Developing Fishtail Testing Platform

CS39440 Major Project Report

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Declaration of originality

I confirm that:

* This submission is my own work, except where clearly indicated.
* I understand that there are severe penalties for Unacceptable Academic Practice, which can lead to loss of marks or even the withholding of a degree.
* I have read the regulations on Unacceptable Academic Practice from the University’s Academic Registry (AR) and the relevant sections of the current Student Handbook of the Department of Computer Science.
* In submitting this work, I understand and agree to abide by the University’s regulations governing these issues.

Name …………………………………………

Date ……………………………………………

Consent to share this work

By including my name below, I hereby agree to this project's report and technical work being made available to other students and academic staff of the Aberystwyth Computer Science Department.

Name …………………………………………

Date ……………………………………………

Acknowledgements

I am grateful to…

I’d like to thank…

Abstract

Include an abstract for your project. This should be approximately 300 words.

The abstract is an overview of the work you have done. Highlight the purpose of the work and the key outcomes of the work.

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# Introduction

This section should discuss your preparation for the project, including background reading, your analysis of the problem and the process or method you have followed to help structure your work. It is likely that you will reuse part of your outline project specification, but as you write this report at the end of the project you should have more to discuss.

**Notes**:

* All of the sections and text in this example are for illustration purposes. The main Chapters are a good starting point, but the content and actual sections that you include are likely to be different.
* Look at the document MMP\_SO8 Project Report and Technical Work **Error! Reference source not found.** for additional guidance.

## Background

Biomimetics, to put it simply, is when something is designed to resemble biological organisms in some way. The notion of biomimetics arose from the observation that organisms in nature have changed over thousands of years to fit their surroundings, something that we are seeing more and more in robotics development. And the applications of various forms of robots are expanding, as we observe when building robotics for specific situations. Whereas many robots employ a wheel system for locomotion; legs, fins, or wings would be used in a biomimetic robot.

This may be observed in Boston Dynamics' recently released Spot agile mobile robot [1], which was designed as a four-legged robot that can navigate rough terrain. Where it is possible to automate routine inspection and data collection while remaining safe.

Then when applying this principle to this project and investigating the fish further. The speed, agility, and silence with which the fish moves.

With the development of an autonomous underwater vehicle (AUV), the AUV may collect data underwater for a variety of tasks. Then, instead of being directed by a person, an AUV has its own system that is either pre-programmed or operates autonomously. Not to be confused with a ROV (remotely operated vehicle), which is connected to a ship or vessel via a system of cables that serve as the vehicle's primary means of communication and control [2]. The ROV is controlled by a human and usually has a variety of sensors and an articulating arm that may be used to remove objects from the seabed or wreckages, whereas the AUV performs the work it was designed to do and then returns to its pre-planned location with the data obtained.

When it comes to constructing an AUV fish robot, Marcus Tjomsaas worked on a project with Dr. Otar Akanyeti as his supervisor. The goal of this project was to create a fully functional 3D printed modular fish robot[3]. This robot was created in 2021 with the goal of improving the robot's joint and emulating the mobility of a fish. While this project is complete and the robot is fully created, we want to improve it and create a platform where different elements of the fish robot may be tested. Whereas this makes it easy to optimize each portion of the fish robot separately, Otar, the project supervisor, proposed that we focus on building a platform where we can test and create different tails, as this is the robot's primary movement. A platform that allows users to test various 3D printed tails that are rigged and flexible and to the usage of various 3D printable materials.

Following the progress of last year's fish robot piqued my curiosity in further building a fish robot. There was also an interest in working with hardware and robotics development, where I could work with both software and hardware. I'm interested in contributing to the development of a fish robot with applications in the ocean, as well as how this will aid future studies in the field.

What was your background preparation for the project? What similar systems did you assess? What was your motivation and interest in this project?

## Requirements

The project's requirement was discussed early in the project's life cycle, where the need for a platform to test 3D printed or moulded fish fins was required. This was asked by my supervisor on this project, despite the fact that there was a previous project in which a fish robot was constructed, as stated in the 1.1 background.

