Dissertation Title

Dissertation

zur

Erlangung der naturwissenschaftlichen Doktorwürde
(Dr. sc. nat.)

vorgelegt der

Mathematisch-naturwissenschaftlichen Fakultät

der

Universität Zürich

von

JANE DOE

aus

Somewhere, ZH

Promotionskommission
Ms. Ada Lovelace (Vorsitz)
Prof. Dr. Marie Curie
Prof. Dr. Albert Einstein
Prof. Isaac Newton

Zürich, 2025

Imprint

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Study program:
PhD in Data Science
Universität Zürich

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Generative AI Disclosure

Purpose of This Declaration

This section requires a declaration about your use of generative AI tools (e.g., ChatGPT, Grammarly, Copilot) during thesis preparation. Transparency about AI usage is increasingly required by academic institutions and publishers to maintain research integrity and scholarly standards.

Your declaration should clearly state:

- Which AI tools you used and for what specific purposes (editing, proofreading, translation, literature search, brainstorming, etc.)
- A clear statement that you reviewed and validated all AI-generated content
- Confirmation that AI was not used for original research, data analysis, or core scientific work (unless explicitly part of your methodology)
- A statement of your full responsibility for the final content and intellectual contributions

Where to Get Guidance

Before writing your declaration, consult the following resources:

- Check your institution's specific AI usage policies and requirements
- Consult your supervisor or thesis committee for their expectations
- Review your field's journal guidelines (e.g., Nature, Science editorial policies on AI)
- UZH resources: visit `https://www.uzh.ch/` and search for AI in academic integrity policies

Example Statement

The following is an example declaration statement that you should adapt to reflect your actual AI usage. Delete or modify sections that do not apply to your work, and ensure all statements accurately represent how you used AI tools in your thesis preparation.

In the preparation of this doctoral thesis, generative artificial intelligence (AI) tools were selectively employed for language refinement and copy editing. Specifically, Grammarly, Perplexity, and Microsoft Copilot assisted in enhancing grammatical accuracy, improving readability, and ensuring clarity of expression. As a non-native English speaker, these tools helped optimize technical communication while preserving academic voice.

All AI-generated content underwent rigorous critical evaluation and manual editing to ensure alignment with research integrity standards. The systems were never used to generate original scientific content, analyze data, or formulate research conclusions. The author remains fully responsible for the work's intellectual content, interpretations, and academic rigor.

This application of AI technologies adhered to institutional ethical guidelines and data privacy protocols. No sensitive or proprietary information was disclosed during AI interactions, with privacy settings activated where available. The tools served exclusively as editorial aids, maintaining human oversight throughout the writing process.

This declaration is made following current best practices for transparency in academic research and reflects my commitment to the responsible and ethical use of generative AI technologies.

Optional Addendum

If you used AI tools for purposes beyond copy editing, you may include an additional statement such as:

During the research process, AI tools were additionally leveraged for [briefly mention other uses, e.g., initial literature discovery or brainstorming], with all outputs rigorously fact-checked and contextualized within the thesis.

Final Note

Remember to delete these instructional sections before submitting your thesis. Your final declaration should contain only your personal statement about AI usage, properly adapted to your specific circumstances.

Abstract

The abstract is like a miniature version of the entire manuscript. Structure it similarly: Begin with the context and motivation for the project, a brief description of the method and available data, your findings, and conclusions. Limit yourself to one page!

Zusammenfassung

Die Zusammenfassung entspricht einer Miniaturversion des gesamten Dokuments. Gliedere sie ähnlich: Beginne mit dem Kontext und der Motivation für das Projekt, einer kurzen Beschreibung der Methode und der verfügbaren Daten, Ihren Ergebnissen und den Schlussfolgerungen. Beschränke dich auf eine Seite!

Acknowledgements

The acknowledgements belong here. Do not forget to mention your project supervisors, without flattering them too much.

Contents

To coffee, without which this thesis would have been written in my sleep.

The magic is not in the analyzing or the understanding.
The magic lives in the wonder of what we do not know.

Rick Rubin, *"The Creative Act: A Way of Being"*

Chapter 1

Introduction

The Introduction chapter establishes the research context, motivates the problem, introduces key concepts, and outlines the thesis structure. A typical introduction is 15–25 pages long, though this may vary depending on your field and institutional requirements.

The first section of your introduction should provide broad context and motivation. Start with the big picture: why does your research area matter? Then progressively narrow down to your specific research topic. This funnel approach helps readers understand where your work fits in the broader scientific landscape.

When writing your introduction, use the `\gls{}` command for the first mention of acronyms. Subsequent uses will automatically show only the abbreviation. Define all acronyms in the file `Front/abbreviations.tex`. Chapter titles should be concise yet descriptive enough to convey the main topic.

1.1 Your Research Field Context

This section should be approximately 3–5 pages and accomplish several goals. First, establish the broader scientific context of your work. Explain why this research field is important: what real-world problems does it address? What fundamental scientific questions does it tackle? Second, highlight recent advances that have made your research possible or necessary. Finally, identify the remaining challenges that motivate your specific contribution.

Remember to use the `\gls{}` command for the first mention of key technical terms. For paragraph breaks, you can use `\newline` instead of blank lines in certain contexts where more control over spacing is needed. When writing compound adjectives, use an en-dash (two hyphens: `--`) as in "decision–making" or "patient–level analysis."

1.1.1 Specific Challenge or Gap #1

Each subsection should be 1–2 pages and address a specific aspect or challenge in your research area. Begin by clearly explaining the challenge, then cite relevant literature to demonstrate that this is a recognized problem in the field. Finally, explain why current approaches are insufficient. This sets up the need for your contribution.

For example, you might discuss technical limitations, scalability issues, lack of generalizability, or gaps in theoretical understanding. Be specific about what exactly is missing or problematic in current work.

