AUTHOR, OLDDEGREE

TITLE

Master's Thesis

to achieve the university degree of

Master of Science

Master's degree programme: Computer Science

submitted to

Graz University of Technology

Supervisor

Dr. Some Body

Institute for Interactive Systems and Data Science
Head: Univ.-Prof. Dipl-Ing. Dr.techn. Some One

Graz, September 2018

Affidavit

I declare that I have authored this thesis independently, that I have not used other than the declared sources/resources, and that I have explicitly indicated all material which has been quoted either literally or by content from the sources used. The text document uploaded to TUGRAZonline is identical to the present master‘s thesis.

Date	Signature

Abstract

This is a place-holder for the abstract. It summarizes the whole work to give a very short overview. Usually, this the abstract is written when the whole work text is finished. Alternatively, write an initial abstract in the beginning (wish how it should look like in the end), and then rewrite it at the end of the work.

The abstract consists of four parts, plus an optional beginning. 0., optionally start the abstract with 1-2 sentences about the background of the work. 1., describe the topic, or problem of the work. It should be clear what the aim of the work is. 2., describe how you solved the problem. It should be clear what steps were necessary to solve the problem. 3., give a short overview of the results. Should be clear how well the problem is solved. 4., give an outlook of what is now possible, since the problem has been solved.

The abstract is typically written in the past tense. It is uncommon to put references directly into the abstract.

Contents

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1 Exposé

The exposé needs to be written before the actual work begins. It serves as an proposal of the thesis, and can be seen as an contract between you and your advisor. It consists of three main parts.

1.1 Introduction

General statement of the problem to be solved. First draft version of the Introduction chapter of the final thesis. Should therefore have the same structure and content as the final thesis. It should be clear, what you intend to do (and also what are the non-goals).

1.2 Background

In the introduction the problem is described. In the background chapter one expects a list of ways how this problem is has already been approached. How well is the problem currently solved? If the problem is already solved, you should talk to your advisor.

This chapter is the initial version of the “State of the Art” section of the background chapter of the final thesis.

1.3 Glossary (optional)

List of key terms used in the thesis with a short explanation of their meaning and usage. Depending on the domain, certain terms have specific meanings (e.g., an ontology in computer science would be described differently to an ontology in philosophy). Typically a glossary is a two column table, but you may also use the "description" LaTeXcommand.

1.4 Research Community (optional)

List of the relevant research groups working in the area of the thesis. Generating by clustering the relevant publications and identify relevant individuals/groups/universities.

List of relevant publication venues, including journals, conferences and workshops. Similar to identifying the key research groups, a thorough literature survey yields such a list. It gives the reader an overview of the main sources to look for future publications from the field.

1.5 Timeline

Give an overview of the planned work. Maybe include a GANTT chart for quick overview. Preferably, try to include milestones, optimally about one month apart. These milestones are good opportunities for exchange with your supervisor, either via E-Mail of via a meeting.

Try to avoid to split the work into the practical part and the writing part. Optimally, writing starts with the first day of the thesis work.

1.5.1 Suggestion on Milestones

Here an inspiration for some initial, potential milestones:

- Exposé finished

  - Topic of thesis finalised and agreed with supervisor
  - First draft version of the introduction chapter
- Literature review finished
  - First version of background chapter available
  - Optionally, plan a presentation on the State-of-the-Art
- Evaluation pipeline established
  - Technical infrastructure to measure each iteration/change of the system

...

2 Structure of the Thesis

Most of the recommendations for the structure of the work are derived from the book Scientific Writing 2.0 [5].

2.1 Introduction

There are two main ways to write the introduction, i) driven by a problem statement, ii) driven by a research question / hypothesis. Either way, it should be clear what the purpose of the work is and why it has been conducted.

The introduction may consists of four parts, plus two optional parts: i) answer the question as to why now?, ii) answer the questions of why this?, iii) answer the question as to why this way, and finally, iv) make clear why the reader should care. The last point is also called impact and refers to what is now possible thanks to the work.

