University of Helsinki
Dissertationes Universitatis Helsingiensis
60/2024

PhD thesis template

Name Here

Academic dissertation

*To be presented, with the permission of the
Faculty of Science of the University of Helsinki,
for public examination in PIII, Porthania, on
March 9, 2024, at 12 o'clock.*

Last edited May 24, 2024

Department of Mathematics and Statistics
Faculty of Science
University of Helsinki
2024

Supervisors Dr. Super M. Visor
Department of Mathematical Sciences
University of Visors
United Kingdom

Professor Proffa Tyyppi
Department of Mathematics and Statistics
University of Helsinki
Finland

Pre-examiners Dr. Essi Tarkastaja
Department of Applied Mathematics and Computer Science
Technical University of Denmark
Denmark

Professor Esa Tarkastaja
Department of Mathematics
University of Aveiro
Portugal

Opponent Professor O. P. Nentti
Department of Mathematics
University of Bologna
Italy

Helsingin yliopisto
Dissertationes Universitatis Helsingiensis 60/2024

ISBN – (print)
ISBN – (online)
ISSN – (print)
ISSN – (online)
PunaMusta, Joensuu 2024

Acknowledgements

This thesis template would not have been possible without numerous feats of inhuman LaTeXing. I am forever in debt for tex.stackexchange and Google for revealing the necessary secrets.

I could add more but this is probably plenty.

Place, Time Year
Name Here

The thesis consists of this introduction and the following articles referenced using Roman numerals **I** – **II**.

Publications

I Y. Name,
Short article revealing the secrets of the universe (2020). Inverse Problems 36, 094002.

II Y. Name & M. Y. Self,
Another article about the secrets of the universe (2021). 21st International Conference on Secrets of the Universe, p. 146-156, IEEE.

Author's contributions

I Theoretical analysis, computational implementation, numerical results and writing are the sole works of the author.

II Theoretical analysis, computational implementation, numerical results and most of the writing are due to the author.

Abstract

This is the abstract written in English.

Tiivistelmä

Tämä on suomenkielinen tiivistelmä. Sattaa olla, että LaTeX tarvitsee apua taivuttamisessa, mutta sen voi pakottaa manuaalisesti.

Contents

Abbreviations

3D Three-dimensional, similarly 2D, 4D and nD whenever appropriate

CT Computerized tomography or computed tomography

etc. et cetera

Notation and common symbols

$\mathbb{R}^2, \mathbb{Z}^d$ Space of two-dimensional real numbers $x = (x_1, x_2) = [x_1, x_2]^T$, space of d-dimensional integers $k = (k_1, k_2, ..., k_d)$.

$\mathbb{R}^{n \times m}$ Space of real-valued matrices with n rows and m columns.

$f, f(x)$ A function, a function evaluated at point x in its domain.

There are currently 2 unresolved parts!

1

Introduction

During writing it is handy to leave notes and remarks to one self.

Important: Explain how the notes works.

```
\NOTE{Importan: Explain how the notes work.}
```

Some notes are minor and require normal sized font.

Notice how the notes update the counter printed by NOTATOR. This is not meant for the final version but to make planning easier.

```
\note{Notice how the notes update the counter printed by NOTATOR.
This is not meant for the final version but to make planning easier.}
```

1.1 Dissertation outline

The dissertation template is organized as follows. There are some example sections and chapters. First chapter is 2 and its first section is 2.1.

After the second chapter 3 and the final chapter 4 the papers are included with their own title pages. The title pages use crazy macro:

```
% This creates the title page and a way to reference it using the key
\begin{papertitle}{<key>}{<Actual Title of Article>}

Text you want to / need to include, such as DOI, publisher, author names etc.

\end{papertitle}

% Includepdf commands come here,
% use: [clip, trim=Wcm Xcm Ycm Zcm] if needed to clip size
% using \ifOnlineVersion{}{}{} is optional!

\ifOnlineVersion{% option 1:
    \includepdf[pages=1\allp]{articles/articleX_final.pdf}
}{% option 2:
    \includepdf[pages=1\allp, clip]{articles/articleX_online.pdf}
```

```
}{ % Option 3:
    0} % Skip this many pages to keep numbering correct
```

But in short they allow for three different options:

1. Print as **the final printed copy would look like**, using the published articles.
2. Print an online version in case the published articles are not allowed in online version.
3. Like printed, but without the pdfs. The amount of skipped pages needs to be given manually to keep the page numbering in sync. For example, **Unigrafia wants the thesis is this format**.

