RESEARCH PROPOSAL / DISSERTATION

The Title

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submitted to
the Faculty of Science, in fulfilment of the requirements for the degree
of
??? in Computer Science

in the

Institute for Intelligent Systems
Academy of Computer Science and Software Engineering

April 28, 2024

Declaration of Authorship

I, Raphael LENKWANE, declare that this research proposal/dissertation titled, "The Title" and the work presented in it are my own. I confirm that:

- This work was done wholly or mainly while in candidature for a research degree at this University.
- Where any part of this research proposal/dissertation has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated.
- Where I have consulted the published work of others, this is always clearly attributed.
- Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this research proposal/dissertation is entirely my own work.
- I have acknowledged all main sources of help.
- Where the research proposal/dissertation is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself.

Signed:

Date:

UNIVERSITY OF ...

Abstract

Faculty of Science
Academy of Computer Science and Software Engineering

??? in Computer Science

The Title

by Raphael LENKWANE

[1] Adaptive bandwidth kernel density estimators (AB-KDEs) have received attention from the academic community due to an analytical promise of increased performance over classical estimators. [2] However, the field is fragmented and there exists no comprehensive comparison of the existing state-of-the-art AB-KDEs. [3] We provide a comparison of some state-of-the-art and classical AB-KDE methods as well a computational framework along with a novel implementation of a full principal axes rotation hyper-ellipsoid variant of the *k*-Nearest Neighbours algorithm. [4] The extensive experimental results show that the fixed bandwidth rule-of-thumb methods achieve satisfactory results. Further, the balloon estimators are shown to be superior in the higher dimensional spaces, with higher modes or with data on non-linear manifolds. The sample point estimators show additional utility when data are scarce in low dimensions. [5] The experimental results lead us to conclude that balloon estimators such as the full rotation hyper-ellipsoid estimator will have a significant impact on data analysis algorithms which depend upon an underlying density estimates with larger volumes of higher dimensional data.

Locate
Focus
Anchor
Report
Argue

[1] Locate: ... is now a significant issue (in/for) ... because ... (Expand by up to one sentence if necessary)

[2] Focus: in this paper we focus on ...

[3] Anchor: The paper draws on (We draw on) findings from a study of... which used ... in order to show that ... (expand through additional sentences)

[4] Report: The analysis of the findings shows that ...

[5] Argue: The paper argues that ... and concludes (We conclude) by suggesting that ...

Hint: Creating an Abstract

The abstract is not more than 150 words for a master's dissertation or research report and not more than 350 words for a doctoral thesis, summary of the entire research. In an empirical paper we (*Tiny Text Elements* 2013):

- **locate** the paper in relation to the larger field to give perspective,
- **focus** on the questions/ issues/ problems to be explored/ examined,
- **anchor** the argument by outlining research, samples and analysis,
- **report** on major findings relevant to the argument, and
- **argue** out the argument and close with this article's perspective.

Acknowledgements

The acknowledgements and the people to thank go here, don't forget to include your project advisor...

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List of Abbreviations

LAH	**L**ist **A**bbreviations **H**ere
WSF	**W**hat (it) **S**tands **F**or

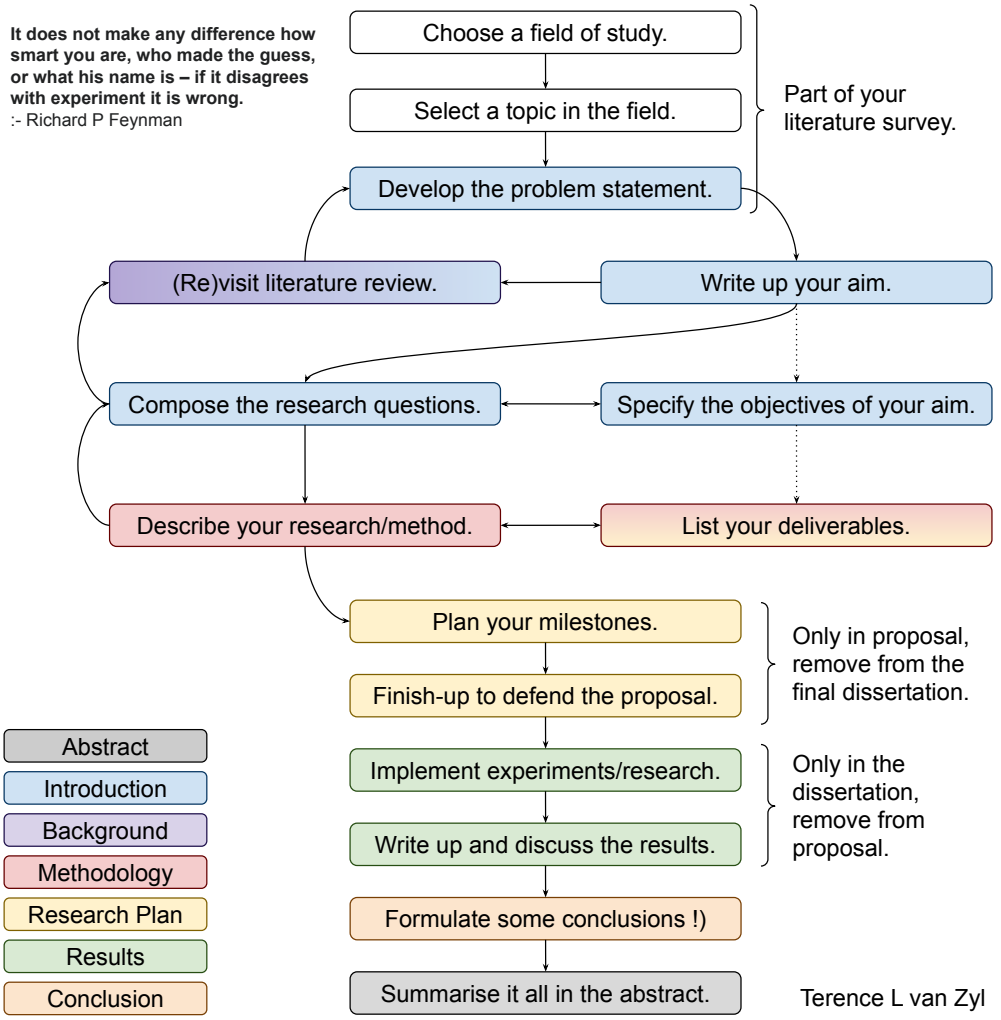
List of Symbols

a	distance	m
P	power	W ($\mathrm{J\,s^{-1}}$)
ω	angular frequency	rad

Chapter 1

Introduction

Hint: Order in which your research writing is most likely to be tackled



First, it is worth noting that a well-written research proposal upon completion of the study can be rapidly transformed into a dissertation. The transformation includes updating missing or stale information and changing a few sections from the future tense into the past tense.