1.1.2 Specific Challenge or Gap #2

When citing multiple sources, separate them with commas but no spaces in the citation command. Describe the second major challenge your field faces, providing historical context if relevant. Trace how researchers have attempted to address this problem over time and explain the current state-of-the-art approaches.

This historical perspective helps readers understand why the problem has persisted and what makes it difficult to solve. It also demonstrates your command of the literature and positions you as a knowledgeable contributor to the field.

1.1.3 Your Methodological Approach

In this subsection, introduce your main methodological framework. What approach do you take to address the challenges outlined above? Explain the core methodology you employ throughout your thesis and describe its key advantages over alternative approaches.

Provide concrete examples of successful applications of this methodology, either from your own preliminary work or from the broader literature. This helps readers understand not just the theoretical merits of your approach, but its practical value.

1.1.4 Positioning Your Work

This subsection positions your specific work within the research landscape you have described. Use the `\fixedspaceword{}` command for hyphenated compound words that should not break across lines, ensuring readability.

Clearly state what makes your work unique. What specific gap does your research fill? How do your contributions advance the field beyond the current state-of-the-art? Preview your key contributions here, but save detailed descriptions for later chapters.

For instance: “This thesis addresses these limitations by developing a novel framework for [your approach]. Unlike previous work, our method [key distinguishing feature]. This enables [important capability or insight] that was not previously possible.”

Depending on your thesis structure and institutional requirements, you may include additional sections here such as Problem Statement, Scope and Limitations, or Ethical Considerations. Common additional sections include a clear problem statement that articulates the specific problem you address, a discussion of scope and limitations that clarifies what is and is not covered in your thesis, and a preview of your key contributions as a bulleted list.

1.2 Research Questions

Number your research questions clearly, as you will reference them throughout your thesis. Each research question should be specific, answerable, and focused. Avoid

overly broad questions like "How can we improve X?" Instead, ask targeted questions like "What factors influence Y under condition Z?" or "To what extent does method A outperform method B for task C?"

This thesis addresses the following research questions:

1. **Research Question 1:** How can [specific method] be adapted to address [specific challenge] in [specific context]?

2. **Research Question 2:** What is the relationship between [variable A] and [variable B] when [specific condition]?

3. **Research Question 3:** To what extent does [proposed approach] improve upon [existing method] for [specific application]?

Add or remove research questions as needed for your thesis. Typically, three to five well-crafted research questions provide sufficient focus. The questions should build on each other logically, often progressing from more fundamental questions about methods or mechanisms to questions about applications or implications.

1.3 Thesis Structure

This section provides a brief roadmap of your thesis, helping readers navigate the document and understand how the pieces fit together. Keep each chapter description to one or two sentences.

This thesis is organized as follows:

Chapter 2 provides a comprehensive overview of the three papers included in this thesis, summarizing their abstracts, scientific contributions, and author contributions for transparency.

Chapter 2.3 presents our investigation of [brief description], demonstrating how [method] can be applied to [problem] with [main finding].

Chapter ?? describes the development of [tool/framework/method], which addresses [research question] by [approach taken].

Chapter ?? discusses the application of our framework to [real-world problem], revealing [key insight or result].

Chapter 3 synthesizes the findings across all papers, explicitly addresses each research question posed above, discusses limitations and broader implications, and outlines promising directions for future research.

If your thesis includes appendices with supplementary material, technical details, or additional analyses, mention them here as well. Use the `\ref{}` command to reference chapters by their labels rather than hard-coding chapter numbers, which ensures consistency if you reorganize your thesis.

Special LaTeX Commands Reference

This section provides a quick reference for common commands used in thesis writing. Remove this section from your final thesis.

Glossary and Acronyms

Use `\gls{acronym}` for the first use (shows full form) and subsequent uses (shows abbreviation only). For plural forms, use `\glspl{acronym}`. For capitalized forms at sentence beginnings, use `\Gls{acronym}`. To force the full form, use `\acrfull{acronym}`, and to force the abbreviation, use `\acrshort{acronym}`.

Citations

Use `\autocite{key}` for standard citations and `\textcite{key}` for textual citations where the author name is part of the sentence (e.g., "Smith et al. \textcite{smith2020} demonstrated that...").

Cross-References

Create labels with `\label{sec:name}` and reference them with `\ref{sec:name}`.
For better readability, add descriptors: `Section~\ref{sec:name}`, `Chapter~\ref{chap:intro}` or `Figure~\ref{fig:results}`.

Typography

Use `\fixedspaceword{text}` to prevent line breaks in compound words. For dashes, remember: single hyphen (-) for compound words like "well-known"; double hyphen or en-dash (–) for ranges like "pages 10–25" and compound terms like "patient–level"; triple hyphen or em-dash (—) for breaks in thought or parenthetical statements.

Use `\newline` to force a line break within a paragraph without starting a new paragraph.

Template Instructions

About This Chapter

This chapter provides comprehensive summaries of all papers included in the thesis. It helps readers understand your contributions without reading the full papers. Each paper summary typically spans 2 to 4 pages and includes the abstract, scientific contributions, and author contributions.

Step 1: Define Paper Acronyms

Before the `\chapter` command, define acronyms for paper titles and authors. This allows easy reference throughout the thesis using the `\acl{}` command:

```
\newacro{paper1title}{Your First Paper Title Here}
\newacro{paper1authors}{First Author, Second Author, Third Author}
\newacro{paper2title}{Your Second Paper Title Here}
\newacro{paper2authors}{First Author, Fourth Author, Fifth Author}
\newacro{paper3title}{Your Third Paper Title Here}
\newacro{paper3authors}{First Author, Second Author, Sixth Author}
```

Add more definitions if you have more than three papers.

Step 2: Write Introductory Statement

Begin with a brief paragraph stating how many manuscripts are included and what information follows. Example: "This thesis consists of three manuscripts. Their contents are briefly summarized below with abstract, scientific contributions, and authors' contributions."