1.2 Second section

Here are many numbered equations (the numbering is based on chapter, not section):

$$1 + 1 = 2 \tag{1.1}$$

$$2 + 1 = 3 \tag{1.2}$$

$$E = mc^2 \tag{1.3}$$

$$\mathrm{ohmi} \times \mathrm{käämi} = \mathrm{Pimenee}(\mathrm{lääni}) \tag{1.4}$$

The cleverref macro allows to reference many equation in the same chapter neatly: equations 1.2–4. Otherwise the chapter number would be repeated.

The articles can be referenced like this: Article **I** can be found on page 13.

Finally the appendix A contains pseudocode.

1.2.1 PDF metadata

Included is a file titled `main.xmpdata`. It sets the PDF metadata which is visible for example if you check the ”properties” of the final PDF file (and by some PDF viewers).

1.2.2 Bibliography options

I have cited books and articles normally [1]. Websites and random things using ”misc” [2], datasets using ”techreport” [3] and PhDthesis with ”phdthesis” [4]. The tilde (~) is used to stop line breaks from separating the citation from the context.

2

Big chapter

Notice how a new chapter always starts from an odd page.

2.1 This is a section

It is worth noting that not all problems are difficult[1]). In 1902 the French mathematician Jacques Hadamard gave the following description.

Definition 1 ([1])**.** *A problem is* well-posed *if the following conditions are satisfied:*

H1) The problem has a solution.

H2) The solution is unique.

H3) The solution depends continuously on the initial conditions.

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.

Nam dui ligula, fringilla a, euismod sodales, sollicitudin vel, wisi. Morbi auctor lorem non justo. Nam lacus libero, pretium at, lobortis vitae, ultricies et, tellus. Donec aliquet, tortor sed accumsan bibendum, erat ligula aliquet magna, vitae ornare odio metus a mi. Morbi ac orci et nisl hendrerit mollis. Suspendisse ut massa. Cras nec ante. Pellentesque a nulla. Cum sociis natoque penatibus et magnis dis parturient montes, nascetur ridiculus mus. Aliquam tincidunt urna. Nulla ullamcorper vestibulum turpis. Pellentesque cursus luctus mauris.

Something smart and motivating is shown in figure 2.1.

[1] Some are impossible.

