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Theses at the Chair of Simulation
- requirements & tips -

Introduction

There are a number of typical difficulties and mistakes when designing thesis documents (Bachelor's thesis, Master's thesis). To help students, this document details some common mistakes. The information listed here can also be used as a guideline for the preparation of project reports (individual scientific projects and team-projects) at the Chair of Simulation.

Expectations and requirements for theses differ greatly; both from subject to subject and among university teachers in the same discipline. The comments and recommendations presented in this document apply only to theses written at the Chair of Simulation; they apply only conditionally (if at all) to other institutions. It is always advisable for students to familiarize themselves with the individual expectations of their own supervisor.

Contents

Structure and scope of the paper

Typical first outline

The first step when writing a paper is to create an outline. It helps to organize your thoughts and provides an overview of topics and contents. Usually this is also the basis for a discussion with the supervisor.
Often, these first outlines are not structured in an optimal way:

1 Introduction (2 pages)
2 Basics (15 pages)
  2.1 Basics
  2.2 More basics
  2.3 Even more basics
3 Own contribution
  3.1 Introduction

3.2 Algorithm
3.2.1 Lots of details
3.2.2 More details
3.2.3 Even more details
4 Implementation (20 pages)
4.1 Lots of details
4.2 more details
4.3 even more details
4.3.1 details about details
4.3.2 details about details
4.3.3 details about details
5 Experiments (5 pages)
6 Conclusion (2 pages)

The difference in scope and the amount of details given, clearly shows what is important to the student. The distribution shown here is inappropriate. Both introduction and conclusion are way too short with two pages each and no subheading, while the more technical chapters 3 and 4 are disproportionally larger and deeper (12 to 20 pages).

The huge differences in depth are not recommended. A better balance of structuring depth, such as 2 levels per chapter, is recommended. Since there are no subheadings in chapter 1, 5 and 6 they are probably not thought through very well. Especially the lack of structure in chapter 5 suggests, that the student has not expectations yet regarding their work yet, not any goals it needs to fulfill. Their work would just randomly go into any direction.

This distribution shows a very common problem of theses: Too much the attention is given to the technical details, leaving no room for explanations and comments. Introduction and conclusion are virtually nonexistent while chapter 4 is filled to the brim.
Unfortunately, those details are the least important part of the thesis. They should focus solely on your own contribution or innovation. Compared to other chapters, they are rather easy to write and don't require much planning.

The reason for this false kind of distribution is easy to find: During your thesis, you will spend months on details, programming, statistics and difficult problems. Since that takes a lot of time and effort, it will be at the forefront of your experience, and therefore reflected in the way the thesis is written. It is important to take a step back and look at your work from a distance as if you were an outside viewer. Try imagining yourself as a reader of the paper, a client interested in the results, or a colleague who would like to take a similar approach to a related problem. Or your supervisor having to judge you on your abilities and performance.

A more suitable structure could look like this:

0 Abstract (1 page)
1 Introduction (8 pages)
1.1 Background
1.2 Motivation
1.3 Goals
1.4 Tasks and framework
2 Requirements (8 pages)
2.1 Needed basics I
2.2 Needed basics II
2.3 Needed basics III
3 Own innovation (8 pages)
3.1 Goals
3.2 Description
3.3 Discussion

4 Implementation (8 pages)
- 4.1 Assumptions and decisions
- 4.2 Implementation details
- 4.3 Effects

5 Verification by experiments (12 pages)
- 5.1 Expectations and goals
- 5.2 Examination of attribute 1
- 5.3 Examination of attribute 2
- 5.4 Examination of attribute 3

6 Conclusions (6 pages)
- 6.1 Summary of results
- 6.2 Interpretation of results compared to expectations and goals
- 6.3 Limitations
- 6.4 Possible expansion
- 6.5 Utility, Use

Appendix

This example has a more balanced structure regarding the chapters' length and depth. Motivation, goals and comments are given the appropriate space. For the experiments, it is clear which attributes are tested. Details that seem necessary but don't fit the flow of argument are moved to the appendix.