Step 3: Structure Each Paper Section

For each paper, include:

Paper Header:

- Section title with Roman numeral (I, II, III) and hyperlink to paper chapter
- Paper title in sans-serif bold: `\textsf{\bf\acl{paperNtitle}}`
- Author list in italics: `\textit{\acl{paperNauthors}}`
- Publication status (DOI for published, status for unpublished)

Abstract: Copy the exact abstract from your paper. Use `\noindent\textbf{\textsf{Abstract:}}~` to format the heading.

Scientific Contributions: Describe 3-5 key scientific contributions. Address:

- What is novel about your work
- What problem it solves
- What methodological frameworks you introduce

- How it addresses specific challenges
- What insights conventional approaches miss
- How it provides foundation for future work

Use `\newline` to separate paragraphs for better readability.

Authors Contributions: List each author in italics with their specific contributions using CRediT taxonomy roles: Conceptualization, Methodology, Software, Validation, Formal Analysis, Investigation, Resources, Data Curation, Writing (Original Draft), Writing (Review & Editing), Visualization, Supervision, Project Administration, Funding.

Publication Status Formatting

For **published papers**:

```
\noindent\href{https://doi.org/YOUR-DOI}{doi:YOUR-DOI}
```

For **submitted papers**:

```
\textit{Submitted Manuscript}
```

For **papers in preparation**:

```
\textit{In Preparation}
```

Formatting Tips

- Maintain consistent formatting across all papers
- Use same fonts and spacing throughout
- Keep abstract lengths comparable when possible
- Ensure all hyperlinks work (compile twice for references)
- Match labels with actual paper chapter labels for working hyperlinks
- Consider including figures if they add significant value

Common Variations

Depending on your field and university requirements, you may:

- Include journal impact factors
- Add publication timeline information
- Include broader impact statements
- Group papers by theme instead of chronologically
- Add acceptance rates or conference rankings

Consult your advisor and university guidelines.

Chapter 2

Paper Overview

This thesis consists of three manuscripts. Their contents are briefly summarized below with abstract, scientific, and authors' contributions.

2.1 Paper I (p. 13)

Title of Your First Research Paper Goes Here

by *Your Name, Co-Author Name, Another Co-Author, Senior Author*

doi:10.1234/your.doi.here

Abstract: This is where you paste the complete abstract from your first paper. The abstract should provide a concise summary of the research question, methodology, key findings, and implications. Typically, abstracts range from 150 to 300 words depending on journal requirements. Describe the background and motivation for the study, the specific approach or methods employed, the main results obtained, and the broader significance of your findings. Avoid using complex LaTeX formatting within the abstract text itself. Keep it straightforward and readable. The abstract should be self-contained and give readers a clear understanding of what the paper contributes without requiring them to read the full manuscript. Include any key quantitative results, statistical significance, or performance metrics that highlight the importance of your work.

Scientific Contributions

This study introduces [describe the novel application, method, or framework you developed]. It focuses on [specific domain or problem area] and addresses [key research gap or challenge].
The research [describe what you compared, demonstrated, or validated]. [Explain the main methodological innovation or approach]. A framework for [specific contribution] is described, effectively [what problem it solves or what it enables]. This approach ensures that [describe key properties or guarantees] while allowing [specific capabilities].
Additionally, the study [describe secondary contribution, e.g., demonstrates how to handle specific challenges]. This addresses a common challenge in [domain], where [describe the problem your approach solves].
The results demonstrate that [summarize key findings]. This [explain the significance

- e.g., confirms, reveals, enables, improves] what conventional approaches may overlook or cannot achieve. This comparative analysis [positions your work relative to existing methods].
Furthermore, the paper showcases [additional contribution such as visualization, tool, or interpretability advance]. This [explain the benefit, e.g., facilitates clinical interpretation, improves transparency, enables wider adoption].
Ultimately, this research establishes a foundation for [future directions]. Such advancements could [describe potential impact or applications].

Authors Contributions

Your Name led the study's conceptualization, developed the methodology, implemented the software, performed the analysis, and prepared the manuscript.
Co-Author Name contributed to [specific role, e.g., conceptualization, methodology development, data curation] and participated in manuscript revision.
Another Co-Author provided [specific expertise or contribution, e.g., domain expertise, validation, resources] and reviewed the manuscript.
Senior Author provided supervision, secured funding, and contributed to manuscript revision.
All authors engaged in critical review and approved the final version of the manuscript.

2.2 Paper II (p. ??)

Title of Your Second Research Paper Goes Here

by *Your Name, Different Co-Author, Another Collaborator, Senior Author*

doi:10.5678/your.doi.here

Abstract: This is where you paste the complete abstract from your second paper. Follow the same guidelines as for Paper I: provide context, describe methods, present key results, and explain significance. The abstract should be self-contained and give readers a complete picture of the paper's contribution. For software papers, describe what the software does, what problem it solves, what features it provides, and how it has been validated or applied. For methodological papers, explain the theoretical contribution, the algorithm or approach, its advantages over existing methods, and any empirical validation. Maintain a clear, professional tone and avoid jargon where possible. If domain-specific terms are necessary, ensure they are properly introduced or defined.

Scientific Contributions

The [software package/method/framework] has been [describe its history, usage, or context in the field]. However, [describe the problem or limitation that motivated your work]. [Provide relevant statistics or evidence supporting the need for improvement].
This project addressed the critical need to [describe what you improved, refactored, or developed]. The existing [system/method/codebase] had [describe specific problems]. Before adding new features, [explain why foundational work was needed].
[Describe your first major contribution, e.g., comprehensive testing, refactoring, new

algorithms]. This [what it achieved or uncovered]. [Provide specific examples of improvements or bugs fixed].
[Describe your second major contribution, e.g., CI/CD pipeline, parallelization, new features]. This [explain the technical challenge and your solution]. [Describe the impact or benefits].
[Describe your core scientific/technical contribution]. The [method/framework/implementation] was extended to [new capability]. [Explain any technical innovations or challenges overcome].
The documentation was [improved/created/updated] to enhance [usability, accessibility, adoption]. [Describe specific documentation improvements].
In summary, [number] new versions were released, representing significant improvements in [key areas]. This publication aligns with [relevant standards or guidelines, e.g., FAIR principles]. [Mention any additional planned contributions or community impact].