The introduction is a summary of the entire proposal/dissertation/thesis and provides the reader with sufficient information about the field to appreciate the proposed study, i.e. it places the project in the context of what is known and states what will be achieved.

We start with relevant literature to show the reader what the research has been done, where the state-of-the-art (SOTA) is and what gaps exist in our knowledge. The **background** section covers this information. Next, we need to state out of all the gaps identified which one this dissertation/thesis will be tackling. The **Problem Statement** section gives the reader clarity on the chosen gap.

Now that we have established the problem we provide the reader with an indication of what the study intends to do about the problem. The **Aims and Objectives** section covers what we aim to do and the set of objectives that we will achieve in doing so. Next, the **Thesis** statement and**Research Questions** formalise our aims and objectives as a scientific pursuit rather than just an engineering exercise.

Now that we have a problem followed by what we aim to do about it, we can explain to the reader what it will mean for society, researchers or practitioners upon our completion. We can state our potential contributions as well. The **Significance and Motivation** section will provide the reader with this information.

We can now close out the introduction by providing clarity on the scope of the study, possible shortcomings and anything we have assumed that we need to be upfront about. The **Delineations, Limitations and Assumptions** are where we put these. Finally, some definitions are followed by a brief outline of the rest of the document.

1.1 Background

The background provides a narrative that summarises the broader context of your research, evaluates the specific details of your problem and places your research within a conversation of the current state of knowledge in the field. By narrative, we mean that the literature review should not be in point form but should instead read as a historical account of what has transpired. That is a lot of big words so we will break it down in the following discussion.

1.1.1 Discuss My Topic

Start Broad and discuss the large area or topic of research you are working on. Are you working in Classification, Clustering, time series Analysis, Natural Language Processing (NLP), Optimisation, or other fields? Include some definitions and references to classic literature that defines the broad field [$1-3$ references].

Hint: In this Section

An annotated bibliography is just a stepping stone, and a good background will go far beyond a list of articles and summaries of its content. It will synthesize them into a single comprehensive view of the field into which your research problem falls.

Replicating research is a significant contribution, especially for new datasets or if very little replication has been done.

1.1.2 Discuss My Research Problem

Narrow it down here and discuss the research problem you are tackling. Is it Biometrics; Anomaly detection for Fraud; Sentiment Analysis in some domain, or some other research problem? You should include definitions and references to classic literature for your research problem [2-4 references]. It is important to problematize the literature by highlighting the current limitations, gaps and ambiguous results. This problematization allows you to articulate later why your research is critical.

The quality of your references is also essential. More weight is placed on highly cited, current research published in journals. The Least weight is placed on low-cited work in books. Any content that is not peer-reviewed should not be considered. When searching for your references, use Google Scholar. Check the citation counts, the source (journal, conference, book), as well as the credibility of the journal. Also, become familiar with the authors' names. It would be best if you had a strong reason for picking a reference. Follow the links to papers that have cited the one you are looking at in Google Scholar to see if a more recent article synthesizes or improves the results. I suggest ten references minimum depending on your field. Be concise and limit yourself to $4-6$ pages IEEE latex formatting.

1.1.3 Finally, Discuss

The conversation should now center on the progress to date, i.e. current literature. You should draw comparisons of their methodologies and synthesize and discuss their results [$2-4$ references].

In summary, the background section provides a broad literature review for your reader. This comprehensive view gives your reader easy access to research your topic by: selecting high-quality articles that are relevant, meaningful, important and valid; synthesizing them into one complete narrative; providing information on where the field is going; highlighting key findings; identifying inconsistencies, gaps and contradictions; and providing a constructive analysis of the methodologies used by other researchers in the area.

Hint: In this Section

A good description of a literature review can be found here: `https://writingcenter.unc.edu/tips-and-tools/literature-reviews/`

1.2 Problem Statement

Hint: In this Section

The problem statement summarises in 1 to 2 paragraphs all the evidence presented and shows its significance.

1. If it is part of a proposal, then it highlights gaps and indicates how previous research leads to your research and chosen methodology.
2. If it is a stand-alone review, it then suggests practical applications of the research and possibilities for the future.

You should be able to give at least a three to four-line problem statement in this section. The ideal problem statement starts with the **ideal** situation we would want, then gives **the reality** of the situation we are in and finally, the way you **proposed to improve** the reality to an ideal situation.

The **proposed improvement** and your aim are closely related.

Having an accurate heuristic method for determining k in the class of k-NN Kernel Density Estimators will allow us to use these techniques more effectively. (IDEAL)

However, although k-NN is a powerful tool for density estimation, current heuristics methods for determining k are sub-optimal when used on simulated data sets. (REALITY)

In response to this problem, we propose to derive, implement and evaluate the accuracy of a new expectation maximisation algorithm for k selection. (IMPROVEMENT)

1.3 Research Aims and Objectives

Hint: In this Section

Effective aims and objectives give you focus and your reader clarity. A clear statement of this research's aim(s) plus a set of 4 to 6 potentially achievable objectives. https://www.discoverphds.com/advice/doing/research-aims-and-objectives

Hint: Aims

The aim(s) is a longer explanation of your research title expanded to a 3

to 6 sentence paragraph. Emphasise what is to be achieved rather than how it will be completed. The aim provides direction to the rest of your research. You may also have sub-aims that reuse the parts of the main aim.

An aim should consist of three parts (i.e. the context). WHY this research? (the actual aim) WHAT is this research? (summary of your objectives) HOW will this research be achieved?