From a tactical standpoint you should keep in mind that you can make mistakes in the technical chapter, but it is rather hard to gain extra points. The technical sections have to be complete and correct but due to their rather standard structure, the author has little chance shine.
In the chapters detailing motivation, context and utility of the project, you can show your linguistic and explanatory expertise as well as show how well the subject is understood. You can show your professional knowledge in the technical chapter and your maturity in the others.

On the following pages you can find a typical thesis structure, which corresponds to the standard structure of a scientific paper. This is only an example structure and variations are not uncommon. As already stated, the structure heavily depends on the contents of the paper - so the content should always infer the structure, not the other way around.
Students tend to give the wrong weight to the chapters. In the upcoming examples they would likely put too many details into chapters 2 and 3, while lacking in chapters 1, 4 and 5.

0. Abstract

Every thesis should start with an abstract to provide an overview for the reader about motivation and goals as well as the most important content. Just from the abstract the reader has to be able to determine how to classify the paper, the motivation behind it and what the main results are. It has to be understandable without reading any other part of the paper. This is why no claims are to be made and no technical terms or abbreviations should be introduced. There should also be no discussion. The abstract shouldn't be longer than one page.
Take a look at a longer article in a good newspaper or magazine for reference. The first paragraph usually acts as an abstract. Six lines in, the reader should know what the article is about and if they want to continue reading.

1. Introduction

The first chapter is setting the stage for the rest of the thesis. It explains the research area of the thesis, what motivated it and which goals it has. The first chapter should be understandable for any reader with basic knowledge in computer science and simulation. Students tend to underestimate the importance of this first chapter.

1.1 Background

The background of the thesis should explain what research filed the thesis belongs to. It helps the reader to categorizing it. No goals or own contributions are mentioned here.

1.2 Motivation

This section should explain why research on this topic was necessary, describing pending questions or problems. It should explain why dealing with this is useful.

1.3 Goals

This is a central point of the thesis. Goals should be objectively measurable final states so that you can determine the amount of success you had. The rest of the thesis is based on these goals:
Your own contribution (chapter 3) explains the steps you took to reach these goals.
The experiments (chapter 4) check if you were able to reach them.
The last chapter discusses your success in reaching your goals.
Since goals are important, the reviewers will judge the thesis based on them.

Phrasing proper goals is difficult! Some common mistakes are:
Tasks are mistaken for goals (like "implementing an algorithm for X"). A thesis is meant to show maturity, answering scientific questions and evaluating the results independently.
Just completing tasks is not sufficient. It would be trivial to just complete tasks given by others. Success would be possible without much input or reflection by the student, just by finishing the list. Rule of thumb to show the difference: A task is something that **has to be done** while a goal describes a **final state** that will be achieved if your actions were successful.
Choosing unobtainable goals: "Finding the optimal solution for X". Here you would need to prove that a solution was optimal by testing all other options.
Trivial goals: "Providing a model for X". As long as there are no expectations regarding the quality of this model, it is trivial to reach. Providing a model for two cars crashing into each other for example could be simulated by having two balls bounce against each other, yet this would neither be helpful for the client nor scientifically relevant.

1.4 Tasks and framework

Figuring out the tasks to be completed in order to reach the goals stated prior, helps the student knowing which steps to take. It also helps the reader understanding how the thesis was approached. Tasks always have to contribute something, not just waste time and space since the success of the paper is not measured in tasks but in goals. Obvious tasks like learning a programming language or writing the paper do not have to be stated here.
The framework of the paper on the other hand often discusses restrictions that have to be minded in reaching the goals. Often, they are given by the client and are not negotiable (like the programming language or the amount of memory usable or even conditions the algorithm has to be able to deal with). They may influence the scope of the goals, for example “the algorithm may only have to deal with data of type X”. the framework has to provide reasons for these restriction (Why does the client want this language?) but they don't have to be justified (Is that a sensible decision by the client?).

2. Basics

This chapter presents the basics for the own contribution. This can include for example:
basic knowledge about the research area that will be needed; specialized basics the own work is built upon, including both existing solutions and other concepts necessary to reach the goals set

Students tend to write lots of general information in this section, often never to be used again. Some general hints:
Topics detailed in textbooks shouldn't be repeated unless they are necessary to define the problem or solution. Only include the information that will be needed to understand the motivation or solution.
Including a lot of unnecessary background will not impact your grade positively. On the contrary, not being able to restrict yourself to only necessary background, gives the impression that the author didn't understand the subject well enough.
The company history of your client as well as physical processes underlying the system to be simulated are rarely relevant.

