INSERT TITLE HERE

By

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MSc Robotics Dissertation

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A MSc dissertation submitted to the University of Bristol and the University of the West of England in accordance with the requirements of the degree of MASTER OF SCIENCE IN ROBOTICS in the Faculty of Engineering.

June 7, 2024

Declaration of own work

I declare that the work in this MSc dissertation was carried out in accordance with the requirements of the University's Regulations and Code of Practice for Research Degree Programmes and that it has not been submitted for any other academic award. Except where indicated by specific reference in the text, the work is the candidate's own work. Work done in collaboration with, or with the assistance of, others, is indicated as such. Any views expressed in the dissertation are those of the author.

Name and Date

Acknowledgement

I would like to thank ...

Abstract

Abstract should give a short summary of the motivation, the approach and important insights and results.

Number of words in the dissertation: .... words.

Contents

List of Tables

1 Introduction

1.1 Motivation

The motivation should provide:

- A clear explanation of the problem that you tackle
- Motivation why this is interesting and worth investigating

To improve communication, it is also recommended that you concisely state the aims and objectives of your project. As part of the introduction, these can be generally stated and not require specialist knowledge. Use the next chapter "Literature Review" to provide specialist knowledge for the reader.

1.2 Aims

The aims of a project are *what you hope to learn*.

1. "To understand why X varies with Y..."
2. "To evaluate [technology] when exposed to unexpected conditions so that..."
3. "To increase understanding of ..."
4. *etc...*

1.3 Objectives

The objectives are *the elements which are necessary to conduct the project*.

1. "To properly design an experiment methodology to mitigate...."
2. "To construct a robotic system including ... to collect meaningful data."
3. "A complete analysis of ... must be conducted prior to the full system evaluation in order to..."
4. *etc...*

You can then repeat and address these explicitly in your Conclusion when evaluating the success and challenges of your project.

2 Key contributions

Outline your key technical contributions.

Explain any existing work done by other researchers that was used in the project.

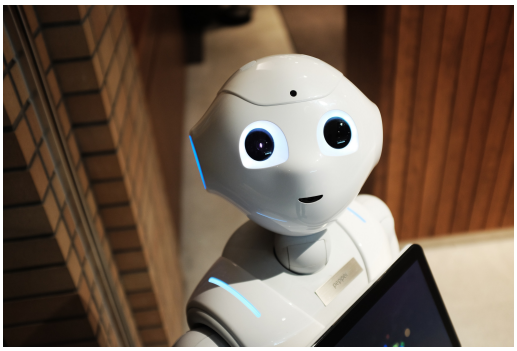
3 Literature Review

Use your literature review to help the reader to understand the value and the interest in your project. You should look for related works already published that either support the merit of your project, or provide the background understanding/information to make your new claims. Try to avoid writing a "catalogue" of related works (e.g this would have little of your own insight added). Instead, describe to the reader why the related work is interesting or relevant to your own work. What did they achieve? What did they overlook? It is highly recommend you finish your Literature Review with a final subsection "Summary", where you may wish to formulate highly specified research questions or hypotheses, or assert the need for your Research Methodology (next chapter).

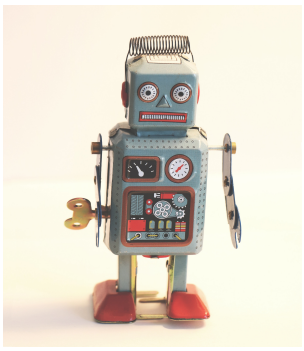
3.1 This is a section

3.1.1 This is a subsection

This is subsubsection



(a) This is a robot.



(b) This another robot.

Figure 3.1: These are two robots

For example, [1] discusses the two robots depicted in Figure 3.1. There is a robot in Figure 3.1a and another robot in Figure 3.1b.

4 Research Methodology

The Methodology section should provide a clear explanation of the research approach. This chapter is you main opportunity to evidence your critical thinking towards the design of your research prior to any results achieved. You should utilise this chapter to evidence your contribution to the work undertaken - which challenges did you identify and address in the steps prior to the analysis and evaluation of any results? Avoid a situation where it is not clear if this is your work or simply ready-made solutions - look to celebrate your achievements!

Because there are a large variety of types of dissertation projects, you should discuss the format of this chapter with your supervisor to find an appropriate form.

