CM065: Individual Project

Project Terms of Reference

Name: Liam Brand

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Course: Computer Science

Project Type: General Computing

Project Title: LIDAR Drone

Supervisor: David Kendall

Second Marker: Chris Rook

Northumbria University
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Background to Project

The purpose of this project is to develop a drone that utilizes LIDAR (Light Detection And Ranging) technology for the purposes of self navigation and mapping. Primarily, this will be achieved using embedded engineering.

Where did the idea come from?

The suggestion initially arose during my time on placement at Nissan. During a brainstorming session with someone discussing potential ideas, they mentioned that the engineers are supposedly lacking an all encompassing map for the assembly line. Instead, they have lots of different maps of varying scales for various parts of the line. Some form of drone that could automatically move around and generate a definitive 3D map would be valuable, as the map would offer a clear and consistent reference for navigation to any part of the assembly line. It could also provide useful in helping see how viable the addition or removal of different machinery might be.

Why is the project of interest?

The project is of interest to me personally for a few reasons. The biggest one for me is the introduction of hardware into the project. Whilst I don't have any problems with pure software development, the introduction of tactile equipment into things makes it more interesting for me. There is a satisfaction in the immediate feedback of hardware (an LED coming on, a wheel moving, etc) that I don't get as much from seeing a piece of software compile. I'm looking forward to being

able to measure my progress by the appearance of function of the drone itself as I build and program it. LIDAR is something I've never used before either, so I'm looking forward to becoming familiar with some technology that I haven't made use of in the past.

To a wider audience, the project is of use due to the potential uses of the technology if the scope is expanded. Self-navigational drones within themselves are not new, but there are many situations where people are beginning to see the advantages in their use. A paper (Tang & Shao, 2015) from the Northeast Forestry University talks about the possible applications in unmanned drones in forests, about how they can be used to survey forests, support forest management or track wildfires. The paper also goes on to talk about how these things would be achievable with low material/operational costs and reduced risks to personnel.

These drones would also have uses underground. In Malaysia there is an intricate cave system known as the Gomantong Caves. Using (among other things) an autonomous drone and LIDAR technology, a team discusses (McFarlane, et al., 2013) how they were able to map this cave network and the overlaying land surface with 'unprecedented precision', also stating that LIDAR scanning provides additional data that can be used biological inventory and management studies.

Proposed Work

The project will start off with me becoming accustomed with the hardware that will be used to make the drone. Following this construction of the drone will be begin. This will encompass fitting the motor, the wheels, the sensor and the board and making sure that it all communicates as it should. The first major milestone will be once the drone has been built and is able to perform a degree of self navigation, which will be tested by simply having it move itself around a created environment, most likely a small space with some basic obstacles in it.

Following this we will begin to look into additional uses for the drone. There will be an investigation into SLAM (Simultaneous Localization and Mapping) algorithms and how viable it would be to implement them into the drone. What happens after this will be largely dependent on the results of the investigation. Depending on hardware limitations and a few other factors, we will either move down the route of generating a map that is stored on the drone and able to be retrieved later or we will look to fit some form of wireless transmitter that can transmit the map data back to a hypothetical base camp. Finding out which of these two options is the most viable is something that will become apparent once the drone becomes functional.

Aims of Project

- To develop a drone capable of self navigation using LIDAR technology.
- To use the self navigation drone for SLAM purposes.

Objectives

- Further enhance knowledge of embedded systems
- Construct the drone
- Carry out tasks to ensure the drone can navigate around a created space
- Learn about LIDAR technology through literature review
- Learn about SLAM through literature review
- Investigate viability of the drone for SLAM
    - Depending on the viability, we will either –
        - Map areas and store the data locally on the drone

        - Wirelessly transmit map data
        - Transmit a simple “I’m Okay” signal
- Evaluation of the project against the aims and objectives.
- Evaluation of how the project could be taken further

Skills

Skill/Knowledge Required	Purpose of Skill	Ways to improve skill
Basic Electronics Assembly	Construction of the drone will require some familiarity with the basics of electronics assembly. The most important part will be the actual construction, but I’ll also need to investigate some other things such as determining the drone’s power draw and finding a suitable power supply for it.	Online tutorials as well as schematics and user manuals for the components that I’ll be using.
Embedded Engineering	Programming of the drone will require embedded knowledge. I’ll need to be able to ensure the LIDAR data is processed in a logical way so that the drone knows how to function based off of it, changing things like the direction it is heading in and potentially the speed that it is moving at.	Embedded engineering module labs and lectures.
LaTeX	In the interest of creating a more academically suitable report, LaTeX will be used rather than Microsoft Word. After picking up the basics it should prove much easier for me to format chapters, citations and bibliographies among other things.	Online documentation.
SLAM Algorithms	For the drone to successfully implement a SLAM algorithm I will need to understand them that allows me to implement it. Knowledge of a few different algorithms would be preferable as it would allow me to implement the most suitable one.	Online reports and textbooks.