3. What's new

This chapter deals with your own contribution. You need to show where your own innovation lies. Again, it is necessary to focus on the essentials. Code snippets are in most cases unnecessary. This chapter deals with the part that took the most time in the thesis project, both mental and temporal. That often leads to putting a too large emphasis on details and problems encountered throughout the thesis project. For the thesis, thesis struggles are usually irrelevant.

Students tend to mistake this chapter for a project report. You are not supposed to document your day to day work. Instead, you should describe which logical steps you took to solve your problems - not every wrong turn you took or dead end you found, unless they contributed insights to the overall project.

Many projects at the Chair for Simulation are experimental in nature. New algorithms and ideas are tested. They are supposed to have some specific properties or advantages that you need to discuss here, which stem from the thesis goals. For example:
- attributes of the new concept
- what factors influence the behavior
- how to evaluate quality and usefulness

4. Experiments

This chapter explains how you tried to verify your work (your algorithm, theory or program). To do so, you defined your expectations and quality criteria in chapter 3. Now you test them. For every attribute you want to test, you should...
- define an appropriate experiment
- describe it and carry it out
- present and comment on the results

Remember that in scientific work measurability and repeatability are required. The reader needs to know everything to repeat your experiments and reproduce your results.

5. Conclusion

This last chapter has three main parts: Summary, outlook and Evaluation. Like the first chapter it has to be understandable by a reader that only read chapter one.

As the name suggests, the summary sums up all the relevant points the thesis contains. Usually it is much like chapter 0 but more detailed. The outlook describes...
- how to use the results
- what questions were not answered
- new questions that came up

It looks into the future and broadens the context of the paper.

The most important part of the chapter is the evaluation of your work. It may even be the most important part of the whole thesis. A reader not caring about details, who only read chapter one and the evaluation, has to know everything of importance. You have to prove that you...
- understood the problem or task and its importance
- know how to interpret the results correctly in this context
- know what was important throughout the thesis

While chapters 2,3 and 4 are technical in nature and don't have much room for creativity, this chapter gives you a chance to show your ability as a writer.

Rough Draft

One of the best recommendations for writing a thesis is the rough draft version. It doesn't only contain the chapters and headlines, but also all thoughts (as bullet points) that should make it into the text. The bullets should be detailed enough, so that for the full text version they only need to be turned into full sentences, without further mental effort. A complete draft version is about half as long as the final paper.
This intermediate writing step has some important advantages.

- You can write down all your thoughts and concepts together, making work more efficient by taking them off your mind.
- You don't have to concentrate on content and good writing style at the same time.
- It helps you achieve a useful structure, and is easily edited if needed using copy and paste, while changes in the final text would be more work due to embedding in the surrounding sections.
- You can clearly see the argument of the thesis. Gaps and unnecessary parts will become obvious. You can remove useless content efficiently, before investing effort in writing it out.
- It helps in writing the full text version of the thesis.

To aid you in writing a rough draft version, we can provide you with some well written examples. They were written alumni of our chair and can be sent to you upon email request.

Common mistakes when writing a thesis

1. Typical mistakes concerning the contents and arguments

Here is a "Top Ten" of problems we see a lot.

#1 Dead ends: The text contains information that is never needed again. They don't help with the argument and are not referenced again. So they are dead ends. They tend to appear in the basics-chapter together with problem #2.

#2 Useless basics: The basics contain information that is essentially copied from textbooks or company documents, which does not contribute to the thesis. This leads to dead ends as described in problem #1. If you don't need something later on the thesis to justify or explain something else, don't mention it.

#3 Lack of motivation: The paper as well as chapters and claims are presented without reason or motivation. The reader understands *what* has been done, but not *why*. Therefore, the thesis becomes nothing but a list of factual descriptions.

#4 Lack of goal: This relates to problem #3. The thesis presents nothing but a factual statement without explaining goals and expectations. Projects are started because the clients as some expectations for the results, which are specified by goals. This is why these have to be part of the thesis. Otherwise there is also no possibility to measure and evaluate success of the thesis.