The following are the project requirements:

- Appropriate hardware for platform construction

- Design the platform to house the hardware and sensors to monitor the fishtail

- A modular platform that can fit different fishtails

- Design the motor controller

## Analysis

The key issue is determining which section of the fish we want to build the platform to research and enhance, and then determining the type of fish tail we want to model to use on this system. The type of fish tail used in the previous project, which was revealed in background work 1.1, was a forked tail, the same type of tail used in the project, which was based on a rainbow trout. As a result, while extending this project further, the same tail would be a good design for the tail. As the forked tail possesses qualities for rapid swimming and sustained speed[4] we wish to test and explore this further with the help of this platform, to test different materials when 3D printing the fish tail with flexible 3D printing, rigid 3D printing, and resin prints.

When we had a clear idea of why we were undertaking this project and where we were going, the following step was to analyse the hardware side of the project. What kind of hardware would be appropriate and best for this application, and what kind of sensors would be required. The first thought was that there has to be some waterproofing of electronics in this, since we're talking about a fishtail that's going into water, and electronics don't like water. This was solved by designing the platform to house the electronics above water, where it would then be necessary to create a drive train from the motor above water to where the fish tail would be installed.

Something to view the fish tails with, such as sensors and cameras, is required with the platform. It is desired that data from the fishtail be collected and compared to other types of fish tails that will be tested on the platform. This is a platform for developing additional 3D printed tails because it is the fish robot's primary source of locomotion, thus a force sensor is desired after some research on it so we can quantify the mobility of the fishtail.

Further development of the hardware to run on this platform would necessitate the selection of a suitable motor to serve as the drive train for the fish tail. Around this, other components would be required to make everything operate together, and a controller would be required. The Arduino platform, which runs the code language C++ and is a decent code language to develop on, would be appropriate controllers for this application. Whereas the Arduino is a solid choice for a low-cost controller, it is open-source in hardware and has a wide range of components and sensors that can be used with the controller. However, one of the most significant limitations of the Arduino is that it lacks certain computing power, which other controllers may have in abundance; however, the early requirements of this platform indicate that this will not be a problem. A motor controller will be in charge of delivering the heavy lifting of power to this.

To identify the best motor to employ for this platform, a servo motor was initially the best choice. Because the motor is operating, it will pulsate rather than complete a full circle of motion to resemble the movement of a fish tail and then travel back and forth. However, the motor ended up using a stepper motor as a compromise because this was the hardware that was available to use for the platform. A stepper motor is used to move an object step by step on a rail system, however this is programmable to match the platform's specifications.

When it came to figuring out how to build and read up on 3D modelling the platform to mount gear to, it was decided that this would be a platform that would be above water to test the system and the fish tail. This is going to be developed in Fusion360, which is a CAD software for product design. It was utilised in this project to 3D model the platform that would hold the motor, Arduino, and other electronic components above water and safe.

The platform and the first iteration of the fish tail were designed in Fusin360, and the fish tail was to be modelled after a forked style tail.

Taking into account the problem and what you learned from the background work, what was your analysis of the problem? How did your analysis help to decompose the problem into the main tasks that you would undertake? Were there alternative approaches? Why did you choose one approach compared to the alternatives?

There should be a clear statement of the objectives of the work, which you will evaluate at the end of the work.

In most cases, the agreed objectives or requirements will be the result of a compromise between what would ideally have been produced and what was determined to be possible in the time available. A discussion of the process of arriving at the final list is usually appropriate.

As mentioned in the lectures, think about possible security issues for the project topic. Whilst these might not be relevant for all projects, do consider if there are relevant for your project. Where there are relevant security issues, discuss how they will this affect the work that you are doing. Carry forward this discussion into relevant areas for design, implementation and testing.

## Prototyping Model

The prototype model was chosen for its life cycle, as all of the project's requirements were not evident at the outset. As a result, a prototype model is appropriate, in which a prototype can be created, the user may provide feedback, and it can then be modified with a new iteration, implementing a trial-and-error process between the developer and the user. Where I am the developer and the user is the project supervisor. The user input occurred at our weekly meetings, when the user could see the progress and then provide feedback on changes or needs so that the new inputs could be developed for the following iteration.

