Tips for writing up your thesis

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1 General principles

Be clear on your objectives and those of your reader. You do not write a thesis simply for the heck it, it takes time and effort and trees to write this thing, and the same also holds for reading it. Your time is valuable, and so is mine, we both want to use it efficiently. You of course want a good mark to send you off on a highly successful professional life. In order for us to give you that we need two things:

- You need to have done good interesting work. No other way I'm afraid.
- In order to appreciate the quality of your work we need a concise and clear record of it. And because our time is at a premium, we need to evaluate this in an efficient manner. If you waste our time, we don't give good marks. Simple as that.

What does an examiner want to find out when he picks up your thesis? With the least amount of pain, effort and time he(she) simply wants the answers to the following questions:

- What does this work try to accomplish, and why?
- What are the specific contributions it makes, in other words, what does it add to the existing state of affairs? (To answer this we also need information on this prior/existing state of affairs.)
- Are those contributions genuine? In other words, was the work done in a scientifically responsible manner? Is the development of theory correct? Are the supporting experiments done correctly and properly interpreted?

It is important to realise that your report is not about accumulating pages, everything in your report must contribute to the above objectives. Either it does, or it detracts. Because if it does not contribute, it wastes your reader's time and increases his pain. Here is a list of general principles to keep in mind:

- Make sure that both you and your reader understand what you want to contribute with each little bit in your report. He should always be in sync with what you are doing and why you want to do so. State it clearly, even before you do the actual thing. Wading through piles of material wondering where all this is going to, simply wastes time and causes frustration. Especially when it turns out that the writer also does not know what and why he is doing something.
- Make sure that the reader can evaluate your contributions easily. He needs to see stuff that convinces him that your work is correct and that you understand it. Does it correlate with other results? Whatever.
- Make sure that all concepts are unambiguously defined *before* you use it. It is *very* frustrating and a total waste of valuable time to try and fathom the meaning of a badly defined concept, even more so when subsequent work is building on it and then by contagion also becomes nebulous.

- Always consider carefully what exactly you are trying to achieve with a certain section or graph. Think of efficient and appropriate ways to show what you have learnt, to reveal your level of understanding. Be inquisitive, when you see something interesting in your results, discuss and try to make sense of it. But always distinguish between fact and opinion.
- Interpret your results. Do not just give a nice picture, but say what is interesting about it. A graph with no interpretation is a "so what?". You do the work - if you only get the results, but do not interpret them - well then you do not get that portion of the the marks (and that's the larger part). I do not want to guess whether you have seen and understood something.
- Some representations work better than others, in some cases graphics are great, at other times tables are better. Don't just generate hordes of stuff, rather first think about what is efficient to communicate a specific concept in a particular situation.
- Then make sure that whatever you have chosen is used properly. For instance, when you include a graph, be clear on what you want to achieve with it. Say it in the caption. Make sure the axes are labelled - it wastes time to infer that from thin air. Make sure that whatever is to be learned from that graph is clearly and *unambiguously* visible on it. Otherwise it is serving no purpose but chewing up trees and wasting valuable time. Instead of it counting for you it is then counting against you (as you might have gathered, I am rather partial to trees). Rethink whether you are communicating your message in an efficient manner. Maybe you should plot something else, or whatever.
- Structure your document decently so that it is clear what is where and what is important. Make it easy to access the important stuff and don't clutter it with useless stuff. The rest of this document focusses on this with many suggestions and hints.

2 Thesis structure

Your thesis is not a flat sequential document to laboriously work through - it should be a hierarchical document. Your first and last chapters are on a higher conceptual level than the ones between them. On reading those two, the important content of the work and the conclusions resulting from it should already be clear. The middle chapters supply the detail.

