Structure of Bachelor-/Master-Thesis

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Contents

1 Before you start

Before start writing the thesis this document should be studied. However, this guidance document does not replace the formal requirements from the faculty service bureau, FSB. This document focusses on the structure and style of the thesis.

This first chapter covers some general issues that should be kept in mind before writing the first line. Chapter 2 to 4 concentrate on the chapter structure of the thesis whereas chapter 5 deals with further topics like the use of an appendix, abbreviations, tables, figures and equations and the handling of references.

1.1 Two things to keep in mind

Two things should be kept in mind when writing the thesis:

First, the *main message* should always be present to the author. On one hand, not everything done must be documented. Only the parts important to understand the main message should be written. On the other hand everything required to understand the subject must be explained. It is a good idea to write down the main message in one or two sentences on a piece of paper and to stick it on the computer monitor where this thesis is written.

Second, the *receiver* should be kept in mind. The potential reader of the thesis is an engineer with the degree of the course the author is studying but who does not know the field of work presented in the thesis. E.g. *fast Fourier transform*, FFT, and *signal to noise ratio*, SNR, do not need to be explained. However, for example working in the field of medical x-ray diagnosis requires a short section on x-rays and the type of systems investigated.

1.2 Spelling style

First, a thesis is written in *passive voice* in *third person*. Since the thesis is a technical or scientific document the whole set-up is fact orientated. Hence terms like "Let's look at this example..." or "As you can see..." must be avoided. Also terms like "An one can see..." are not appropriate.

Second, with only one exception the whole text is written in present tense. The exception is the chapter *methods*, see section 4.1.2, where a procedure on a time-line is explained. This may be true for other small sections but should remain an exception.

2 Chapter structure

There are two types of theses that require a different system of chapters. The first two and the last chapter are the same for both types.

2.1 Analysis type of work

If the work is based on measurements this is the structure of choice. E.g. some measurements have been performed and compared with simulations. Therefore, many topics in research use this type of structure:

1. Introduction
2. Theory
3. Materials
4. Methods
5. Results
6. Discussion
7. Conclusion
8. Summary

2.2 Construction type of work

If the main content is the creation of hard- or software this is the structure of choice:

1. Introduction
2. Theory
3. Requirements
4. Design
5. Implementation
6. Test
7. Summary

3 Common chapters

3.1 Content of *Introduction*

The introduction (in German: *Einleitung*) has two parts.

The first part guides the reader to the subject of the thesis. One may imagine a funnel: Out of the entire set of possible subjects the reader is directed to the field of work covered in this thesis. For example:

> In medical diagnosis computer tomography, CT, is a useful technique to gain three-dimensional information of covered organs in humans. Since CT is based on x-rays that goes along with risk for patient and stuff, a reasonable balance between risk and image quality is required. This work deals with a new technique to estimate the risk due to radiation dose by a modified simulation method.

In this example the first sentence narrows the 'funnel' in several steps: *Medicine*, *diagnosis*, the special technique *CT* and medicine on *humans* (not animals). The second and third sentences further narrow the 'funnel': The work has to do with the *balance* of *image quality* and *risk* and on a *new technique* to *simulate* the radiation dose. After this short paragraph the reader is guided to the field of work of the thesis.

The second part of the introduction describes the task of the thesis. It gives a quick overview of the planned activities documented there. The summary at the end picks up the items mentioned here.

3.2 Content of *Theory*

This chapter (in German *Theorie* oder *Grundlagen*) acts like a tool box for the subsequent chapters. The reader gets all required information to be prepared for the main topic.

Following the example given in the previous section the thesis may have the following sections in this chapter:

- 2.1 Properties of x-rays
- 2.2 X-ray exposure
- 2.3 CT-scanners
- 2.4 Monte-Carlo simulation method

This chapter does not contain the actual work of the author but rather well known facts from literature. The reader does not expect that the content of this chapter is the result of the authors work. However, it must become clear where the information comes from (see section 5.4).

3.3 Content of *Summary*

The summary (in German *Zusammenfassung*) contains two important parts:

The first part picks up the task description of the introduction and gives a quick summary of the achievements. Hence, together with the introduction the summary acts like an envelope around the thesis. The introduction describes the *plan* and the summary gives a quick overview what *has* been done.

The second part of the summary is an outlook with recommendations for future work on this topic. Here the suggestions made during the whole thesis are mentioned once again.

