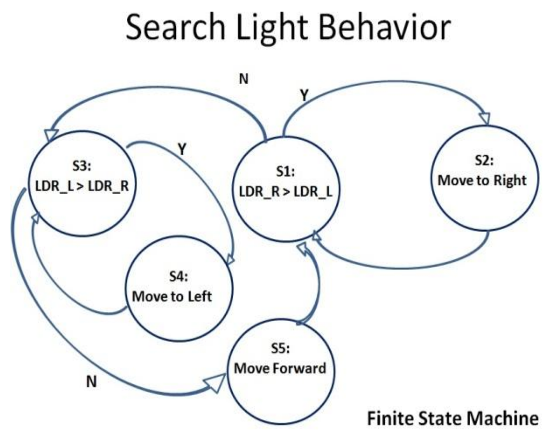

Fig 3: FSM for Search Max. Light behavior

The light sensors used for the search of maximum light are LDRs which are most commonly used for light detection in robotics. The LDR is connected in voltage divider manner as shown in the fig 4. Where the analog output from the divider circuit is given to analog input of the ATmega2560 based microcontroller development board.

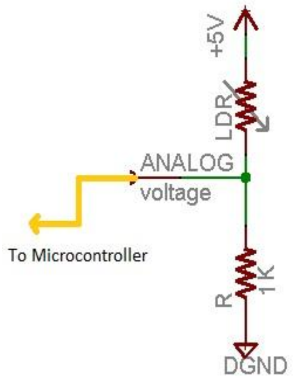

Fig 4: LDR as a light sensor

For the avoid obstacle behavior ultrasonic distance sensor is used. It is most popular exteroceptive active sensor used to acquire distance information from the robot's environment. The sensor has resolution of 2cm and field of view between 20 to 40 degrees. Ultrasonic sensor is active sensor because it generates sound energy. It works by emitting a short burst of 40 kHz ultrasonic sound from a piezoelectric transducer. A small amount of sound energy is reflected by objects in front of the device and returned to the detector, another piezoelectric transducer. The receiver amplifier sends these echoes to ATmega2560 based microcontroller development board micro-controller which is then used to determine how far away the objects are, by using the speed of sound in air.
In this system, the major role is of ATmega2560 microcontroller based development board using which robot is controlled to get desired output through the actuators. The actuators used in the system are twelve servomotors as two for each leg.
Servomotors are fast with high torque, accurate rotation within a limited angle and generally have a high performance alternative to stepper motors, but more complicated setup with PWM tuning therefore they are

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most suited for robotic arms/legs. To implement the real time obstacle avoiding legged robot with subsumption architecture following flowchart [fig 5] is used for the programming the robot.

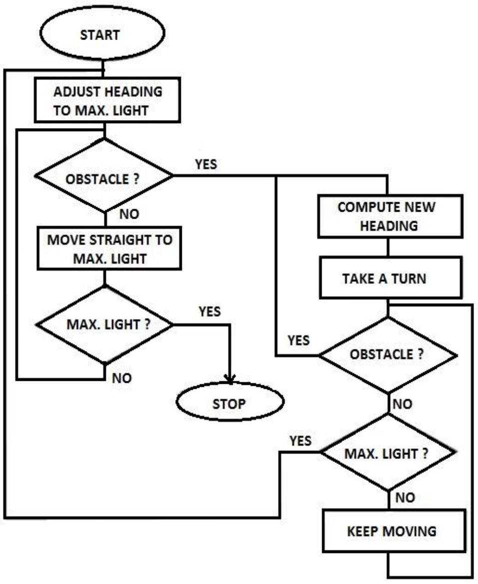

Fig 5: Flowchart

IV. RESULTS

The results of the subsumption architecture based robot are based on the various layers of behaviors. For the search light behavior, two LDRs are used at right and left side of the robot to sense the maximum light. When the difference between two sensors is more than the set threshold level, it takes turn either to the right or left as mentioned in the fig 3. Fig 6 shows the project setup with multiple light sources and obstacles. The subsumption based robot as shown in fig 6 avoids the obstacles while searching the maximum light source.