Additionally, the introduction may also contain the list of main research questions. It may also contain the list of main contributions that are generated thanks to the work.

Often, the introduction ends with a short table of contents (for example, in chapter 2 the background…). This part can be omitted, if the work follows the usual structure, and is only necessary, if the structure of the work deviates from the common norm.

The introduction is typically written in the present tense.

2.2 Related Work

2.2.1 Background

Explain all concepts used in your work. What are the main underlying technologies? If you use certain (textbook) algorithms, briefly explain how they work.

The idea of this section is to give non-experts explanations for the main techniques being used in the work.

References to Wikipedia[1] and other online resources are okay in this sections. Please use footnotes to refer to online references, if used for further information. If online sources serve as reference, treat them like other references (optimally, with access date)

If there are tools, that solve (part of) the problem, there are listed in this section. Screenshot will help the reader to get an understanding of them.

2.2.2 State of the Art

How well is the problem solved so far? Please cite existing scientific work (publications, books). Use bibtex for proper citations. Ask your advisor for how to search for relevant literature.

Typically, the beginning of this section is devoted to describe the methodology, of how relevant literature is researched. For example, which sources (e.g., Google Scholar), are being used and which searches were submitted. Often, there will be an overview table of how many publications have been found in total, how many were considered to be relevant and how many have been studied.

The quality of this section is an important aspect for judging the overall quality of the thesis. This section demonstrated that you value the work of others. In short, this section should demonstrate that the author is capable of:

- Research relevant literature
  - … and identify the key terms used in the scientific community

[1] http://en.wikipedia.org (Accessed on: 2018-02-13)

- Read and understand (scientific) literature
- Summarise the key findings of the literature in own words
- Put the literature in the context in relation to the own work (thesis)
- Create a coherent storyline over all cited source

This section is more important in Master thesis.

2.3 Use Cases & Requirements

For software engineering thesis, there might be a section dedicated to the use cases. For other types of thesis, this section can be omitted.

Often such section will start with personas or narratives of the planned systems. From there a number of use cases can be derived. Out of the use cases, the (functional, non-functional, contextual) requirements can be described. Optionally, also list important quality attributes that need to be addressed (for example, usability, security, ...).

This section may also host mock-ups of a the user interface of the system.

2.4 Problem Statement

Alternative names: Scope, Problem Definition, Problem Formalisation

This section formalises the problem and typically also introduces the notation of the remainder of the work. Typically this section contains definitions of the main concepts and terms being used. Often using mathematical notation. One would expect to read statements like "given input X, the task is to find a function f so that [...]".

For thesis that are more practical in nature, e.g., focus on software engineering, this section will can be omitted.

2.5 Method

Alternative names: Approach, System

Describe the approach in this section, how the solution looks like? It should be sufficiently detailed as to allow others to replicate the presented findings. Please do not write this section as a protocol of what you did (report style), but as a way how the system/method can be replicated.

Typically, this sections is organised in a way to go from abstract concepts to more detailed information. Often the section is then split into a "Concepts" and an "Implementation" subsection. The concepts will describe relevant definition, often in mathematical notation. Alternatively, the concepts will contain system architecture diagrams. Flow charts are another tool to present how the components work together. How does the system work in principle/in general and how do the system components interact?

The implementation subsection will then more fine grained. Pseudo code, or even snippets from the code will be presented here. The libraries being used (together with their version number - as footnotes) are presented in this section. The reader should be able to replicate the system as good as possible. In this subsection, often UML diagrams will be used (class level).

This section is mostly written in the presence tense.

2.6 Evaluation

Alternative names: Experiments

Often, this section starts with a description of the evaluation methodology (how is the method being tested). The methodology should cover all aspects relevant to assess how well the problem is being solved. If the system/method has multiple parameters, these should be individually being tested/reported.

A good evaluation needs to include a baseline as reference. Typically, this will be either the current state-of-the-art (how well is the problem solved so far), or an artificial baseline.

