Hexapod Floor Plan Mapping

Final Year Project Plan
HKU CS Department

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1. Background

The project involves a six legged robot called a Hexapod developed by the MakerLab of The University of Hong Kong's CS Department. The hexapod can currently walk and run, being controlled by a remote controller. It also has various types of locomotion capabilities. However, the robot has no ability to move on its own and thus needs to be controlled.

Our project aims to give this hexapod robot the ability to move autonomously and give it understanding of its surroundings using Artificial Intelligence. In the next phase, the robot should be able to map the floor plan of buildings and demonstrate the ability to recognise its surroundings using techniques like Simultaneous Localization and Mapping (SLAM Algorithms) and computer vision. The end goal would be a bugbot that can navigate by itself, build a map, and take photos of the scene during the process and produce something similar to the street view of Google Maps.

The robots navigation and vision would be built into an android app developed using Android Studio. A custom 3D Printed Gimbal would be designed to be attached to the robot which can hold an android phone. This gimbal would allow the phone to pan and tilt omnidirectionally, and the phone's front and back cameras would serve as the robots vision. The phone would also link to a relevant backend server or house the navigation logic locally.

This project employs Computer Vision, Artificial Intelligence, SLAM Algorithms, 3D Printing Methodology, Application Development and Hardware and Robotics. While all these fields are quite mature and have been developed in some form, the project will combine fundamental knowledge from all the fields to solve a relevant problem in indoor mapping and vision using the hexapod robot.

2. Objectives

- Design and develop a custom 3D Printed Gimbal and mount it on the bugbot.
- Mount the phone to the gimbal and establish a connection to the robot, replacing the existing Raspberry Pi used by the robot.
- Develop an android application that would allow for interaction between the robot and the phone.
- Setup basic navigation commands to manually move the robot via the android application.
- Use the built in cameras to gather information as well as the phones cameras to gather information and take images.
- Program the phone to gather information from the depth sensors.
- Developing a Simultaneous Localization and Mapping Algorithm using data from the phone and sensors on the robot and phone in order to allow the robot to self navigate.
- Developing an artificial intelligence engine to enable pattern and object recognition using the phone.
- Stitching together a complete floor plan map along with relevant images
- Testing BugBot

3. Methodology

The project is to be developed in several exploration and implementation phases. Initially, modifications must be made to the hexapod robot, BugBot to introduce a new mobile application based communication interface. The other main exploration and implementation phases largely involve selection and implementation of SLAM algorithms, and object detection and labeling algorithms, explained in the following subsections. SLAM algorithms provide an approach to autonomously mapping the required floor plan. For object detection and labeling, R-CNN and similar models will be explored. This is highly efficient for navigation as well as labeling relevant objects in floor plan maps.

3.1 BugBot

BugBot, developed by the MakerLab of The University of Hong Kong's Computer Science department is a Hexapod robot with six actuators for a variety of movement/locomotion functionalities. Additionally, BugBot possesses two video cameras with depth sensors that can be leveraged for computer vision capabilities. Currently, BugBot is operated by a single-board Arduino microcontroller, controlled by a Raspberry Pi computer interface. BugBot's functionality can be triggered by string commands received via Bluetooth transmission and reception.

According to the current plan, modifications will be made to the current communication interface. A 3D printed gimbal will be designed to be mounted on BugBot that can house a smartphone. The gimbal will support omnidirectional movement, which will enable utilizing the smartphone's front and back cameras for vision. Additionally, the current Raspberry Pi computer will be replaced by the smartphone with a custom built Android application communication interface. All navigation and recognition functionality will be processed and relayed to BugBot via the Android application. These modifications will better support the computationally heavy processing required for object recognition and navigation. Furthermore, an Android application interface enhances marketability of the project making it a useful modification.

