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- with an Optional Subtitle

En himla bra svensk titel

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Abstract

The abstract resides in file `Abstract.tex`. Here you should write a short summary of your work.

Acknowledgments

Acknowledgments.tex

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1 Introduction

This thesis template is intended as an alternative to the standard LiU Latex template¹. Most of the content is kept from the original template, but some additions and changes have been made. Where the original template follows the IMRaD model², this template is more tailored towards computer science subjects at large and in particular topics where some kind of software prototype is developed. Based on the analysis by Posteguillo [1] on the structure of research papers in computer science, this template does not prescribe a fixed set of chapter headings. Rather, it tries to balance between providing a basic structure that facilitates the writing process and freedom to adapt to different sorts of research output.

The introduction can be divided into these sections:

1.1 Motivation

This is where the studied problem is described from a general point of view and put in a context which makes it clear that it is interesting and well worth studying. The aim is to make the reader interested in the work and create an urge to continue reading.

Basic points to cover:

- What is the background for this problem?
- Why is it interesting/important to study this?
- What are the challenges? Why is it hard?
- What does the existing literature say about this problem? What is already known?
- What are the knowledge gaps?

1.2 Aim

What is the underlying purpose of the thesis project?

¹<https://gitlab.liu.se/olale55/liuthesis>

²<https://en.wikipedia.org/wiki/IMRAD>

1.3 Research questions

This is where the research questions are described. Formulate these as explicit questions, terminated with a question mark. A report will usually contain several different research questions that are somehow thematically connected. There are usually 2-4 questions in total.

Examples of common types of research questions (simplified and generalized):

1. How does technique X affect the possibility of achieving the effect Y?
2. How can a system (or a solution) for X be realized so that the effect Y is achieved?
3. What are the alternatives to achieving X, and which alternative gives the best effect considering Y and Z? (This research question is normally broken down in to 2 separate questions.)

Observe that a very specific research question almost always leads to a better thesis report than a general research question (it is simply much more difficult to make something good from a general research question.)

The best way to achieve a really good and specific research question is to conduct a thorough literature review and get familiarized with related research and practice. This leads to ideas and terminology which allows one to express oneself with precision and also have something valuable to say in the discussion chapter. And once a detailed research question has been specified, it is much easier to establish a suitable method and thus carry out the actual thesis work much faster than when starting with a fairly general research question. In the end, it usually pays off to spend some extra time in the beginning working on the literature review. The thesis supervisor can be of assistance in deciding when the research question is sufficiently specific and well-grounded in related research.

1.4 Approach

Give a short (maximum 1/2 page) overview of the methodology used to answer the research questions. It should be written in present tense (happening now), and should not sound like a diary. Basic points to cover:

- What kind of research methods are used?
- If a prototype is constructed, what is the purpose of the prototype, how can it be used, what are its limitations?
- What basic assumptions/delimitations are used.
- If an evaluation is made, what are the aspects that will be evaluated? What metrics are used?

1.5 Contributions

Summarize the main strengths of your thesis by listing the main contributions. This should preferably be in the form of a bullet list. Examples of contributions can be:

- A new algorithm/tool/prototype with some advantage/benefit/improvement over existing artifacts. If this is brought as a contribution, it should be made open source or at least accessible to the surrounding (research) community.
- New insights/knowledge/results about the topic which is investigated. Be specific.
- New methods for analyzing/creating/modelling.
- Evaluation of some system/software/artifact



2 Background and Related Work

The main purpose of this chapter is to make it obvious for the reader that the report authors have made an effort to read up on related research and other information of relevance for the research questions. It is a question of trust. Can I as a reader rely on what the authors are saying? If it is obvious that the authors know the topic area well and clearly present their lessons learned, it raises the perceived quality of the entire report.

After having read the theory chapter it shall be obvious for the reader that the research questions are both well formulated and relevant.

The chapter must contain theory of use for the intended study, both in terms of technique and method. If a final thesis project is about the development of a new search engine for a certain application domain, the theory must bring up related work on search algorithms and related techniques, but also methods for evaluating search engines, including performance measures such as precision, accuracy and recall.

It is recommended to have two sections in this chapter, *Background* and *Related work*. The background section should contain information about methods, tools and techniques used in your work. The related work section should summarize scientific research that is in some way related or similar.

2.1 Background

This section should be fairly concise and describe what the reader needs to know to understand the rest of the thesis and provide the context. It should not be a full tutorial describing the whole field, but rather point to places where the reader can learn more and focus on specific aspects.

While tools, frameworks, programming languages and libraries can be briefly introduced here, the main focus should be on methodological background. What is the scientific basis for this work?

2.2 Related work

This section should summarize scientific literature (including other bachelor/master theses) that investigate related topics. It is not acceptable to argue that there are no such related works. Instead, include the most similar ones that can be found.

The section shall be structured thematically, not per author. A good approach to making a review of scientific literature is to use *Google Scholar*, as well as services provided by the library. The bibliography sources (bibtex) should always be collected from the publisher, not from Google, Citeseer, or Researchgate.

Having found a relevant article one can use the function for viewing other articles that have cited this particular article, and also go through the article's own reference list. Among these articles one can often find other interesting articles and thus proceed further.