Alternatively, human baselines can be given (for example, using interrater agreement), these can be often seen as upper bound for the achievable performance.

Then, the used data sets are being described in detail, for example the size of the data set, class distributions, number of instances. Generally, the more (diverse) data sets and the bigger the data set are - the better. Optimally, combine an artificial data set with real-life data sets.

2.6.1 Results

Report of the achieved results, typically in form of tables and charts. The way the results are displayed depends on how well a chart/table is suited to convey the main message. The findings in this subsection are objective - no room for interpretation.

2.6.2 Discussion

This subsection than puts the achieved result into perspective. Is the problem solved; how well is the problem solved? Subjective assessments can be done here, but expressed appropriately (hedging), for example the results indicate that [...].

An additional subsection is "Lessons Learnt", which contains information of what went well, and what did not work out as expected. Often, multiple iterations of the solutions are presented here. This subsection is more often found in Bachelor thesis, rather than Master thesis.

2.7 Conclusions

Wrap up of the whole work. There should be no new information here. Try to avoid a conclusion that reads like: "First I did that, then I did that, next I did, ...". Focus on the main results and insights. The conclusions are a direct answer to the questions raised in the introductions, e.g. How well is the problem solved? Ideally, one can read just the introduction and the conclusions and get a good picture of the whole work.

This section is written in the past tense.

2.7.1 Future Work

What parts of the problem are not solved yet? How to progress further?

This is an optional subsection.

2.8 Bibliography

Should be automatically generated by this template using the `.bib` file.

2.9 Appendix

Optional section, contains additional source code fragments (for example long regular expressions), additional tables and charts.

3 Writing Tips

The is three groups of readers of your thesis: i) those, who read the full text, ii) those, reading just the introduction and conclusions, iii) those, only looking at images and tables. For all of these groups the thesis should designed for.

For example, the introduction and conclusions should contain all the necessary information to understand your work. The introduction contains the description of the problem that is being solved (e.g. research questions), and the conclusions contains the answers of how well it worked out.

Some readers just skim the text and look at images. Still it should be possible for them to understand large parts of the work. Please include captions to the figures that explain, what can be seen (even if it appears redundant). Typically the caption is split into three parts, i) a short title, ii) a description of what can be seen, and iii) an optional interpretation, if one anticipates questions that a reader might have. People reading the full text will only skim over the caption, thus a certain amount of redundancy is fine. Always refer to your images from within the text to avoid dangling figures, please see Figure 3.1.

The same applies to tables, see Table 3.1. Depending on the type of information to be presented, either a table or a chart is the better option. In general, the reader should not be overwhelmed by information. If a table has too many entries, a good idea is to put such a table into the appendix and have a summary table in the text.

Figure 3.1: Title. Description. Interpretation.

Table 3.1: Explanation of what can be seen in the table. Provide aids in how to interpret the key facts in the table. You may also highlight certain values with bold, e.g., best results.

	Column 1	**Column 2**
Row 1	1	Some text
Row 2	**2**	Some more text

3.1 When to write what?

The sequence in which the individual chapters are written depends on the author, hence these guidelines should be considered just as an orientation.

Start with an outline of the whole work, with the chapters and expected content. This serves as storyline to guide the writing processes. It is common that the outline changes with time.

A suggested sequence of writing the chapters is:

1. Abstract (first draft, as it would read if everything works out like planned)
2. Background
3. Problem definition or use cases
4. Methods
5. Evaluation
6. Introduction & conclusions
7. Abstract (rewritten to reflect the true outcome)

3.2 Useful Tips

Here a few tips that are commonly mentioned in literature:

- Reserve a time slot for writing
  - Turn off distractions (e.g., mails, mobile phone, ...)
- Avoid empty pages

