# Prelude

A typical MSc thesis will be structured according to a fairly standard sequence of sections, and one example is shown here. However, it is hard and perhaps even counter-productive to generalise: the goal of this document is *not* to be prescriptive, to show you how you *must* structure your thesis; rather it is to simply to act as a guideline, to show you how you *could* structure your thesis. In particular, each chapter's indicated page-count is important but *not* absolute: the aim is simply to highlight that a clear and concise description is better than a rambling alternative that makes it hard to separate important content and facts from irrelevant trivia.

You can use this document as a LaTeX-based template for your own thesis by simply deleting extraneous sections and content, and adding your own text. If you do that, we recommend using BibTeX to deal with the associated bibliography. You may want to use Overleaf (an online cloud-based collaborative LaTeXplatform).

The words "thesis" and "dissertation" are used interchangeably here. All active hyperlinks in the PDF file are rendered in the same shade of dark blue.

DEPARTMENT OF ENGINEERING MATHEMATICS

# Some Structural Guidelines for Data Science MSc Theses, Including Those With Long Titles that Run Across Multiple Lines on the Front Page

## And those including an optional subtitle too, for good measure

Daniel Page

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A dissertation submitted to the University of Bristol in accordance with the requirements of the degree of Master of Science in the Faculty of Engineering.

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Wednesday 6$^{\text{th}}$ July, 2022

Supervisor: Dr. Andrew Calway

# Declaration

This dissertation is submitted to the University of Bristol in accordance with the requirements of the degree of MSc in the Faculty of Engineering. It has not been submitted for any other degree or diploma of any examining body. Except where specifically acknowledged, it is all the work of the Author.

Daniel Page, Wednesday 6$^{th}$ July, 2022

# Contents

# List of Figures

# List of Tables

# List of Algorithms

# List of Listings

# Abstract

**A compulsory section, of at most** 1 **page**

This section should summarise the project context, aims and objectives, and main contributions (e.g., deliverables) and achievements. The goal is to ensure that the reader is clear about what the topic is, what you have done within this topic, *and* **what your view of the outcome is.**

Essentially this section is a (very) short version of what is typically covered in more depth in the first chapter. If appropriate, you should include here a clear statement of your research hypothesis. This will obviously differ significantly for each project, but an example might be as follows:

> My research hypothesis is that a suitable genetic algorithm will yield more accurate results (when applied to the standard ACME data set) than the algorithm proposed by Jones and Smith, while also executing in less time.

The latter aspects should (ideally) be presented as a concise, factual list of the main points of achievement. Again the points will differ for each project, but an might be as follows:

- I spent 120 hours collecting material on and learning about the Java garbage-collection sub-system.
- I wrote a total of 5000 lines of *Python* source code, and associated orchestration scripts.
- I designed a new algorithm for computing the non-linear mapping from A-space to B-space using a genetic algorithm.
- I implemented a version of the algorithm proposed by Jones and Smith (2010), corrected a mistake in it, and compared the results with several alternatives.

# Summary of Changes

**A conditional section, of at most 1 page**

If (and only if) the dissertation represents a resubmission (e.g., as the result of a resit), then this section is compulsory: the content should summarise all non-trivial changes made to the initial submission. Otherwise you can omit it, since **a summary of this type is only needed for resubmissions**.

When included, the section will ideally be used to highlight additional work completed, and address criticism raised in any associated feedback. Clearly it is difficult to give generic advice about how to do so, but an example might be as follows:

- Feedback from the initial submission criticised the design and implementation of my genetic algorithm, stating "there seems to have been no attention to computational complexity during the design, and obvious methods of optimisation are missing within the resulting implementation". Chapter 3 now includes a comprehensive analysis of the algorithm, in terms of both time and space. While I have not altered the algorithm itself, I have included a cache mechanism (also detailed in Chapter 3) that provides a significant improvement in average run-time.
- I added a feature in my implementation to allow automatic rather than manual selection of various parameters; the experimental results in Chapter 4 have been updated to reflect this.
- Questions after the presentation highlighted a range of related work that I had not considered: I have make a number of updates to Chapter 2, resolving this issue.

# Supporting Technologies

**A compulsory section, of at most 1 page**

This section should present a detailed summary, in bullet point form, of any third-party resources (e.g., hardware and software components) used during the project. Use of such resources is always perfectly acceptable: the goal of this section is simply to be clear about how and where they are used, so that a clear assessment of your work can result. The content can focus on the project topic itself (rather, for example, than including "I used LaTeX to prepare my dissertation"); an example is as follows:

- I used the *Pandas* and *Seaborn* public-domian Python Libraries.
- I used a parts of the OpenCV computer vision library to capture images from a camera, and for various standard operations (e.g., threshold, edge detection).
- I used Amazon Web Services for remote storage and processing of data. Specifically, I used:
  - Simple Storage Service (S3) for data storage
  - Elastic Compute Cloud (EC2) for provision of virtual machines
  - Elastic Beanstalk for scaling and load management
  - Sagemaker for all the machine learning components of my project.
- I used LaTeX to format my thesis, via the online service *Overleaf*.