Authors Contributions

Your Name led the [specific technical contributions], developed [specific components], implemented [specific features], and authored the manuscript.
Co-Author Name designed and implemented [specific technical contribution], provided expertise in [domain], and contributed to [specific aspect].
Another Co-Author provided [supervision, funding, scientific guidance], contributed to [methodological development], and [other specific contribution].
Senior Author provided overall supervision, scientific guidance, financial support, and [other specific contributions].
[If applicable] The authors acknowledge the contributions of previous developers, particularly [names], whose earlier work established the foundation for this version.

2.3 Paper III (p. ??)

Title of Your Third Research Paper Goes Here

by *Your Name, Co-Author Name, International Collaborator, Multiple Authors, Consortium Name, Senior Author*

Submitted Manuscript

Abstract

This is where you paste the complete abstract from your third paper. For papers that build on previous work in your thesis, you may want to briefly acknowledge that connection in the Scientific Contributions section below, but the abstract itself should stand alone. Third papers in a cumulative dissertation often represent the culmination or synthesis of insights from earlier work, applying developed methods to new datasets, or extending frameworks to more complex scenarios. Ensure the abstract clearly articulates how this work contributes uniquely beyond your previous publications. Describe the specific research question, the dataset or experimental setup, the analytical approach, key findings, and implications for the field. Emphasize any novel applications, methodological extensions, or important empirical results.

Scientific Contributions

Building on the foundations established in previous publications, this project represents [describe how it extends or synthesizes earlier work]. This work [describe the specific advancement or application].
This work employs [specific method or framework] to [describe capability]. This methodological innovation allows for [specific advancement]. The [method/framework] supports [specific data types or capabilities], addressing a critical gap in [domain] and extending capacity for [specific application].
A key contribution is [describe major technical or empirical contribution, e.g., data curation, novel algorithm, large-scale validation]. This process ensures [specific benefits] and enhances [specific qualities].
By applying [your method], we are able to [specific achievements]. Notably, our results show that [key finding or insight].
The [method/framework] demonstrates [specific performance improvement or capability]. For example, [provide concrete example with metrics if available]. This underlines the value of [your approach] in [application domain] and provides a robust template for future research.
All [computational tools, code, protocols] are made available to the community in alignment with [relevant principles, e.g., open science, FAIR]. This transparency supports [reproducibility, future development, community benefit].
Taken together, this work [summarize overall impact]. The developed framework is [extensibility statement] to other [domains or applications] where [relevant challenges] are central.

Authors Contributions

Your Name conceived and designed the study, led [specific activities], developed and implemented [specific technical work], conducted [analysis activities], interpreted results, and drafted, revised, and finalized the manuscript.
Co-Author Name provided [domain expertise], facilitated [specific contribution such as data acquisition], and critically revised the manuscript for [specific aspects].
Another Co-Author supported [specific contribution] and participated in manuscript review.
Senior Author 1 provided expert supervision in [specific domain], contributed to [specific aspects], and reviewed the manuscript.
Multiple Collaborators were responsible for [specific contributions such as data acquisition, resources, or expertise] at their respective institutions.
[If applicable] *Consortium Name* provided [specific resources or contributions].
Senior Author 2 oversaw [specific aspects], secured funding, facilitated [collaboration or resources], and participated in [manuscript preparation].
All authors contributed to the interpretation of results and approved the final version of the manuscript.

Additional Notes

Including Figures

If a figure significantly enhances understanding (e.g., download statistics, workflow diagram, key result visualization), include it:

```
\begin{figure}
```

```
    \centering
    \includegraphics[width=0.9\textwidth]{Figures/your_figure.pdf}
    \caption{Your descriptive caption here. Explain what the figure
    shows and why it is relevant.}
    \label{fig:your_label}
\end{figure}
```

Reference it in text with: `(\ref{fig:your_label})`

Managing Long Author Lists

For papers with many authors or consortia:

- List key contributors individually with specific roles
- Group remaining authors: "Additional co-authors contributed..."
- Acknowledge consortia: "The [Consortium Name] provided..."
- Be specific about your contributions as first author

Consistency Checklist

Before finalizing, verify:

- All acronyms are defined before the chapter command
- All section labels match references in other chapters
- All DOIs are accurate and hyperlinks work
- Page references are correct (compile twice)
- Formatting is consistent across all papers
- Author contribution statements match published versions
- All figures are properly referenced and captioned
- Scientific contributions avoid redundancy across papers
- Language and tone are consistent throughout

Connection to Thesis Narrative

In your Introduction and Conclusion chapters, reference specific contributions:

```
As demonstrated in Paper I (see Section~\ref{paperoverview:paper1})...
```

This creates a cohesive narrative connecting your papers to the overall thesis argument.

Bayesian network analysis reveals the interplay of intracranial aneurysm rupture risk factors

Your Name, Co-Author Name, Another Co-Author, Senior Author

Published in *Computers in Biology and Medicine*
10.1016/j.compbiomed.2022.105740

Tutorial: Including Published Papers in Your Thesis

Overview

This tutorial explains how to include a published or submitted paper as a PDF chapter in your thesis. This approach is common in paper-based theses where papers are included as they were published in journals, preserving their original formatting and layout.

Setting Up the Chapter Heading

You have two options for creating the chapter heading. The first option creates a numbered chapter that will appear in the table of contents with an automatic chapter number using the standard `\chapter` command with optional short and full titles.