  - Do not stop at the end of a chapter, at least write the first sentence of the next chapter (even, if this sentence needs to be rewritten in the next session)
- Plan you line of argument
  - Organise in which sequence information should be presented to the reader
  - For example, have for each chapter one sentence summarising the main content of this chapter
- Mention important aspects multiple times
  - Readers will not remember everything (max. 30%)
  - For the general thesis
    * In the introduction prepare the readers, what they will read
    * In the main body of the thesis all the details are given
    * In the conclusion, the main results are summarised
  - For each chapter
    * In the beginning tell the reader, what they have to expect
    * In the body of the chapter the details are given
    * The end of the chapter may give a summary of the main content of the chapter
  - The same can be applied to paragraphs (i.e., introduce the idea, describe the idea, summarise the idea)
- Tell the reader, what to expect in a chapter, so there are no surprises
- In scientific literature synonyms are typically avoided (i.e., use the same term to refer to the same concept to avoid ambiguities)

3.3 Interaction with the Supervisor

If you send iterations of your work to your supervisor, consider using latexdiff. With this tool, visual differences between two versions of the thesis become more apparent and is of great help to the supervisor.

4 Language and Writing Style

This chapter is an adopted version of a single chapter of a thesis template by Keith Andrews [1] in its version from 2011-12-11.

The original template makes use of a more 'traditional' LaTeX implementation. The information contained regarding 'How to write a thesis' is generally brilliant and worth reading.

Using this chapter here is meant as a teaser. If you do like this chapter, please go and download the full template to read its content.

What was modified from the original chapter:

- strikethrough of bad examples
- minor typographical details
- technical modifications
  - moved citations from "`citet-` and "`citep-` to "`cite-` and "`cite-`
  - changed quoting style to "`enquote-`
  - created various commands and environments to encapsulate format

The classic reference for English writing style and grammar is [12]. The original text is now available for free online [11], so there is no excuse at all for writing poor English. Readers should consult it first, then continue reading this chapter. Another good free guide is [7].

[13] and [4] are guides specifically aimed at computer science students. [8] gives practical advice for PhD students.

The following Sections 4.3 and 4.4 are adapted from the CHI'94 language and writing style guidelines.

4.1 Some Basic Rules of English

There are a few basic rules of English for academic writing, which are broken regularly by my students, particularly if they are non-native speakers of English. Here are some classic and often encountered examples:

- *Never* use I, we, or you.
  Write in the passive voice (third person).
  Bad: ~~You can do this in two ways.~~
  Good: There are two ways this can be done.
- *Never* use he or she, his or her.
  Write in the passive voice (third person).
  Bad: ~~The user speaks his thoughts out loud.~~
  Good: The thoughts of the user are spoken out loud.

  See Section 4.4 for many more examples.
- Stick to a consistent dialect of English. Choose either British or American English and keep to it throughout the whole of your thesis.
- Do *not* use slang abbreviations such as 'it's', 'doesn't', or 'don't'.
  Write the words out in full: 'it is', 'does not', and 'do not'.
  Bad: ~~It's very simple to…~~
  Good: It is very simple to…
- Do *not* use abbreviations such as 'e. g.' or 'i. e.'.
  Write the words out in full: 'for example' and 'that is'.
  Bad: ~~…in a tree, e. g.the items…~~
  Good: …in a tree, for example the items…
- Do *not* use slang such as 'a lot of'.
  Bad: ~~There are a lot of features…~~
  Good: There are many features…
- Do *not* use slang such as 'OK' or 'big'.
  Bad: ~~…are represented by big areas.~~
  Good: …are represented by large areas.
- Do *not* use slang such as 'gets' or 'got'.
  Use 'becomes' or 'obtains', or use the passive voice (third person).

Bad: ~~The radius gets increased…~~
Good: The radius is increased…

Bad: ~~The user gets disoriented…~~
Good: The user becomes disoriented…

- *Never* start a sentence with ‘But’.
  Use ‘However,’ or ‘Nevertheless,’. Or consider joining the sentence to the previous sentence with a comma.
  Bad: ~~But there are numerous possibilities…~~
  Good: However, there are numerous possibilities…

- *Never* start a sentence with ‘Because’.
  Use ‘Since’, ‘Owing to’, or ‘Due to’. Or turn the two halves of the sentence around.
- *Never* start a sentence with ‘Also’. Also should be placed in the middle of the sentence.
  Bad: ~~Also the target users are considered.~~
  Good: The target users are also considered.

