Master Thesis

Title of Your Master Thesis

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Submitted to
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Abstract

Your thesis must contain an abstract. A good reference for thesis writing is Zobel (2014); we highly recommend that you study this or a similar book during your studies. He writes the following about the abstract:

> An abstract is typically a single paragraph of about 50 to 200 words. The function of an abstract is to allow readers to judge whether or not the paper is of relevance to them. It should therefore be a concise summary of the paper's aims, scope, and conclusions. There is no space for unnecessary text; an abstract should be kept to as few words as possible while remaining clear and informative. Irrelevancies, such as minor details or a description of the structure of the paper, are inappropriate, as are acronyms, abbreviations, and mathematics. Sentences such as "We review relevant literature" should be omitted.
>
> The more specific an abstract is, the more interesting it is likely to be. Instead of writing "space requirements can be significantly reduced", write "space requirements can be reduced by 60%". Instead of writing "we have a new inversion algorithm", write "we have a new inversion algorithm, based on moveto-front lists".
>
> Many scientists browse research papers outside their area of expertise. You should not assume that all likely readers will be specialists in the topic of their paper-abstracts should be self-contained and written for as broad a readership as possible. Only in rare circumstances should an abstract cite another paper (for example, when one paper consists entirely of analysis of results in another), in which case the reference should be given in full, not as a citation to the bibliography. (Zobel 2004)

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1. Introduction

The structure of this example thesis is *non-binding*, but is highly topic-dependent and should be discussed with your advisor. You probably do not want to go below the level of subsections, though.

To cite, do it in one of the following ways:

- A single paper in text: As shown by Doe (2024), X holds.
- Same with additional information: As shown by Doe (2024, p. 20), X holds.
- A single paper in parenthesis: X holds (Doe 2024).
- Multiple papers in parenthesis: X holds (Brown 2022; Smith and Johnson 2023; Lee and Green 2023; Doe 2024).
- Use footnotes to reference a website, such as the DWS thesis guidelines.[1] Note that footnote marks are set after punctuation in English text. Only reference a website when needed—e.g., the website of a library or a blog post—and always cite corresponding scientific publications (if any) in addition.

Format the bibliography consistently, e.g., as in the the example bibliography in this template. Only cite archival versions of papers (such as those published on arXiv) when there are no corresponding official publications (such as in conference proceedings); if there are such publications, then cite those instead.

Some examples of references are:

1. Table 5.1 is an example table.
2. Section 2.1 is a later section of this thesis.
3. Algorithm 4.1 is an example algorithm.
4. And finally, Equation (1.1) is an example equation.

Here is the equation referred to above:

$$\mathcal{S} = \{\, a \cdot \mathrm{relu}(\mathbf{W}^\top \mathbf{x}) : a \in \mathbb{R} \,\} \tag{1.1}$$

Important: Fill out and sign the last page when you submit/deliver the final version of your thesis. Otherwise, your work cannot be accepted for legal reasons.

The purpose of the introduction as summarized by Zobel (2004):

[1] https://www.uni-mannheim.de/dws/teaching/thesis-guidelines/

An introduction can be regarded as an expanded version of the abstract. It should describe the paper's topic, the problem being studied, references to key papers, the approach to the solution, the scope and limitations of the solution, and the outcomes. There needs to be enough detail to allow readers to decide whether or not they need to read further. It should include motivation: the introduction should explain why the problem is interesting, what the relevant scientific issues are, and why the solution is a good one.

That is, the introduction should show that the paper is worth reading and it should allow the reader to understand your perspective, so that the reader and you can proceed on a basis of common understanding.

Many introductions follow a five-element organization:

1. A general statement introducing the broad research area of the particular topic being investigated.
2. An explanation of the specific problem (difficulty, obstacle, challenge) to be solved.
3. A brief review of existing or standard solutions to this problem and their limitations.
4. An outline of the proposed new solution.
5. A summary of how the solution was evaluated and what the outcomes of the evaluation were.

An interesting exercise is to read other papers, analyze their introductions to see if they have this form, and then decide whether they are effective. The introduction can discuss the importance or ramifications of the conclusions but should omit supporting evidence, which the interested reader can find in the body of the paper. Relevant literature can be cited in the introduction, but unnecessary jargon, complex mathematics, and in-depth discussion of the literature belong elsewhere.

