Department of Computer Science and Informatics
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Reconnaissance Robot

Project Proposal

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Abstract

There exists scenarios where robots can be used to perform reconnaissance missions where human access may not be available or preferred. The proposed project will consist of a proof of concept reconnaissance robot, focusing on mobility and basic information gathering within the problem space. The gathered data via various environmental sensors will be used for data analysis. This data will provide the robot to function independently in the event where communication from the host control may be disrupted.

Contents

1 Introduction

The use of robots have steadily become increasingly popular. Most notably in the automotive sector in the from of assembly robots and military use (Darpa). With the advancements in miniaturization of semiconductors, the ever increasing computational power and availability, robots are becoming a more feasible choice with respect to tasks that concerns human safety. Scenarios of interest regarding this project are bomb threats (detection, disarmament) and the exploration of unstable building structures. Both scenarios have their own respective problem space, in which the robot should be equipped with the necessary sensor array to complete its tasks. The main goal is to develop an adaptable interfacing platform where the robot may be used in multiple different scenarios, with little or no changes to its programming. This will lay the foundation for more complex functionality such as Artificial Intelligence (AI) and Artificial Neural Networks (ANN). These disciplines will, on a later stage, be used to provide the goal-based(Stuart Russell, et al, 2010) agent with information about the current state, and the desired state with respect to a generic model of the problem space.

2 Problem Definition and Aims

2.1 Problem statement

The most challenging part will be to make the movement of the robot (hexapod) as dynamic as possible. The reason why this is fundamentally important is because, all future algorithmic implementation should only serve as a suggestible means of motion. This will prevent code flaws or unforeseen events during a selected algorithm from disrupting the overall stability of the robot. The main goal in this project will be to: (a) develop the base movement interface with an authentication protocol securing all communication networks, (b) ensuring that the robot maintains stability under the most challenging environment with respect to a three dimensional space, and (c) provide extensibility for gait algorithms using an authorization protocol. The authentication will ensure domain security, whereas authorization will protect the overall stability, denying or allowing commands to be executed base on the environment and current state.

2.2 Existing work

There are various gait algorithms that make use of Kalman Filters(Wikipedia.com, 2017b) and Inverse kinematics(Wikipedia.com, 2017a) in order to provide quick functionality, simulating insect movement gait(IJERA, 2017). A subdivision of the Google umbrella corporation, Boston Dynamics has done some of the most advance walking robotics publicly seen. These robots can maintain stability in some of the most challenging environments.

2.3 Proposed solution

Movement calculation based on predefined algorithms may limit future extensibility such as the possible implementation of ANN in my opinion. Therefore a level of abstraction with a generic implementation will serve as the coupling point where different algorithms may be chosen at the user's or goal-based agents' request at runtime. This project will focus on providing a dynamic framework where movement will be based on goals determined by the environment and tactical goals.

- The primary aim of this project is to provide a viable generic model for robotic development using object oriented approach with design pattern principles.
- A secondary aim is to create reusable artifacts during the process of development, adding knowledge, be it either complications or something new that may have been previously overlooked.

3 Design considerations and specifications

3.1 Performance limitations

- The robot should be able to maintain stability in extreme environments (Highest Priority).
- It should be secure, and robust against outside manipulations.
- It should be able to extend it functionality without being damaged by malicious commands.
- It should be able to gather and store sensor data whilst disconnected from its host and upload data, when connection is restored.
- It should be able to function without a host controller (Lowest priority).

3.2 Hardware and software limitations

- The robot controller may not draw to much current reducing operation time.
- Components should be light to reduce total load.
- Components should be properly shielded from water when deployed in an uncontrolled environment.
- Communication via radio frequencies might limit the operational distance from host to robot.

3.3 Development Requirements

All the components required to produce the project have already been acquired.

3.4 Technologies involved

The host controller (Workstation) language will require a fourth generation coding language with multi threading capabilities and an easily accessible data access layer to communicate with a database for storing environment data.