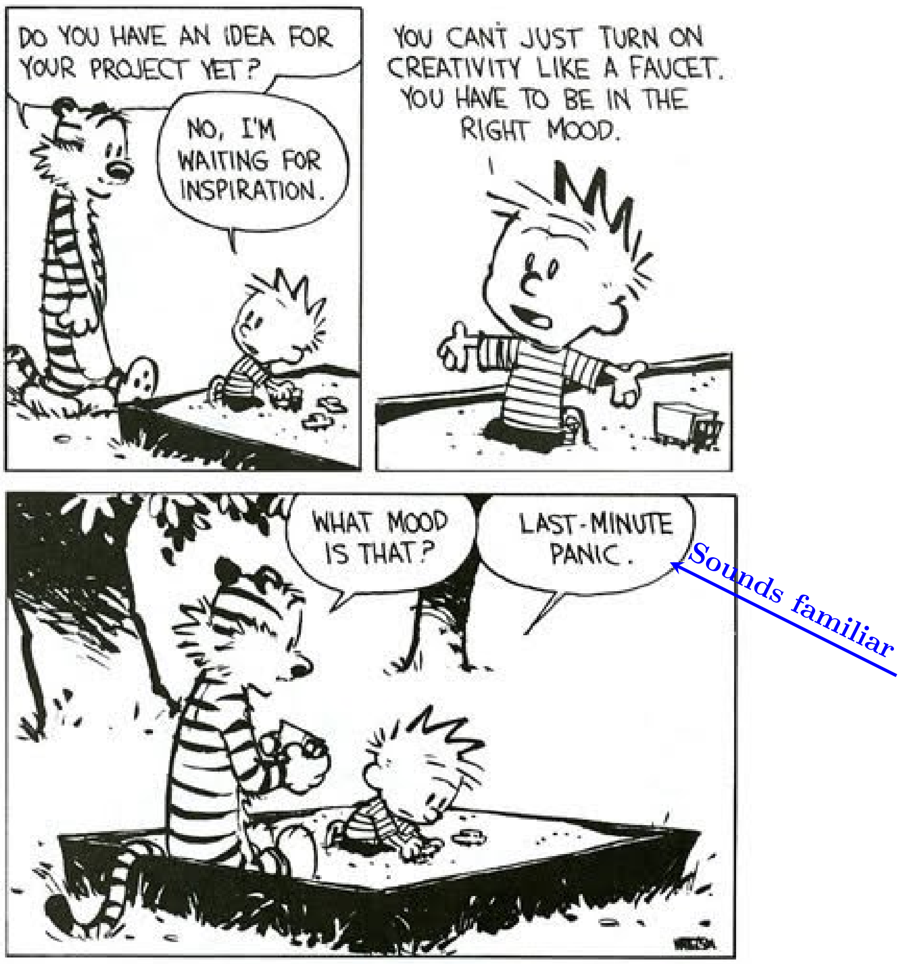

Figure 2.1: Cool figure, which is formatted in TikZ for better control of random things but this is not necessary. Image souce: *Calvin and Hobbes by Bill Watterson for May 21, 1992*.

2.1.1 Blablabla

Blablabla

2.2 Very important section

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.

Nam dui ligula, fringilla a, euismod sodales, sollicitudin vel, wisi. Morbi auctor lorem non justo. Nam lacus libero, pretium at, lobortis vitae, ultricies et, tellus. Donec aliquet, tortor sed accumsan bibendum, erat ligula aliquet magna, vitae ornare odio metus a mi. Morbi ac orci et nisl hendrerit mollis. Suspendisse ut massa. Cras nec ante. Pellentesque a nulla. Cum sociis natoque penatibus et magnis dis parturient montes, nascetur ridiculus mus. Aliquam tincidunt urna. Nulla ullamcorper vestibulum turpis. Pellentesque cursus luctus mauris.

Nulla malesuada porttitor diam. Donec felis erat, congue non, volutpat at, tincidunt tristique, libero. Vivamus viverra fermentum felis. Donec nonummy pellentesque ante. Phasellus adipiscing semper elit. Proin fermentum massa ac quam. Sed diam turpis, molestie vitae, placerat a, molestie nec, leo. Maecenas lacinia. Nam ipsum ligula, eleifend at, accumsan nec, suscipit a, ipsum. Morbi blandit ligula feugiat magna. Nunc eleifend consequat lorem. Sed lacinia nulla vitae enim. Pellentesque tincidunt purus vel magna. Integer non enim. Praesent euismod nunc eu purus. Donec bibendum quam in tellus. Nullam cursus pulvinar lectus. Donec et mi. Nam vulputate metus eu enim. Vestibulum pellentesque felis eu massa.

Quisque ullamcorper placerat ipsum. Cras nibh. Morbi vel justo vitae lacus tincidunt ultrices. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. In hac habitasse platea dictumst. Integer tempus convallis augue. Etiam facilisis. Nunc elementum fermentum wisi. Aenean placerat. Ut imperdiet, enim sed gravida sollicitudin, felis odio placerat quam, ac pulvinar elit purus eget enim. Nunc vitae tortor. Proin tempus nibh sit amet nisl. Vivamus quis tortor vitae risus porta vehicula.