A paper isn't a story in which results are kept secret until a surprise ending. The introduction should clearly tell the reader what in the paper is new and what the outcomes are. There may still be a little suspense: revealing what the results are does not necessarily reveal how they were achieved. If, however, the existence of results is concealed until later on, the reader might assume there are no results and discard the paper as worthless. (Zobel 2004)

2. Literature Review

Zobel (2004) writes:

> Few results or experiments are entirely new. Most often they are extensions of or corrections to previous research-that is, most results are an incremental addition to existing knowledge. A literature review, or survey, is used to compare the new results to similar previously published results, to describe existing knowledge, and to explain how it is extended by the new results. A survey can also help a reader who is not expert in the field to understand the paper and may point to standard references such as texts or survey articles.
>
> In an ideal paper, the literature review is as interesting and thorough as the description of the paper's contribution. There is great value for the reader in a precise analysis of previous work that explains, for example, how existing methods differ from one another and what their respective strengths and weaknesses are. Such a review also creates a specific expectation of what the contribution of the paper should be-it shapes what the readers expect of your work, and thus shapes how they will respond to your ideas.
>
> The literature review can be early in a paper, to describe the context of the work, and might in that case be part of the introduction; or the literature review can follow or be part of the main body, at which point a detailed comparison between the old and the new can be made. If the literature review is late in a paper, it is easier to present the surveyed results in a consistent terminology, even when the cited papers have differing nomenclature and notation. In many papers the literature review material is not gathered into a single section, but is discussed where it is used-background material in the introduction, analysis of other researchers' work as new results are introduced, and so on. This approach can help you to write the paper as a flowing narrative.
>
> An issue that is difficult in some research is the relationship between new scientific results and proprietary commercial technology. It often is the case that scientists investigate problems that appear to be solved or addressed in commercial products. For example, there is ongoing academic research into methods for information retrieval despite the success of the search engines deployed on the web. From the perspective of high research principle, the existence of a commercial product is irrelevant: the ideas are not in the public domain, it is not known how the problems were solved in the product, and the researcher's contribution is valid. However, it may well be reckless

> to ignore the product; it should be cited and discussed, while noting, for example, that the methods and effectiveness of the commercial solution are unknown. (Zobel 2004)

An example structure for the literature review is given below; as before, this structure is non-binding and should be changed as appropriate.

2.1. Preliminaries

2.2. Related Work on A

2.3. Related Work on B

2.4. Related Work on C

2.5. Summary

3. Body Chapter 1

Zobel (2004) writes:

> The body of a paper should present the results. The presentation should provide necessary background and terminology, explain the chain of reasoning that leads to the conclusions, provide the details of central proofs, summarize any experimental outcomes, and state in detail the conclusions outlined in the introduction. Descriptions of experiments should permit reproduction and verification, as discussed in Chapter 11. There should also be careful definitions of the hypothesis and major concepts, even those described informally in the introduction. The structure should be evident in the section headings. Since the body can be long, narrative flow and a clear logical structure are essential.
>
> The body should be reasonably independent of other papers. If, to understand your paper, the reader must find specialized literature such as your earlier papers or an obscure paper by your advisor, then its audience will be limited.
>
> In some disciplines, research papers have highly standardized structures. Editors may require, for example, that you use only the four headings Introduction-Methods-Results-Discussion. This convention has not taken hold in computer science, and in some cases such a structure impedes a clear explanation of the work. For example, use of fixed headings may prohibit development of a complex explanation in stages. In work combining two query resolution techniques, we had to determine how they would interact, based on a fresh evaluation of how they behaved independently. The final structure was, in effect, Introduction-Background-Methods-Results-Discussion-Methods-ResultsDiscussion.
>
> Even if the standardized section names are not used, the body needs these elements, if not necessarily under their standard headings. Components of the body might include, among other things, background, previous work, proposals, experimental design, analysis, results, and discussion. Specific research projects suggest specific headings. For the "compression for fast external sorting" project sketched earlier, the complete set of section headings might be:
>
> 1. Introduction
> 2. External sorting

3. Compression techniques for database systems
4. Sorting with compression
5. Experimental setup
6. Results and discussion
7. Conclusions

The wording of these headings does not follow the standard form, but the intent of the wording is the same. Sections 2 and 3 are the background; Section 4 contains novel algorithms, and Sections 4 and 5 together are the methods.

The background material can be entirely separate from the discussion of previous work on the same problem. The former is the knowledge the reader needs to understand your contribution. The latter is, often, alternative solutions that are superseded by your work. Together, the discussion of background and previous work also introduce the state of the art and its failings, the importance and circumstances of the research question, and benchmarks or baselines that the new work should be compared to.

A body that consists of descriptions of algorithms followed by a dump of experimental results is not sound science. In such a paper, the context of prior work is not explained, as readers are left to draw their own inferences about what the results mean.