4 Specific chapters

4.1 *Analyse* type of work

The *analyse* type of work concentrates on some sort of measurement or simulation. Although it may contain some special developed equipment the focus is on the experimental outcome rather than on the equipment. Hence, the documentation is about set-up (materials), procedures (methods), results, discussion and gained learnings (conclusion).

4.1.1 Content of *Materials*

This chapter (in German *Materialien* oder *Messaufbau*) is often combined with the next chapter as *materials and methods*. Here the set-up for the measurements is described. A list of used instruments is given together with their set-up. It must be as detailed that someone is able to repeat the measurements in another laboratory. (Serial numbers of the devices as in some lab-reports are not required.)

It is often useful to illustrate the set-up by some sketches. This helps the reader to quickly get into the subject although he/she did not spent month of time on this. Every step with a different set-up must be explained here.

E.g. if the task is to measure and simulate CT images this chapter could have the following sections:

- 3.1 Test-object for measurements
- 3.2 Set-up for measurements
- 3.3 Simulation set-up
- 3.4 Tools to estimate image quality

4.1.2 Content of *Methods*

This chapter (in German *Methoden* oder *Messablauf*) is often combined with the previous chapter as *materials and methods.* Here the procedure of measurements and simulations is described. This includes preparations like calibration of instruments, record of room temperature and humidity etc. Then the main measurements/simulations are described followed by the post-processing.

E.g. the sections of this chapter could be as follows:

- 4.1 Calibrations of instruments
- 4.2 Procedure of measurements
- 4.3 Performance of simulations
- 4.4 Analysis of data

This chapter does not show the results; it just explains the steps required to gain the results. The outcomes are shown in the subsequent chapters.

4.1.3 Content of *Results*

This chapter (in German *Messergebnisse* or just *Ergebnisse*) is often combined with the next chapter as *results and discussion.* This chapter presents the raw results i.e. without post-processing. It must be seen in combination with the subsequent two chapters *discussion* and *conclusion*: First the raw results are presented. Second, the results are edited/discussed. Third, the author draws the conclusion out of the edited data.

In chapter *results* the gained data are presented as they are: no removal of outlier, no normalization, no filtration etc. This is done in chapter *discussion.*

E.g. the thesis may have the following sections:

- 5.1 Calibration results
- 5.2 Phantom measurement results
- 5.3 Simulation results

4.1.4 Content of *Discussion*

This chapter (in German *Diskussion* or *Bearbeitung der Ergebnisse*) is often combined with the previous chapter as *results and discussion* and may be seen in combination with chapter *conclusion.*

This chapter takes the results of the previous chapter and prepares them to draw the conclusions. Outliers are removed, values are normalized, curves may be smoothed by filtering, different visualizations may be used etc. The aim is to point out effects to draw the conclusion in the next chapter.

Possible sections of this chapter may be:

- 6.1 Normalized CT-images
- 6.2 Normalized simulated images
- 6.3 Image quality indicators
- 6.4 Deviation between measurements and simulations

4.1.5 Content of *Conclusion*

After the results have been presented (chapter *results*) and edited (chapter *discussion*) this chapter draws the conclusion (in German *Auswertung*). This is somehow the core of the thesis: The reader is presented the outcome the work done.

Here the discussed results are analysed to gain new knowledge. The author shows his/her analytical skills by studying the presented data. Expected and unexpected results are evaluated.

Effects that are yet not understood are not skipped. Situations where the reader recognizes some obvious pattern that the author does not mention at all must be avoided. The author is open with limitations or weaknesses of the presented work. In this case the author should give suggestions for future work to improve the results (and keep a note for the *summary* chapter, see section 3.3).

Sections of this chapter could be:

- 7.1 Analysis of CT-images
- 7.2 Analysis of simulated images
- 7.3 Analysis of deviations

4.2 *Construction* type of work

Here some sort of hard- or software has been constructed by the author which is to be documented. Developing a device on a professional scale follows a structured process that requires a number of documents. A common process in systems engineering follows the so called V-model, see figure 1.