The second option, which is more convenient for paper-based theses, creates an unnumbered chapter with a manual table of contents entry which gives you complete control over how the paper appears in the table of contents. You can format it as "Paper I" followed by the full paper title, maintaining consistency across all included papers.

Formatting Author and Publication Information

After the chapter heading, you should display the author list and publication information. The author list typically uses emphasized italic formatting at a larger font size, followed by appropriate vertical spacing for visual clarity. Below the author list, you need to indicate the publication status of your paper. For published papers, include the journal name in italics along with the DOI as a clickable hyperlink. This allows readers to easily access the original publication online. If your paper has been submitted but not yet published, you can indicate this by stating "Unpublished Manuscript" followed by the name of the journal where it was submitted. For papers that have been accepted but are not yet in print, use "Accepted for publication" with the journal name and note that it is "In Press". For preprints available on arXiv or similar platforms, state "Published in arXiv" and provide the arXiv identifier as a hyperlink. This ensures readers can access the preprint version while awaiting formal publication.

Cross-Referencing and Page Setup

Create a label for the chapter using `\label{Paper1}` so you can reference this paper elsewhere in your thesis. This is particularly useful when discussing the paper's contributions in your introduction or conclusion chapters. Before including the PDF, ensure you start a new page and set the page style to plain. The `\cleardoublepage` command ensures the paper starts on a right-hand page in two-sided printing, which is the conventional placement for new chapters.

Including the PDF File

The basic approach for including a PDF uses the `\includepdf` command with several parameters. The `pages=-` option includes all pages from the PDF. The `trim` parameter allows you to adjust margins if needed, while `width=1.2\textwidth` scales the PDF to 120% of the text width, which is a common setting that maintains readability while fitting journal-formatted pages onto thesis pages.

Advanced PDF Inclusion Options

Sometimes you need more control over which pages to include. You can specify a page range such as pages 1 through 10 if you only want to include part of the paper. This is useful when excluding supplementary materials that appear elsewhere in your thesis.

For papers with non-contiguous sections, you can use multiple `\includepdf` commands with different page ranges.

Some papers contain large tables or figures in landscape orientation. To handle these properly, you can include portrait pages normally, then use the `angle=90` parameter to rotate landscape pages by 90 degrees. After the landscape section, continue with remaining portrait pages. This ensures all content appears correctly oriented in the final thesis.

Scaling and Formatting Options

You have several options for adjusting how the PDF appears on the page. Setting `width=1.2\textwidth` scales to 120% of the text width, which works well for most journal articles. Using `width=\textwidth` scales to the exact text width, while `height=\textheight` scales to the page height. The `fitpaper=true` option automatically fits the PDF to the page size.

If you want page numbers to appear in the thesis style rather than the original paper's style, you can add `pagecommand={\thispagestyle{plain}}` to the include command. This overrides the PDF's original page numbering with your thesis's numbering scheme.

File Organization

Organize your PDF files by placing them in the `Chapters/papers/` directory. Use descriptive filenames like `descriptive-name.pdf` or simple sequential names like

`paper1.pdf`, `paper2.pdf`. Consistent naming makes it easier to manage multiple papers and reduces the chance of errors when referencing files in your LaTeX code.

Copyright and Permissions

Before including a published paper, verify that you have the rights to include it in your thesis. Check your journal's thesis inclusion policies, as most journals allow authors to include their published work in their thesis, but some may have specific requirements or restrictions.

Some journals require an acknowledgment statement noting where the paper was originally published. Keep documentation of your permission to include the work, particularly if your institution requires proof for thesis submission or if the journal has specific terms.

Alternative to PDF Inclusion

If you need to modify the paper's content or do not have permission to include the published PDF, you can recreate the paper in LaTeX. Instead of using `\includepdf`, use `\input{}` or `\include{}` to incorporate a LaTeX file containing the paper's content. This gives you complete control over formatting but requires more work to maintain consistency with the published version.

Implementation Checklist

To implement this in your own thesis, replace the placeholder filename with your actual PDF filename. Verify that the PDF is placed in the `Chapters/papers/` directory. Adjust page ranges and orientations as needed based on your paper's layout. Update the publication status to reflect whether your paper is published, submitted, accepted, or available as a preprint. Add the correct DOI or other publication identifiers so readers can locate the original publication. Finally, test the compilation and check that page numbers appear correctly in the table of contents and throughout the chapter.

Working Example

Below is a complete working example demonstrating how to include a published paper. This example shows a paper titled "Bayesian network analysis reveals the interplay of intracranial aneurysm rupture risk factors" published in the journal Computers in Biology and Medicine.

The example demonstrates several key elements. First, it creates an unnumbered chapter with the full paper title. The table of contents entry is manually added with "Paper I:" as a prefix, followed by the full title. This formatting ensures consistency across all papers in a paper-based thesis.

The author list is displayed using emphasized italic formatting at a large font size, with vertical spacing of 0.7cm for visual separation. The publication information includes the journal name in italics, followed by the DOI as a clickable hyperlink. The

DOI format uses the standard doi.org resolver, making it easy for readers to access the original publication.

A label is created for cross-referencing purposes, allowing you to refer to this paper elsewhere in your thesis. The `\cleardoublepage` command ensures the paper begins on a right-hand page, and the page style is set to plain for consistent formatting throughout the included paper.

The PDF inclusion command specifies all pages using `pages=-`, no trimming of margins, and a width of 120% of the text width. The PDF file is stored in the `Chapters/papers/` directory with the filename `bnaiar.pdf`, following the recommended file organization structure.