(An Example)

(WHY?) There is an industry need for the latest and greatest model of all time. **(WHAT?)** This research aims to develop a theory for an all-time latest and greatest model **(HOW?)** by expanding the current latest and greatest model with the latest and greatest theories **(WHY? Sub-aim)** and **(WHAT?)** contribute to the body of knowledge on which of these latest and greatest models is the greatest model **(HOW?)** through an empirical evaluation using all the data.

The above aim(s) of this research project will be achieved through the following objectives:

- investigate which are the current top three latest and greatest models in the literature for my task;
- replicate implementation of the three latest and greatest models;
- implement a working prototype of my own all-time latest and greatest model;
- collect data on which of the four latest and greatest models, including my all-time latest and greatest model, is the greatest through an empirical evaluation of these particular datasets and my dataset; and
- analyse and discuss the results of my empirical evaluation and write them up.

Hint: Objectives

Objectives are how you will achieve your aim. You should be:

S pecific: be precise about what you are going to do: collect, construct, classify, develop, devise, measure, produce, revise, select, synthesise, replicate, implement, . . .

M easurable: you will know when you have succeeded in this objective

A chievable: within your resource constraints, you can get access to data, GPUs, CPUs, . . .

R elevant: links directly to answering the research question(s)

T ime-bound: has a clear end

1.4 Thesis

Hint: In this Section

Only for a PhD do we need a hypothesis statement and research questions. **Research questions are sufficient otherwise**.

The research questions allow for more specific/focused attention on particular aspects of the hypothesis.

Hint: Hypothesis

The hypothesis is a more formal statement of your aim. It is a tentative theory, a statement of belief about the world that can be tested and falsified by investigation. The hypothesis must be clearly and unambiguously stated since it will guide the research through the practical portions. The hypothesis is central to the written dissertation, so consider the wording and composition carefully.

1.5 Research Questions

Hint: In this Section

Research questions and objectives make the same statements but in different formats. Sometimes achieving multiple research objectives will be required to answer a single research question.

We only need one good research question, but we may have more sub-questions. If we have a single research question, it would talk directly to our aim and achieve our objectives.

Here are two examples of research questions:

1. Is it possible for people from all walks of life, including but not limited to mothers, fathers, sisters and brothers, to produce in written form research questions that would be considered good[1]? (BAD)
2. By how much can a post-graduate computer science student's grade for their research questions be improved after attending a short seminar[2]? (GOOD)

[1] Not clear. Not concise, i.e. very wordy. Yes/no answer. How would we even go about finding people from all walks of life? How would we produce data, and what is the metric for these good research questions in what field? Does this even add new knowledge?

[2] Clear, concise, complex, focused, measurable and arguable

Hint: Research Questions

A good research question is:
Clear Needs no additional explanations to understand the question.
Concise In as few words as possible.
Complex With not just a simple yes-no answer.
Focused Answerable given the resources you have.
Measurable Data can be produced that falsifies the question.
Arguable Adds new knowledge rather than being a known fact.

1.6 Significance and Motivation

Hint: In this Section

Provide the relevance and context for tackling the problem statement.

Motivation: The easiest way to fill in this is to write a paragraph or two that answers these two questions:

1. Why Us? Why are we in the right position to do this research?
2. Why Now? Why is now the right time to be doing this research?

Highlighted what changed.

Significance: It would help if you summarised your expected contributions; later in your dissertation/thesis/report, this will be reworded from the future tense to the past tense.

1.7 Delineations, Limitations and Assumptions

Hint: In this Section

Three paragraphs state any known delineations and limitations of this research and any assumptions made that may not necessarily be true. It can also have three subheadings.

Delineations set the scope of the research, why we did not include certain aspects.

Limitations explain to the reader upfront what we expect to be the shortcomings of our results.

Assumptions are anything we assume to be true and, if found not to be true, would impact the validity of our results.

This research will only focus on the grade a student obtains in their research proposal from their supervisor and will not include any external reviewers. In addition, this research will be conducted on WITS Honours students only. (An Example)

As a result, the outcomes might not be generalisable to other universities or MSc and PhD levels. Since the supervisors write the research questions, they might be biased.

We also assume that a student's grade obtained from a supervisor for their research question is a reasonable proxy for showing improvement.

1.8 Definitions

Hint: In this Section

Any definitions that the reader may need to understand this text. These are usually your definitions of terms that have yet to be defined.

1.9 Outline

Hint: In this Section

Outline the rest of this proposal, a sort of table of contents but in a narrative form. You have seen these inside research articles.

Chapter 2

A Background Chapter

Hint: In this Chapter

We will add background chapters to the final dissertation or thesis but not the research proposal.

Hint: In this Chapter

Background chapters provide a reader who lacks knowledge concerning a particular area of your research with a concise and thorough reference to the relevant literature.

The intent is to allow a knowledgeable reader to become familiar with the literature in the specific field or topic in the field.

Chapter 3

The Model, Framework or Algorithm

Hint: Chapter Title

The title of this chapter can be the name of your model.

Hint: In this Chapter

Your novel contribution to the research.

Suppose you have devised a novel idea and want to compare it to several other baselines and state-of-the-art methods using an empirical evaluation. You would describe the idea and how it links to the other methods here.

1. Describe the idea, algorithm, mathematics, etc.
2. Describe other background needed to understand the idea

Hint: In this Chapter

Suppose you have a machine learning system you want to build a system using design science paradigm.

1. Describe the Use Cases
2. Add Use Case Diagram
3. Describe question stories a part of functional requirements

Chapter 4

Methodology

This chapter provides the reader with a description of the research we will undertake.

4.1 Research Design

Hint: In this Section

Unpack the theory behind your research in a single paragraph maximum two.

[1] [2] I will be undertaking confirmatory experimental research. Experimental confirmatory research is . . . (An Example)

[3] I will be undertaking design science research. Design science is . . . (Another Example)

[1] https://en.wikipedia.org/wiki/Research_design
[2] https://en.wikipedia.org/wiki/Scientific_method
[3] https://en.wikipedia.org/wiki/Design_science_(methodology)

4.2 Methodology

4.2.1 Instruments and Tools

Hint: In this Section

Can be replaced as subsections or included as subsubsections:

1. The **algorithms**, **architectures**, **loss functions**, **optimisers** you will use to get your data.
2. The **hardware and libraries** you will use to support your algorithms.
3. The **protocol** that you will follow to ensure that your experiment is correct, K-fold cross validation, training test split, preventing data leakage, number of runs.
4. The **hyper-parameters** that you will use, the protocol to be followed to tune them.
5. The **baseline** from the literature you will compare your results to.
6. If you got **data** from somewhere else you should describe and justify that source, #features, #classes, #records, . . .