In general, you want to document **how it was made** and **how it was measured**. Typically, this will create the sections:

- **Implementation:** Use this section to describe what technologies were used and how they were configured. Remember that your approach and thinking is valuable - so communicate the challenges *you* have addressed, discussing how and why you took the approach that you did. As a benchmark, ask yourself if you have provided enough information for your work to be **reproducible**. If someone cannot reproduce your work, it means they also cannot understand it well enough to appreciate the design of your methodology and the results gained.

- **Experiment Methodology:** Use this section to describe the processes you have designed to measure your system. You should discuss and justify your choices, where your choices are to create a fair, trustworthy and meaningful evaluation of your work - how you capture **credible** results. This can mean such things as the number of trials, the number of participants, the structuring of scenarios, the use of metrics, etc. It will likely be useful to consider the experiment variables: dependent, independent and controlled.

There may be exceptions to the above structure (Implementation and Experiment Methodology). For example, a project that explores a new approach to fabricating a type of soft robot. For that example, it might be more appropriate to first have a section on **Workflow & Processes**, which documents and discusses your choices of materials and fabrication processes. Then, a section called *Experiment Methodology* which defines how you then measured the output of your fabrication processes to gain meaningful analysis and evaluation.

4.1 Implementation

In this section you should describe the specifics for your implementation such that your reader could recreate your work. If you have used a well understood algorithm or technology you can reference an external source,

unless explaining the algorithm/technology provides vital information for the reader regarding your project. You may wish to present technical information or preliminary results (e.g. a plot of a sensor response) to support your justification of certain design choices.

Algorithm 1 PPO

for $iteration = 1, 2, \ldots$ **do**
  for $actor = 1, 2, \ldots, N$ **do**
    Run policy $\pi_{\theta_{old}}$ in environment for T time steps
    Compute advantage estimates $\hat{A}_1, \ldots, \hat{A}_T$
  end for
  Optimize surrogate L wrt. θ, with K epochs and minibatch size $M \leq NT$
  $\theta_{old} \leftarrow \theta$
end for

It can be a good idea to include pseudocode (see Algorithm 1), and you may also want to include equations in a clear format such as eq.4.1.

$$E = mc^2 \tag{4.1}$$

If it helps to communicate, consider a block diagram to communicate the architecture of your system (such as the flow of information between system components), a flow-chart to describe a sequence of events or behaviours, or something like a state-diagram to describe your robot controller/behaviours. Rather than attempt to use all of these, consider which are most important to include to provide sufficient detail to allow your work to be reproduced.

Remember that, to design an experiment - and therefore to identify the experiment variables - we first have to fully understand what system we have built. The experiment variables come out of the system we have built and used.

4.2 Experiment Methodology

You want your reader to agree that you carefully considered your method so that we can trust your results to be both insightful (mean something) and credible (not subject to error):

- If your work is *hypothesis driven*: your method should clearly outline how we expect to gain evidence to address your hypothesis.
- If your work is *solution driven*: your method should clearly outline how and why the measurements you will take are the most important to understand the performance of your system.
- A clear description of the methodology, how it creates a scientific investigation and operates to collect meaningful data.

- A clear justification of why you have chosen this particular approach.
- Information needed for a reader to understand how you did it (can a reader reproduce your work, and collect equally valid results? e.g. hardware/software used, configuration, number of trials, any procedures involving people, the design of any surveys, etc.)
- A description of any approaches taken to process collected data, e.g. metrics are used to combine or post-process data in a meaningful way - you should state any used explicitly, their utility, their suitability to your methodology and their limitations.

5 Results

In this section you should present your results. How to report and discuss results varies within each discipline. In general, use the Results section to provide a focused, high-detail analysis/observation of your system. Later, use the Conclusion section to discuss the broader, more general implications of your results and study.

You can find help and advice on plotting high quality graphs via Python and Google Colab at the link provided for this reference: [2].

