Project SpiderBot

Team Members:

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Executive Summary:

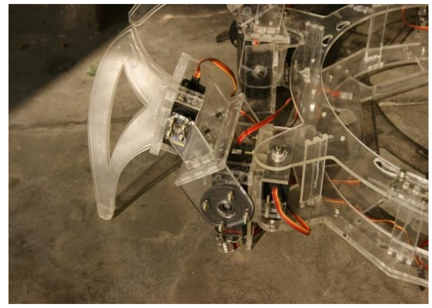
In today's world, one of the significant areas of research in robotics is developing a multi-terrain robot that is flexible enough to traverse a variety of surfaces. A multi-terrain robot finds its application in disaster relief, in the military and much more. One of the best modes of locomotions for a robot is through the use of multiple legs, using which it can move itself through difficult terrain and overcome obstacles easily.

Project SpiderBot will be a hexapod with six independent legs, each with three degrees of freedom. We chose to make a hexapod because they offer more excellent stability while moving and standing than bipedal or quadrupedal robots. They can be perfectly stable on just three legs, the remaining legs of the hexapod robot provide a great deal of flexibility and increase its capabilities.

The project SpiderBot will be capable of locomotion on the ground, climbing up slopes and steps, and even scaling vertical walls kept parallel and close to each other. Inspired by similar robots in the sci-fi movies, and some of ERC’s recent projects, this project aims to utilise those concepts and implement them in reality.

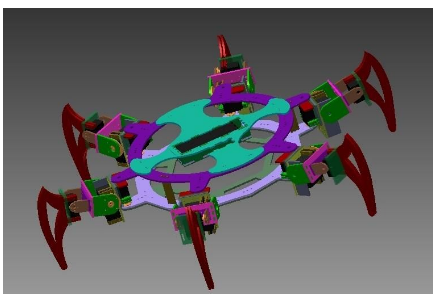
The applications of this type of technology are vast, as discussed already, since a legged robot is the most versatile type of locomotion for a robot. From nanobots to rescue bots, the potential for this type of design is limitless. Hence, developing and smoothening a mechanism for the motion of the bot is crucial, which we aim to develop through simulations and their implementation on real models. Thereafter, those models can be upgraded and modified to suit the different applications as and when required.

Project Idea Description:



This project would be a step towards designing and refining locomotion algorithms for hexapods. Since the design of the bot would be basic and not superficial, the same techniques can be implemented in various other types of bots as well. We plan to make a hexapod that is truly multi-terrain, can traverse walls and avoids obstacles.

Basic Idea planned till now:



The legs of the hexapod will have three degrees of freedom each. The initial prototype will be using servo motors in its legs for more accurate and smoother motion.

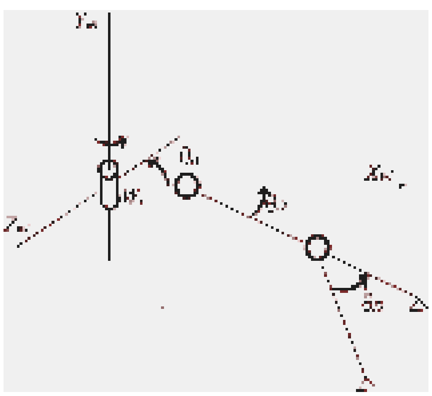
The hexapod will be able to transition between three different gaits. The tripod 3+3 gait mainly gives more speed and more turning capability to the robot while the 4+2 gait provides better stability and more fault tolerance. The 4+2 gait helps in achieving step climbing as well. We will accomplish wall climbing tasks by horizontal climb gait and 5+1 walking gait.

We also plan to add obstacle avoidance and path planning algorithms to the robot using ROS. To achieve this, we plan on using a stereo camera as input. We also plan to include base stabilisation for better performance as the hexapod walks on slopes. The robot will also be able to adjust its base height according to the obstacles in its path.

Technical Prerequisites:

- ROS, Gazebo simulations
- Matlab, Simulink, Simscape library
- Coding a Raspi
- Basics of Control Systems
- Basic Solidworks and Autocad
- Knowledge of Arduino Integration for motors
- Design of controller relay systems
- Basics of obstacle detection and path planning algorithms
- Basic knowledge of the motors to be used
- Coding of a Nvidia Jetson
- Knowledge of Mechanical joints

Progress Till Now:



➔ We have some basic knowledge of ROS, Matlab, Simulink and control systems. We are in the process of perfecting them and further learn more about Jetson Xavier, different libraries of ROS.

➔ We are also in the process of studying the existing simulation files of a hexapod and deriving our own simulation from them.

