16630927 - MTH3007M

Mathematics of Image Processing and Recognition: Research Plan

Project Description

Image processing and recognition are about breaking down images into numerical descriptors and using this to recognise patterns. For example, there are many systems now that can spot a face from a photograph, such as Microsoft's face detection and recognition technologies [1]. The wide range of applications behind this topic is my primary motivation for selecting this project title.

This project will research the mathematics behind image processing and use technology to practice image processing and pattern recognition. I have divided this topic into three sections; the mathematics behind feature extraction (converting images to appropriate numerical descriptors), pattern recognition, and applications. Within the applications section, I intend to look at the mathematical foundations and how this has evolved with technology, then move on to current applications and intend to work on a practical application using a computer language, such as Python or C++.

The project was provided with the example application of categorisation of Atomic Force Microscope images. However, I would like to focus on everyday examples such as medical or social uses. We have already introduced facial recognition [1], which is also helpful for unlocking electronic devices such as our phones. Image recognition is also used in traffic management, such as road sign recognition [2]. Medically there are applications in diagnosis, such as organ detection in tumour patients [3], and refining ultrasound images [4].

In 2021 I undertook the module MTH2006M: Industrial And Financial Mathematics, where we were introduced to industrial applications of mathematics. One that particularly fascinated me was a talk given by Natasha Maurits, UMCG, 23 February 2021 [4], on the enhancement of ultrasound images using a feature extraction method, the Sobel Operator, to diagnose ALS. The Sobel Operator is an edge detection filter that can take noisy images and refine them, allowing for a more definite diagnosis. I chose this application among others to research and finalised this with a poster on the topic.

Literature Review

Bishop states that understanding statistical pattern recognition is necessary to understand neural networks [5]. As such, this book provides a solid statistics foundation, focusing on Baye's Theorem (chapter 1), probability density estimation (chapter 2), and single-layer networks (chapter 3). I will be starting my project research by studying these chapters. Additionally, this book will research feature extraction (chapter 7) and pattern recognition (chapter 8: learning and recognition).

Pattern Classification [6] is a book recommended by Bishop [5]. It, too, has a statistical base but focuses more on techniques for this project. In summary, it has Bayesian Decision Theory (chapter 2), Non-Parametric Techniques (chapter 4), Neural Networks (chapter 6), machine-learning (chapter 9), and more. Pattern Recognition [7] is a book similar to this. It starts with Bayes decision theory, though it focuses more on feature extraction and has several chapters on cluster analysis. This will not necessarily be a book to start with, but I see this being useful when researching pattern recognition. I anticipate both of these books being the main resources of the project.

I found it necessary to find a preliminary report on neural networks, as they may be a vital part of my project towards the computer application section. They are based on the human brain and allow computers to recognise patterns [8]. I also found a helpful article [9] from a software developer that explains neural networks from a mathematical standpoint and explains them well too. These resources will be necessary to support my understanding alongside the books already mentioned.

Another book I have found, Intelligent Biometric Techniques in Fingerprint and Face Recognition [10], focuses on applications. This application can be used in security and social applications such as organising photographs by faces [1]. I intend to read this book alongside others, as it does not seem as maths-intense as it is descriptive of processes, to provide a thorough understanding of an application.

When it comes to the practical side of my project, I have found resources from Mathworks on Image Filtering [11], and also region of interest (ROI) based processing [12]. Resources such as this will help explore techniques and different types of feature extraction.

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Conducting Research

The majority of my research will be conducted through reading the material mentioned in the literature review and any new resources I find and then collating and relating the information found to be relevant for the project. Towards the end of the module, I will be moving to computer applications, using Python, Julia, and C++. My project report will be written in LaTeX using the online editor Overleaf [13].

Supervisor Meetings

I have arranged to meet with my supervisor, Dr Matthew Watkins, every Tuesday (apart from Christmas break) between 10:30 - 10:50.

Equipment and Costs

There are no requirements beyond standard equipment already available. I will be using a laptop, electronic tablet, and my logbook to conduct my research, alongside books from the library. I also have access to online resources such as library databases that the university subscribes to. When I cannot use my laptop, I will be using the computers in the computer lab INB2305, with access to all necessary C++, Python, and MATLAB software. For storage, I will use online cloud storage, such as my OneDrive university.