4.2.2 Results Data

Research data comes in four main varieties based on how we collect it: observational, experimental, simulation, and derived [4].

Hint: In this Section

Describe the data WE will generate, includes:

1. the results of running your experiment, and
2. data you will collect and/or label, #features, #classes, #records . . .

Make a case for your data being good. How will it be labelled or generated, and can we trust it?

[4] https://libguides.macalester.edu/c.php?g=527786/&p=3608643

4.2.3 Results Analysis

Hint: In this Section

It would help if you answered the following questions:

1. What analysis will you do on the data that you have generated?
2. What descriptive statistic will you use? Mean, Standard Deviations, ...
3. What metrics will you use? Mean Average Precision, R^2, Recall, ...
4. What comparisons will you use? Confusion matrices, AUC_ROC Curve, ...
5. How will you determine statistical significance?

4.3 Limitations

Hint: In this Section

What are the limitations of your research methodology?

4.4 Ethical Considerations

4.5 Conclusion

Chapter 5

Project Plan

Hint: In this Chapter

Not part of the dissertation or thesis.

5.1 Introduction

Hint: In this Section

A project plan starts with a set of deliverables. Tangible things you will create and would able to hand over to someone. Your outcomes, from your introduction, supplement the deliverables by outlining the tasks required to achieve the deliverable. Along the way, we place critical checkpoints for ourselves; these are the milestones.

An Example

The deliverables of this research will be[1]:

Research proposal This document completed and approved.

Classical techniques Implementation of the K-NN KDE as well as . . .

Point process dataset Collection, collation and creation of a point process benchmark dataset. Will include classical existing data as well as some new dataset we create.

Conference proceedings "A comparison of classical kernel density estimators for spatial point process data" in proceeding of IEEE Geospatial and Remote Sensing Symposium

Implementation of DNN-KDE Prototype

Journal article 1 "Empirical simulation evaluation of new non-parametric density estimation using deep neural networks for adaptive bandwidth selection" in IEEE Transactions on Knowledge and Data Engineering

[1] All titles, journals and conferences are tentative.

Journal article 2 "Application of deep neural network bandwidth selection for non-parametric density estimation to spatial point process data" in IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing

Draft dissertaion the First draft write up of dissertation, introduction and conclusion with the three papers.

5.2 Time Plan

Hint: In this Section

Must be a table and Gantt chart.

The Gannt chart for this research proposal is available in Table 5.1.

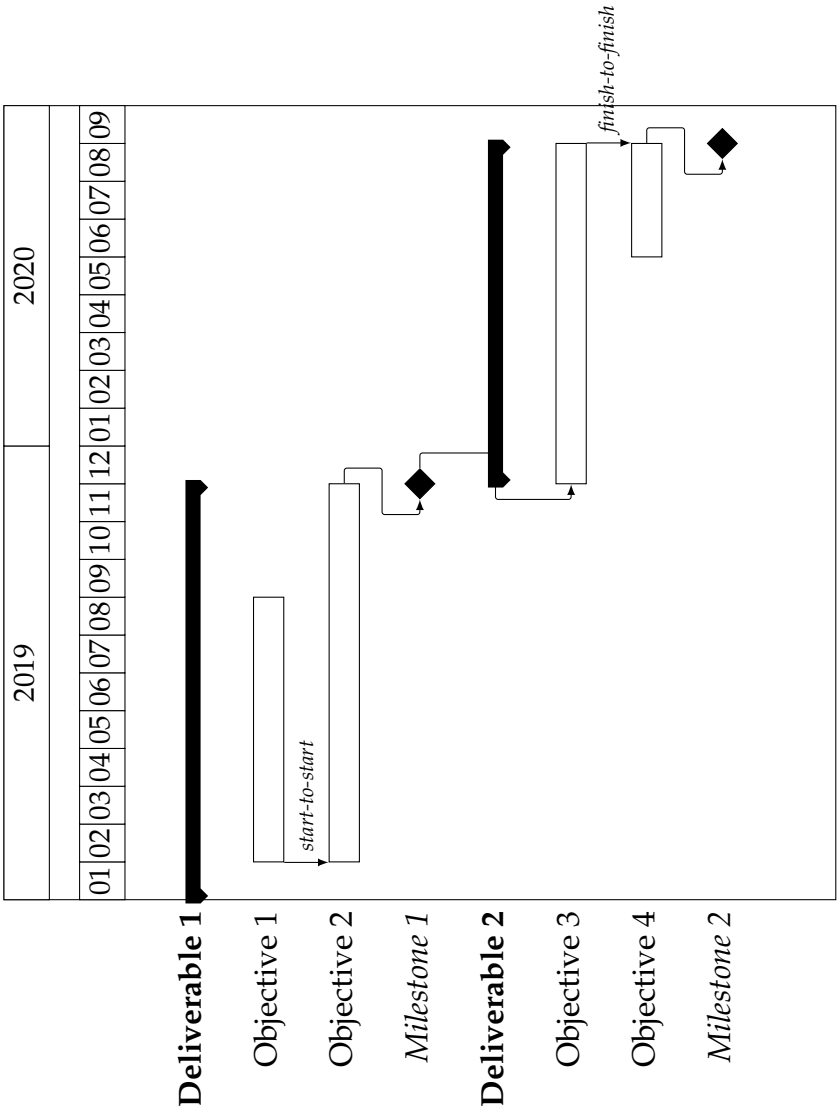
5.3 Verification and Validation Plan

5.4 Potential Issues

None

5.5 Conclusion

TABLE 5.1: Gannt Chart for Time Plan.



Chapter 6

Results and Discussion

Hint: In this Chapter

Not a part of the research proposal. It can be split into two chapters.

6.1 Results

Hint: In this Section

The results section identifies the tables or figures, indicates their content, highlights, and points out and describes the relevant or significant outcomes. For each result (figure or table), take a sentence from each of the:

1. Referring back to the research aims or procedures
2. Referring to data in a table or chart
3. Highlighting significant data in a table or chart

Then possibly a sentence or two for:

1. Stating a positive or negative result
2. Highlighting exciting or surprising results

6.2 Discussion

Hint: In this Section

The discussion contextualises the results within the existing research literature.

