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CERTIFICATE OF APPROVAL

PH.D. DEGREE DISSERTATION

The Ph.D. Degree Dissertation of Student's Name has been examined and approved by the dissertation committee as satisfactory for the dissertation required for the Ph.D. degree in Computer Science.

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This Ph.D. thesis is dedicated to all the L^AT_EX errors that tested my patience, the compiler warnings that kept me humble, and the endless debug sessions that taught me resilience. Without them, this journey would have been far too easy-and far less memorable. And to coffee, for being the true unsung hero of this endeavor.

Acknowledgments

Gratitude is one of the noblest feelings of a man. Thus, I could not fail to mention that the accomplishment of this work is the result of the collaboration of many people. I would like to express my gratitude in a particular way.

I would like to thank the one person without whom this document would never have seen the light of day: me. Yes, that's right—me. For not only creating this L^AT_EX template, but also generously sharing it with the students of this esteemed university. Truly, my brilliance knows no bounds, and my magnanimity knows no limits.

I must also thank my coffee mug, which stood loyally by my side through countless lines of code, offering solace and caffeine in equal measure. Finally, a nod to my keyboard, whose steadfast resilience endured my furious typing as I resolved bugs and made this template a reality.

To the students who will use this template: you're welcome.

*“With regard to performance, commitment, effort,
dedication, there is no middle ground.
Or you do something very well or not at all.”*

Ayrton Senna do Brasil (1960-1994)

Abstract

This document introduces a custom L^AT_EX template designed to simplify students' lives at IT University of Copenhagen, empowering them to create beautifully formatted academic documents with minimal effort. The template encapsulates the Brazilian Association of Technical Standards (ABNT) formatting guidelines while incorporating features that enhance usability, adaptability, and visual appeal. By providing this template, we aim to reduce formatting-related stress, encourage consistent document presentation, and gently guide students into the wonderful (and occasionally maddening) world of L^AT_EX. Whether you are writing a thesis, report, or any academic work, this template is your steadfast companion. Just don't forget to thank the creator in your acknowledgments.

Keywords: L^AT_EX, template, thesis, computer science, IT University of Copenhagen.

Resume

Dette dokument introducerer en skræddersyet L^AT_EX-skabelon, der er designet til at gøre livet lettere for studerende på IT-Universitetet i København. Skabelonen gør det muligt for dem at skabe smukt formaterede akademiske dokumenter med minimal indsats. Skabelonen overholder retningslinjerne fra Den Brasilianske Standardiseringsorganisation (ABNT) og indeholder samtidig funktioner, der forbedrer brugervenlighed, tilpasning og æstetik. Med denne skabelon stræber vi efter at reducere stress forbundet med formatering, fremme ensartet præsentation af dokumenter og blidt introducere de studerende til den fantastiske (og til tider frustrerende) verden af L^AT_EX. Uanset om du skriver en afhandling, en rapport eller et andet akademisk arbejde, er denne skabelon din trofaste følgesvend. Husk blot at takke skaberne i dine taksigelser.

Nøgleord: L^AT_EX, skabelon, afhandling, datalogi, IT-Universitetet i København.

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List of Acronyms

ABNT Den Brasilianske Standardiseringsorganisation.

ABNT Brazilian Association of Technical Standards.

ITU IT University of Copenhagen.

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Part I

Foundations and Context

Introduction

THIS L^AT_EX template provides a structured and professional foundation for the bachelor's, master's, and Ph.D. students from the IT University of Copenhagen (ITU), ensuring consistency, clarity, and ease of use as they develop their theses. The students can use this template to guide them in organizing their work effectively, allowing them to focus on the content while adhering to academic formatting standards.

The introduction chapter is where you set the stage for your thesis. It provides the reader with the necessary background, clearly defines the problem, and outlines the goals and significance of your study. This chapter serves as a roadmap for the rest of the thesis, giving the audience a clear understanding of what to expect and why your work matters.

1.1 Background and Context

This section introduces the reader to the broader context of your research area. You should:

1. **Describe the Field:** Provide an overview of your work's domain or discipline. Discuss recent trends or developments that make your research relevant.
2. **Highlight the Motivation:** Explain what motivated you to pursue this topic. This might include societal challenges, technological advancements, or gaps in existing knowledge.

Keep this section concise but informative. The goal is to give the reader enough context to appreciate the importance of the problem you aim to solve.

1.2 Problem Statement

Here, you define the specific problem your research addresses. This section should include:

1. **Current Challenges:** Summarize the key issues or limitations in the current state of knowledge or practice.
2. **Focus of the Study:** Clearly articulate the specific problem you aim to solve, ensuring it is well-defined and measurable.

A well-written problem statement helps the reader immediately grasp your thesis's core issue.

1.3 Objectives of the Study

In this section, clearly outline the goals of your research. These objectives should be specific, measurable, and aligned with the problem statement. Use bullet points or numbered lists to make them easy to read. For example:

- *To analyze...*
- *To develop...*
- *To evaluate...*

Ensure your objectives are realistic and achievable within the scope of your thesis.