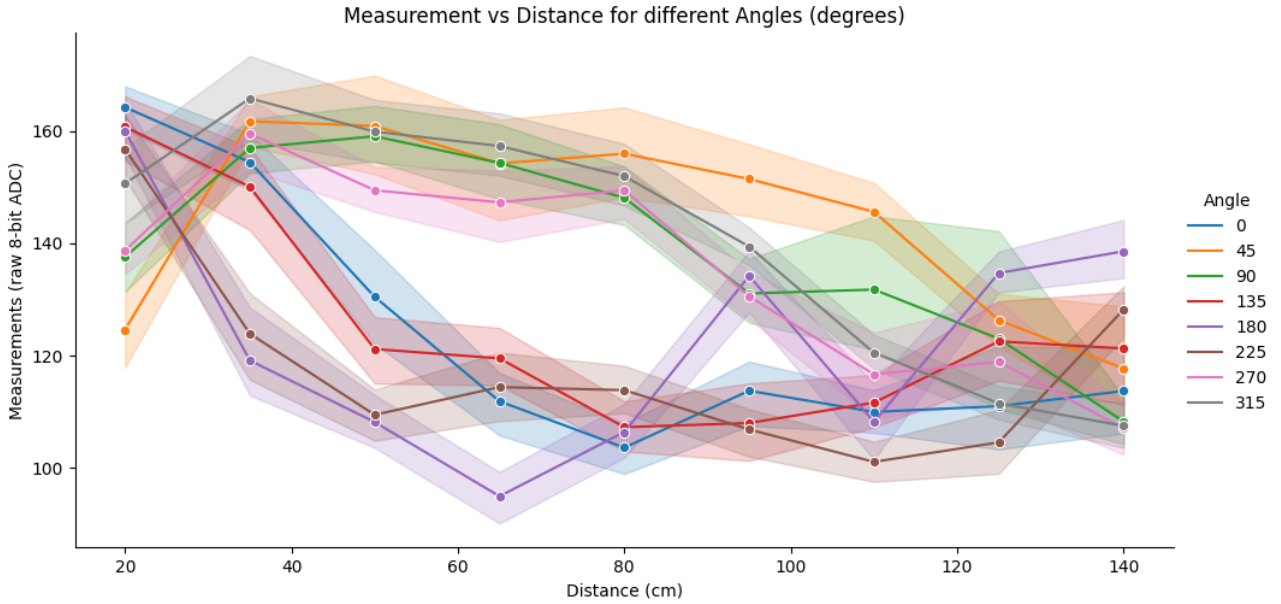


Figure 5.1: Use the caption to give the context of the plot to the reader.

In general, it is best to aim for both *quantitative* results (e.g., lots of data collated together and presented for comparison) and *qualitative* results (e.g., a plot of data from a single trial, a written observation or a graphic produced from data which is representative). As a general rule, *quantitative* results provide greater evidence, more information and better confidence in your work.

You should use subsections where they aid in clarity. Usually, if you have described experiment scenarios in your Experiment Method (chapter 4, section 4.2), we would see the structure reflected (repeated) here again in the results. For instance, it may be useful to present results for a “baseline" system, then results for an “improved" system, and then finally results which consider both “baseline" and “improved" systems together. However, avoid repetition - try to ensure a graph or figure is explicitly discussed and therefore has purpose. However, this will depend on your project, how you have designed your experiment, and some thought on the best communication of the results.

When presenting results, aim for a presentation which clearly communicates an insight. Avoid making the reader do extra work - for example, if you are going to compare two results, put them on the same plot. Avoid

a need for the reader to make their own interpretation - instead, write guidance on what to observe, how/where, and what it means - and do this by referencing your figures. For example, in figure 5.2 we can observe a single outlier at *distance=35*, which is believed to have occurred because... (you would write your understanding here).