Example LaTeX Code

Use this template as a starting point for including your first paper. Simply copy this code to a new file or replace the placeholders with your specific information.

```
% !TEX root = ../main.tex

\chapter*{[Full Title of Your First Paper]}
\addcontentsline{toc}{chapter}{Paper I:\\ [Full Title of
Your First Paper]}

{\em \large [Author 1, Author 2, Author 3]}\\[0.7cm]
{\large Published in {\em [Journal Name]}}\\[0.2cm]
{\large \href{https://doi.org/[YOUR-DOI]}{doi:[YOUR-DOI]}}

\label{Paper1}
\cleardoublepage
\pagestyle{plain}
\includepdf[pages=-, trim=0cm 0cm 0cm 0cm, width=1.2\textwidth,
pagecommand={}]{Chapters/papers/[your-paper-filename].pdf}
```

Chapter 3

Synthesis and Conclusion

How to Write This Chapter

The Conclusion or Synthesis chapter serves as the culmination of your thesis, bringing together all papers to demonstrate how your cumulative contribution exceeds the sum of individual parts. This chapter outlines future directions and shows how your work advances the field.

Begin with an opening paragraph of 3 to 4 sentences that previews the chapter structure. This paragraph should synthesize your research findings while explicitly linking them to the original research objectives you raised in your introduction. While writing the synthesis, go back and forth between this chapter and your Introduction chapter to ensure consistency in terminology, research questions, and framing. Situate your work within the broader context of your field and relevant subfields. Focus on several central themes that unify your contributions. Articulate how these threads weave together to form your thesis's cumulative contribution, and delineate clear, actionable pathways for future research and practical applications.

Ask your supervisor(s) for good examples of synthesis chapters from previous theses in your field.

Remember to reference the research questions from your Introduction chapter using the `\ref{}` command.

3.1 Main Results

Writing Your Main Results Section

This section directly addresses your research questions and forms the core of your synthesis. Organize your subsections either by research question or by thematic contribution, depending on which structure best reveals the relationships between your papers. Consider including a visual summary such as an overview figure to help readers grasp how your contributions fit together.

Begin with a paragraph that describes how your papers collectively chart a progression, whether methodological, theoretical, or empirical. Explain the journey from your starting point to your end point, and specify the application domain you are targeting. Reference a summary figure that illustrates how the individual papers interrelate and contribute to your overarching research objectives and questions.

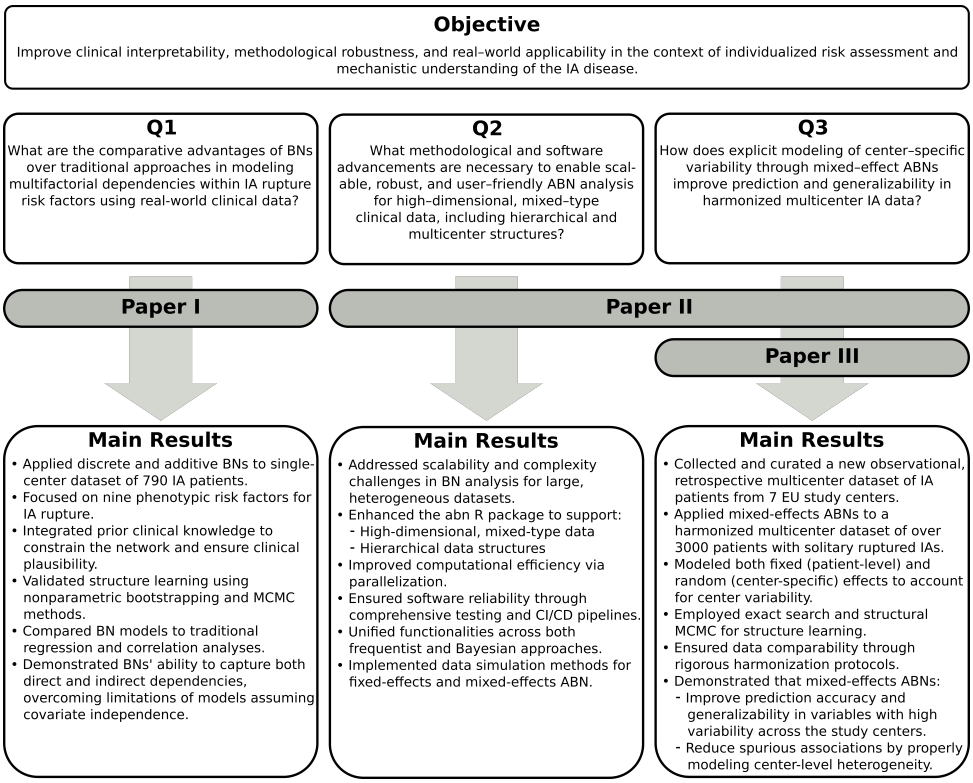

FIG. 1 : *Overview of thesis contributions showing how Papers I through III address the research questions and build upon each other. This figure should clearly illustrate the progression and connections between your papers, making explicit how each paper contributes to answering specific research questions. Adapted from [1].*

Here is an example opening paragraph:

The [number] papers collectively chart a [methodological/theoretical/empirical] progression, moving from [starting point] to [end point] tailored for [application domain]. Figure Fig. 1 summarizes the results, illustrating how the individual papers interrelate and contribute to the overarching research objective and questions.

Create an overview figure that summarizes how your papers relate to each other. Ensure this figure clearly shows the progression and connections between papers, making it easy for readers to understand your research trajectory at a glance.

Addressing Each Research Question

Now address each research question with its own subsection. Use unnumbered subsections with the `\subsubsection*{}` command when your research question titles are long. Reference the question labels from your Introduction chapter to maintain consistency throughout your thesis.

[Research Question 1: Full text of your first research question]

When addressing each research question, begin by briefly describing what the relevant paper did and found. Explain the study's distinguishing features, particularly any key methodological innovations that ensure important outcomes. Describe your validation approach and how it enhanced the robustness of your results, findings,

or models. Discuss how you systematically compared your outputs to baseline or alternative approaches. Demonstrate the feasibility, superiority, or advantages of your method, explicitly stating how it overcomes the limitations of conventional approaches.

