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DESIGN OF MODULAR SELF-RECONFIGURABLE ROBOTS

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Abstract — *We have proposed a self-reconfigurable robotic module, which has a very simple structure. The system is capable of not only building static structure but generating dynamic robotic motion. We also developed a simulator for motion planning. In this paper, we present details of the mechanical / electrical design of the developed module and its control system architecture. Experiments using ten modules demonstrate robotic configuration change, crawling locomotion and three types of quadruped locomotion. In this paper we examine the development of modular self-reconfigurable robots. A survey of existing modular robots is given. Some limitations of homogeneous designs and connection mechanisms are discussed. Therefore, we propose a heterogeneous self-reconfigurable robot with genderless, fail-safe connecting mechanisms. We initially design three basic types (joint, power and special units) of module.*

I. INTRODUCTION

Real robots that change their shape, made up of many identical modules have been created and are being studied by a wide variety of groups. These robots are capable of more useful contributions to society. They promise to be versatile, low cost, and robust. While these systems do not yet behave like liquid metal, systems on the order of 100 modules have been built and promise to be useful in search and rescue or space exploration. Conceptually, the best known example of an MSR robot would be the fictional T1000 liquid - metal robot from the James Cameron film,Terminator 2 : Judgment Day.Inthis movie, a robot made from a futuristic liquid-like metal, (possibly many million microscopic modules) can change itsshape,copyforms,or reconstitute it to carry out sinister aims. The concept of modular Self-Reconfigurable robots can be traced back to the “quick change” end erecter and automatic tool changers in computer-controlled machining centers in the 1970’s. Here, special modules, each with a common connection mechanism, were automatically interchanged on the end of an electro-mechanical or robotic arm. The concept of applying a common connection mechanism to an entirely modular robot was introduced by Fukuda with the biologically-inspired Cellular robot (CEBOT) in the late 1980’s . These units have independent processors and motors, and can communicate with each other to approach, connect, and separate automatically.

In the early 1990’s, modular re-configurable robots were shown to have the ability to perform the task of locomotion. In 1994, Yim explored many statically stable locomotion gaits with Polypod. Polypod is an MSR robot that is significantly lighter and smaller than CEBOT. A module by itself could not locomote, but through the collective behavior of the system of many modules it could move itself from place to place and achieve many different locomotion gaits such as a slinky, caterpillar, or rolling trackgait.

PROBLEM STATEMENT

Existed System

A design philosophy behind modular robots is that each module is very simple. In fact, one group proposed the Ensemble Axiom “A [module] should include only enough functionality to contribute to the desired functionality of the ensemble.” A module by itself cannot achieve much, but modules arranged together in a system can achieve complex tasks such as manipulation and locomotion. Similarly, the control of a single module is usually simple whereas controlling a system of many modules becomes difficult very quickly.

OBJECTIVE

Compared with fixed morphology robots, MSR robots are flexible in that they can adapt to a wide range of tasks and environments. However, this flexibility may compromise performance or cost. Fixed morphology systems can be optimized for a particular known task, therefore, MSR robotic systems are particularly well-suited for tasks where the operating conditions and ability requirements are not known or not well specified a prior.

METHODOLOGY

A chain based MSR system consists of modules arranged in groups of connected serial chains, forming tree and loop structures. Since these modules are typically arranged in an arbitrary point in space, the coordination of are configuration is complex. In particular, forward and inverse kinematics, motion planning, and collision detection are problems that do not scale well as the number of modules increases.

The mobile class of reconfiguration occurs with modules moving in the environment disconnected from other modules. When they attach, they can end up in chains or in a lattice. Examples of mobile reconfiguration devices include

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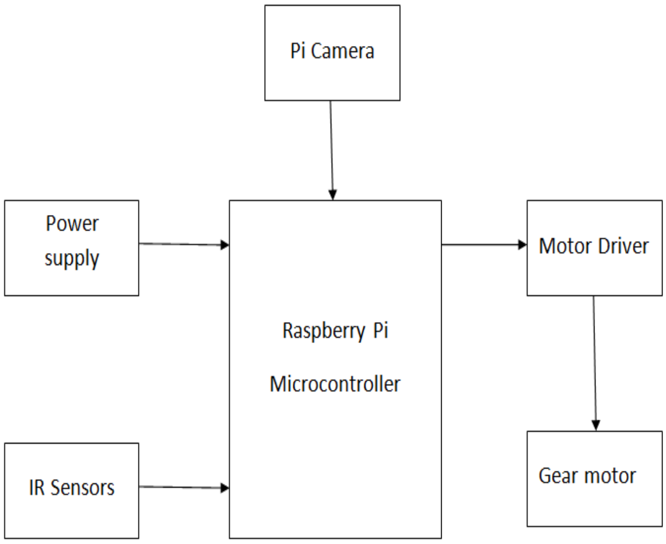
multiple wheeled robots that drive around and link together to form trains, modules which float in a liquid or outer space and dock with other modules.