## Tools

This project was completed using the following tools:

* **Arduino IDE:** The open-source Arduino software (IDE) is a coding environment that is often used to programme the Arduino microcontroller, which was used in this project. The Arduino IDE is not only limited to the Arduino microcontroller, but it can also be used with a variety of other microcontrollers because it is open-source software.
* **Fusion 360:** is a product design software package that includes 3D modelling, CAD, CAM, CAE, and PCB layout. In this project, this programme was used to model the hardware platform and the fish tail.
* **3D Printer:**
* **Blynk:**

You need to describe briefly the life cycle model or research method that you used. You do not need to write about all of the different process models that you are aware of. Focus on the process model that you have used. It is possible that you needed to adapt an existing process model to suit your project; clearly identify what you used and how you adapted it for your needs.

# Hardware

## Hardware selection

## Schematics

# Software

You should concentrate on the more important aspects of the design. It is essential that an overview is presented before going into detail. As well as describing the design adopted it must also explain what other designs were considered and why they were rejected.

The design should describe what you expected to do and might also explain areas that you had to revise after some investigation.

Typically, for an object-oriented design, the discussion will focus on the choice of objects and classes and the allocation of methods to classes. The use made of reusable components should be described and their source referenced. Particularly important decisions concerning data structures usually affect the architecture of a system and so should be described here.

How much material you include on detailed design and implementation will depend very much on the nature of the project. It should not be padded out. Think about the significant aspects of your system. For example, describe the design of the user interface if it is a critical aspect of your system, or provide detail about methods and data structures that are not trivial. Do not spend time on long lists of trivial items and repetitive descriptions. If in doubt about what is appropriate, speak to your supervisor.

You should also identify any support tools that you used. You should discuss your choice of implementation tools - programming language, compilers, database management system, program development environment, etc.

Some example sub-sections may be as follows, but the specific sections are for you to define.

## Overall Architecture

## Detailed Design

### Even More Detail

## User Interface Design

## Other Relevant Sections

# Implementation

The implementation should discuss any issues you encountered as you tried to implement your design. During the work, you might have found that elements of your design were unnecessary or overly complex; perhaps third-party libraries were available that simplified some of the functions that you intended to implement. If things were easier in some areas, then how did you adapt your project to take account of your findings?

It is more likely that things were more complex than you first thought. In particular, were there any problems or difficulties that you found during implementation that you had to address? Did such problems simply delay you or were they more significant?

You can conclude this section by reviewing the end of the implementation stage against the planned requirements.

# Testing

Detailed descriptions of every test case are definitely not what is required in this section; the place for detailed lists of tests cases is in an appendix. In this section, it is more important to show that you adopted a sensible strategy that was, in principle, capable of testing the system adequately even if you did not have the time to test the system fully.

Provide information in the body of your report and the appendix to explain the testing that has been performed. How does this testing address the requirements and design for the project?

How comprehensive is the testing within the constraints of the project? Are you testing the normal working behaviour? Are you testing the exceptional behaviour, e.g. error conditions? Are you testing security issues if they are relevant for your project?

Have you tested your system on “real users”? For example, if your system is supposed to solve a problem for a business, then it would be appropriate to present your approach to involve the users in the testing process and to record the results that you obtained. Depending on the level of detail, it is likely that you would put any detailed results in an appendix.

Whilst testing with “real users” can be useful, don't see it as a way to shortcut detailed testing of your own. Think about issues discussed in the lectures about until testing, integration testing, etc. User testing without sensible testing of your own is not a useful activity.

The following sections indicate some areas you might include. Other sections may be more appropriate to your project.

## Overall Approach to Testing

## Automated Testing

### Unit Tests

### User Interface Testing

### Stress Testing

### Other Types of Testing

## Integration Testing

## User Testing

# Critical Evaluation

Examiners expect to find a section addressing questions such as:

* Were the requirements correctly identified?
* Were the design decisions correct?
* Could a more suitable set of tools have been chosen?
* How well did the software meet the needs of those who were expecting to use it?
* How well were any other project aims achieved?
* If you were starting again, what would you do differently?

Other questions can be addressed as appropriate for a project.

The questions are an indication of issues you should consider. They are not intended as a specification of a list of sections.