# Notation and Acronyms

**An optional section, of roughly 1 or 2 pages**

Any well written document will introduce notation and acronyms before their use, *even if* they are standard in some way: this ensures any reader can understand the resulting self-contained content.

Said introduction can exist within the dissertation itself, wherever that is appropriate. For an acronym, this is typically achieved at the first point of use via "Advanced Encryption Standard (AES)" or similar, noting the capitalisation of relevant letters. However, it can be useful to include an additional, dedicated list at the start of the dissertation; the advantage of doing so is that you cannot mistakenly use an acronym before defining it. A limited example is as follows:

| | | |
|---|---|---|
| AES | : | Advanced Encryption Standard |
| DES | : | Data Encryption Standard |
| | ⋮ | |
| $\mathcal{H}(x)$ | : | the Hamming weight of $x$ |
| $\mathbb{F}_q$ | : | a finite field with $q$ elements |
| $x_i$ | : | the $i$-th bit of some binary sequence $x$, st. $x_i \in \{0, 1\}$ |

# Acknowledgements

**An optional section, of at most** 1 **page**

It is common practice (although totally optional) to acknowledge any third-party advice, contribution or influence you have found useful during your work. Examples include support from friends or family, the input of your Supervisor and/or Advisor, external organisations or persons who have supplied resources of some kind (e.g., funding, advice or time), and so on.

Dave Cliff writes here to say huge thanks to his colleague Dr Dan Page for sharing this LaTeX thesis template, which was originally written by Dan, for Computer Science dissertations. Dave edited Dan's original to better suit the needs of the Data Science MSc: please don't hassle Dan about any of this, but do feel free to contact Dave if you have any questions or comments on it.

# Chapter 1

# Introduction

**A compulsory chapter, roughly 10% of the total page-count**

This chapter should describe the project context, and motivate each of the proposed aims and objectives. Ideally, it is written at a fairly high-level, and easily understood by a reader who is technically competent but not an expert in the topic itself.

In short, the goal is to answer three questions for the reader. First, what is the project topic, or problem being investigated? Second, why is the topic important, or rather why should the reader care about it? For example, why there is a need for this project, who will benefit from the project and in what way (e.g., clients/end-users who needed some analysis done, or other data scientists who might need the tools you have developed), what work does the project build on and why is the selected approach either important and/or interesting (e.g., fills a gap in literature, applies results from another field to a new problem). Finally, what are the central challenges involved and why are they significant?

The chapter should conclude with a concise bullet point list that summarises the aims, objectives, **and achievements** of your work.

# Chapter 2

# Background

**A compulsory chapter, roughly 20% of the total page-count**

This chapter is intended to describe the technical basis on which execution of the project depends. The goal is to provide a detailed explanation of the specific problem at hand, and existing work that is relevant such as an existing algorithm that you use, alternative solutions proposed, supporting technologies, and relevant literature. The literature you include should cover appropriate peer-reviewed academic publications and books, and maybe also news and current-affairs articles published in reputable sources such as *The Economist* magazine or *The Financial Times* newspaper.

Your thesis should include complete set of references/bibliography: everything that you cite should be in there, in full. This means including the publisher's name for anything that is a book; the editors and title of books that a paper appears in as one item in a larger collection (e.g. proceedings volumes and/or thematic edited collections) and the relevant page-numbers; and so on. Put most simply, we require and expect your references to look like the references in a published peer-reviewed academic paper, so you can work out whether you still have work to do by comparing your references to the reference-list on the publications that you're working from.

Note there is a subtle difference from this and a full-blown literature *survey*. The latter might try to capture and organise (e.g., categorise somehow) *all* related work, potentially offering meta-analysis, whereas here the goal is simply to ensure that your thesis is self-contained. Put another way, after reading this chapter an intelligent non-expert reader with no prior knowledge of your project should have obtained enough background to understand what *you* have done (by reading subsequent sections), and then accurately assess your work. You might view an additional goal as giving the reader confidence that you are able to absorb, understand and clearly communicate highly technical material.

Just as there is no single ideal structure for an MSc thesis, there is no one correct name for this chapter. You could just call it *Background* if you wish, or *Technical Background*. Or if you feel you have a lot to say you could split this chapter into two: you might have your first three chapters being:

1. Introduction
2. Context
3. Related Work

But if you prefer to use a more concise structure, you could instead use:

1. Introduction: Contextual Background
2. Technical Background

The choice is yours.