2.1 Before the first chapter

This mostly is stuff you can sort out very late in your writing up - a lot of it can be generated automatically. Page numbering is lower case roman (e.g.. i, ii, ... iv etc) where-as the rest of the thesis is normal Arabic numbering (1,2, ... 4 etc). There is a standard list of things that go in here, will expand on it during a later rewrite of this document. In the meanwhile, consult one of those "gidse" which you got from the department.
One of these that is important to start with early on in your writing, is the "List of symbols". This helps you to maintain consistent use of a minimal set of symbols throughout the whole document (if S means state in Chapter 2, it should preferably also do that in all other chapters). This assists the reader to build a consistent mental map of what things mean as he/she progresses.
The other useful thing is the table of contents - mostly automatically generated. Probably the third step to complete when writing up your thesis is to fill in all the chapter and paragraph (and maybe sub-paragraph) headings and generate a TOC from it (see lower down for the first and second things to complete). This then gets a lot of eyeball until the thesis structure feels right. For a general idea of chapter layout, read on.

2.2 Chapter 1: Introduction

In your mind you can subtitle this very important chapter as *Executive Summary*. It serves as a high level, *self-contained summary/synopsis* of your work. Typical length is about 10 to 15 pages. A simple test to determine whether this chapter is ready: If you should give *only* this chapter to an examiner, will he be able to award a mark, maybe while also muttering under his breath that he still needs more checking on the finer detail? It should be clear to you by now that this chapter is serious business, not something to skimp on. Typically the following sections are included (these titles are not necessarily the actual ones to use, or even the precise order for them to be in, they just indicate the idea):

2.2.1 Motivation and topicality of this work

Why is this work of importance - why should the reader be interested?

2.2.2 Background

After reading this the concepts necessary to understand the rest of *this chapter* should be in place.

2.2.3 Literature synopsis

As the name says, a synopsis of the most important literature. The stuff that's necessary to put your work in perspective in the next sections. If the extent of the literature allows it, the full/detailed literature study appears in Chapter 2. If your work is novel enough that very little literature is available, it can be fully covered here.

2.2.4 Objectives of this study

Probably one of the most important sections in your whole thesis, and also THE thing to write/right before anything else. Typically very to the point - what were you supposed to accomplish. Note, your goals need not correspond precisely with what they were at the onset of your studies. Rather see it as the goals of this document that you are now writing. This section is very important, your examiner will specifically measure your work against what you say here. That's why you should write it first, then you can make sure that the rest of your thesis finds resonance with it. It is typical to write this as a bulleted list.

2.2.5 Contributions

Also one of the most important sections and the second thing that you should nail down in words. Here you are highlighting specific items in your work that you consider to be great! They should, of course, also satisfy the objectives you have so carefully listed before. By putting it down here you are telling your examiners to focus special attention on these aspects, they are not simply part of the general background noise. This section is also very much to the point - once again make use of a bulleted list.
Note how contributions differ from the objectives: The latter is the goal-posts while contributions lists the interesting stuff that you did to achieve those goals. E.g. evaluating a "such-and-such" technique is an objective, not a contribution. However, if you evaluate the "such-and-such" technique and find that it really "sucks-and-sucks" and that this is due to the presence of a formerly unknown internal black hole, then you're talking about a contribution.

2.2.6 Overview of this work

Give a synopsis of your work. No, I am not talking about a description of what can be found where in the document, I really mean a proper summary (three to five pages long) of your whole thesis. Yes it overlaps with the previous two sections, but this one is less terse and shows how it all fits together. As the discussion progresses, give the sections (with page numbers) where the detail can be found. You *must* discuss the key results and conclusions (use graphs and tables as necessary), and cross-reference to the important tables and figures that it is based on. Don't just rehash the table of contents, you must add some value here! If I can more-or-less get the same information by reading the table of contents, this overview is just a ritualistic farce, a waste of space and time.

2.3 Chapter 2: Literature study

Detailed literature study. Please don't just list them, that is boring. Try to interpret, bring perspective, find trends etc.

2.4 Chapter 3 up to N-3: Theoretical work

The theory you build on and the theory that you create. Can be supplemented with smallish experiments that serves as examples to clarify.