1.4 Research Questions and Hypotheses

Here, you present the research questions that guide your study. These questions should be directly related to your objectives and problem statement. If applicable, state your hypotheses, explaining the assumptions or predictions your study will test. For example:

- **Research Question:** How does [variable] influence [outcome]?
- **Hypothesis:** It is hypothesized that [specific prediction].

This section demonstrates the focus and clarity of your study.

1.5 Scope and Limitations

This section defines the boundaries of your research and acknowledges its limitations. Include:

1. **Scope:** Explain what your study covers (e.g., data, methods, population).
2. **Limitations:** Be transparent about time, resources, or data availability constraints that may affect your results.

Being upfront about the limitations, adds credibility to your work and sets realistic expectations for the reader.

1.6 Significance of the Study

Discuss why your research is essential and its contribution to the field. Address questions like:

- How does this work fill existing gaps in knowledge?
- What are the practical or theoretical implications of your findings?

Convince the reader that your study has meaningful value and relevance.

1.7 Structure of the Thesis

This final section provides a brief overview of the chapters to follow. Write 1-2 sentences summarizing the content of each chapter. For example:

This thesis has six chapters, each addressing specific aspects of the research topic. The introduction composes Chapter 1 and sets the scene for the presented research project.

Chapter 2 provides a comprehensive overview of the relevant literature and existing research in the field. It critically evaluates previous works, identifies gaps in the knowledge, and establishes the theoretical foundation for the study.

Chapter 3 describes the research approach and methods to achieve the study's objectives. It includes details on data collection, experimental design, implementation, and

evaluation metrics. It also discusses ethical considerations and limitations of the methodology.

Chapter 4 presents the research findings clearly and systematically. It includes data visualizations, tables, and detailed analyses to interpret the results in the context of the research questions.

Chapter 5 provides a deeper interpretation of the results, comparing them with existing studies. It discusses the findings' implications, the study's strengths and limitations, and potential areas for future research.

Chapter 6 is the last chapter, and it summarizes the key findings, highlights the study's contributions, and provides actionable recommendations. It concludes with final reflections on the research and its broader impact.

Literature Review

THE literature review chapter is where you demonstrate your understanding of the existing body of knowledge in your research area. This chapter establishes the foundation for your work, highlighting the theoretical underpinnings, critically analyzing relevant studies, and identifying research gaps that your study aims to address. A well-structured literature review is essential for establishing the credibility and significance of your research.

Start this chapter by briefly explaining its purpose. Provide a roadmap for the reader, outlining what this chapter covers. For example: “*This chapter presents the theoretical foundations of the research, analyzes the state-of-the-art literature, critically evaluates existing studies, and identifies the gaps that this thesis seeks to address.*”

2.1 Theoretical Framework

In this section, you should introduce the theoretical concepts and models that underpin your research. This is where you establish the theoretical foundation of your study and explain the key concepts that inform your research questions. Discuss the relevant theories, frameworks, and methodologies that guide your work. Use equations or definitions if necessary. For example, you might write: “*According to X theory, you can express the relationship between A and B as: $A = f(B)$.*” Or, “*The study draws on the theoretical framework of Narcizo [1]. Equation 2.1 expresses his theory as:*”

$$y = mx + c \quad (2.1)$$

where y represents the dependent variable, m is the slope, and c is the intercept.

If necessary, you can comment or hide some sentences in your document. In L^AT_EX,

comments are created using the percent symbol (%). Any text following % on the same line will not be compiled, making it an excellent way to add notes or explanations to your code. Use comments to clarify your code for yourself and others, but avoid overusing them to maintain readability.

2.2 State-of-the-Art Review

Provide an overview of existing research in your topic area. Summarize key studies, methodologies, and findings to give the reader a comprehensive understanding of the current state of knowledge. Identify the major trends, debates, and controversies in the literature. You can organize this section thematically, chronologically, or methodologically, depending on what makes the most sense for your research.

2.2.1 Overview of Existing Research in the Topic Area

Briefly outline significant studies and highlight patterns or trends, for example: “*Research on this topic has grown significantly in recent years. Studies such as Narcizo [2] and Narcizo et al. [3] provide a comprehensive analysis of eye-tracking studies.*”

2.3 Critical Analysis of Related Work

This section is not just a summary but a critique. Compare methodologies, highlight strengths and weaknesses, and discuss how these studies inform your research. Identify gaps, contradictions, or limitations in the existing literature. For example:

The following critical points were identified in the literature:

- **Strengths:** Study *A* [4] effectively applies method *X* to context *Y*, demonstrating high reliability.
- **Weaknesses:** Study *B* [5] lacks generalizability due to a small sample size.

2.4 Research Gap Identification

Clearly articulate the gaps in the literature that your study addresses. This is a critical transition point that justifies your research. Explain how your work builds on existing

knowledge and contributes to the field. For example:

Despite extensive research in *XYZ*, significant gaps remain:

1. Limited exploration of *ABC* in context *DEF*.
2. Inadequate integration of *GHI* with *JKL*.

This thesis aims to address these gaps by focusing on . . .