1. First sentence - What is 'the answer' to the problem
2. Second sentence and on - justify your answer.

Hint: In this Section

Then with references to previous literature (Literature Survey) for each significant result, do one or more of the following:

1. Providing background information
   (a) reference to the question
   (b) reference to the literature
2. Restating the result or one of several results
3. Indicating an unexpected outcome
4. Comparing the result
   (a) supporting previous findings
   (b) contradicting previous findings
5. Explaining the findings

Hint: In this Section

Finally:

1. Advising cautious interpretation of findings
2. Suggesting general hypothesis
3. Noting implications of the findings

Chapter 7

Conclusion

The conclusion is the inverse of an introduction, so we start narrow and go wide. It provides a summary, highlights key points and pulls all the ideas together. The conclusion should include, at a minimum: research objectives (a summary of your findings and the resulting conclusions), recommendations, and contributions to knowledge.

Hint: In this Section

Research proposal Start with the **research objectives** and answer these two questions:

1. After the literature review, what did you find out concerning your research objectives and questions?
2. What conclusions can you make?

next, offer the reader in the form of **recommendations** advice on what YOU think should happen next.

Hint: In this Section

Research dissertation Start with the **research objectives** and answer these two questions:

1. After the literature review and the completed empirical research, what are the results concerning your research objectives and questions?
2. What conclusions can you make? Do not go into analysis again.

next, offer the reader in the form of **recommendations** advice on what you think should happen next. Finally, identify what other researchers have done and how your work builds upon theirs. This location is also a good time to mention your publications and how they contributed to "filling the gap".

Hint: In this Section

Cheat Sheet You can start by putting down a sentence or two for each of these:

1. Restate your research topic.
2. Restate the thesis.
3. Summarize the main points.
4. State the significance or results.
5. Conclude your thoughts.

To summarise this section, remember that a conclusion is your last opportunity to tell the reader what you want them to remember. The chapter needs to be comprehensive and might include sub-sections.

Appendix A

Cheat Sheet

1. https://www.cl.cam.ac.uk/~pr10/teaching/dissertation.html
2. http://www.eecs.qmul.ac.uk/~norman/papers/good_writing/Technical%20writing_ver_5_2.pdf
3. https://rossieronline.usc.edu/wp-content/uploads/Passive-Voice-1st-3rd-Person.pdf

A.1 Basic Rules

A.1.1 Third person and Passive Voice

1. It is we as in you and me the reader in the first person. We *(You and I)* must always use this we. (No 2nd Person)
2. We as in us the writers/researchers. Don't feel shy to use we in the first person. Although unlikely, if you are the only person involved in the research use I.
3. Use the third person in the Literature Review and Results.
4. Use the first person in the Introduction, Method, Discussion and Conclusion.
5. Use the passive voice sparingly. Use it when we want to emphasise the object as the most important thing in the sentence.

A.1.2 Tense

1. Exception: Research proposals are written in the future tense.
2. Exception: Use the present tense when you writing about other researchers' work.
3. Introduction, Method and Results in the past tense.
4. Literature Review and Discussion in the present tense.
5. Conclusion in the present tense with future work in the future tense.

A.1.3 Tables and Figures

1. All table and figures must have a caption, must float and must be referred by its label not the words above or below.
2. Table captions always above tables. Figure captions always below figures.
3. Figure captions are sentences helping the reader interpret the figure.
4. Table captions are headings so aren't sentences describing the table.
5. Write out Figure and Table in full.

A.1.4 Style

1. Numbers ten and less we always write out in full in the text.
2. Avoid remarks in parentheses and excessive use of footnotes. If something matters, say it. If it doesn't matter, leave it out.
3. Do not use don't or any other informal abbreviations.
4. Use simple language. Short sentences are more effective. Convoluted sentences with multiple clauses, especially nested using stray punctuation, make it harder for the reader to follow the argument; avoid them.

Appendix B

Frequently Asked Questions

B.1 How do I change the colors of links?

The color of links can be changed to your liking using:

`\hypersetup{urlcolor=red}`, or

`\hypersetup{citecolor=green}`, or

`\hypersetup{allcolor=blue}`.

If you want to completely hide the links, you can use:

`\hypersetup{allcolors=.}`, or even better:

`\hypersetup{hidelinks}`.

If you want to have obvious links in the PDF but not the printed text, use:

`\hypersetup{colorlinks=false}`.

Appendix C

Chapter Title Here

C.1 Welcome and Thank You

Welcome to this LaTeX Thesis Template, a beautiful and easy to use template for writing a thesis using the LaTeX typesetting system.

If you are writing a thesis (or will be in the future) and its subject is technical or mathematical (though it doesn't have to be), then creating it in LaTeX is highly recommended as a way to make sure you can just get down to the essential writing without having to worry over formatting or wasting time arguing with your word processor.

LaTeX is easily able to professionally typeset documents that run to hundreds or thousands of pages long. With simple mark-up commands, it automatically sets out the table of contents, margins, page headers and footers and keeps the formatting consistent and beautiful. One of its main strengths is the way it can easily typeset mathematics, even *heavy* mathematics. Even if those equations are the most horribly twisted and most difficult mathematical problems that can only be solved on a super-computer, you can at least count on LaTeX to make them look stunning.

C.2 Learning LaTeX

LaTeX is not a WYSIWYG (What You See is What You Get) program, unlike word processors such as Microsoft Word or Apple's Pages. Instead, a document written for LaTeX is actually a simple, plain text file that contains *no formatting*. You tell LaTeX how you want the formatting in the finished document by writing in simple commands amongst the text, for example, if I want to use *italic text for emphasis*, I write the `\emph{text}` command and put the text I want in italics in between the curly braces. This means that LaTeX is a "mark-up" language, very much like HTML.