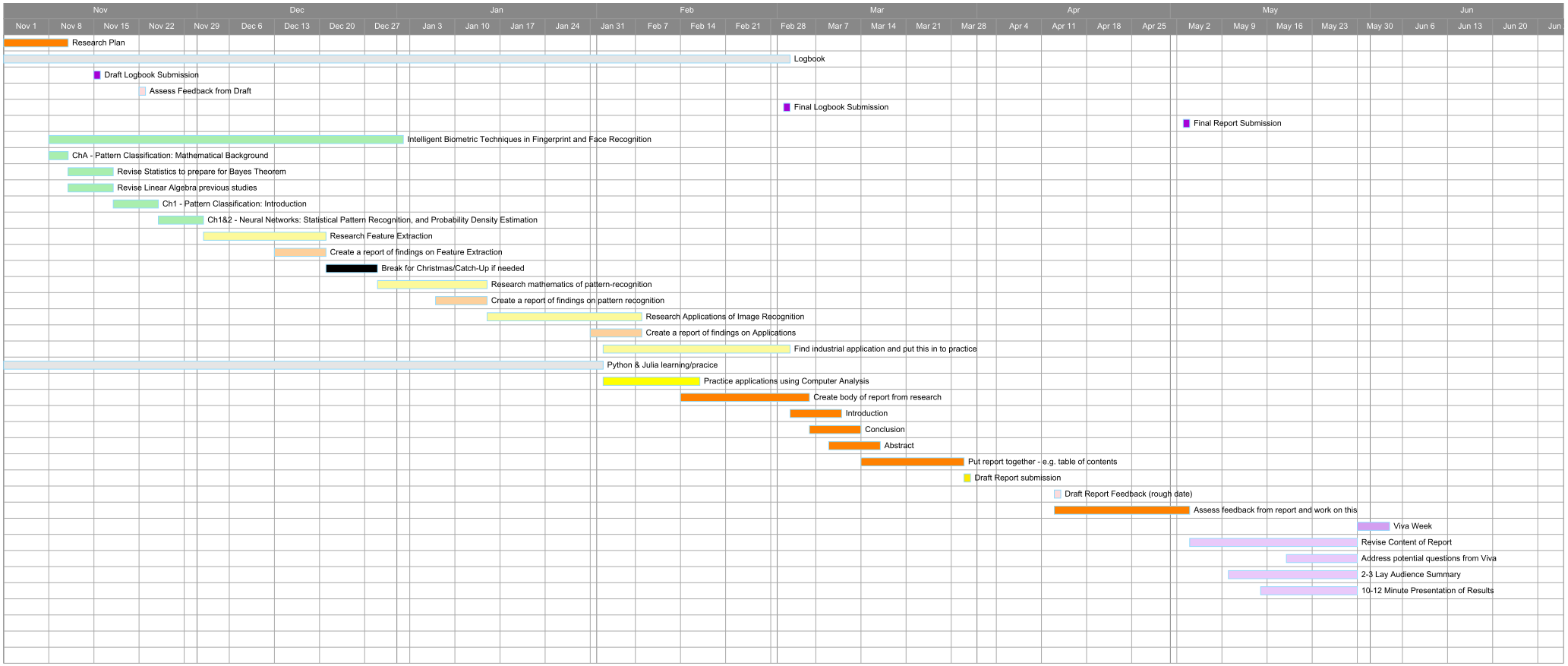
As my research relies heavily on technology (project written in LaTeX, research done on my laptop or tablet, using computer software for applications), I will be saving work onto my university OneDrive wherever possible.

Action Plan

My research will begin with reviewing the literature mentioned, particularly gaining a solid mathematical basis in statistics and linear algebra, as recommended by my supervisor. I then plan to research feature extraction, followed by pattern recognition, and then applications. Afterwards, my research will culminate in putting an application into practice, using those applications found in my research.

Alongside my research, I will continue learning Python and Julia for the computer application section as recommended by my supervisor. I will, too, be building upon my Python and C++ knowledge through my current study of the module MTH3007M - Numerical Methods.

Overleaf is a copy of the action plan I have created using Smartsheet [14]. You can also view a larger version, spread across three pages, in the appendices.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Research Plan
Logbook
Draft Logbook Submission
Assess Feedback from Draft
Final Logbook Submission
Final Report Submission
Intelligent Biometric Techniques in Fingerprint and Face Recognition
ChA - Pattern Classification: Mathematical Background
Revise Statistics to prepare for Bayes Theorem
Revise Linear Algebra previous studies
Ch1 - Pattern Classification: Introduction
Ch1&2 - Neural Networks: Statistical Pattern Recognition, and Probability Density Estimation
Research Feature Extraction
Create a report of findings on Feature Extraction
Break for Christmas/Catch-Up if needed
Research mathematics of pattern-recognition
Create a report of findings on pattern recognition
Research Applications of Image Recognition
Create a report of findings on Applications
Find industrial application and put this in to practice
Python & Julia learning/pracice
Practice applications using Computer Analysis
Create body of report from research
Introduction
Conclusion
Abstract
Put report together - e.g. table of contents
Draft Report submission
Draft Report Feedback (rough date)
Assess feedback from report and work on this
Viva Week
Revise Content of Report
Address potential questions from Viva
2-3 Lay Audience Summary
10-12 Minute Presentation of Results

References

[1] "Group photos by faces", Support.microsoft.com, 2021. [Online]. Available: https://support.microsoft.com/en-us/windows/group-photos-by-faces-1ab09703-f0a6-5835-d27b-58672b23fdd2. [Accessed: 07- Nov- 2021].