2.5 Summary

Conclude the chapter with a summary that recaps the major findings from the literature and emphasizes the research gaps. For example: “*This chapter reviewed the theoretical foundations, state-of-the-art research, and critical analyses relevant to the study. Key gaps identified in the literature include . . . These findings establish the need for the research presented in the following chapters.*”

Part II

Research Methodology and Execution

Methodology

THE methodology chapter describes the approaches, tools, and processes you used to conduct your research. It should provide sufficient detail for the reader to understand how you gathered and analyzed data, making it possible for others to replicate your study if needed. This chapter demonstrates the rigor and validity of your research.

Start this chapter with a brief explanation of its purpose. Provide a roadmap for the reader. For example: “*This chapter outlines the research design, data collection methods, implementation details, evaluation metrics, and ethical considerations of this study. It provides a comprehensive explanation of the processes used to address the research questions presented in Section 1.4.*”

3.1 Research Design and Approach

Describe the overall design of your study. Explain whether it is experimental, observational, qualitative, or quantitative, and justify why this approach is appropriate for addressing your research questions.

If necessary, you can include figures or diagrams to illustrate the research design. You might include a flowchart showing the sequence of steps in your study or a diagram of the experimental setup. You must insert figures after you cited them in the text, and their captions should be below the them. There are two alternatives to include figures in your document: 1) a single figure or 2) a figure with subfigures. The former is used when you want to include a single image, while the latter is used when you want to include multiple images in a single figure. For example, Figure 1 shows the diagram of a binocular eye feature detector that I developed during my Ph.D. research project [6].

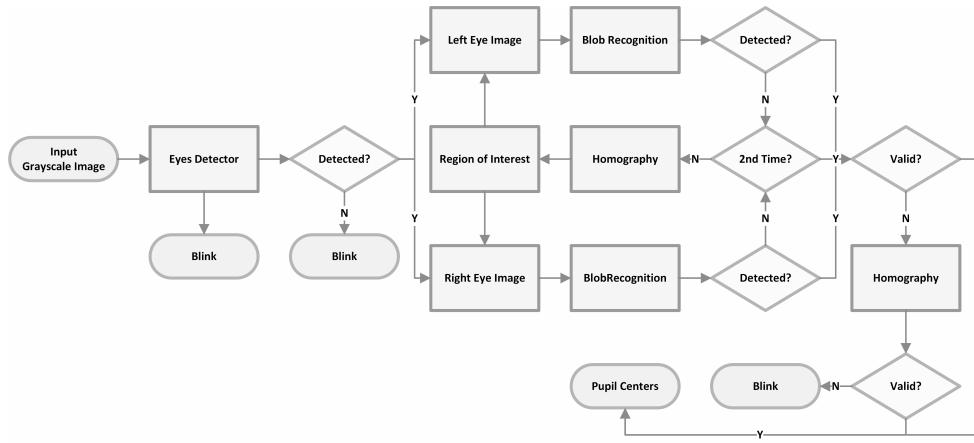


Figure 1: The proposed eye feature detector using information from both eyes

On the other hand, Figure 2 shows an example of a figure with subfigures. This figure includes two images side by side, each with its own caption. You can use subfigures to present related images or data together in a single figure. Figure 2a shows an off-the-shelf head-mounted eye tracker I built during my Ph.D. research project, while Figure 2b shows a participant of kayak experiments I performed to collect eye-tracking data of elite kayak/canoe athletes.

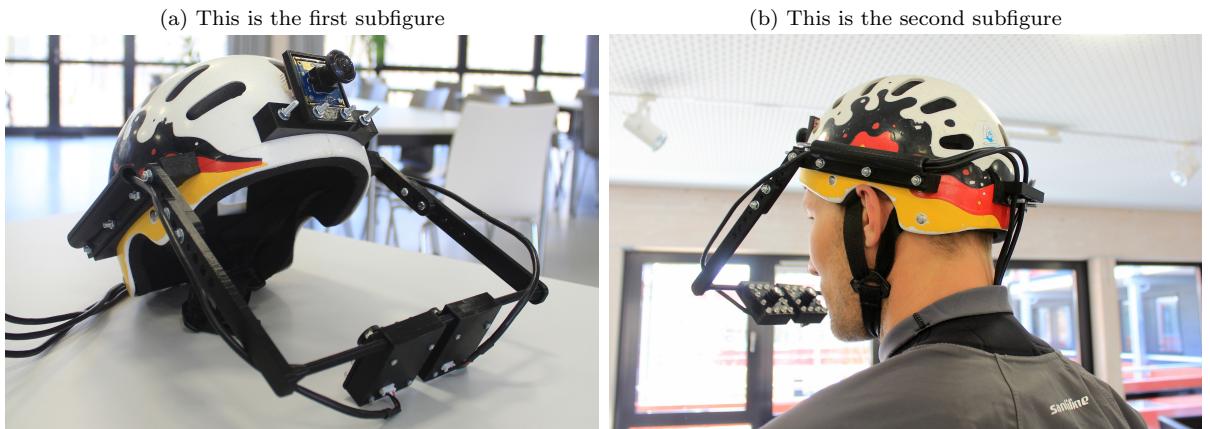


Figure 2: A head-mounted eye tracker prototype built with off-the-self hardware in a kayak helmet

3.2 Data Collection

Provide a detailed description of how data was collected, including the datasets, tools, or systems used. Explain the sampling strategy, data sources, and data collection methods. If you conducted experiments, describe the experimental setup and procedures.