2.3 Not as important section

Suspendisse vel felis. Ut lorem lorem, interdum eu, tincidunt sit amet, laoreet vitae, arcu. Aenean faucibus pede eu ante. Praesent enim elit, rutrum at, molestie non, nonummy vel, nisl. Ut lectus eros, malesuada sit amet, fermentum eu, sodales cursus, magna. Donec eu purus. Quisque vehicula, urna sed ultricies auctor, pede lorem egestas dui, et convallis elit erat sed nulla. Donec luctus. Curabitur et nunc. Aliquam dolor odio, commodo pretium, ultricies non, pharetra in, velit. Integer arcu est, nonummy in, fermentum faucibus, egestas vel, odio.

3

New chapter

This is a new chapter.

3.1 New section too!

So cool.

4

Conclusions

Oh boy it is finally over!

Bibliography

[1] Jacques Hadamard. Sur les problèmes aux dérivés partielles et leur signification physique. *Princeton University Bulletin*, 13:49–52, 1902.

[2] Nobel Media AB. The Nobel Price in Physiology or medicine 1979. (Accessed 26.9.2022), 2018. URL `https://www.nobelprize.org/prizes/medicine/1979/summary/`.

[3] Tommi Heikkilä, Hanna Help, and Alexander Meaney. Gel phantom data for dynamic X-ray tomography. Data set, University of Helsinki, March 2020. URL `https://doi.org/10.5281/zenodo.3696816`. v1.1.

[4] Neil D. Dizon. *Optimisation in the Construction of Multidimensional Wavelets.* PhD thesis, The University of Newcastle, 2021.

I

Short article

Article 1 – published version

Nulla malesuada porttitor diam. Donec felis erat, congue non, volutpat at, tincidunt tristique, libero. Vivamus viverra fermentum felis. Donec nonummy pellentesque ante. Phasellus adipiscing semper elit. Proin fermentum massa ac quam. Sed diam turpis, molestie vitae, placerat a, molestie nec, leo. Maecenas lacinia. Nam ipsum ligula, eleifend at, accumsan nec, suscipit a, ipsum. Morbi blandit ligula feugiat magna. Nunc eleifend consequat lorem. Sed lacinia nulla vitae enim. Pellentesque tincidunt purus vel magna. Integer non enim. Praesent euismod nunc eu purus. Donec bibendum quam in tellus. Nullam cursus pulvinar lectus. Donec et mi. Nam vulputate metus eu enim. Vestibulum pellentesque felis eu massa.

II

Another article

The manuscript is reprinted with permission from Myself.

Article 2 – final version

This is the only version needed

Quisque ullamcorper placerat ipsum. Cras nibh. Morbi vel justo vitae lacus tincidunt ultrices. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. In hac habitasse platea dictumst. Integer tempus convallis augue. Etiam facilisis. Nunc elementum fermentum wisi. Aenean placerat. Ut imperdiet, enim sed gravida sollicitudin, felis odio placerat quam, ac pulvinar elit purus eget enim. Nunc vitae tortor. Proin tempus nibh sit amet nisl. Vivamus quis tortor vitae risus porta vehicula.

Fusce mauris. Vestibulum luctus nibh at lectus. Sed bibendum, nulla a faucibus semper, leo velit ultricies tellus, ac venenatis arcu wisi vel nisl. Vestibulum diam. Aliquam pellentesque, augue quis sagittis posuere, turpis lacus congue quam, in hendrerit risus eros eget felis. Maecenas eget erat in sapien mattis porttitor. Vestibulum porttitor. Nulla facilisi. Sed a turpis eu lacus commodo facilisis. Morbi fringilla, wisi in dignissim interdum, justo lectus sagittis dui, et vehicula libero dui cursus dui. Mauris tempor ligula sed lacus. Duis cursus enim ut augue. Cras ac magna. Cras nulla. Nulla egestas. Curabitur a leo. Quisque egestas wisi eget nunc. Nam feugiat lacus vel est. Curabitur consectetuer.

Suspendisse vel felis. Ut lorem lorem, interdum eu, tincidunt sit amet, laoreet vitae, arcu. Aenean faucibus pede eu ante. Praesent enim elit, rutrum at, molestie non, nonummy vel, nisl. Ut lectus eros, malesuada sit amet, fermentum eu, sodales cursus, magna. Donec eu purus. Quisque vehicula, urna sed ultricies auctor, pede lorem egestas dui, et convallis elit erat sed nulla. Donec luctus. Curabitur et nunc. Aliquam dolor odio, commodo pretium, ultricies non, pharetra in, velit. Integer arcu est, nonummy in, fermentum faucibus, egestas vel, odio.