This paper consists of 6 sections. First, Section 1 provides the information about the evolution of robots, Section 2 includes Working Principle, Section 3 describes Experimental results, Section 4 consists of Applications, Section 5 provides the details of Future work and Section 6 consists of Conclusion.

II. WORKING PRINCIPLE

Proposed System Block diagram

The principle of operation of the system and the operation of all components used in the system are discussed in detailed.



MSR robot consists of hardware components like Raspberry Pi 3 Microcontroller, Pi Camera, IR Sensors, and Motor Driver. In Existing system, Self reconfigurable robots where it consists of one centralized controlling robot with reconfigurable robotic arms. In Proposed system, Self reconfigurable robots is modified into 2 modules like Master and Slave where one Master robot is used to controlled or lead the chain of slave robot.

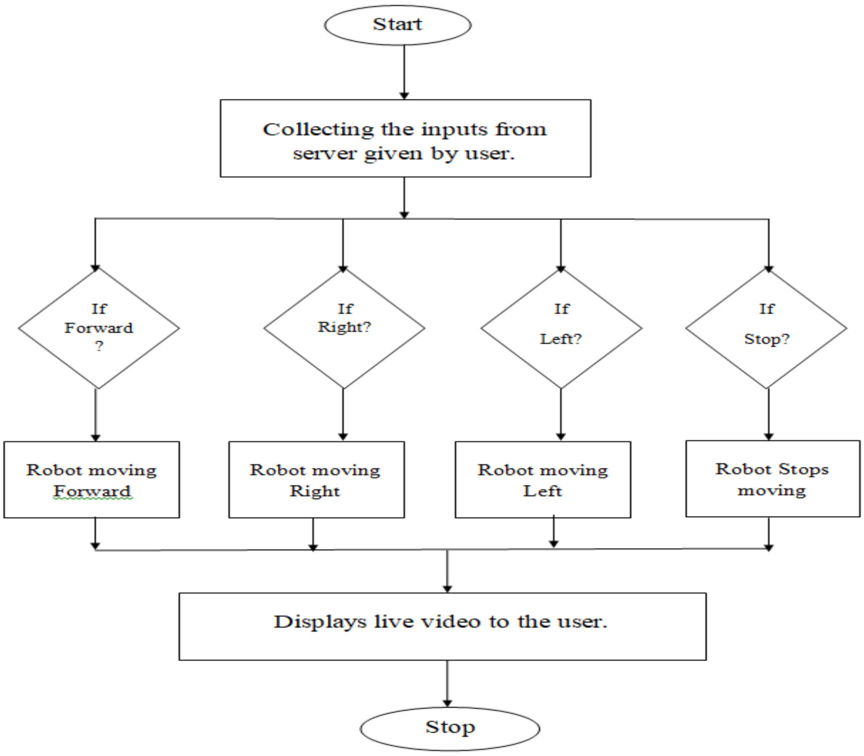
Modular self-reconfigurable robot is constructed using Raspberry Pi 3(Wi-Fi enabled), motor driver, IR sensor, Pi camera etc. Robot is developed into master robot (main module) and slave robot (sub module). In this project, the basic model of robot is developed in order to understand requirements power supply, interface application task, synchronization w.r.t robotic modules.
Modular Robot is developed by Phython programming in Raspberry Pi3 based using Raspbian OS interfaced with Raspberry Pi camera.

It is controlled by IP address based web server and IR sensors are used to detect the obstacles and stop the robot in motion. A web server is developed and an IP-address link is used to activate, initiate and control the motion of the robot in the following direction –front, left, right and stop. Web server link can be accessed through PC, laptop or smart phone through browser software.

Similarly it is used in accessing the video clips or footage from CCTV camera. In this paper, real time video is relayed to PC or mobile but captured by Pi camera where as real time images captured by Pi camera is saved in internal memory of PC or SD card of smart phone.

Flowchart

Step1: To give power supply to the robot and initiate the robot.
Step2: Use web server link IP address through PC or smartphone and control the motion of the robot modules.
Step3: User defines the direction of robot through web server like forward, right, left and stop.
Step4: Robot moves in the direction as per user instruction through web server.
Step5: Robot while moving displays the real time video on PC or phone and captures real time images and stores in the internal memory of PC or phone.
Step6: Repeat Step3, to Step6.



III. EXPERIMENTAL RESULTS

Introduction

Modular self-reconfigurable robot is constructed using Raspberry Pi 3(Wi-Fi enabled), motor driver, IR sensor, Pi camera etc. Robot is developed into master robot (main module) and slave robot (sub module). In this project, the basic model of robot is developed in order to understand requirements power supply, interface application task, synchronization w.r.t robotic modules.