➔ We have finalised some components we will be requiring for the basic prototype

Timeline of the Project:

- ➔ Before Next Semester
  - ◆ Learn basics of ROS
  - ◆ Learn Matlab, Simulink, Simscape
  - ◆ Learn to code a Raspi
  - ◆ Learn basics of Control systems and how to control a motor to get desired outputs
  - ◆ Try out basic simulations of individual leg movement

- ➔ 2020-21 First Semester
  - ◆ Complete more complex simulations like
    - Whole body simulations of different gaits
    - Simulation of base stabilisation
  - ◆ Manufacture a basic prototype
  - ◆ Complete desired walking gaits on the prototype
  - ◆ Try obstacle avoidance

- ➔ 2020-21 Second Semester
  - ◆ Complete the path planning algorithm including obstacle avoidance
  - ◆ Complete base stabilisation on slopes
  - ◆ Step climbing simulations

- ➔ 2021-22 First Semester
  - ◆ Complete step climbing coding
  - ◆ Try wall climbing simulation and computation

Impact and Utility of the Project:

- ➔ One of the motivating factors often given for pursuing the development of hexapod robots is that they can climb over obstacles larger than the equivalent sized wheeled or tracked vehicle. In fact, the use of wheels or crawlers limits the size of the obstacle that can be climbed to half the diameter of the wheels. On the contrary, legged robots can overcome obstacles that are comparable with the size of their leg.
- ➔ The legged robot design is a very versatile one, with a robot such as a hexapod finding its application in vast areas. Since we are working on a basic framework, which when completed, can be built upon to suit a wide variety of applications with suitable modifications to the bot.
- ➔ Hexapod walking robots also benefit from a lower impact on the terrain and have greater mobility in natural surroundings. This is especially important in dangerous environments like mine fields, or where it is essential to keep the terrain largely undisturbed for scientific reasons.
- ➔ Hexapod legged robots have been used in exploration of remote locations and hostile environments such as seabed, in space or on planets in nuclear power stations, and in search and rescue operations.

Comparison with Existing Product:

Our idea to make a multi-terrain hexapod was inspired by the existing hexapods made by Rhoeby and Romela.

The Rhoeby hexapod is a lidar-based obstacle avoiding autonomous robot. Using ROS to control the motion of the robot and MiniIMU to map it, the hexapod assigns most of its computational work on the commanding device(i.e the laptop operating it) or the cloud. This can result in particular issues pertaining to network lag/loss and thus the robot is not very ideal for applications where it is required to work autonomously. We aim to overcome this by having the computational capabilities on the hexapod itself, thus making it a truly autonomous device.

The Romela hexapod is capable of climbing between two vertical parallel walls, non-parallel walls and avoiding obstacles while rising.But Romela hexapod does not have any vision sensor on it and is just a basic skeleton without much computational complexity or adaptability. We plan to build upon it and make it so that the skeleton is able to perform a wide variety of locomotive operations with ease, although it would entail adding sensors and powerful microcontrollers to it.

Project SpiderBot looks to integrate the workings of both of these hexapods; along with adding step climbing ability and base stabilisation on slopes. These features will make SpiderBot a superior hexapod as to the ones already in the market, with its all computation on the robot itself.

Rhoeby hexapod:
https://www.youtube.com/watch?v=C1SvSdthFzs
Romela wall climbing hexapod:
https://www.youtube.com/watch?v=AXmrqnt3JIA

Requirements:

- ➔ From Sandbox
  - ◆ 3-D Printer access
  - ◆ Laser cutter access
  - ◆ PCB Printing machine access
  - ◆ Boards
    - Raspberry Pi

        - Arduino
        - Nvidia Jetson
    - Equipment to test like power sources and simulation platforms
    - Mechanical tools
        - Jigsaw
        - Hexsaw
        - Drill Machine
    - Batteries and wires
    - Computer access for various needs
    - Soldering iron
    - LCD
    - Acrylic sheets, nuts, bolts, washers, spacers etc.
    - Voltage regulator
    - PCB

- From CTE funds
    - 18 Servo motors
    - Lipo Batteries, wires, connectors
    - Sensors like pressure sensor, infrared sensor

- Other Requirement
    - Intel RealSense camera for computer vision

Expected Costs:

- ₹1000 * 18 = ₹18000 for servo motors
- ₹1000 * 6 = ₹6000 for pressure sensors
- ₹5800 for lipo battery
- ₹60 * 12 = ₹720 for infrared sensors

Total: ₹30,520

Team Member details:

- ➔ Ashutosh Anil Gupta (Project Lead) :
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- ➔ Abdul Jawad Khan:
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