Here is an example structure:

Paper I [briefly describe what Paper I did and found]. The study was distinguished by its [key methodological feature] to [ensure some property], thereby ensuring that [important outcome]. [Describe validation approach] which enhanced the robustness of the [results/findings/models]. The resulting [outputs] were systematically compared to [baseline/alternative approaches]. This approach demonstrated the [feasibility/superiority/advantages] of [your method] in [capability], overcoming the limitations of [conventional approaches] that typically [describe limitation].

Summarize how this paper addresses the research question, state your key findings and their significance, and compare your approach with existing methods in the field.

[Research Question 2: Full text of your second research question]

For your second research question, explain how the subsequent paper builds upon the foundations established previously. Address the challenges, limitations, or extensions inherent in broader application or scaling. Describe how you formalized key contributions and what capabilities these enabled. Explain the methodological advances you made and any related developments these necessitated, such as software, theory, or experiments. Clarify what you developed and why these developments were necessary. Show how your contributions provided the backbone necessary for application to real-world, complex, or challenging datasets, problems, or scenarios.

Here is an example structure:

Building upon the foundations from Paper I, Paper II addressed the [challenges/limitations/extensions] inherent in [broader application or scaling]. The authors formalized [key contribution], enabling [capability]. These methodological advances necessitated [related development, e.g., software, theory, experiments]. [Describe what was developed and why]. By [enabling/supporting/providing] [key features], [your contribution] provided the [type of] backbone necessary for the application to [real-world/complex/challenging] [datasets/problems/scenarios].

Make explicit how this paper builds on previous work, describe the key methodological or theoretical advances, and explain why these advances were necessary for addressing your research question.

[Research Question 3: Full text of your third research question]

For your third research question, describe how this paper leveraged the methodological advancements from previous work. Explain how you applied your methods or framework to specific datasets or problems. Show how the study explicitly modeled, addressed, or investigated key aspects, thereby addressing critical issues that often plague, limit, or affect certain types of studies or applications. Describe the approaches you employed to achieve your goals, and detail any additional methods you conducted. If applicable, describe your data quality measures. Demonstrate the

practical utility of your approach by showing how your models or framework not only improved specific metrics but also provided additional benefits, particularly in addressing problematic scenarios.

Here is an example structure:

Paper III leveraged the methodological advancements from Paper II by applying [methods/framework] to [describe dataset or problem]. This study explicitly [modeled/addressed/investigated] [key aspects], thus addressing the critical issue of [important challenge] that often [plagues/limits/affects] [type of studies/applications]. [Describe approach] were employed to [achieve goal], while [additional methods] were conducted using [techniques]. [Describe data quality measures if applicable]. The practical utility of [your approach] was clearly demonstrated as [these models/this framework] not only improved [metric A] by [achieving property], but also [additional benefit] that can arise when [problematic scenario].

Describe how this paper brings everything together, explain your practical validation or comprehensive application, and state your key results and their implications. If you have more research questions, add additional subsections following the same structure.

3.2 Overall Contributions

Writing Your Overall Contributions Section

This section steps back from individual papers to see the big picture. Focus on what is new that emerges from combining all papers rather than simply listing what each paper achieved. This section is often organized thematically rather than by paper, allowing you to highlight cross-cutting innovations and synergies.

Begin by characterizing your results according to interrelated themes. Identify the unifying aspects that tie your contributions together. Show how your work collectively demonstrates advantages over prior approaches. A comparison table can be very effective for showing how your contributions advance the field.

Consider to create a comparison table that highlights your key advances. Be specific about what is new in your work versus what existed in prior approaches. This helps readers quickly grasp your contributions.

3.2.1 [Thematic Contribution Area 1]

Name your thematic contribution areas with descriptive titles such as "Unified Methodological Innovations" or "Theoretical Advances" that capture the essence of your contributions.

[Specific Contribution A]

For each specific contribution, use descriptive titles such as "Advancing Interpretable Machine Learning" or "Novel Framework for X" that clearly indicate what you achieved.

Structure each contribution subsection as follows: first describe the problem that existed, then present your solution, and finally demonstrate the impact. Begin by explaining what traditional approaches have achieved in your domain context, citing relevant literature. However, also note the limitations of these approaches, such as limited capabilities or lack of desired properties. Explain how these limitations have hindered, slowed, or prevented desired outcomes.

Then contrast this with your approach. Explain how your framework or method explicitly provides key capabilities. Show how your method distinguishes itself from, enables advantages over, or provides benefits compared to alternative approaches. Describe additional capabilities that strengthen your approach and ensure desired properties or outcomes. Clearly state the problem, explain your solution, and demonstrate impact with evidence from your papers.

[Specific Contribution B]

For subsequent specific contributions within a thematic area, use descriptive titles such as "Software Engineering for Reproducible Research" or "Scalable Implementation."

Describe how your developments exemplify best practices or innovations in your domain, addressing specific crises, challenges, or problems in the field. Explain the features your system, package, or framework supports and the benefits these features ensure. Highlight notable innovations, such as specific features within your framework or system. Explain how these features allow certain capabilities through particular mechanisms. Demonstrate how your approach addresses challenges, providing evidence or metrics from your papers.

3.2.2 [Thematic Contribution Area 2]

Continue with additional thematic contribution areas. Most theses have 2 to 4 major thematic areas. Use descriptive titles such as "Practical Applications" or "Data Contributions" that clearly convey the nature of your contributions.

[Specific Contribution C]

For each additional contribution area, provide detailed descriptions of your important contributions. Organize your contributions thematically rather than simply by paper. This organization allows you to show how your contributions work together synergistically, creating value that exceeds the sum of individual parts.

3.3 Limitations

Writing Your Limitations Section

Every thesis has limitations, and addressing them honestly demonstrates scientific maturity. Organize this section either by paper or by type of limitation, depending on which structure better serves your narrative. Common limitation categories include data limitations such as size, quality, or scope; methodological constraints such as assumptions, scalability, or generalizability; validation limitations such as limited external validation or specific domains; scope limitations that identify what

was not addressed or boundary conditions; and resource constraints such as time, computational resources, or access limitations.