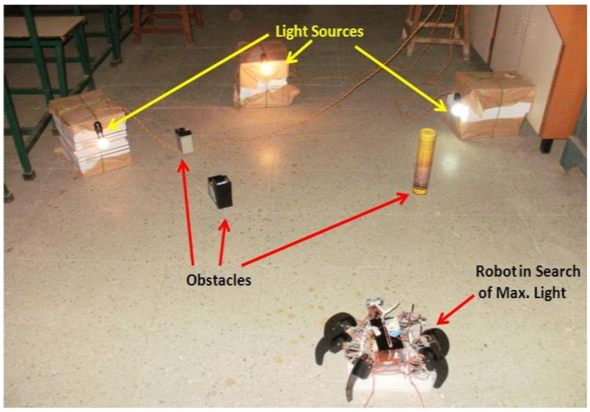

Fig 6: Project Setup

Fig 7 shows the values of two LDRs obtained from serial port of the ATmega2560 based microcontroller development board.

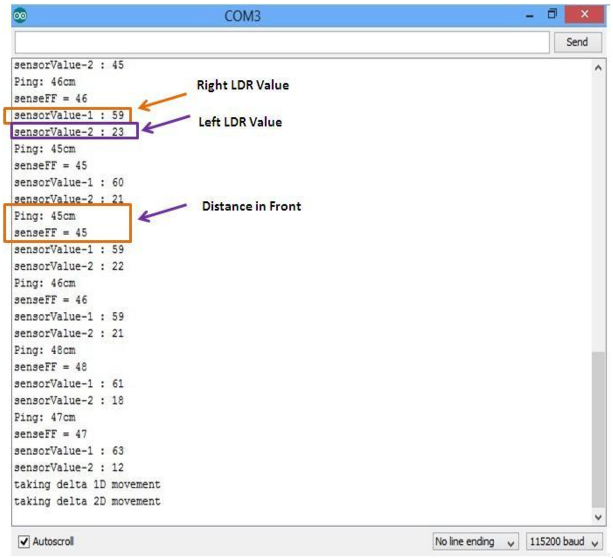

Fig 7: Results 1

The result 1 also shows the distance values obtained from the ultrasonic sensor which indicates concurrent perception to each behavior.

Fig 8 shows the values obtained from the ultrasonic sensor in various directions. The values in the result 2 indicate the distance between the ultrasonic sensor mounted on the robot and the obstacle in front of it. If the distance is within the set threshold value then it senses the distance at right hand side of the obstacle and continues to the left side. If obstacle is detected in the front, right and left then the moves backward.

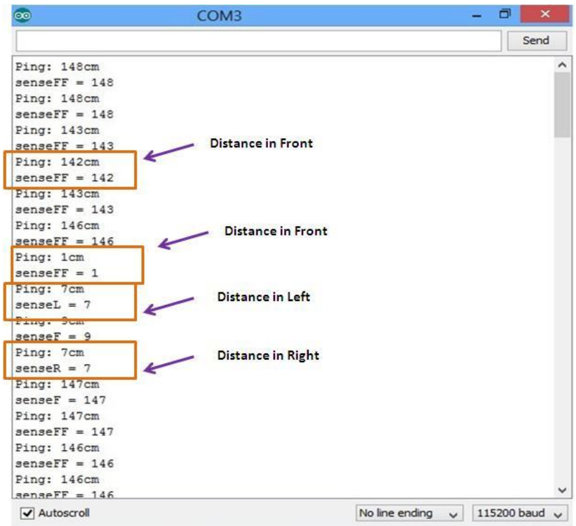

Fig 8: Results 2

V. CONCLUSION

The subsumption based architecture gives reactive and real time response which is suitable for the real time obstacle avoidance. The architecture is also flexible to add behaviors to obtain multiple goals. Wheeled robot may be stuck at the position even for the small obstacle but the legged robot is also capable of moving over the small obstacle.

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