For example, you might write: “*Data was collected from 100 participants using an online survey tool. Participants were recruited through social media advertisements and*

were asked to complete a series of tasks related to the study. The survey included Likert scale questions, open-ended responses, and demographic information.”

3.2.1 Description of Datasets, Tools, or Systems Used

Include details about the datasets, their sources, and preprocessing steps if any. Mention tools or platforms you used, such as APIs, software, or hardware. For example: “We collected data from the Twitter API using Python scripts. The dataset consisted of 10,000 tweets related to the topic of interest. We preprocessed the data by removing duplicates and filtering out irrelevant tweets.”

If necessary, you can include tables to present data collection details. Tables are useful for organizing large amounts of data in a structured format. For example, Table 3.1 shows a summary of the demographic information of the participants in the study.

Table 3.1: Summary of the demographic information of the participants in the study

Participant ID*	Age†	Gender‡	Occupation
1	25	Female	Student
2	30	Male	Engineer
3	22	Female	Designer
4	28	Male	Teacher
5	35	Female	Scientist
6	40	Male	Manager
7	27	Female	Developer
8	32	Male	Analyst
9	29	Female	Researcher
10	31	Male	Consultant§

* Participant ID is used to identify each participant.

† Age is presented in years.

‡ Gender is categorized.

§ This occupation is different from the others.

In the case of a table with multiple columns, you can add the table in landscape. For example, Table 3.2 shows similar information as Table 3.1 but in a horizontal format.

Table 3.2: Demographic Information of Participants

Participant ID	Age	Gender	Education Level	Occupation	Country	Survey Score	Comments
1	25	Male	Bachelor's	Engineer	USA	85	Good
2	30	Female	Master's	Scientist	UK	90	Excellent
3	22	Non-binary	Bachelor's	Student	Canada	75	Average
4	28	Female	PhD	Researcher	Germany	88	Very Good
5	35	Male	High School	Technician	Australia	80	Good
6	40	Female	Bachelor's	Manager	India	95	Excellent
7	27	Male	Master's	Developer	Brazil	78	Good
8	32	Female	PhD	Professor	Japan	92	Excellent
9	24	Male	Bachelor's	Analyst	France	82	Good
10	29	Female	Master's	Consultant	Italy	87	Very Good
11	26	Male	Bachelor's	Designer	Spain	83	Good
12	31	Female	Master's	Architect	Netherlands	89	Very Good
13	23	Male	Bachelor's	Writer	Sweden	77	Average
14	34	Female	PhD	Scientist	Switzerland	91	Excellent
15	28	Male	High School	Technician	Norway	79	Good
16	36	Female	Bachelor's	Engineer	Finland	94	Excellent
17	29	Male	Master's	Developer	Denmark	81	Good

If your table is too long to fit on a single page, you can use the `longtable` environment to create a table that spans multiple pages. For example, Table 3.3 shows a `longtable` that continues on the next page.

Table 3.3: Demographic information of participants (`longtable` example)

ID	Age	Gender	Occupation	Country
1	25	Male	Engineer	USA
2	30	Female	Scientist	UK
3	22	Non-binary	Student	Canada
4	28	Female	Designer	Australia
5	35	Male	Teacher	Germany
6	27	Female	Developer	India
7	32	Male	Manager	Brazil
8	29	Female	Nurse	Japan
9	24	Male	Artist	France
10	31	Female	Researcher	Italy
11	26	Male	Analyst	Spain
12	33	Female	Consultant	Netherlands
13	23	Male	Technician	Sweden
14	34	Female	Pharmacist	Norway
15	28	Male	Writer	South Africa
16	30	Female	Lawyer	Mexico
17	27	Male	Architect	China
18	29	Female	Chef	South Korea
19	25	Male	Pilot	Russia
20	32	Female	Accountant	Argentina
21	28	Male	Journalist	Egypt
22	31	Female	Dentist	Turkey
23	26	Male	Plumber	Greece
24	33	Female	Veterinarian	Israel
25	29	Male	Electrician	Portugal
26	27	Female	Librarian	Finland
27	34	Male	Carpenter	Denmark
28	30	Female	Biologist	Belgium

continues on the next page

Table 3.3 – continued from previous page

ID	Age	Gender	Occupation	Country
29	25	Male	Chemist	Austria
30	32	Female	Physicist	Switzerland
31	28	Male	Mathematician	Poland
32	31	Female	Economist	Hungary
33	26	Male	Statistician	Czech Republic
34	33	Female	Sociologist	Slovakia
35	29	Male	Psychologist	Romania
36	27	Female	Historian	Bulgaria
37	34	Male	Geologist	Croatia
38	30	Female	Anthropologist	Serbia
39	25	Male	Archaeologist	Slovenia
40	32	Female	Linguist	Bosnia