The key thing is that by the end of these first two or three chapters you have told the reader everything they need to know so that they can understand the rest of your thesis. This is particularly important because at least one of the people who actually examines your thesis will be a UoB academic, one of our lecturers or professors, who you can assume knows almost nothing about the specifics of what work you have done, and who is given a copy of your thesis to mark. So what you write has to adequately explain things to that examiner. You can safely assume that whoever examines your thesis is numerate,

intelligent, understands programming and data analytics etc, but you cannot safely assume that their specific individual expertise is a perfect match to the topic of your thesis (it's in that sense that the examiner is a *non-expert*). So, the person you write for, your *audience*, should be that undefined group of academics who might possibly examine your thesis: if you write for that audience and do a good job, your thesis should be understandable by a wide range of people, including potential employers and colleagues in the world of work.

# Chapter 3

# Execution

**A topic-specific chapter, roughly 30% of the total page-count**

This chapter is intended to describe what you did: the goal is to explain the main activity or activities, of any type, which constituted your work during the project. The content is highly topic-specific. For some projects it will make sense to split the content into two main sections, or maybe even into two separate chapters: one will discuss the design of something, including any rationale or decisions made, and the other will discuss how this design was realised via some form of implementation. You could instead give this chapter the title "Design and Implementation"; or you might split this content into two chapters, one titled "Design" and the other "Implementation" .

Note that it is common to include evidence of "best practice" project management (e.g., use of version control, choice of programming language and so on). Rather than simply a rote list, make sure any such content is useful and/or informative in some way: for example, if there was a decision to be made then explain the trade-offs and implications involved.

## 3.1 Example Section

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Figure 3.1: This is an example figure.

| foo | bar | baz |
|---|---|---|
| 0 | 0 | 0 |
| 1 | 1 | 1 |
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| 9 | 9 | 9 |

Table 3.1: This is an example table.

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### 3.1.1 Example Sub-section

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**for** $i = 0$ **upto** $n$ **do**
  $t_i \leftarrow 0$
**end**

**Algorithm 3.1:** This is an example algorithm.

```
for( i = 0; i < n; i++ ) {
  t[ i ] = 0;
}
```

Listing 3.1: This is an example listing.

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### Example Sub-sub-section

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**Example paragraph.** This is an example paragraph; note the trailing full-stop in the title, which is intended to ensure it does not run into the text.

# Chapter 4

# Critical Evaluation

**A topic-specific chapter, roughly 30% of the total page-count**

This chapter is intended to evaluate what you did. The content is highly topic-specific, but for many projects will have flavours of the following:

1. functional testing, including analysis and explanation of failure cases,
2. behavioural testing, often including analysis of any results that draw some form of conclusion wrt. the aims and objectives, and
3. evaluation of options and decisions within the project, and/or a comparison with alternatives.

This chapter often acts to differentiate project quality: even if the work completed is of a high technical quality, critical yet objective evaluation and comparison of the outcomes is crucial. In essence, the reader wants to learn something, so the worst examples amount to simple statements of fact (e.g., "graph X shows the result is Y"); the best examples are analytical and exploratory (e.g., "graph X shows the result is Y, which means Z; this contradicts [1], which may be because I use a different assumption"). As such, both positive *and* negative outcomes are valid *if* presented in a suitable manner.

# Chapter 5

# Conclusion

**A compulsory chapter, roughly 10% of the total page-count**

The concluding chapter(s) of a dissertation are often underutilized because they're too often left too close to the deadline: it is important to allocate enough time and attention to closing off the story, the narrative, of your thesis.

Again, there is no single correct way of closing a thesis.

One good way of doing this is to have a single chapter consisting of three parts:

1. (Re)summarise the main contributions and achievements, in essence summing up the content.
2. Clearly state the current project status (e.g., "X is working, Y is not") and evaluate what has been achieved with respect to the initial aims and objectives (e.g., "I completed aim X outlined previously, the evidence for this is within Chapter Y"). There is no problem including aims which were not completed, but it is important to evaluate and/or justify why this is the case.
3. Outline any open problems or future plans. Rather than treat this only as an exercise in what you *could* have done given more time, try to focus on any unexplored options or interesting outcomes (e.g., "my experiment for X gave counter-intuitive results, this could be because Y and would form an interesting area for further study" or "users found feature Z of my software difficult to use, which is obvious in hindsight but not during at design stage; to resolve this, I could clearly apply the technique of Bloggs *et al.*.

Alternatively, you might want to divide this content into two chapters: a penultimate chapter with a title such as "Further Work" and then a final chapter "Conclusions". Again, there is no hard and fast rule, we trust you to make the right decision.

And this, the final paragraph of this thesis template, is just a bunch of citations, added to show how to generate a BibTeX bibliography. Sources that have been randomly chosen to be cited here include: [**?**, **?**, **?**, **?**, **?**, **?**, **?**, **?**, **?**, **?**].

# Appendix A

# An Example Appendix

Content which is not central to, but may enhance the dissertation can be included in one or more appendices; examples include, but are not limited to

- lengthy mathematical proofs, numerical or graphical results which are summarised in the main body,
- sample or example calculations, and
- results of user studies or questionnaires.

Note that in line with most research conferences, the examiners are not obliged to read such appendices.