2.5 Chapter N-2: Implementation issues

What were the practical hiccups/aspects and how were they handled. Optimisation etc.

2.6 Chapter N-1: Experimental investigation

The main experiments with a detailed discussion of them. Make sure that for all experiments the following items are clear:

- The motivation for it - what are you trying to show and why?
- The experimental setup and execution - What data and techniques are you using, what are you doing with/to them?
- The results - typically in the form of tables or graphs.
- The interpretation - what did you actually learn from it. Remember about statistical significance tests - if you are comparing techniques and want to come to the conclusion that one is better/different compared to the other, you got to take into account that your test/measurement results also are random variables. Use something like the McNemar test to quantify how sure you are that the improvement is genuine and not simply a fluke. Read the paper by Cox and Hinkley in ICASSP89 for more details.

2.7 Chapter N: Conclusions and Recommendations

On looking back, what are your main conclusions? On a higher level than for instance in the previous chapter. Will overlap slightly with the first chapter, try to change to a different "hindsight" perspective. What should be done by the next research efforts on this topic?
This chapter is often a rather useless read, making one wonder why it is there at all. Yours should not be so! A test for whether this chapter is ready: Does this chapter cap your work with a very high

level summary of what was learned from this study? And will it make sense for your study leader to first give this to some-one doing a follow-up thesis on your work?

2.8 Appendices (numbered A to whatever)

Stuff that is OPTIONAL to read. You don't want to burden your reader with optional material in the main body (Chapters) of your thesis. Rather highlight/summarise the relevant aspects there and put the rest here where it may (optionally) be consulted if the reader so desires. DON'T put stuff here that MUST be read in order to follow the material in the chapters.

3 Chapter internal structure

As already said about the chapters in your thesis, neither is any specific chapter a flat sequential blob. The first section (Introduction) should provide a motivation (the reason) for the chapter, an overview of what is covered (the objective) and how it is approached (the path). From it, it should be clear why somebody should want to read it, how it fits together and what he can expect to find where. The last section (Conclusion) summarises what is learnt from this chapter. Between them they should supply a high level summary of the chapter, pretty much like the first and last chapters do for the thesis. The in-between sections cover the detail.

4 Language, style and general editorial issues

The guiding principle underlying your writing should be to transfer all you valuable knowledge in a clear and easily understood manner. You don't want to distract your reader/examiner with all sorts of niggling little problems, neither do you want him to puzzle over what you actually meant or whether a specific piece of work is correct. Any of these distract him from your flow of your ideas. Generally your marks are inversely proportional to the time he needs to spend to verify or figure your work out. The following is easy to get right - **don't even think of handing in before you have** done justice to them - make sure you don't loose marks that really should have been yours!

4.1 A logical and causal layout

- Carefully design a logical chapter layout according to the above suggestions.
- State things as directly and clearly as possible. Your study-leader and examiners do not like to read between the lines.
- Make absolute sure that all theoretical concepts that a certain section of work depends on, are properly and unambiguously defined and explained *prior* to that section. Similarly, make sure that all symbols, acronyms, terms etc are defined *before* you use them (at a pinch you can get away by defining them *immediately* after their first appearance). It is highly frustrating to read a thesis and encounter a symbol or concept that is undefined. Initially one searches the preceding material to find whether you might have missed it. Failing that you try to deduce/guess its meaning from the rest of the context. All of this takes up a lot of time while causing much annoyance. When you (the reader) then ultimately gives up on the search, you read on with a vague nebulous idea instead of a clear and firm idea of the concept. This makes it more difficult to understand whatever else builds on it, wasting even more time. If, as an examiner, I encounter such a 'mystery' concept and suspects that it is important for

understanding the rest of the thesis, I *will* terminate examining your thesis and insist that you first get your writing up to a decent level.