End of Table 3.3

3.3 Implementation Details

Explain the algorithms, frameworks, or models you implemented. Provide a step-by-step description of how the implementation was done, including programming languages, libraries, or tools. If you developed new methods or models, describe them in detail. For example: “*We implemented a convolutional neural network using TensorFlow and Keras. The model consisted of two convolutional layers followed by two fully connected layers. We trained the model on a GPU cluster using the Adam optimizer with a learning rate of 0.001. Listing 3.1 shows the architecture of the CNN model implemented in Python.*”

Listing 3.1: Convolutional neural network implemented in Python using TensorFlow and Keras.

```

1 # Build the CNN model.
2 model = models.Sequential([
3     layers.Conv2D(32, (3, 3), activation="relu", input_shape=(32, 32, 3)),
4     layers.MaxPooling2D((2, 2)),
5     layers.Conv2D(64, (3, 3), activation="relu"),
6     layers.MaxPooling2D((2, 2)),
7     layers.Flatten(),
8     layers.Dense(128, activation="relu"),
9     layers.Dense(10, activation="softmax")
10])

```

3.4 Evaluation Metrics

Describe the metrics used to evaluate your results. Provide mathematical definitions if applicable. For example:

The performance of the model is evaluated using accuracy, precision, recall, and F1-score, defined as:

$$F1 = 2 \times \frac{\text{Precision} \times \text{Recall}}{\text{Precision} + \text{Recall}}. \quad (3.1)$$

These metrics provide a comprehensive assessment of model performance.

3.5 Ethical Considerations

Discuss any ethical considerations related to your research. Explain how you addressed issues such as data privacy, informed consent, and participant anonymity. If your research involved human subjects, describe the steps you took to ensure their safety and well-being. For example: “*Participants were informed about the purpose of the study and provided written consent before participating. All data collected was anonymized to protect participant privacy. The study was approved by the Institutional Review Board (IRB) and followed ethical guidelines for research involving human subjects.*”

3.6 Summary

Summarize the key points of the methodology chapter. Provide a brief overview of the research design, data collection methods, implementation details, evaluation metrics, and ethical considerations. This section should reinforce the importance of the methodology in ensuring the validity and reliability of your research.

Part III

Results and Interpretation

Results and Analysis

THE results and analysis chapter presents the outcomes of your study and provides an in-depth interpretation of the findings. This chapter should be structured to highlight the connection between your research questions, the data, and the insights derived from the analysis.

Start the chapter with a brief overview of its purpose. For example: “*This chapter presents the results obtained from the experiments and analyzes them in the context of the research objectives. The findings are discussed with the support of tables, figures, and graphs, followed by a detailed interpretation of their significance.*”

4.1 Data Processing and Preparation

Detail the steps taken to preprocess the data and make it suitable for analysis. Include techniques such as cleaning, normalization, or feature extraction. For example:

The data preparation involved the following steps:

1. Data cleaning to handle missing values and outliers.
2. Normalization of numerical features to ensure consistent scaling.
3. Feature extraction using principal component analysis (PCA).

See Chapter 3 for details on the preprocessing tools used¹.

¹This is a footnote example. Footnotes are useful for providing additional information or clarifications without disrupting the flow of the text.

4.2 Experimental Setup

Explain the experimental configuration, including software, hardware, and parameters used. Provide enough detail for others to replicate your experiments. For example: “*The experiments were conducted on a system with the specifications shown in Table 4.4.*”

Table 4.4: Experimental setup

Parameter	Value
Processor	Intel Core i7
Memory	16 GB
Framework	PyTorch 2.0

4.3 Results Presentation

Use tables, figures, and graphs to present your results. Be sure to label and caption all visuals for easy reference. I strongly recommend using the `tikz`. For example, Figure 3 shows the gaze-error distribution on the *Y*-axis of real eye-tracking data.