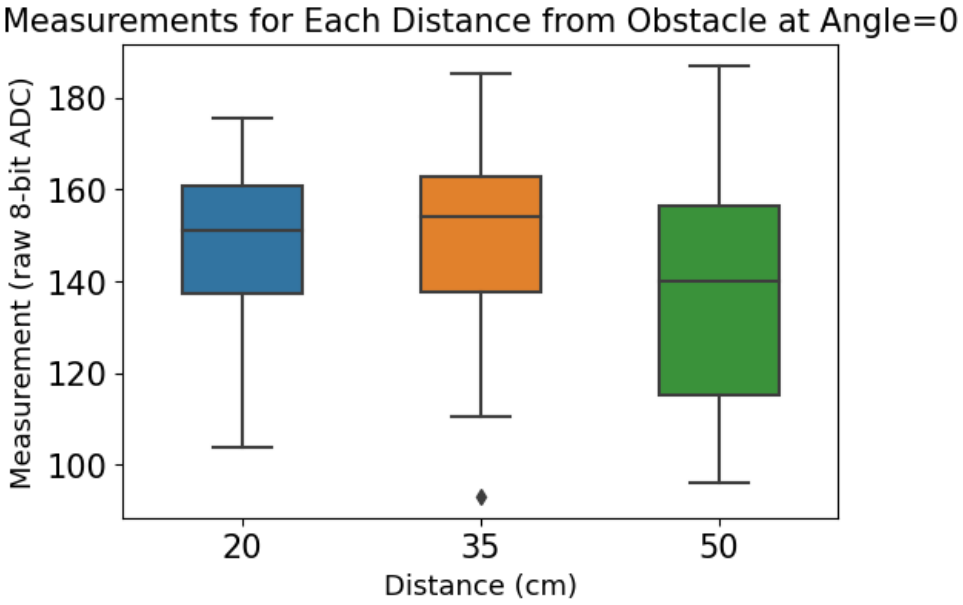


Figure 5.2: Use the caption to give the context of the plot to the reader.

For example, a large table of all the individual data requires the reader to do a lot of work to find out what is important. It is also difficult to spot outliers or patterns in a table of numbers. Statistics are important, but they can also be misleading (see this example on Wikipedia[3]).

Because you have designed a robust experimental method that has many repeated trials, you will almost *always* want to plot the distribution of your results. This gives the reader confidence that you have done repeated trials, and we can learn about how reliable the performance was (etc). We can see that in figure 5.1 the distribution is represented as a shaded region (a confidence interval of 95%) and figure 5.2 is a boxplot with whiskers.

Remember to label all axis, caption all graphs, figures and tables, and to reference these elements in the report text (e.g. see figure 5.1) - never require a reader to have to come to their own conclusion or understanding, explain what they are looking at. Remember to attempt to give an explanation for any anomalies in your results.

5.1 Common attributes to pay attention to are:

- When comparing plots, keep the scale of axes consistent. To do otherwise is misleading for the reader.
- If you are going to compare separate plots, consider if they can be better evaluated when combined into a single plot.

- When plotting data, particularly the *mean*, ensure that you also plot error bars (or other method) of indicating the distribution.
- If a figure or plot is included, ensure it is referenced explicitly in the body text discussion.
- When a large table of data is included, consider whether it would be better communicated as a box-plot or something similar.
- All axes should be labelled and include units of measurement where applicable.
- All captions and figures should have captions with enough information to be understood at a glance. Do not use captions to provide information that is better placed in the body text.
- Remember to identify result outliers and anomalous data and to attempt an explanation or justification.

6 Discussion and Conclusion

The conclusion needs to provide

- A short summary (What has been done and what are the main results)
- Limitations of your work, where applicable.
- Discussion of your work in the bigger picture (How does this contribute to the research field?)
- Future work (What could be next steps in this work?). Remember to keep future work realistic. A good approach is to discuss what the next progression of this project would be, and to justify why this would be interesting.

You will find it easier to write your conclusion if you copy-and-paste your *Aims, Objectives*, and any research questions or hypotheses you stated. You can then discuss each of these explicitly in turn, and how you were able to answer them or complete them successfully. When things have not gone as well as you would have hoped, demonstrate your critical thinking and reasoning to analyse the short-comings of your project - to demonstrate that you understand the underlying causes and that you could conduct good futurework from this learning experience.

A Appendix

This is optional. Not every report needs an appendix If you have additional information like code pieces, long tables, etc. that would break the flow of the text in the report, you can put it here.

References

[1] D. Olivaw and I. Asimov, Discussion of two robots, *Nature*, vol. 548, no. 7665 2021, pp. 43–51, 2021.

[2] P. O'Dowd. "Plotting guidance." (2023), available from: `https://github.com/paulodowd/PlottingGuidance` [Accessed 09/21/2023].

[3] Wikipedia. "Anscombes quartet – Wikipedia, the free encyclopedia." (2023), available from: `https://en.m.wikipedia.org/wiki/Anscombe%27s_quartet` [Accessed 09/24/2023].