C.2.1 A (not so short) Introduction to LaTeX

If you are new to LaTeX, there is a very good eBook – freely available online as a PDF file – called, "The Not So Short Introduction to LaTeX". The book's title is typically shortened to just *lshort*. You can download the latest version (as it is occasionally updated) from here: http://www.ctan.org/tex-archive/info/lshort/english/lshort.pdf

It is also available in several other languages. Find yours from the list on this page: http://www.ctan.org/tex-archive/info/lshort/

It is recommended to take a little time out to learn how to use LaTeX by creating several, small 'test' documents, or having a close look at several templates on:
http://www.LaTeXTemplates.com
Making the effort now means you're not stuck learning the system when what you *really* need to be doing is writing your thesis.

C.2.2 A Short Math Guide for LaTeX

If you are writing a technical or mathematical thesis, then you may want to read the document by the AMS (American Mathematical Society) called, "A Short Math Guide for LaTeX". It can be found online here: http://www.ams.org/tex/amslatex.html under the "Additional Documentation" section towards the bottom of the page.

C.2.3 Common LaTeX Math Symbols

There are a multitude of mathematical symbols available for LaTeX and it would take a great effort to learn the commands for them all. The most common ones you are likely to use are shown on this page: http://www.sunilpatel.co.uk/latex-type/latex-math-symbols/

You can use this page as a reference or crib sheet, the symbols are rendered as large, high quality images so you can quickly find the LaTeX command for the symbol you need.

C.2.4 LaTeX on a Mac

The LaTeX distribution is available for many systems including Windows, Linux and Mac OS X. The package for OS X is called MacTeX and it contains all the applications you need – bundled together and pre-customized – for a fully working LaTeX environment and work flow.

MacTeX includes a custom dedicated LaTeX editor called TeXShop for writing your '`.tex`' files and BibDesk: a program to manage your references and create your bibliography section just as easily as managing songs and creating playlists in iTunes.

C.3 Getting Started with this Template

If you are familiar with LaTeX, then you should explore the directory structure of the template and then proceed to place your own information into the *THESIS INFORMATION* block of the `main.tex` file. You can then modify the rest of this file to your unique specifications based on your degree/university. Section C.5 on page 30 will help you do this. Make sure you also read section C.7 about thesis conventions to get the most out of this template.

If you are new to LaTeX it is recommended that you carry on reading through the rest of the information in this document.

Before you begin using this template you should ensure that its style complies with the thesis style guidelines imposed by your institution. In most cases this template style and layout will be suitable. If it is not, it may only require a small change to bring the template in line with your institution's recommendations. These modifications will need to be done on the `MastersDoctoralThesis.cls` file.

C.3.1 About this Template

This LaTeX Thesis Template is originally based and created around a LaTeX style file created by Steve R. Gunn from the University of Southampton (UK), department of Electronics and Computer Science. You can find his original thesis style file at his site, here: `http://www.ecs.soton.ac.uk/~srg/softwaretools/document/templates/`

Steve's `ecsthesis.cls` was then taken by Sunil Patel who modified it by creating a skeleton framework and folder structure to place the thesis files in. The resulting template can be found on Sunil's site here: `http://www.sunilpatel.co.uk/thesis-template`

Sunil's template was made available through `http://www.LaTeXTemplates.com` where it was modified many times based on user requests and questions. Version 2.0 and onwards of this template represents a major modification to Sunil's template and is, in fact, hardly recognisable. The work to make version 2.0 possible was carried out by Vel and Johannes Böttcher.

C.4 What this Template Includes

C.4.1 Folders

This template comes as a single zip file that expands out to several files and folders. The folder names are mostly self-explanatory:

Appendices – this is the folder where you put the appendices. Each appendix should go into its own separate `.tex` file. An example and template are included in the directory.

Chapters – this is the folder where you put the thesis chapters. A thesis usually has about six chapters, though there is no hard rule on this. Each chapter should go in its own separate `.tex` file and they can be split as:

- Chapter 1: Introduction to the thesis topic
- Chapter 2: Background information and theory
- Chapter 3: (Laboratory) experimental setup
- Chapter 4: Details of experiment 1
- Chapter 5: Details of experiment 2
- Chapter 6: Discussion of the experimental results
- Chapter 7: Conclusion and future directions

This chapter layout is specialised for the experimental sciences, your discipline may be different.

Figures – this folder contains all figures for the thesis. These are the final images that will go into the thesis document.

C.4.2 Files

Included are also several files, most of them are plain text and you can see their contents in a text editor. After initial compilation, you will see that more auxiliary files are created by LaTeX or BibTeX and which you don't need to delete or worry about:

example.bib – this is an important file that contains all the bibliographic information and references that you will be citing in the thesis for use with BibTeX. You can write it manually, but there are reference manager programs available that will create and manage it for you. Bibliographies in LaTeX are a large subject and you may need to read about BibTeX before starting with this. Many modern reference managers will allow you to export your references in BibTeX format which greatly eases the amount of work you have to do.

MastersDoctoralThesis.cls – this is an important file. It is the class file that tells LaTeX how to format the thesis.

main.pdf – this is your beautifully typeset thesis (in the PDF file format) created by LaTeX. It is supplied in the PDF with the template and after you compile the template you should get an identical version.

main.tex – this is an important file. This is the file that you tell LaTeX to compile to produce your thesis as a PDF file. It contains the framework and constructs that tell LaTeX how to layout the thesis. It is heavily commented so you can read exactly what each line of code does and why it is there. After you put your own information into the *THESIS INFORMATION* block – you have now started your thesis!

Files that are *not* included, but are created by LaTeX as auxiliary files include:

main.aux – this is an auxiliary file generated by LaTeX, if it is deleted LaTeX simply regenerates it when you run the main `.tex` file.

main.bbl – this is an auxiliary file generated by BibTeX, if it is deleted, BibTeX simply regenerates it when you run the `main.aux` file. Whereas the `.bib` file contains all the references you have, this `.bbl` file contains the references you have actually cited in the thesis and is used to build the bibliography section of the thesis.

main.blg – this is an auxiliary file generated by BibTeX, if it is deleted BibTeX simply regenerates it when you run the main `.aux` file.

main.lof – this is an auxiliary file generated by LaTeX, if it is deleted LaTeX simply regenerates it when you run the main `.tex` file. It tells LaTeX how to build the *List of Figures* section.

main.log – this is an auxiliary file generated by LaTeX, if it is deleted LaTeX simply regenerates it when you run the main `.tex` file. It contains messages from LaTeX, if you receive errors and warnings from LaTeX, they will be in this `.log` file.

main.lot – this is an auxiliary file generated by LaTeX, if it is deleted LaTeX simply regenerates it when you run the main `.tex` file. It tells LaTeX how to build the *List of Tables* section.

main.out – this is an auxiliary file generated by LaTeX, if it is deleted LaTeX simply regenerates it when you run the main `.tex` file.