The evaluation is regarded as an important part of the project report; it should demonstrate that you are capable not only of carrying out a piece of work but also of thinking critically about how you did it and how you might have done it better. This is seen as an important part of an honours degree.

There will be good things in the work and aspects of the work that could be improved. As you write this section, identify and discuss the parts of the work that went well and also consider ways in which the work could be improved.

In the latter stages of the module, we will discuss the evaluation. That will probably be around week 9, although that differs each year.

# References

[1] “Spot® - The Agile Mobile Robot,” *Boston Dynamics*. https://www.bostondynamics.com/products/spot (accessed May 02, 2022).

[2] N. O. and A. A. US Department of Commerce, “What is the difference between an AUV and a ROV?” https://oceanservice.noaa.gov/facts/auv-rov.html (accessed May 03, 2022).

[3] M. Tjomsaas, “The Development of a Modular 3D Printed Autonomous Robotic Fish.” May 07, 2021.

[4] “Structure and Function - Fish | manoa.hawaii.edu/ExploringOurFluidEarth.” https://manoa.hawaii.edu/exploringourfluidearth/biological/fish/structure-and-function-fish (accessed May 03, 2022).

# Appendices

The appendices are for additional content that is useful to support the discussion in the report. It is material that is not necessarily needed in the body of the report, but its inclusion in the appendices makes it easy to access.

If you have used any 3rd party code, i.e. code that you have not written yourself such as libraries, then you must include Appendix A. In that appendix, you will provide details of the 3rd party code that you have used.

For most other items, it would be better to include them in your technical submission instead of including them as an appendix. For example:

* If you have developed a Design Specification document as part of a plan-driven approach for the project, then it would be appropriate to include that document in the technical work. In this report, you would highlight the most interesting aspects of the design, referring your reader to the full specification for further detail.
* If you have taken an agile approach to developing the project, then you may be less likely to have developed a full requirements specification at the start of the project. Perhaps you used stories to keep track of the functionality and the ‘future conversations.’ If it isn’t relevant to include all those stories in the body of your report, you could detail those stores in a document in the technical work.
* If you have used manual testing, then include a document in the technical work that records the tests that have been done. In this report, you would talk about the use of those tests.

Documents included in the technical work or in the appendices are supporting evidence of the work done. Where you include documents, this report should refer to the documents. You should not be relying on detailed study of those documents in order to understand what is written in this report.

Speak to your supervisor or the module coordinator if you have questions about this.

* 1. Third-Party Code and Libraries

If you have made use of any third-party code or software libraries, i.e. any code that you have not designed and written yourself, then you must include this appendix.

As has been said in lectures, it is acceptable and likely that you will make use of third-party code and software libraries. If third-party code or libraries are used, your work will build on that to produce notable new work. The key requirement is that we understand what your original work is and what work is based on that of other people.

Therefore, you need to clearly state what you have used and where the original material can be found. Also, if you have made any changes to the original versions, you must explain what you have changed.

The following is an example of what you might say.

**Apache POI library** – The project has been used to read and write Microsoft Excel files (XLS) as part of the interaction with the client’s existing system for processing data. Version 3.10-FINAL was used. The library is open source and it is available from the Apache Software Foundation [5]. The library is released using the Apache License [6]. This library was used without modification.

Include as many declarations as appropriate for your work. The specific wording is less important than the fact that you are declaring the relevant work.

* 1. Code Samples

This is an example appendix. Include as many appendices as you need. The appendices do not count towards the overall word count for the report.

For some projects, it might be relevant to include some code extracts in an appendix. You are not expected to put all of your code here - the correct place for all of your code is in the technical submission that is made in addition to the Project Report. However, if there are some notable aspects of the code that you discuss, including that in an appendix might be useful to make it easier for your readers to access.

As a general guide, if you are discussing short extracts of code then you are advised to include such code in the body of the report. If there is a longer extract that is relevant, then you might include it as shown in the following section.

Only include code in the appendix if that code is discussed and referred to in the body of the report.

Random Number Generator

The Bayes Durham Shuffle ensures that the pseudo random numbers used in the simulation are further shuffled, ensuring minimal correlation between subsequent random outputs.

// Some example code here…