#5 Insularism: The work is presented without looking left or right. It seems to be set on a lone isle without testing alternatives or discussing advantages and disadvantages of the solution presented. The experiments do not compare the newly developed method with existing solutions. Sometimes it is even hard to tell what the contribution of the thesis was and what was already given.

#6 Not seeing the wood for the trees: Some papers are so caught up in details that the reader will fail to see the bigger picture. At the end the reader is exhausted but does not have the feeling of having understood anything.

#7 Lack of arguments: This is related to problem #3 and #4. No discussion happens, there are no arguments given for or against any decisions and courses of action. The thesis does not employ arguments like “therefore”, “for this reason”, “because”. The reader only understands what was done, but not why.

#8 Lack of consequences: Consequences of decisions and experimental results are not discussed. Often you will read sections and chapters filled with technical details but lacking a conclusion. Interpretation of the results and discussion of consequences is a very good chance to collect points towards the grade.

#9 *Insider jargon:* Abbreviations and technical terms are used without explaining them first. The reader doesn't understand what is going on, because he is lacking important background. This tends to happen when a thesis is dealing with industry thesis, where the company has a whole set of internal jargon.

#10 Keeping the reader in the dark: The paper is lacking explanations and examples, making it hard or impossible for the reader to follow. Often a good illustration will go a long way in aiding the reader (remember, a picture is worth a thousand words). Another problem is found when using diagrams that show something else than what is described in the text (usually because they are overly complicated or taken out of their original context).

These Top Ten mistakes can be summed up into three categories:

Lack of reflection (3, 4, 5, 6, 7, 8): the reader has the impression that the author did not really understand what the project would be useful for or did not think it through properly. Even when the technical work is flawless, this will lead to grade deductions.

Lack of a red thread (1, 2, 3, 4, 7, 8): The paper doesn't follow a red thread or keeps loosing it running into dead ends. This will be the difference between a mediocre and a good thesis. A good thesis will always keep the train of thought on track and weave the arguments and technical statements in between a motivating introduction and a conclusion that restates and discusses all relevant points.

Technical problems (9,10): These are mistakes in explaining and arguing.

Among these three categories the first is most important one for the grade. Without reflection, the thesis reads as "This is what I did because my supervisor told me to". This shows competence only in task execution and is enough for a passing grade at best. Proper reflection shows maturity and competence and leads to a good grade.

Some further mistakes often encountered
- Gap between title and text: can the text deliver what the headline promised?
- obviously wrong statements
- sweeping or absolute statements
- repetition (often word by word)
- redundant details: details of implementation (like model structure, UML etc.) are rarely needed or useful. Usually a more abstract way of presentation is preferable
- no or unclear separation between own contribution and given knowledge
- decisions: assumptions aren't explained, alternatives aren't discussed
- no clear goal of the thesis
- mistake tasks for goals
- experiments don't seem to have a goal or answer a question (description/construction -> goal -> discussion of results)
- not enough experiments, not all interesting properties of the concept are discovered or tested
- lack of creativity when choosing experiments, only obvious choices
- change of parameters is not justified
- conclusion lacks evaluation or interpretation of results

2. Typical mistakes in structure and form

Structure and outlining
- chapter headlines are to generic or unfitting
- two separate topics are mixed and handled in one chapter
- lacking structure: Pages of text without subheadings
- structure too deep (use a maximum of 3 levels)
- improper structure (sections with no more than two lines of text)
- too long paragraphs: New thought -> new paragraph!
- not using bullet points when they would be called for

Phrasing
- use of colloquial language
- use of over-complicated long sentences
- improper use of "I", "we" or "someone"
- use of abbreviations without defining or explaining them
- unnecessary use of abbreviations (harder to read)

Spelling and grammar
- problems with punctuation
- numbers between one and twelve not written out

Illustrations
- lack of reference in the text
- missing or lacking description of the illustrations used
- poor quality of illustrations
- too small illustrations
- too much detail in pictures (like layout plans that don't mark the important areas)
- incomplete diagrams (missing title, axis labels etc.)
- crowded illustrations: Showing more than the relevant information

References and footnotes
- unused references
- missing references when citing directly or indirectly
- improper formatting for references
- useless footnotes, not common in engineering disciplines