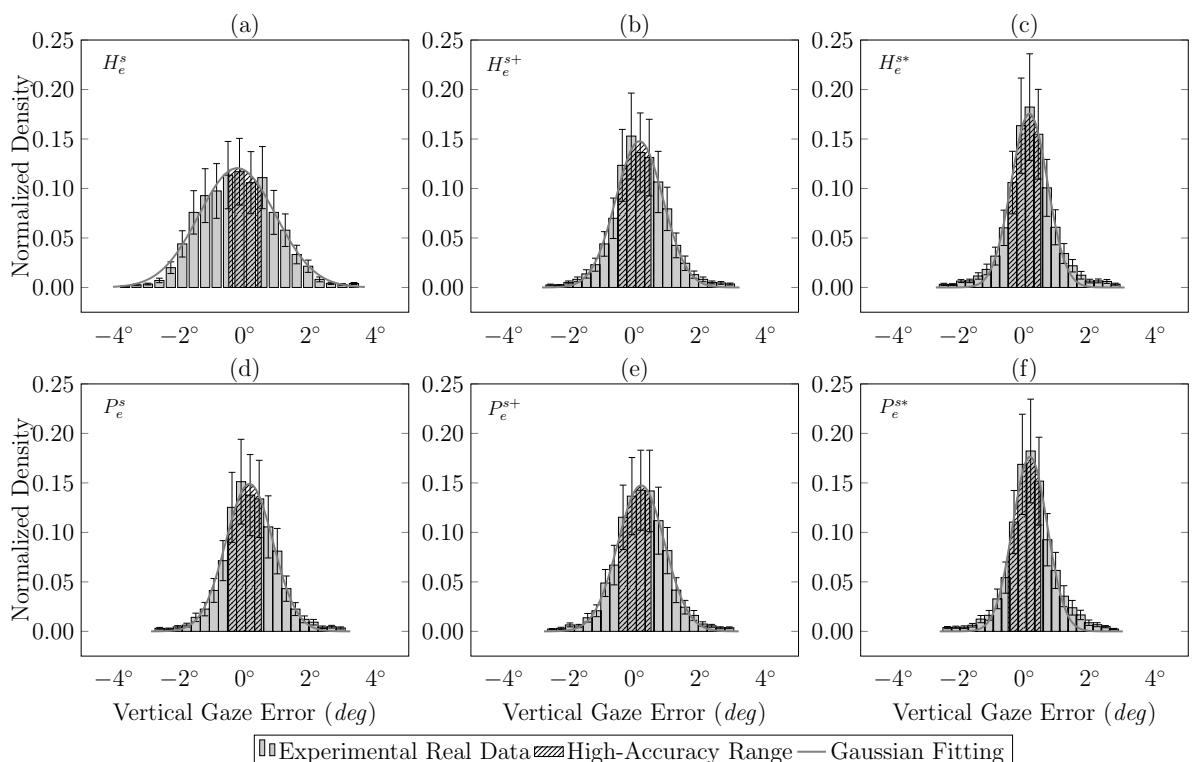


Figure 3: Example of dynamic `tikz` plot that reads `csv` files with actual results data.

Table 4.5 shows a smaller variance in the gaze-error on the *X*-axis than on *Y*-axis.

The number of gaze estimations between -0.5° and 0.5° increases using the methods proposed in this study [7]. When compared with traditional gaze estimation methods, the proposed methods (signed with + and * symbols) present a significant improvement in gaze estimation accuracy.

Table 4.5: The Gaussian PDF of real gaze estimations between -0.5° and 0.5°

Methods	Gaze _X	Gaze _Y	Average
H_e^s	0.50	0.32	0.41
H_e^{s+}	0.50	0.50	0.50
H_e^{s*}	0.51	0.62	0.57
P_e^s	0.47	0.50	0.49
P_e^{s+}	0.49	0.50	0.50
P_e^{s*}	0.55	0.63	0.60

`Tikz` is a powerful tool for creating high-quality graphics directly in L^AT_EX. In my paper from 2021 [7], I used `tikz` to create all the figures and plots. This example reads `csv` files with the actual results data and generates a dynamic plot. The `tikz` code is available in the `tikz/real-data-histogram.tex` file and the `csv` data in the `data` folder. This file and data are the same used in the paper [7].

Another good alternative for creating plots is the `pgfplots` package. This package is based on `tikz` and provides a high-level interface for creating plots. For example, Figure 4 shows the relationships between driver characteristics (experience and age) and various driving parameters, including speeding behavior, engine speed, and vehicle speed across age groups. You can save the `Matplotlib` plots as `.pgf` files using the following Python code, just after showing the plot: `plt.savefig("pgf/co-rq-1.pgf")`.