It can also be a good idea to consider which sources seem most relevant for the problem area at hand. Are there any special conference or journal that often occurs one can search in more detail in lists of published articles from these venues in particular. One can also search for the web sites of important authors and investigate what they have published in general.

A decorative graphic consisting of several vertical lines of varying heights and thicknesses, positioned to the left of the chapter title.

3

System Model / Design Choices / Prestudy / Requirement Analysis

Often some sort of initial investigation is made at the startup phase of a thesis project, which can be summarised as the first chapter where the student's own contribution is described. Some typical examples of such chapters are as follows.

- System Model - If the work is theoretical this chapter can be used to introduce definitions, notation, assumptions that form the basis of the rest of the work.
- Design Choices - If the work is focused on the creation of a new software prototype or similar, then this chapter can be used to systematically describe the design choices made. Note that this is not just about motivating why a certain choice is made, but rather to present alternatives (each with their pros and cons) and then to describe the choice made. In some cases the choice is made after some initial experiments/simulation in which case it can either come here or later in an evaluation chapter.
- Prestudy - If the work starts with interviews, or a more extensive literature review, this chapter can present the method and result of that prestudy.
- Requirement Analysis - In some cases, gathering and analyzing requirements is a major part of the investigation and deserves its own chapter. However, do take care not to confuse your thesis with software engineering documentation. A MSc/BSc thesis should focus on scientific aspects and the new insights and knowledge that can be learned from your work.

Feel free to use a name that describes your initial investigation other than the generic names given above.



4 Design of ...

If a prototype system has been developed, this needs to be described here. Replace “...” in the title with the name of your system or something descriptive. Some hints for writing this chapter:

- Use figures!
- Figures should either be drawn by you, or carefully cited in the caption.
- Figures should always be referenced in the text, and explained in the text what they represent/contain.
- You should start with a structural overview of your prototype/system.
- Show clearly what parts you have created, and which parts that were already existing when you started. Remember that assembling existing components can also be a contribution.
- Avoid programming code and strangely-sounding variable/function names.
- You are free to call a module something else than what it is called in the source code.
- Always have the reader in mind when writing. Be pedagogic.



5 Evaluation

Assuming that some kind of prototype/artifact/system/component has been developed/adapted/changed/implemented this should typically be evaluated. This chapter then becomes a “mini”-version of the IMRaD model. The structure below is just one example of how one can structure this kind of chapter. It must be adapted to the kind of evaluation that is being done.

5.1 Evaluation method

Describe the method used in the evaluation. Be detailed and specific. Use tables to summarise parameters used if you are running simulations. Describe what experiments that are conducted, and their purpose. Explain the metrics used, and motivate their choice.

5.2 Results

Show the results of your evaluation. Explain to the reader what the results show.

5.3 Summary of results

It is often useful to provide some kind of summary of the results, especially if there are many graphs and tables.



6 Discussion

This chapter contains the following sub-headings.

6.1 Results

Are there anything in the results that stand out and need be analyzed and commented on? How do the results relate to the material covered in the theory chapter? What does the theory imply about the meaning of the results? For example, what does it mean that a certain system got a certain numeric value in a usability evaluation; how good or bad is it? Is there something in the results that is unexpected based on the literature review, or is everything as one would theoretically expect?

6.2 Method

This is where the applied method is discussed and criticized. Taking a self-critical stance to the method used is an important part of the scientific approach.

A study is rarely perfect. There are almost always things one could have done differently if the study could be repeated or with extra resources. Go through the most important limitations with your method and discuss potential consequences for the results. Connect back to the method theory presented in the theory chapter. Refer explicitly to relevant sources.

The discussion shall also demonstrate an awareness of methodological concepts such as replicability, reliability, and validity. Replicability means that someone reading a scientific report should be able to follow the method description and then carry out the same study and check whether the results obtained are similar. Reliability is a term for whether one can expect to get the same results if a study is repeated with the same method. A study with a high degree of reliability has a large probability of leading to similar results if repeated. The concept of validity is, somewhat simplified, concerned with whether a performed measurement actually measures what one thinks is being measured. A study with a high degree of validity thus has a high level of credibility. A discussion of these concepts must be transferred to the actual context of the study.

The method discussion shall also contain a paragraph of source criticism. This is where the authors' point of view on the use and selection of sources is described.

6.3 The work in a wider context

There must be a section discussing ethical and societal aspects related to the work. This is important for the authors to demonstrate a professional maturity and also for achieving the education goals. If the work, for some reason, completely lacks a connection to ethical or societal aspects this must be explicitly stated and justified in the section Delimitations in the introduction chapter.

In the discussion chapter, one must explicitly refer to sources relevant to the discussion.

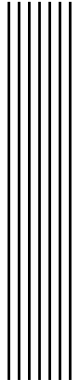


7

Conclusion

This chapter contains a summarization of the purpose and the research questions. To what extent has the aim been achieved, and what are the answers to the research questions?

The consequences for the target audience (and possibly for researchers and practitioners) must also be described. There should be a section on future work where ideas for continued work are described. If the conclusion chapter contains such a section, the ideas described therein must be concrete and well thought through.



Bibliography

- [1] Santiago Posteguillo. "The Schematic Structure of Computer Science Research Articles". In: *English for Specific Purposes* 18.2 (1999), pp. 139–160. ISSN: 0889-4906. DOI: 10.1016/S0889-4906(98)00001-5.