Bibliography

McFarlane, D. A., Buchroithne, M., Lundberg, J., Petters, C., Roberts, W., & Van Rentergen, G. (2013). *Integrated Three-Dimensional Laser Scanning And Autonomous Drone Surface-Hotogrammetry at Gomantong Caves, Sabah, Malaysia.* Retrieved from https://www.researchgate.net/profile/Manfred_Buchroithner/publication/261097340_Gomantong_Congress_Paper_2013/links/00b7d5332d8cf3bd16000000.pdf

Tang, L., & Shao, G. (2015, June 21). *Drone remote sensing for forestry research and practices.* Retrieved from https://www.researchgate.net/profile/Lina_Tang2/publication/283655699_Drone_remote_sensing_for_forestry_research_and_practices/links/5672302108aecc73dc09c776.pdf

Resources

3WD 48mm Omni-Directional Triangle Mobile Robot Chassis

FRDM-K22F MBed Board

K22F Reference Manual - https://www.nxp.com/docs/en/reference-manual/K22P121M120SF7RM.pdf

K22F User Guide - https://www.nxp.com/docs/en/user-guide/FRDMK22FUG.pdf

RPLidar A1M8 - 360 Degree Laser Scanner Development Kit

LIDAR Sensor Manual - https://www.robotshop.com/media/files/pdf2/ld108_slamtec_rplidar_datasheet_a1m8_v1.1_en_2_.pdf

Structure and Contents of Project Report

Report Plan

Table of Contents
Abstract
Introduction
Analysis
Problem Identification
Literature Review
Solutions
Product Requirements
Review of Tools and Techniques
Synthesis
Design
Implementation
Testing
Evaluation
Product Evaluation
Process Evaluation
Conclusion and Recommendations
Appendices

Report Appendices

Terms of Reference
Ethics Form
Software Documentation (e.g. test plan, use case)

Marking Scheme

This project is to be marked according to the General Computing Project marking scheme.

Project Report

Report Section	Relevant Marking Section
Abstract	Abstract
Introduction	Introduction
Analysis	
Problem Identification	Analysis
Literature Review	
Solutions	
Product Requirements	
Review of Tools and Techniques	
Synthesis	
Design	Synthesis
Implementation	
Testing	
Evaluation	
Product Evaluation	Evaluation of the Product
Process Evaluation	Evaluation of the Product Process
Conclusions and Recommendations	Conclusions and Recommendations

Product

The following section lists the deliverables of my project and the criteria which they will be assessed upon to determine their fitness for purpose, build quality or both.

Physical Drone

Fitness for Purpose

To be fit for purpose the drone must achieve one of the core project aims of developing a self-navigational drone that utilises LIDAR technology.

The way in which it achieves this must be of an acceptable quality as well. The drone must be able to detect obstacles and navigate around them before reaching them, if it is coming toward a wall it must stop and change direction before crashing, else the self-navigation is not sufficient.

The drone must also be able to perform SLAM functions. As it navigates itself around a space it should transmit map data back to a terminal.

Build Quality

To be of an acceptable build quality, the provided tests and their results should show that it has been thoroughly tested to check for faults that might occur in the maximum possible amount of situations that the drone would find itself in.

Drone Software

Fitness for Purpose

The primary way to determine whether the code is fit for purpose is to ensure that the drone is performing the necessary functions. It can be assumed from this that the code has been appropriately written to achieve what was needed. The language that the code is written in should be justified within the report however, with outlined specifics as to why the drone's software is written in was chosen.

Build Quality

The code itself should be written to a good standard, comments should be plentiful ensuring that it is clear what various parts of the code are achieving with appropriate function and variable names. As well, the code should be broken down into appropriate functions and methods with no large cumbersome super functions performing many different tasks at once.

Project Plan – Schedule of Activities

		Semester One											
Task	**Hours Needed**	**01-Oct-18**	**08-Oct-18**	**15-Oct-18**	**22-Oct-18**	**29-Oct-18**	**05-Nov-18**	**12-Nov-18**	**19-Nov-18**	**26-Nov-18**	**03-Dec-18**	**10-Dec-18**	**17-Dec-18**
Initiate	**37**												
Project Initiation Document	3												
Read Hardware Documentation	8												
Terms of Reference Draft	12												
Terms of Reference Final	10												
Ethics Form	4												
Review Marking Scheme	2												
Build	**72**												
Basic Board Program	2												
Test LIDAR Sensor	4												
Assemble Empty Chassis	16												
Connect Board and Sensor	20												
Automate Drone	30												
Report	**94**												
Introduction Draft	10												
Synthesis - Design	18												
Analysis - Problem Analysis	16												
Analysis - Product Requirements	10												
Analysis - Literature Review	16												
Analysis - Solutions	12												
Analysis - Tools and Techniques	12												

		Semester Two											
Task	**Hours Needed**	**14-Jan-19**	**21-Jan-19**	**28-Jan-19**	**04-Feb-19**	**11-Feb-19**	**18-Feb-19**	**25-Feb-19**	**04-Mar-19**	**11-Mar-19**	**18-Mar-19**	**25-Mar-19**	**01-Apr-19**
Build	**60**												
Investigate SLAM Algorithms	20												
Assess and Implement SLAM functionality	40												
Report	**108**												
Synthesis - Implementation	20												
Synthesis - Testing	20												
Evaluation - Product Evaluation	20												
Evaluation - Process Evaluation	20												
Evaluation - Conclusions and Reccommendation	28												

08-Apr-19	15-Apr-19	22-Apr-19	29-Apr-19	06-May-19	13-May-19	20-May-19	27-May-19