So from this long list, only the files with the `.bib`, `.cls` and `.tex` extensions are the most important ones. The other auxiliary files can be ignored or deleted as LaTeX and BibTeX will regenerate them.

C.5 Filling in Your Information in the `main.tex` File

You will need to personalise the thesis template and make it your own by filling in your own information. This is done by editing the `main.tex` file in a text editor or your favourite LaTeX environment.

Open the file and scroll down to the third large block titled *THESIS INFORMATION* where you can see the entries for *University Name*, *Department Name*, etc ...

Fill out the information about yourself, your group and institution. You can also insert web links, if you do, make sure you use the full URL, including the `http://` for this. If you don't want these to be linked, simply remove the `\href{url}{name}` and only leave the name.

When you have done this, save the file and recompile `main.tex`. All the information you filled in should now be in the PDF, complete with web links. You can now begin your thesis proper!

C.6 The `main.tex` File Explained

The `main.tex` file contains the structure of the thesis. There are plenty of written comments that explain what pages, sections and formatting the LaTeX code is creating. Each major document element is divided into commented blocks with titles in all capitals to make it obvious what the following bit of code is doing. Initially there seems to be a lot of LaTeX code, but this is all formatting, and it has all been taken care of so you don't have to do it.

Begin by checking that your information on the title page is correct. For the thesis declaration, your institution may insist on something different than the text given. If this is the case, just replace what you see with what is required in the *DECLARATION PAGE* block.

Then comes a page which contains a funny quote. You can put your own, or quote your favourite scientist, author, person, and so on. Make sure to put the name of the person who you took the quote from.

Following this is the abstract page which summarises your work in a condensed way and can almost be used as a standalone document to describe what you have done. The text you write will cause the heading to move up so don't worry about running out of space.

Next come the acknowledgements. On this page, write about all the people who you wish to thank (not forgetting parents, partners and your advisor/supervisor).

The contents pages, list of figures and tables are all taken care of for you and do not need to be manually created or edited. The next set of pages are more likely to be optional and can be deleted since they are for a more technical thesis: insert a list of abbreviations you have used in the thesis, then a list of the physical constants and numbers you refer to and finally, a list of mathematical symbols used in any formulae. Making the effort to fill these tables means the reader has a one-stop place to refer to instead of searching the internet and references to try and find out what you meant by certain abbreviations or symbols.

The list of symbols is split into the Roman and Greek alphabets. Whereas the abbreviations and symbols ought to be listed in alphabetical order (and this is *not* done automatically for you) the list of physical constants should be grouped into similar themes.

The next page contains a one line dedication. Who will you dedicate your thesis to?

Finally, there is the block where the chapters are included. Uncomment the lines (delete the `%` character) as you write the chapters. Each chapter should be written in its own file and put into the *Chapters* folder and named `Chapter1`, `Chapter2`, etc... Similarly for the appendices, uncomment the lines as you need them. Each appendix should go into its own file and placed in the *Appendices* folder.

After the preamble, chapters and appendices finally comes the bibliography. The bibliography style (called *authoryear*) is used for the bibliography and is a fully featured style that will even include links to where the referenced paper can be found online. Do not underestimate how grateful your reader will be to find that a reference to a paper is just a click away. Of course, this relies on you putting the URL information into the BibTeX file in the first place.

C.7 Thesis Features and Conventions

To get the best out of this template, there are a few conventions that you may want to follow.

One of the most important (and most difficult) things to keep track of in such a long document as a thesis is consistency. Using certain conventions and ways of doing things (such as using a Todo list) makes the job easier. Of course, all of these are optional and you can adopt your own method.

C.7.1 Printing Format

This thesis template is designed for double sided printing (i.e. content on the front and back of pages) as most theses are printed and bound this way. Switching to one sided printing is as simple as uncommenting the *oneside* option of the `documentclass` command at the top of the `main.tex` file. You may then wish to adjust the margins to suit specifications from your institution.

The headers for the pages contain the page number on the outer side (so it is easy to flick through to the page you want) and the chapter name on the inner side.

The text is set to 11 point by default with single line spacing, again, you can tune the text size and spacing should you want or need to using the options at the very start of `main.tex`. The spacing can be changed similarly by replacing the *singlespacing* with *onehalfspacing* or *doublespacing*.

C.7.2 Using US Letter Paper

The paper size used in the template is A4, which is the standard size in Europe. If you are using this thesis template elsewhere and particularly in the United States, then you may have to change the A4 paper size to the US Letter size. This can be done in the margins settings section in `main.tex`.

Due to the differences in the paper size, the resulting margins may be different to what you like or require (as it is common for institutions to dictate certain margin sizes). If this is the case, then the margin sizes can be tweaked by modifying the values in the same block as where you set the paper size. Now your document should be set up for US Letter paper size with suitable margins.

C.7.3 References

The `biblatex` package is used to format the bibliography and inserts references such as this one (Hawthorn, Weber, and Scholten, 2001). The options used in the `main.tex` file mean that the in-text citations of references are formatted with the author(s) listed with the date of the publication. Multiple references are separated by semicolons (e.g. (Wieman and Hollberg, 1991; Hawthorn, Weber, and Scholten, 2001)) and references with more than three authors only show the first author with *et al.* indicating there are more authors (e.g. (Arnold et al., 1998)). This is done automatically for you. To see

how you use references, have a look at the `Chapter1.tex` source file. Many reference managers allow you to simply drag the reference into the document as you type.

Scientific references should come *before* the punctuation mark if there is one (such as a comma or period). The same goes for footnotes[1]. You can change this but the most important thing is to keep the convention consistent throughout the thesis. Footnotes themselves should be full, descriptive sentences (beginning with a capital letter and ending with a full stop). The APA6 states: "Footnote numbers should be superscripted, [...], following any punctuation mark except a dash." The Chicago manual of style states: "A note number should be placed at the end of a sentence or clause. The number follows any punctuation mark except the dash, which it precedes. It follows a closing parenthesis."