Begin with a brief acknowledgment that your thesis, while making significant contributions, has several limitations that warrant discussion.

3.3.1 [Limitation Category 1]

For each limitation category, use descriptive titles such as "Data Limitations" or "Methodological Constraints." Describe the limitation clearly and explain why it exists. Was it a deliberate choice, a practical constraint, or a theoretical boundary? Discuss the potential impact of this limitation on your results or conclusions. If applicable, explain how future work could address this limitation, thereby connecting your limitations to future research directions.

3.3.2 [Limitation Category 2]

Continue with additional limitation categories using descriptive titles such as "Computational Constraints" or "Scope Limitations." Follow the same structure as for the first category: describe the limitation, explain why it exists, discuss its potential impact, and if applicable, suggest how future work could address it.

Aim to describe 3 to 5 key limitations across your work. For each limitation, explain its impact on your findings and discuss potential mitigation strategies. This balanced treatment shows that you understand the boundaries of your work while still maintaining confidence in your contributions.

3.4 Future Research Directions

Writing Your Future Research Directions Section

Future work should be concrete and actionable, providing clear pathways for others to build on your research. Distinguish between three types of future work: extensions that represent natural next steps, improvements that address limitations identified in your work, and new directions inspired by your findings. Balance ambitious vision with practical next steps to make your future work both inspiring and achievable.

Begin with a paragraph that introduces the promising avenues your findings have opened, spanning areas such as methodological refinements, broader applications, and fundamental extensions.

3.4.1 [Future Direction 1]

For each future research direction, use descriptive titles such as "Methodological Extensions" or "Integration with Complementary Approaches." Describe the future direction clearly, explaining how it builds on the foundation, framework, or methods established in your thesis. Specify what capabilities this extension would enable and what current limitations or new opportunities it would address. Provide concrete next steps that make the future work actionable.

3.4.2 [Future Direction 2]

Continue with additional future research directions using descriptive titles such as "Applications to New Domains" or "Clinical Translation." Follow the same structure for each direction, making the work concrete and actionable.

3.5 Broader Impact

Writing Your Broader Impact Section

This section is optional but increasingly expected in modern theses. It addresses important questions such as: Who benefits from your research? What are the societal implications? What are the ethical considerations? A thoughtful broader impact section demonstrates that you understand your work's implications beyond the immediate scientific community.

Begin by stating that beyond the immediate scientific contributions, your work has broader implications for specific domains, society, or your field.

3.5.1 [Impact Area 1]

For each impact area, use descriptive titles such as "Clinical Decision-Making" or "Policy Implications." Describe the real-world impact or applications of your research. Discuss who benefits from your work and how they benefit. Be specific about the mechanisms through which your research creates value or addresses important problems.

3.5.2 [Impact Area 2]

For additional impact areas, consider topics such as "Ethical Considerations" or "Open Science." Discuss ethical implications, potential biases, or responsible use of your methods and findings. Address how your work promotes responsible research practices. Be honest about both positive impacts and potential negative consequences or misuse.

Discuss positive impacts on practice, policy, or society. Address potential negative consequences or misuse of your research. Describe how your work promotes responsible research practices, such as through open science, reproducibility, or ethical guidelines.

3.6 Concluding Remarks

Writing Your Concluding Remarks

Your concluding remarks should consist of 1 to 2 paragraphs that tie everything together. End on a forward-looking, inspiring note that leaves readers with a clear sense of your work's significance and future potential.

In the first paragraph, provide a high-level summary of your main achievement. Explain how your key contributions address fundamental challenges in your field related to specific problems. Describe how the integration of your methodological

approach with your application domain has yielded key innovations that advance the field.

In an optional final sentence, connect your work to the bigger picture. Consider how your research embodies the spirit of scientific progress, demonstrating that the value of your domain lies not only in specific metrics but in deeper values such as clarity, transparency, trust, or impact that it brings to stakeholders, your field, or society.

Alternative Organizational Structures

You have flexibility in organizing your Conclusion chapter. Here are three common structures:

Structure A (Question-based): This structure organizes your synthesis around your research questions. It includes Main Results organized by research questions, Overall Contributions, Limitations, Future Work, and Broader Impact.

Structure B (Theme-based): This structure organizes your synthesis around thematic contributions. It includes Key Findings organized by themes, Methodological Contributions, Practical Contributions, Limitations and Future Work, and Impact and Outlook.

Structure C (Paper-synthesis): This structure emphasizes how your papers build on each other. It includes Paper-by-Paper Summary, Cross-Cutting Themes, Cumulative Contribution, Limitations, and Future Directions.

Choose your structure based on how your papers relate to each other, whether questions or themes emerge more naturally from your work, and the conventions in your university or field.

Bibliography

(1) Delucchi, M. Modelling Evolution of the Intracranial Aneurysm Disease by Applying Probabilistic Graphical and Machine Learning Models, Ph.D. Thesis, University of Zurich, 2025.

Appendix A

Frequently Asked Questions

A.1 How do I change the colors of links?

The color of links can be changed to your liking using:

`\hypersetup{urlcolor=red}`, or

`\hypersetup{citecolor=green}`, or

`\hypersetup{allcolor=blue}`.

If you want to completely hide the links, you can use:

`\hypersetup{allcolors=.}`, or even better:

`\hypersetup{hidelinks}`.

If you want to have obvious links in the PDF but not the printed text, use:

`\hypersetup{colorlinks=false}`

A.2 How can I add a Figure in the Appendix?

You can refer to a figure in the Appendix (like Fig. 1) and it will show up as expected.

FIG. 1 : *Bart Simpson. (2023, May 17). In Wikipedia.* `https://en.wikipedia.org/wiki/Bart_Simpson`