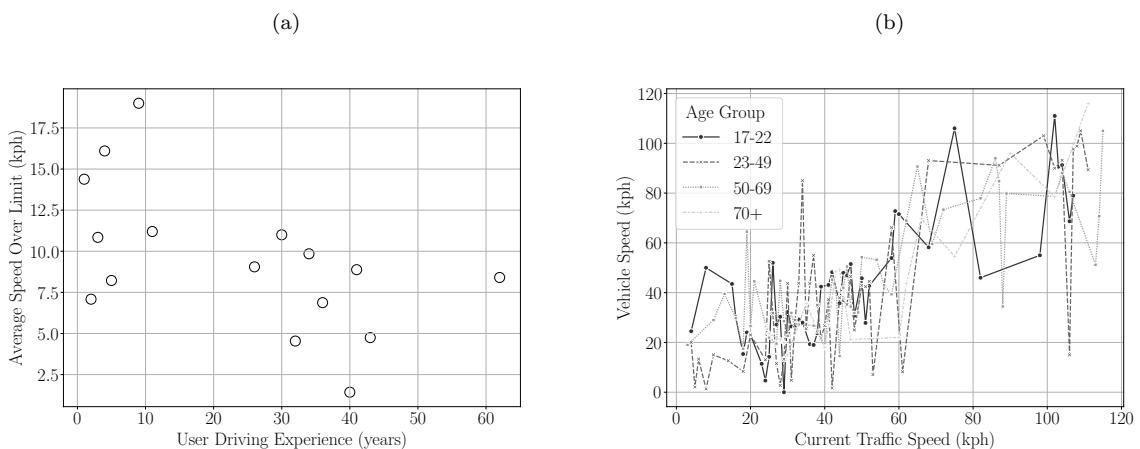


Figure 4: Example of `pgfplots` generated using Python.

4.4 Analysis and Interpretation

Analyze the results in the context of your research questions or hypotheses. Discuss trends, patterns, and implications, and highlight how your findings relate to previous work. For example: “*The results show a significant improvement in gaze estimation accuracy using the proposed method. The average gaze accuracy increased up to 30% compared to the traditional methods, as shown in Table 4.5. The results indicate a significant improvement in performance compared to prior work [6]. Models H_e^{s*} and P_e^{s*} outperformed other models, increase the high-accuracy gaze estimation to 62% and 63% respectively.*”

4.5 Summary

Conclude the chapter by summarizing and connecting the primary findings to your research objectives. Indicate how the results cover the way for discussions in the next chapter. For example: “*In the first example, the results demonstrate the effectiveness of the proposed method in improving gaze estimation accuracy [7]. In the second one, the findings provide valuable insights into the relationship between driver characteristics and driving behavior. The next chapter will discuss the implications of these results and suggest future research directions.*”

Discussion

THE discussion chapter is where you interpret your findings in depth, placing them in the context of existing research and explaining their significance. This chapter is an opportunity to critically evaluate your work, address its limitations, and propose directions for future research. Start the chapter by summarizing the key findings from your results chapter. Highlight how these findings answer the research questions or address the hypotheses. For example:

This chapter provides a concise summary of the primary outcomes of this research, emphasizing their relevance to the stated objectives and hypotheses. The analysis revealed several significant insights:

- Model P_e^{s*} achieved the highest accuracy (63%) among all tested models.
- The proposed methodology improved performance metrics compared to existing techniques (see Table 4.5).
- This supports the hypothesis $H_1 : \mu_1 \neq \mu_2$.

5.1 Comparison with Existing Work

Compare your findings with those from the literature. Highlight similarities, differences, and how your work contributes to the existing body of knowledge. For example:

The results align with prior studies, such as Melo et al. [8], who observed similar trends in model performance. However, unlike Narcizo [2], this study demonstrates that ... As illustrated in Figure 3, Model P_e^{s*} outperformed benchmarks by a significant margin.

5.2 Implications of Findings

Discuss the practical, theoretical, or methodological implications of your research. Explain how your findings can be applied in real-world scenarios or how they advance the field. For example:

The findings have several important implications:

1. **Practical Implications:** The proposed model can be integrated into real-time systems for *XYZ* applications.
2. **Theoretical Implications:** This study provides evidence supporting the hypothesis that . . .

5.3 Strengths and Limitations

Critically evaluate your work, acknowledging its strengths while being transparent about its limitations. This section adds credibility by showing awareness of potential weaknesses. For example:

This research has several strengths:

- Rigorous evaluation using state-of-the-art benchmarks.
- Use of diverse datasets to ensure generalizability.

However, there are limitations:

- Limited dataset size for certain experiments, which may affect statistical power.
- The scope of the study excludes . . .

5.4 Future Research Directions

Propose potential directions for extending your research. This demonstrates a forward-thinking approach and contributes to the ongoing development of the field. For example:

Future research could explore the following directions:

1. Investigating the scalability of the proposed methodology to larger datasets.

2. Extending the approach to incorporate deep learning techniques for ...
3. Conducting cross-domain studies to validate the generalizability of findings.

Part IV

Conclusion and Outlook

Conclusions

THE conclusions chapter serves as the final summary and reflection of your work. It highlights the key contributions of your thesis and discusses potential avenues for future research. This chapter is crucial as it ties together all your findings and reinforces the significance of your work in the broader context of your field.

6.1 Contributions of this Thesis

In this section, you should clearly articulate the specific contributions your work has made to the field. This is your opportunity to summarize the original insights, developments, or innovations your thesis has provided. Focus on:

1. **Key Achievements:** Highlight the major findings or results of your study. Ensure you connect them to the objectives outlined in your introduction.
2. **Significance:** Explain why these contributions are important and how they address gaps or challenges identified in the literature.
3. **Scope of Impact:** Discuss how your work may influence future research, applications, or industry practices.