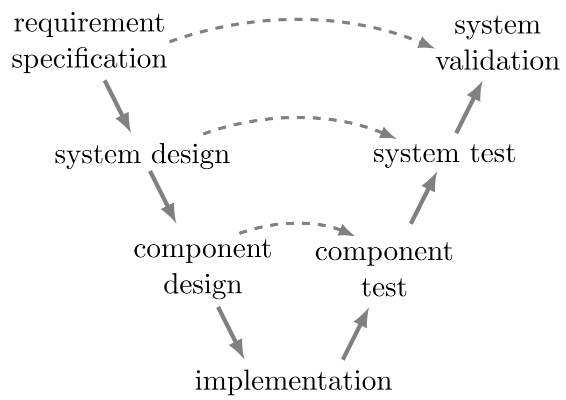

Figure 1: V-model for system engineering.

The major parts that must be documented in a master/bachelor thesis are *requirement specification*, *design*, *implementation* and *testing*. Here a high performance audio extension board for the Raspberry Pi 3 serves as an example.

4.2.1 Content of *Requirements*

This chapter (in German *Anforderungen* or *Lastenheft*) defines the requirements of the new hard- or software to be developed. It makes no sense to design, implement and test something without knowing the expected result.

In an professional environment the requirements are defined together with the customer who wants to buy and use the device. The requirement specification is the basis for a contract between customer and supplier. Only if all items of this specification are fulfilled the customer pays the full price.

Possible sections could be:

- 3.1 Audio requirements
- 3.2 Software requirements
- 3.3 Electrical requirements
- 3.4 Mechanical requirements
- 3.5 Cost for production

In a professional environment separate specifications are derived for the *system*, the *components*, the overall *hardware*, the *software* etc. However, for a thesis this level auf detail is usually not required.

4.2.2 Content of *Design*

Before implementation a thorough design and plan is required (in German *Design* or *Plan*).

The design starts with a high level structure which separates the total system into its major components and defines the interfaces between them. Then the separate components are defined and structured.

Yet not source-code or circuit diagram is presented. The diagrams of UML 2.x or other types of diagrams are useful tools to express the concept. Avoid a mixture between diagram types like flow chart, activity diagram and Nassi–Shneiderman diagram. If in doubt take a modern diagram like the ones described in UML 2.x.

Part of the design is the choice of components. This may be hard- or software. If more than one software platform are available they should be compared and a decision should be taken. The advantages and disadvantages are rated and the choice should be explained.

For the mentioned example the structure could be:

- 4.1 High level design
- 4.2 Interface to Raspberry Pi
- 4.3 Analogue-digital-converter, ADC
- 4.4 Digital-analogue-converter, DAC
- 4.5 Software on Raspberry Pi

4.2.3 Content of *Implementation*

This chapter (in German *Realisierung* or *Implementierung*) describes the actual realization of the hard- or software. Mechanical drawings including photographs may be shown. The realized cirquit diagram is illustrated. Fragments of the source code are listed.

How much detail should be shown? The main objective is that the reader understands readily the content of the thesis. I.e. pages upon pages of source code or circuit diagrams are not the best idea. There are three places for the required information: a) within text, b) in the appendix and c) on the CD provided with the thesis. The full set of source code, mechanical drawings or circuit diagrams must be provided, but the position should be chosen to support readability. See also section 5.1.

It is a good style to illustrate the implementation by some diagrams. Again, the thesis should use one style of diagrams and, if possible, state of the art techniques.

For the extension board the sections could be:

- 5.1 Implementation of circuit diagram
- 5.2 Mechanical realisation
- 5.3 Software to use extension board

4.2.4 Content of *Test*

(In German *Test* or *Verifikation/Validation*) A device not tested is worth nothing. Hence, any hard- or software must be tested thoroughly. The tests should reflect all items pointed out in the chapters *requirements* and *design*.

Failed tests should not be hidden. In the context of a bachelor/master thesis it is not expected to develop a perfect device. However, it is expected that the limitations are detected and suggestions are made to overcome them. These suggestions should then be mentioned again in a section *outlook* in chapter *summary*, see section 3.3.

It is a good technique to list all items of the specifications and to indicate the test results. Also the way of testing must be described.

For the example the section could be:

- 6.1 Mechanical and visual inspection
- 6.2 Launch Hardware
- 6.3 Test of requirements

5 Some general comments

5.1 Use of the appendix

The appendix (in German *Anhang*) is meant for data and information which are of use for the reader but not necessary to follow the flow of the thesis. E.g. a mathematical proof, some pages of source code, extended tables with measured data or a whole set of diagrams may be placed in the appendix.

There is no strict rule to decide if a part should be kept in the main text or shifted to the appendix. Not using the appendix at all may confront the reader with lots of data which disturbs the flow of reading. On the other hand placing necessary information in the appendix makes the reader thumb through the thesis back- and forward which again does not support the reading.