The bibliography is typeset with references listed in alphabetical order by the first author's last name. This is similar to the APA referencing style. To see how LaTeX typesets the bibliography, have a look at the very end of this document (or just click on the reference number links in in-text citations).

A Note on bibtex

The bibtex backend used in the template by default does not correctly handle unicode character encoding (i.e. "international" characters). You may see a warning about this in the compilation log and, if your references contain unicode characters, they may not show up correctly or at all. The solution to this is to use the biber backend instead of the outdated bibtex backend. This is done by finding this in `main.tex`: *backend=bibtex* and changing it to *backend=biber*. You will then need to delete all auxiliary BibTeX files and navigate to the template directory in your terminal (command prompt). Once there, simply type `biber main` and biber will compile your bibliography. You can then compile `main.tex` as normal and your bibliography will be updated. An alternative is to set up your LaTeX editor to compile with biber instead of bibtex, see here for how to do this for various editors.

C.7.4 Tables

Tables are an important way of displaying your results, below is an example table which was generated with this code:

[1] Such as this footnote, here down at the bottom of the page.

TABLE C.1: The effects of treatments X and Y on the four groups studied.

Groups	Treatment X	Treatment Y
1	0.2	0.8
2	0.17	0.7
3	0.24	0.75
4	0.68	0.3

```
\begin{table}
\caption{The effects of treatments X and Y on the four groups studied.}
\label{tab:treatments}
\centering
\begin{tabular}{l l l}
\toprule
\tabhead{Groups} & \tabhead{Treatment X} & \tabhead{Treatment Y} \\
\midrule
1 & 0.2 & 0.8\\
2 & 0.17 & 0.7\\
3 & 0.24 & 0.75\\
4 & 0.68 & 0.3\\
\bottomrule\\
\end{tabular}
\end{table}
```

You can reference tables with `\ref{<label>}` where the label is defined within the table environment. See `Chapter1.tex` for an example of the label and citation (e.g. Table C.1).

C.7.5 Figures

There will hopefully be many figures in your thesis (that should be placed in the *Figures* folder). The way to insert figures into your thesis is to use a code template like this:

```
\begin{figure}
\centering
\includegraphics{Figures/Electron}
\decoRule
\caption[An Electron]{An electron (artist's impression).}
\label{fig:Electron}
```

```
\end{figure}
```

Also look in the source file. Putting this code into the source file produces the picture of the electron that you can see in the figure below.

FIGURE C.1: An electron (artist's impression).

Sometimes figures don't always appear where you write them in the source. The placement depends on how much space there is on the page for the figure. Sometimes there is not enough room to fit a figure directly where it should go (in relation to the text) and so LaTeX puts it at the top of the next page. Positioning figures is the job of LaTeX and so you should only worry about making them look good!

Figures usually should have captions just in case you need to refer to them (such as in Figure C.1). The `\caption` command contains two parts, the first part, inside the square brackets is the title that will appear in the *List of Figures*, and so should be short. The second part in the curly brackets should contain the longer and more descriptive caption text.

The `\decoRule` command is optional and simply puts an aesthetic horizontal line below the image. If you do this for one image, do it for all of them.

LaTeX is capable of using images in pdf, jpg and png format.

C.7.6 Typesetting mathematics

If your thesis is going to contain heavy mathematical content, be sure that LaTeX will make it look beautiful, even though it won't be able to solve the equations for you.

The "Not So Short Introduction to LaTeX" (available on CTAN) should tell you everything you need to know for most cases of typesetting mathematics. If you need more information, a much more thorough mathematical guide is available from the AMS called, "A Short Math Guide to LaTeX" and can be downloaded from: `ftp://ftp.ams.org/pub/tex/doc/amsmath/short-math-guide.pdf`

There are many different LaTeX symbols to remember, luckily you can find the most common symbols in The Comprehensive LaTeX Symbol List.

You can write an equation, which is automatically given an equation number by LaTeX like this:

```
\begin{equation}
E = mc^{2}
\label{eqn:Einstein}
\end{equation}
```

This will produce Einstein's famous energy-matter equivalence equation:

$$E = mc^2 \tag{C.1}$$

All equations you write (which are not in the middle of paragraph text) are automatically given equation numbers by LaTeX. If you don't want a particular equation numbered, use the unnumbered form:

```
\[ a^{2}=4 \]
```

C.8 Sectioning and Subsectioning

You should break your thesis up into nice, bite-sized sections and subsections. LaTeX automatically builds a table of Contents by looking at all the `\chapter{}`, `\section{}` and `\subsection{}` commands you write in the source.

The Table of Contents should only list the sections to three (3) levels. A `chapter{}` is level zero (0). A `\section{}` is level one (1) and so a `\subsection{}` is level two (2). In your thesis it is likely that you will even use a `subsubsection{}`,

which is level three (3). The depth to which the Table of Contents is formatted is set within `MastersDoctoralThesis.cls`. If you need this changed, you can do it in `main.tex`.

C.9 In Closing

You have reached the end of this mini-guide. You can now rename or overwrite this pdf file and begin writing your own `Chapter1.tex` and the rest of your thesis. The easy work of setting up the structure and framework has been taken care of for you. It's now your job to fill it out!

Good luck and have lots of fun!

Guide written by —
Sunil Patel: www.sunilpatel.co.uk
Vel: LaTeXTemplates.com

Bibliography

Arnold, A. S. et al. (Mar. 1998). "A Simple Extended-Cavity Diode Laser". In: *Review of Scientific Instruments* 69.3, pp. 1236–1239. URL: http://link.aip.org/link/?RSI/69/1236/1.

Hawthorn, C. J., K. P. Weber, and R. E. Scholten (Dec. 2001). "Littrow Configuration Tunable External Cavity Diode Laser with Fixed Direction Output Beam". In: *Review of Scientific Instruments* 72.12, pp. 4477–4479. URL: http://link.aip.org/link/?RSI/72/4477/1.

Tiny Text Elements (2013).

Wieman, Carl E. and Leo Hollberg (Jan. 1991). "Using Diode Lasers for Atomic Physics". In: *Review of Scientific Instruments* 62.1, pp. 1–20. URL: http://link.aip.org/link/?RSI/62/1/1.