3.4.1 C# 6.0 Language:

The host application that resides on the host controller should use C# as the main language as it provides the most versatile environment providing many of the required basic function. The use of design patterns are easily incorporated. The language natively supports Task Parallelism and Data Parallelism. The .Net framework written in C# provides easy access to database functionality. The technology that will be used to connect to a SQL Server database, will be Entity Framework. It provides the ability to write dynamic sql queries using lambda expressions in C#, thus reducing the need for multiple IDE's. As mentioned, SQL Server will be used as the main data store. A secondary motivation for SQL Server (2014) is the ability to create memory optimized tables. These tables reside completely in memory, optimizing data throughput between 2-25X faster than regular tables, with a file-based backup for sustainability. C# also provides communications service layer that will be used as the main medium for sending information from the host to slave elements via serial communications port.

3.4.2 C++ Language:

Most micro controllers are coded in low level C or C++. This language is a requirement for this project's robot controller, and will only contain basic procedural code such as sending/receiving requests and local data storing in the event of a signal loss.

3.4.3 Tools:

Visual Studio 2015 Enterprise as the main IDE. It contains numerous project design tools by means of project modeling, database modeling and creation, code validation, application insights, code complexity analysis and general code testing and debugging. It provides a central integration point for all the technologies to seamlessly work in accord, reducing the development time. VS 2015 also supports all the languages required for this project.

XCTU: Wireless Point-To-Point configuration software. Configuration of the various wireless modules for communication between devices.

Arduino IDE: The Arduino environment will be used to upload c++ code developed to the robots micro controller, and basic testing of communications.

4 Required skills

As C++ is a requirement, I will need to research some of its data structures and functions. Memory optimized tables are relatively new and I will need to learn how to implement this functionality and viability. Design patterns exists to solve regular occurring problems in the industry, but there are limited literature about design patterns with respect to robotics. This will require further understanding in the use of multiple design pattern working together.

5 Design Approach/Methodology

Design and Creation Methodology will compliment this proof of concept project. This will provide tangible results in many areas, even in the event of hardware failure near project demonstration. The hardware serves only as a demonstration and visualization medium during the development phase. Documenting at regular intervals, by means of video recordings, will provide added substance to the engineering process. The code artifacts and project deliverables will contribute to future projects and hopefully to body of knowledge.

6 Environmental Impact

This system's main design purpose is to perform tasks currently done by humans that are life threatening and in the same sense life saving in terms of rescue missions. Ethical considerations noted are illegal reconnaissance and or target elimination. Another noted consideration is the fear of robots.

7 Evaluation of solution

A live demonstration of the prototype system should be presented with the predefined requirements. In the event of unforeseen hardware failure, a short compilation video containing progress advancements taken at regular intervals will be presented. Deliverables should at least include:

- A stable framework that is highly extensible,
- Reusable code artifacts,

- Documentation that records the whole project process, containing not only advances but setbacks as well.

8 Conclusion

This will be a challenging project with many interwoven disciplines. The reason I decided on this project, is to further my understanding of complex systems integrations and automations. This project will hopefully serve as the foundation for future extensions and more complex functionality.

Project Tracking

February

Name	Development	Testing	Completed	Due date
Environment Setup and Configuration				2017-02-25
Installation of all required development Tools				2017-02-26

March

Name	Development	Testing	Completed	Due date
Setup and Configuration of component communications				2017-03-04
Develop Slave Controller Operating System				2017-03-11
Develop Host Controller Framework				2017-07-08

April

Name	Development	Testing	Completed	Due date
Communication Integration between slave and host controllers				2017-04-29

May

Name	Development	Testing	Completed	Due date
Hardware (Servo) Integration				2017-05-27

June

Name	Development	Testing	Completed	Due date
Proximity and Movement Sensor Integration				2017-06-10

July

Name	Development	Testing	Completed	Due date
Initial Stand-up Sequence and Stabilization Procedure				2017-07-22

August

Name	Development	Testing	Completed	Due date
Movement Gaits (Walking)				2017-08-26
Collision Avoidance				
Uneven Terrain Deployment				

September

Name	Development	Testing	Completed	Due date
Database Connectivity				2017-09-09
Finalization of Project Documentation				2017-09-30

October

Name	Development	Testing	Completed	Due date
Project Presentation				

References

IJERA. (2017). *Analytical Development of the Forward and Inverse Kinematics of A Robotic Leg Biologically-Inspired In Insect.* http://www.ijera.com/papers/Vol4_issue9/Version%206/G49065055.pdf. (Accessed: 2017-02-20)

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