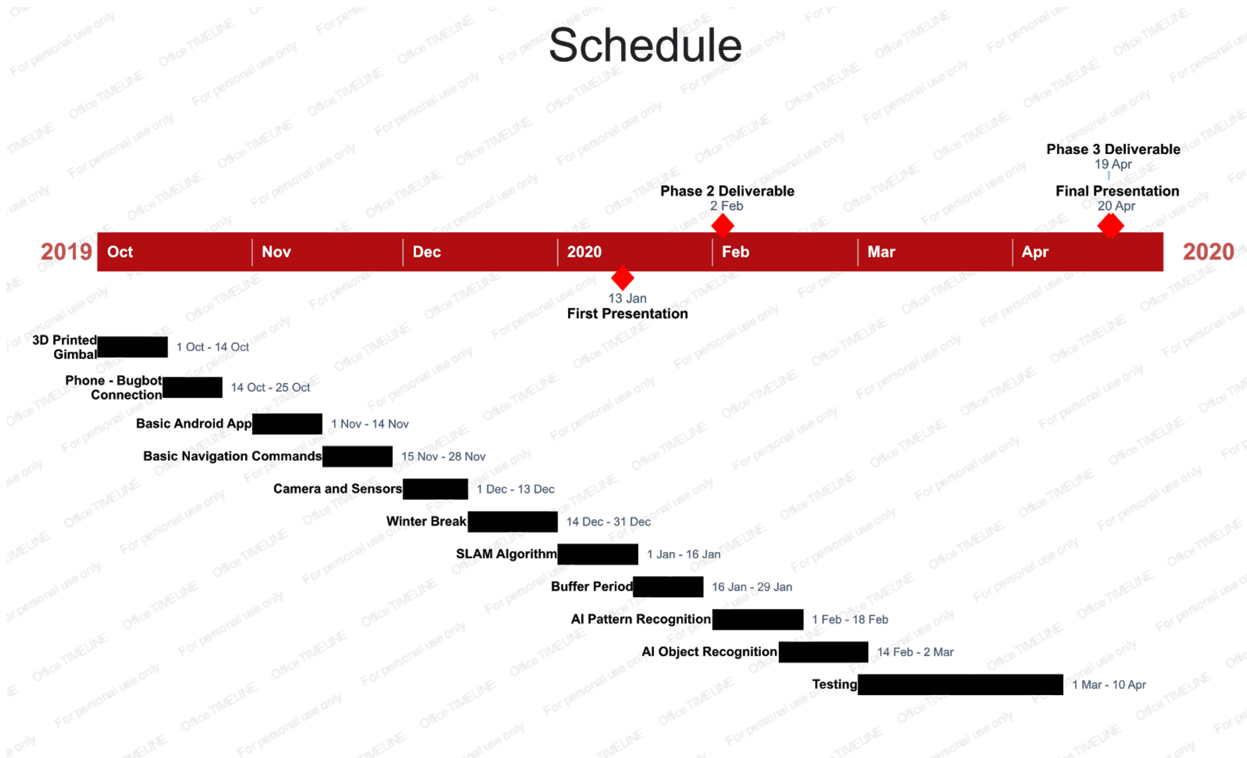
3.2 Simultaneous Localization and Mapping (SLAM)

Simultaneous Localization and Mapping (SLAM) algorithms deal with the computational mapping of an unknown environment while simultaneously tracking the location of the mapping agent within the environment (Durant-Whyte, H & Bailey, T, 2006). Various SLAM algorithms will be explored such as conventional filter-based SLAM algorithms, vision-based global optimization algorithms, as well as CNN SLAM algorithms to determine the best approach for navigation and floor plan mapping. An optimal algorithm will then be integrated within the Android application to support navigation and mapping.

3.3 Region-based Convolutional Neural Networks (R-CNN)

Region-based Convolutional Neural Networks (R-CNN’s) are widely used for object detection and classification. R-CNN’s will be explored along with Fast R-CNN and Faster R-CNN algorithms for object detection and labeling. This is useful for stitching up images and labeling useful objects and patterns in the developed floor plans. Object detection is further useful for navigation and optimal floor mapping by acting as additional support input in vision-based SLAM algorithms mentioned in section 3.2. Several relevant object datasets will be explored and selected to be used to train these models.

4. Schedule



October -

2 weeks: Design and develop a custom 3D Printed Gimbal.

2 weeks: Mount the phone to the gimbal and establish a connection to the robot.

November -

2 weeks: Develop a basic android application that would allow for interaction between the robot and the phone.

2 weeks: Setup basic navigation commands to manually move the robot via the android application.

December -

- 2 weeks: Program the phone to gather data from cameras and bugbot sensors.
- 2 weeks: Break for winter.

January -

- 2 weeks: Developing a Simultaneous Localization and Mapping Algorithm using data from the phone.
- 2 weeks: Self navigating robot should be functional at this point, Buffer period to finish unfinished work.

February -

- 2 weeks: Implement AI Pattern and Object Recognition.
- 2 weeks: Implement AI Pattern and Object Recognition.

March Onwards -

Testing completed robot and map quality.

5. References

H. Durrant-Whyte, T. Bailey, "Simultaneous localization and mapping (SLAM): Part I the essential algorithms", Jun. 2006.