Hence, decisions should be made from the readers perspective. Does the reader need this piece of information or is it possible to follow the flow of documentation without this part? Dealing with a large set of data/source code/information a good style is to present a small fraction within the text and to place the larger fraction in the appendix.

Another option is to place large data sets on the CD provided with the thesis. The interested reader may then take the CD for further investigation.

5.2 Use of abbreviations

First, if possible, NAB (new abbreviations) should be avoided. Since the POR (potential reader) is an EEN (electrical engineer) SAB (standard abbreviations) like FFT or SNR may be used. However, it is hard for the reader to memorize a LSE (large set) of TLAs (three letter acronym).

Second, if a new abbreviation belongs to the core of the subject, an abbreviation may support the flow of reading. All abbreviations must be introduced with full wording. If an abbreviation hasn't been used for many pages it is advisable to once more introduce the abbreviation upon next use.

Third, if the thesis requires some more abbreviations a *list of abbreviations* should be considered. It should be placed at the beginning between the table of contents and the introduction. By this the reader is clearly pointed to this list and can go back to it at any time. Now, of course, all used abbreviations should be listed here (except the familiar ones like FFT, SNR etc.).

5.3 Tables, figures and equations

Figures and tables should get a number and a caption below them. Equations may get a number in round brackets with right alignment. All tables and figures are numbered whereas only the referenced equations get a number.

Typically the number consist of the chapter number, a point and a counter starting new for each chapter. E.g. *figure 3.2* for the second figure in chapter 3 or (2.5) for the fifth quoted equation in chapter 2. (Since this document is only an article the number of figure 1 does not include the chapter number.)

Tables, figures and equations are counted separately. I.e. there may exist a figures, tables and equations with the same number. For tables and figures a reference is given by the word *table* or *figure* followed by the number, e.g. see figure 3.2. An equation is referenced with or without the word *equation* or in short *eq.* but in any case with the number in round brackets, e.g. see eq. (2.5) of just see (2.5).

A list of figures and a list of tables are not required. However, if the author regards them as important they should be placed at the end behind the appendix.

5.4 Handling of references

All data and texts taken from elsewhere must be referenced. This is done by a *list of references* at the end of the thesis and *quotes* to this list within the text.

The *List of References* or just *References* is placed between summary and appendix. The references are numbered in square brackets, see section *References* of this document. Depending on the source the references are given differently:

Book. All authors, title in italics, publisher, year of publication in round brackets and ISBN-number, see [1].

Article. All authors, title in italics, name of journal, volume, year of publication in round brackets and range of pages, see [2].

Thesis. Name of author, title in italics, type of thesis and university and year of submission in round brackets, see [3].

Internet. Should be avoided if possible. If essential: Name of authors, title in italics, link and date of call in square brackets, see [4].

Patent. All authors, title in italics, patent number and year of publication in round brackets, see [5].

Within the text the references are quoted in square brackets. E.g. "This work is based on a function model [3]." Terms "see..." or "taken from..." are not required. A particular page may be inserted within the square brackets, e.g. [1, p 2–4]. More than one quote may be placed in one pair of square brackets, e.g. [2, 3].

Throughout the whole text it must be clear which parts are from the author and which are taken from elsewhere. In Germany even ministers lost their job due to not quoting properly in their PhD-thesis! (They copied large parts as their own work.) Care must be taken here.

5.5 Typesetting

The thesis is printed single sided with left side margin not less than 3 cm and the other margins not less than 2 cm.

The font size should be 12 pt and not less than 11 pt. A serif font like *times new roman* is preferable since it supports readability. Line spacing should be 1.5. Headings usually have a non-serif font.

Text in figures should not be too small, e.g. not less than 8 pt. Colours should be used only it they support readability. (The focus is not marketing!)

References

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[3] Dimitri Nahm, *Entwicklung und Realisierung eines Funktionsmodells einer Instillationseinheit für ein Unterdruck-Wundtherapie-System*, Master-thesis at Department Informations- und Elektrotechnik der HAW-Hamburg (2017)

[4] Matteo Frigo, Steven G. Johnson, *FFTW*, http://fftw.org/fftw3.pdf [27.02.2017]

[5] Robert Hess, Frank Demuth, *X-ray tube provided with a flat cathode*, US Patent 6,556,656 B2 (2003)