Implementation

Modular Robot is developed by Phython programming in Raspberry Pi3 based using Raspbian OS interfaced with Raspberry Pi camera. It is controlled by IP address based web server and IR sensors are used to detect the obstacles and stop the robot in motion. A web server is developed and an IP-address link is used to activate, initiate and control the motion of the robot in the following direction –front, left, right and stop. Web server link can be accessed through PC, laptop or smart phone through browser software. Similarly it is used in accessing the video clips or footage from CCTV camera. In this project, real time video is relayed to PC or mobile but captured by Pi camera where as real time images captured by Pi camera is saved in internal memory of PC or SD card of smart phone.

1 .TOP VIEW

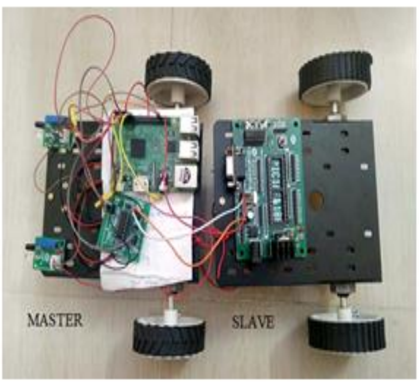


Fig5.1: Self modular robot includes master robot and slave robot. Master robot acts as controller and slave acts as follower.

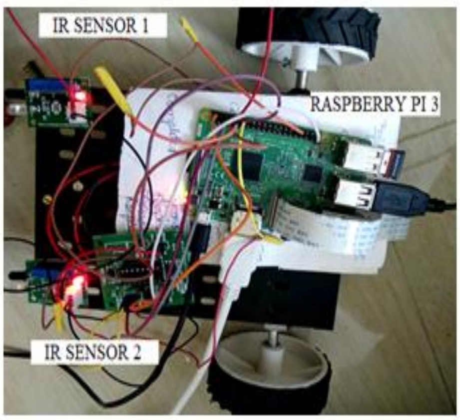


Fig5.2:Master robot interfaced with IR sensors. IR sensors are "ON" means obstacles are detected and the stops the robot.

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2. FRONT VIEW

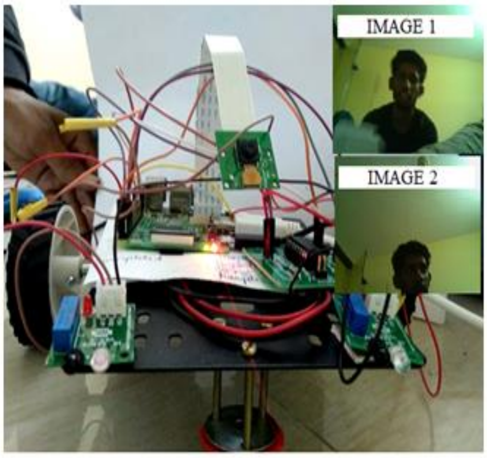

Fig5.3: IR sensors are "OFF", Robot is in motion and Pi camera is capturing real time images (inset).

3. SIDE VIEW

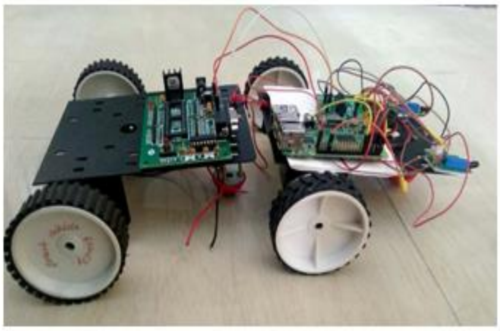

Fig5.4: Slave robot module is interfaced with master robot module, master robot has sufficient 12V power supply but slave robot acts as a load to master robot. Due to insufficient power from master robot to slave robot we are connecting two 9V batteries to 2 DC motor of slave robot.

IV. APPLICATIONS

The applications of Self modular reconfigurable robots are – Security, Medical aids, Traffic monitoring, Space exploration and Tele pario robot. The advantages are – (i) It is easy and simple to implement the robot, (ii) It is portable, and (iii) It requires less space and it is light weight. The only disadvantage is that it lacks suitable power supply to add more robot modules (slaves) as loads.

V. FUTURE WORK

As no sensors are embedded in current module hardware, the modules have no ability to sense the surrounding environments. We plan to install sensors (e.g. an angle sensor, a torque sensor, an inclination sensor, a proximity sensor and a vision sensor) in the next prototype. A proposed ultimate goal for these systems would be to one day use them in vast numbers for practical applications where un-supervised, adaptive self-organization is needed.

VI. CONCLUSION

We have proposed a self-reconfigurable robotic module, which has a very simple structure. The system is capable of not only building static structure but generating dynamic robotic motion. We also developed a IP address based server for motion planning. In this paper, we present details of the mechanical / electrical design of the developed module and its control system architecture. Experiments using two modules demonstrate robotic configuration change, crawling locomotion and three types of quadruped locomotion.

In this paper, we have described the hardware of the proposed module, the control system architecture, the IP address based server is used for motion planning and the experimental results using the developed modules. We have confirmed that various kinds of robotic configurations and transformations between them are possible by the proposed system. We are now working on the next prototype system with a larger number of modules.

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