Write in a confident tone and avoid repeating detailed results already presented in the earlier chapters. Instead, provide a concise overview that emphasizes the importance of your work.

6.2 Future Work

This section reflects on the limitations of your study and proposes directions for future research. A thoughtful discussion here demonstrates your awareness of the boundaries of your work and your vision for advancing the field. Include:

1. **Unresolved Questions:** Identify areas where additional research is needed to build on your findings;
2. **New Opportunities:** Suggest innovative applications or extensions of your work that were beyond the scope of your thesis; and
3. **Practical Suggestions:** Provide actionable ideas for researchers or practitioners interested in exploring the topics further.

Be honest about the limitations of your work and frame them as opportunities for future exploration. This demonstrates maturity in your understanding of the research process and contributes to a constructive academic dialogue.

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- [3] F. B. Narcizo, J. E. R. de Queiroz, and H. M. Gomes, “Remote eye tracking systems: technologies and applications,” in *Proceedings of the 26th Conference on Graphics, Patterns and Images Tutorials*, SIBGRAPI-T ’13, (Washington, DC, USA), pp. 15–22, IEEE Computer Society, aug. 2013.
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- [5] E. Munzlinger, F. B. Narcizo, and J. E. R. de Queiroz, “Sistematização de revisões bibliográficas em pesquisas da área de ihc,” in *Proceedings of the 11th Brazilian Symposium on Human Factors in Computing Systems*, IHC ’12, (Porto Alegre, RS, Brazil), pp. 51–54, Brazilian Computer Society, nov. 2012.
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- [8] J. C. de Carvalho Melo, F. B. Narcizo, D. W. Hansen, C. Brabrand, and A. Wasowski, “Variability through the eyes of the programmer,” in *Proceedings of the 25th International Conference on Program Comprehension*, ICPC ’17, (Washington, DC, USA), pp. 34–44, IEEE Computer Society, may 2017.

Annex

A

Standard Front Page



SUBMISSION OF WRITTEN WORK

Class code:

Name of course:

Course manager:

Course e-portfolio:

Thesis or project title:

Supervisor:

Full Name:

Birthdate (dd/mm/yyyy): E-mail:

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Source Code

PLEASE, avoid to add source-codes directly in your thesis chapters. Instead, add them as an appendix or in a separate document. This approach ensures that the document remains clean and easy to read. Below is an example of how to include a Python script in the document. See Listing A.1 for the source code.

Listing A.1: Convolutional neural network implemented in Python using TensorFlow and Keras.

```
1  #
2  # MIT License
3  #
4  # Copyright (c) 2024 Fabricio Batista Narcizo
5  #
6  # Permission is hereby granted, free of charge, to any person obtaining a copy
7  # of this software and associated documentation files (the "Software"), to deal
8  # in the Software without restriction, including without limitation the rights
9  # to use, copy, modify, merge, publish, distribute, sublicense, and/or sell
10 # copies of the Software, and to permit persons to whom the Software is
11 # furnished to do so, subject to the following conditions:
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13 # The above copyright notice and this permission notice shall be included in
14 # all copies or substantial portions of the Software.
15 #
16 # THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS OR
17 # IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY,
18 # FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL THE
19 # AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER
20 # LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING FROM,
21 # OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN THE
22 # SOFTWARE.
23 #
24
25 """This script shows how to train a CNN model using the CIFAR-10 dataset and
26 evaluate its performance."""
27
28 # Import the required libraries.
29 import matplotlib.pyplot as plt
```

```
30
31 from tensorflow.keras import layers, models
32 from tensorflow.keras.datasets import cifar10
33
34
35 # Load the dataset.
36 (X_train, y_train), (X_test, y_test) = cifar10.load_data()
37
38 # Normalize the pixel values.
39 X_train, X_test = X_train / 255.0, X_test / 255.0
40
41 # Build the CNN model.
42 model = models.Sequential([
43     layers.Conv2D(32, (3, 3), activation="relu", input_shape=(32, 32, 3)),
44     layers.MaxPooling2D((2, 2)),
45     layers.Conv2D(64, (3, 3), activation="relu"),
46     layers.MaxPooling2D((2, 2)),
47     layers.Flatten(),
48     layers.Dense(128, activation="relu"),
49     layers.Dense(10, activation="softmax")
50 ])
51
52 # Compile the model.
53 model.compile(
54     optimizer="adam",
55     loss="sparse_categorical_crossentropy",
56     metrics=["accuracy"]
57 )
58
59 # Train the model
60 history = model.fit(
61     X_train, y_train, epochs=20, validation_data=(X_test, y_test)
62 )
63
64 # Plot the training and validation accuracy and loss over epochs.
65 plt.plot(history.history["accuracy"], label="accuracy")
66 plt.plot(history.history["val_accuracy"], label = "val_accuracy")
67 plt.xlabel("Epoch")
68 plt.ylabel("Accuracy")
69 plt.ylim([0.5, 1])
70 plt.legend(loc="lower right")
71 plt.show()
```