- Do *not* use ‘that’ as a connecting word.
  Use ‘which’.
  Bad: ~~…a good solution that can be computed easily.~~
  Good: …a good solution which can be computed easily.

- Do *not* write single-sentence paragraphs.
  Avoid writing two-sentence paragraphs. A paragraph should contain at least three, if not more, sentences.

4.2 Avoid Austrianisms

I see these mistakes time and time again. Please do not let me read one of them in your work.

- ‘actual’ ≠ ‘current’
  If you mean ‘aktuell’ in German, you probably mean ‘current’ in English.
  Bad: ~~The actual selection is cancelled.~~
  Good: The current selection is cancelled.

- ‘allows to’ is not English.
  Bad: ~~The prototype allows to arrange components…~~
  Good: The prototype supports the arrangement of components…
- ‘enables to’ is not English.
  Bad: ~~it enables to recognise meanings…~~
  Good: it enables the recognition of meanings…
- ‘according’ ≠ ‘corresponding’
  Bad: ~~For each browser, an according package is created.~~
  Good: For each browser, a corresponding package is created.
- ‘per default’ is not English.
  Use ‘by default’.
  Bad: ~~Per default, the cursor is red.~~
  Good: By default, the cursor is red.
- ‘As opposed to’ is not English.
  Use ‘In contrast to’.
  Bad: ~~As opposed to C, Java is object-oriented.~~
  Good: In contrast to C, Java is object-oriented.
- ‘*anything*-dimensional’ is spelt with a hyphen.
  For example: two-dimensional, three-dimensional.
- ‘*anything*-based’ is spelt with a hyphen.
  For example: tree-based, location-based.
- ‘*anything*-oriented’ is spelt with a hyphen.
  For example: object-oriented, display-oriented.
- ‘*anything*-side’ is spelt with a hyphen.
  For example: client-side, server-side.
- ‘*anything*-friendly’ is spelt with a hyphen.
  For example: user-friendly, customer-friendly.
- ‘*anything*-to-use’ is spelt with hyphens.
  For example: hard-to-use, easy-to-use.
- ‘realtime’ is spelt with a hyphen if used as an adjective, or as two separate words if used as a noun.
  Bad: ~~…using realtime shadow casting.~~
  Good: …using real-time shadow casting.

Bad: ~~…display the object in realtime.~~
Good: …display the object in real time.

4.3 Clear Writing

The written and spoken language of your thesis is English as appropriate for presentation to an international audience. Please take special care to ensure that your work is adapted to such an audience. In particular:

- Write in a straight-forward style, using simple sentence structure.
- Use common and basic vocabulary. For example, use 'unusual' for 'arcane', and 'specialised' for 'erudite'.
- Briefly define or explain all technical vocabulary the first time it is mentioned, to ensure that the reader understands it.
- Explain all acronyms and abbreviations. For example, the first time an acronym is used, write it out in full and place the acronym in parentheses.
  Bad: ~~…When using the GUI version, the use may…~~
  Good: …When using the Graphical User Interface (GUI) version, the use may…
- Avoid local references. For example, not everyone knows the names of all the provincial capitals of Austria. If local context is important to the material, describe it fully.
- Avoid 'insider' comments. Ensure that your whole audience understands any reference whose meaning you do not describe. For example, do not assume that everyone has used a Macintosh or a particular application.
- Do not 'play on words'. For example, do not use 'puns', particularly in the title of a piece. Phrases such as "red herring" require cultural as well as technical knowledge of English.
- Use unambiguous formats to represent culturally localised things such as times, dates, personal names, currencies, and even numbers. 9/11 is the 9th of November in most of the world.
- Be careful with humour. In particular, irony and sarcasm can be hard to detect if you are not a native speaker.
- If you find yourself repeating the same word or phrase too often, look in a thesaurus such as [10, 9] for an alternative word with the same meaning.