- When you have just waded through a rather involved algorithm, follow it up by a table with a summary of this algorithm. The level should be such that it is sufficient for an implementation. Make sure that all the preconditions/prerequisites as well as variables are defined *before* each step. (See Simon Haykin's "Adaptive filter theory" book for pleasing examples of this.) Then go back to you prior in-depth discussion of the algorithm and make sure that these aspects also hold true there.

- Do not make wild or unsupported statements. If you want to speculate, say clearly that it is a speculation. Never confuse fact with opinion.

- Use ample references to back up what you are saying.

4.2 Language and style issues

- Use short sentences - seriously, break up your long sentences, try to keep to less than a line and a half per sentence.

- You don't need to use the third person, the "royal we" is more direct. Hunt down sentences containing "will be" and shorten them e.g. "It will be shown that" becomes "We show that" etc.

- Use a British English spelling checker, not American. (You can invoke the British version of ispell on your Latex document with the -d option "ispell ...bla... -d path_to_it/uk-english.hash ...bla...". Look for words containing "ize" (such as optimize), they probably should be "ise" (optimise). Also keep a lookout for "eling" (modeling) which probably should be "elling" (modelling). With the tools that are available spellling erors are close to unforgivuble.

- Don't use sloppy language (like stuff etc) as I do in this document. It also is very much worth your while to pay a professional person to sort out your language. But this is only a sensible investment after the logical coherence of your thesis is pretty much sorted out.

- Always be polite, even if somebody else's work peeves you somewhat (the art of diplomacy). You do not know whether this person might be appointed as an examiner!

- Pleeeezzzz! Use "number" when you can count it, as in number of states. "Amount" is for generally uncountable stuff, such as time, money, sand etc. (yes, i know, that is why we print notes).

- Check that your tenses, singular plural, the use of which and that, and that sort of stuff is ok. Even better, use somebody professional to do it, especially if you are not writing in your mother-tongue.

4.3 Maths and equations

- Make sure whatever you are saying is correct. Does the stuff on the left-hand side have the same units/dimensions as what is on the right-hand side. Are they really equal? Bad news if they're not!

- Before you define a new symbol, make sure that there isn't an existing one that will do the trick. Prefer a minimal but consistently used set of symbols - a plethora of inconsistent and duplicated symbols simply creates a muddle in the puddle.
- Punctuate your equations. Yep, they are also part of sentences and should have commas or full stops or the like as needed.
- Since your examiner will need to confirm its correctness, supply the intermediate steps when you do a non-standard derivation. If you use the "*it can easily be shown that*" stunt, he will have to resort to pen and paper to figure it out. In this way you are wasting his valuable time - he will reward you for this somehow!
- If it is a well-known and pretty standard derivation, and you have no secondary reason to include it, rather just give the result (properly referenced of course).
- Make sure your equations are properly numbered - go and consult any IEEE journal if you want to know how.

4.4 Graphs and tables

- The captions for graphs and tables should be complete enough that the reader can understand them on their own (that is, without referring to the main text). It should not only include the "what" of the figure/table, but also the "why". Say what you want the reader to notice there. There is nothing wrong in using 2-4 lines in your caption, often when people start using your thesis as a reference, they will want to make sense of these items without reading the main text. Also remember to punctuate your captions.
- The axes of all graphs should have units on them.
- If more than one graph appear on the same set of axes, they should be clearly distinguishable and identified in a legend (or some other way).
- If at all possible, never put a table or figure in the text before your first reference to it, and neither further away than the very next page.
- Make sure your figures and tables are properly numbered - go and consult any IEEE journal if you want to know how.

4.5 Physical layout and general remarks

- Use one-and-a-half line spacing - your study-leader and examiners do like to be able to write between the lines.
- Chapters (and Parts) start on new pages, smaller units don't.
- Have a look at `www.cl.cam.ac.uk/~mgk25/publ-tips.html` for some other useful tips.

Bottom line: if you've got good material, and you are nice to your examiner, he will also be nice to you.

Johan du Preez