Sed commodo posuere pede. Mauris ut est. Ut quis purus. Sed ac odio. Sed vehicula hendrerit sem. Duis non odio. Morbi ut dui. Sed accumsan risus eget odio. In hac habitasse platea dictumst. Pellentesque non elit. Fusce sed justo eu urna porta tincidunt. Mauris felis odio, sollicitudin sed, volutpat a, ornare ac, erat. Morbi quis dolor. Donec pellentesque, erat ac sagittis semper, nunc dui lobortis purus, quis congue purus metus ultricies tellus. Proin et quam. Class aptent taciti sociosqu ad litora torquent per conubia nostra, per inceptos hymenaeos. Praesent sapien turpis, fermentum vel, eleifend faucibus, vehicula eu, lacus.

Appendix A: Algorithms

Here is the first appendix which contains an example algorithm. To simplify things, some macros are created first (but not rendered of course).

A.1 First algorithm in appendix

New things can still be cited, they will just appear in the biboliography which is printed already. We can also reference a specific line from the algorithm, like line 12.

Algorithm 1 2D discrete wavelet decomposition algorithm

Here we can put some detailed explanation. For example this algorithm does

$$\mathcal{W} : \boldsymbol{f} \longmapsto (\boldsymbol{a}, \boldsymbol{d}_1, ..., \boldsymbol{d}_J),$$

which is great.

Input: real-valued array $\boldsymbol{f}[k_1, k_2]$ of size $n_1 \times n_2$, decomposition level J, low-pass filter $l[k]$, high-pass filter $h[k]$

Output: detail coefficients $\boldsymbol{d} = [\boldsymbol{d}_1, \ldots, \boldsymbol{d}_J]$ for each scale, approximation coefficients $\boldsymbol{a}$ for coarsest scale

Require: $J \leqslant \log_2(\min\{n_1, n_2\})$

1: $n = \text{LENGTH}(h)$ ▷ *We assume both filters have the same length*
2: $\boldsymbol{a} \leftarrow \boldsymbol{f}$ ▷ *Initial input*
3: **for** scale $j = J : 1$ **do**
4: $\quad \boldsymbol{a} \leftarrow \text{PADDATA}(\boldsymbol{a}, n-1, \dim = 1)$ ▷ *Pad data based on filter length n*
5: $\quad L \leftarrow \text{CONV}(\boldsymbol{a}, l, \dim = 1)$
6: $\quad H \leftarrow \text{CONV}(\boldsymbol{a}, h, \dim = 1)$
7: $\quad L \leftarrow \text{DOWNSAMPLE}(L, \dim = 1)$
8: $\quad H \leftarrow \text{DOWNSAMPLE}(H, \dim = 1)$

9: $\quad L \leftarrow \text{PADDATA}(L, n-1, \dim = 2)$
10: $\quad H \leftarrow \text{PADDATA}(H, n-1, \dim = 2)$
11: $\quad LL \leftarrow \text{CONV}(L, l, \dim = 2)$
12: $\quad LH \leftarrow \text{CONV}(L, h, \dim = 2)$
13: $\quad HL \leftarrow \text{CONV}(H, l, \dim = 2)$
14: $\quad HH \leftarrow \text{CONV}(H, h, \dim = 2)$
15: $\quad \boldsymbol{a} \leftarrow \text{DOWNSAMPLE}(LL, \dim = 2)$
16: $\quad LH \leftarrow \text{DOWNSAMPLE}(LH, \dim = 2)$
17: $\quad HL \leftarrow \text{DOWNSAMPLE}(HL, \dim = 2)$
18: $\quad HH \leftarrow \text{DOWNSAMPLE}(HH, \dim = 2)$
19: $\quad \boldsymbol{d}_j \leftarrow [LH, HL, HH]$
20: **return** $[\boldsymbol{d}_1, \ldots, \boldsymbol{d}_J]$ and $\boldsymbol{a}$