Clear writing experts recognise that part of writing understandable documents is understanding and responding to the needs of the intended audience. It is the writer's job to maintain the audience's willingness to go on reading the document. Readers who are continually stumped by long words or offended by a pompous tone are likely to stop reading and miss the intended message.

4.4 Avoiding Gender Bias

Part of striking the right tone is handling gender-linked terms sensitively. Use of gender terms is controversial. Some writers use the generic masculine exclusively, but this offends many readers. Other writers are experimenting with ways to make English more neutral. Avoiding gender bias in writing involves two kinds of sensitivity:

1. being aware of potential bias in the kinds of observations and characterisations that it is appropriate to make about women and men, and
2. being aware of certain biases that are inherent in the language and of how you can avoid them.

The second category includes using gender-specific nouns and pronouns appropriately. Here are some guidelines for handling these problems:

- Use a gender-neutral term when speaking generically of people:

man	the human race
mankind	humankind, people
manpower	workforce, personnel
man on the street	average person

- Avoid clearly gender-marked titles. Use neutral terms when good ones are available. For example:

chairman	chairperson
spokesman	speaker, representative
policeman	police officer
stewardess	flight attendant

- If you are speaking of the holder of a position and you know the gender of the person who currently occupies the position, use the appropriate gender pronoun. For example, suppose the 'head nurse' is a man:

Bad: ~~The head nurse must file her report every Tuesday.~~
Good: The head nurse must file his report every Tuesday.

- Rewrite sentences to avoid using gender pronouns. For example, use the appropriate title or job name again:
  Bad: ~~Interview the user first and then ask him to fill out a questionnaire.~~
  Good: Interview the user first and then ask the user to fill out a questionnaire.
- To avoid using the third person singular pronoun (his or her), recast your statement in the plural:
  Bad: ~~Each student should bring his text to class.~~
  Good: All students should bring their texts to class.
- Address your readers directly in the second person, if it is appropriate to do so:
  Bad: ~~The student must send in his application by the final deadline date.~~
  Good: Send in your application by the final deadline date.
- Replace third person singular possessives with articles.
  Bad: ~~Every student must hand his report in on Friday.~~
  Good: Every student must hand the report in on Friday.
- Write your way out of the problem by using the passive voice.
  Bad: ~~Each department head should do his own projections.~~
  Good: Projections should be done by each department head.
- Avoid writing awkward formulations such as ‘s/he’, ‘he/she’, or ‘his/her’. They interfere when someone is trying to read a text aloud. If none of the other guidelines has been helpful, use the slightly less awkward forms ‘he or she’, and ‘his or hers’.

Remember, the goal is to avoid constructions that will offend your readers so much as to distract them from the content of your work.

4.5 Titles and Headings in Initial Caps

Please use title case for all titles and heading.

4.6 Use a Spelling Checker

In these days of high technology, spelling mistakes and typos are inexcusable. It is *very* irritating for your supervisor to have to read through and correct spelling mistake after spelling mistake which could have been caught by an automated spelling checker. Believe me, irritating your supervisor is not a good idea.

So, use a spelling checker *before* you hand in *any* version, whether it is a draft or a final version. Since this is apparently often forgotten, and sometimes even wilfully ignored, let me make it absolutely clear:

> *Use a spelling checker, please.*
> *Use a spelling checker!*
> *Use a spelling checker, you moron.*

4.7 Use a Dictionary

If you are not quite sure of the meaning of a word, then use a dictionary. [3] is a free English dictionary, [2] and [6] are two very good English-German dictionaries.

4.8 Use a Thesaurus

If a word has been used several times already, and using another equivalent word might improve the readability of the text, then consult a thesaurus. [10] and [9] are free English thesauri.

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Appendix