In a thesis, each chapter has structure, including an introduction and a summary or conclusions. This structure varies with the chapter's purpose. A background chapter may gather a variety of topics necessary to understanding of the contribution of the thesis, for example, whereas a chapter on a new algorithm may have a simple linear organization in which the parts of the algorithm are presented in tum. However, the introduction and summary should help to link the thesis together-how the chapter builds on previous chapters and how subsequent chapters make use of it. (Zobel 2004)

4. Body Chapter 2

Our key result is given as Algorithm 4.1. It's complete non-sense, of course! Note that algorithms, figures, and tables should generally be placed at the top of the page or on an individual page, but not within the main text.

The following highly informative text is here so that the correct placement of Algorithm 4.1 is visible. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis. Curabitur dictum gravida mauris. Nam arcu libero, nonummy eget, consectetuer id, vulputate a, magna. Donec vehicula augue eu neque. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Mauris ut leo. Cras viverra metus rhoncus sem. Nulla et lectus vestibulum urna fringilla ultrices. Phasellus eu tellus sit amet tortor gravida placerat. Integer sapien est, iaculis in, pretium quis, viverra ac, nunc. Praesent eget sem vel leo ultrices bibendum. Aenean faucibus. Morbi dolor nulla, malesuada eu, pulvinar at, mollis ac, nulla. Curabitur auctor semper nulla. Donec varius orci eget risus. Duis nibh mi, congue eu, accumsan eleifend, sagittis quis, diam. Duis eget orci sit amet orci dignissim rutrum.

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Algorithm 4.1 Proof that X Holds

Require: A hypothesis H that X holds
Ensure: A proof that X holds

```
P ← ∅                                   // Initialize proof as an empty set of statements
A ← Assumptions from hypothesis H       // Extract assumptions from H
for all a ∈ A do
    if a is a known axiom then
        Add a to P
    else if a can be derived from known axioms then
        Derive a from axioms and add to P
    else
        fail                            // If any assumption cannot be derived, proof fails
    end if
end for
Use logical deductions on P to prove intermediate results
Combine intermediate results to prove X
return P                                // Return the completed proof
```

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5. Experimental Evaluation

5.1. Experimental Setup

5.2. Results 1

5.3. Results 2

5.4. Results 3

5.5. Discussion

Item	Quantity	Price
Apples	10	$2.00
Oranges	5	$3.00
Bananas	7	$1.50

Table 5.1.: Sample table using booktabs

6. Conclusions

Zobel (2004) writes:

> The closing section, or summary, is used to draw together the topics discussed in the paper. It should include a concise statement of the paper's important results and an explanation of their significance. This is an appropriate place to state (or restate) any limitations of the work: shortcomings in the experiments, problems that the theory does not address, and so on.
>
> The conclusions are an appropriate place for a scientist to look beyond the current context to other problems that were not addressed, to questions that were not answered, to variations that could be explored. They may include speculation, such as discussion of possible consequences of the results.
>
> A *conclusion* is that which concludes, or the end. *Conclusions* are the inferences drawn from a collection of information. Write "Conclusions", not "Conclusion". If you have no conclusions to draw, write "Summary". (Zobel 2004)

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A. Additional Experimental Results

Zobel (2004) writes:

> Some papers have appendices giving detail of proofs or experimental results, and, where appropriate, material such as listings of computer programs. The purpose of an appendix is to hold bulky material that would otherwise interfere with the narrative flow of the paper, or material that even interested readers do not need to refer to. Appendices are rarely necessary. (Zobel 2004)

In the context of a BSc or MSc thesis, the last sentence often does not hold.

B. Proof Details

Ehrenwörtliche Erklärung

Ich versichere, dass ich die beiliegende Bachelor-, Master-, Seminar-, oder Projektarbeit ohne Hilfe Dritter und ohne Benutzung anderer als der angegebenen Quellen und in der untenstehenden Tabelle angegebenen Hilfsmittel angefertigt und die den benutzten Quellen wörtlich oder inhaltlich entnommenen Stellen als solche kenntlich gemacht habe. Alle KI-unterstützten Inhalte wurden von mir geprüft. Für den Inhalt der Arbeit übernehme ich die volle Verantwortung und bin in der Lage, ihn auf Nachfrage zu erläutern. Diese Arbeit hat in gleicher oder ähnlicher Form noch keiner Prüfungsbehörde vorgelegen. Ich bin mir bewusst, dass eine falsche Erklärung rechtliche Folgen haben wird.

Declaration of Used AI Tools

AI Tool	Purpose	Where?	Useful?
ChatGPT	Rephrasing	Throughout	+
DeepL	Translation	Throughout	+
ResearchGPT	Summarization of related work	Sec. 2.2	-
Dall-E	Image generation	Figs. 2, 3	++
GPT-4	Code generation	functions.py	+
ChatGPT	Related work hallucination	Most of bibliography	++

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