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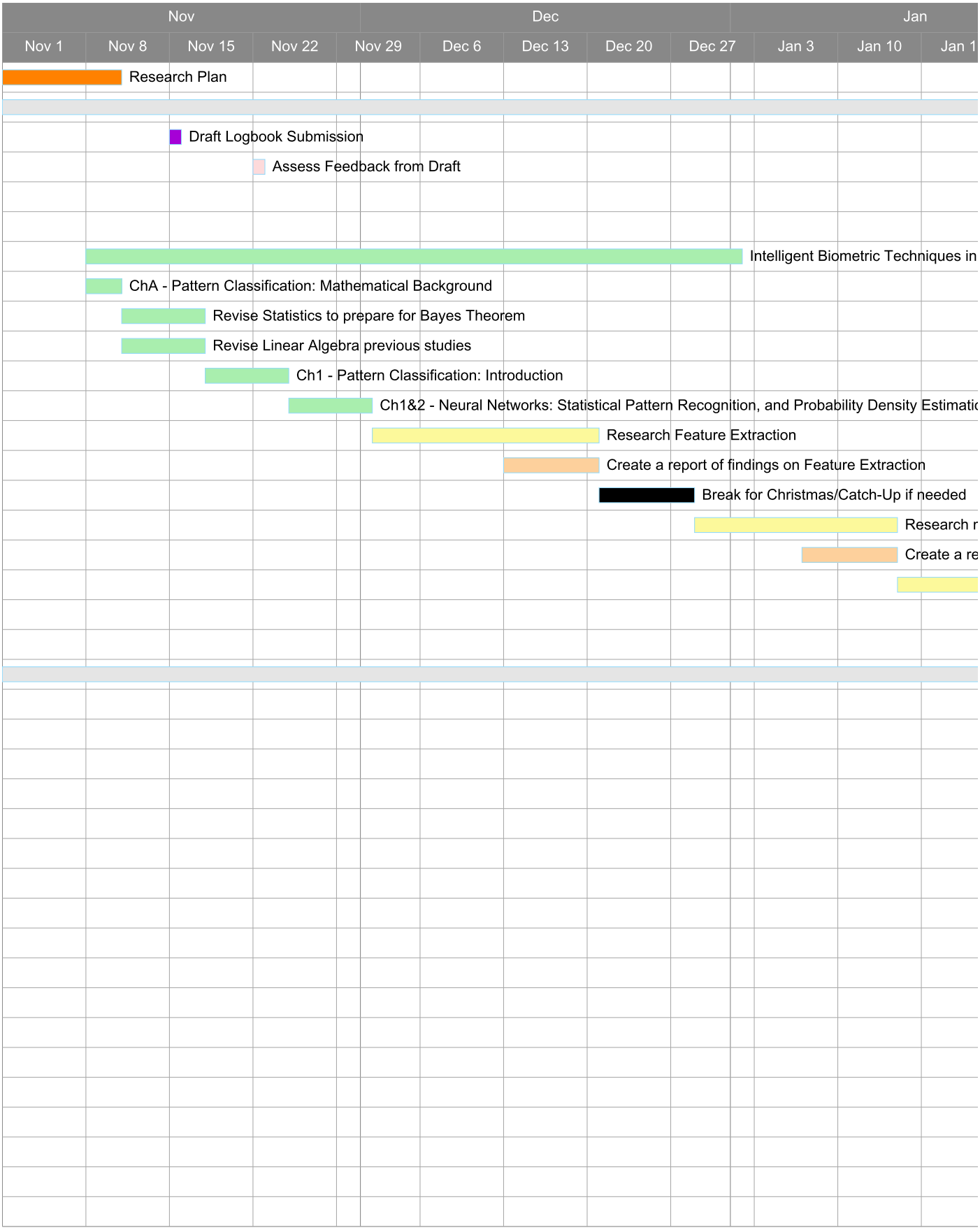
[13] "Overleaf, Online LaTeX Editor", Overleaf.com, 2021. [Online]. Available: https://www.overleaf.com/. [Accessed: 07- Nov- 2021].

[14] "Smartsheet Browser Compatibility — Smartsheet", App.smartsheet.com, 2021. [Online]. Available: https://app.smartsheet.com. [Accessed: 07- Nov- 2021].

Apendices

The next three pages contain the enlarged action plan [14].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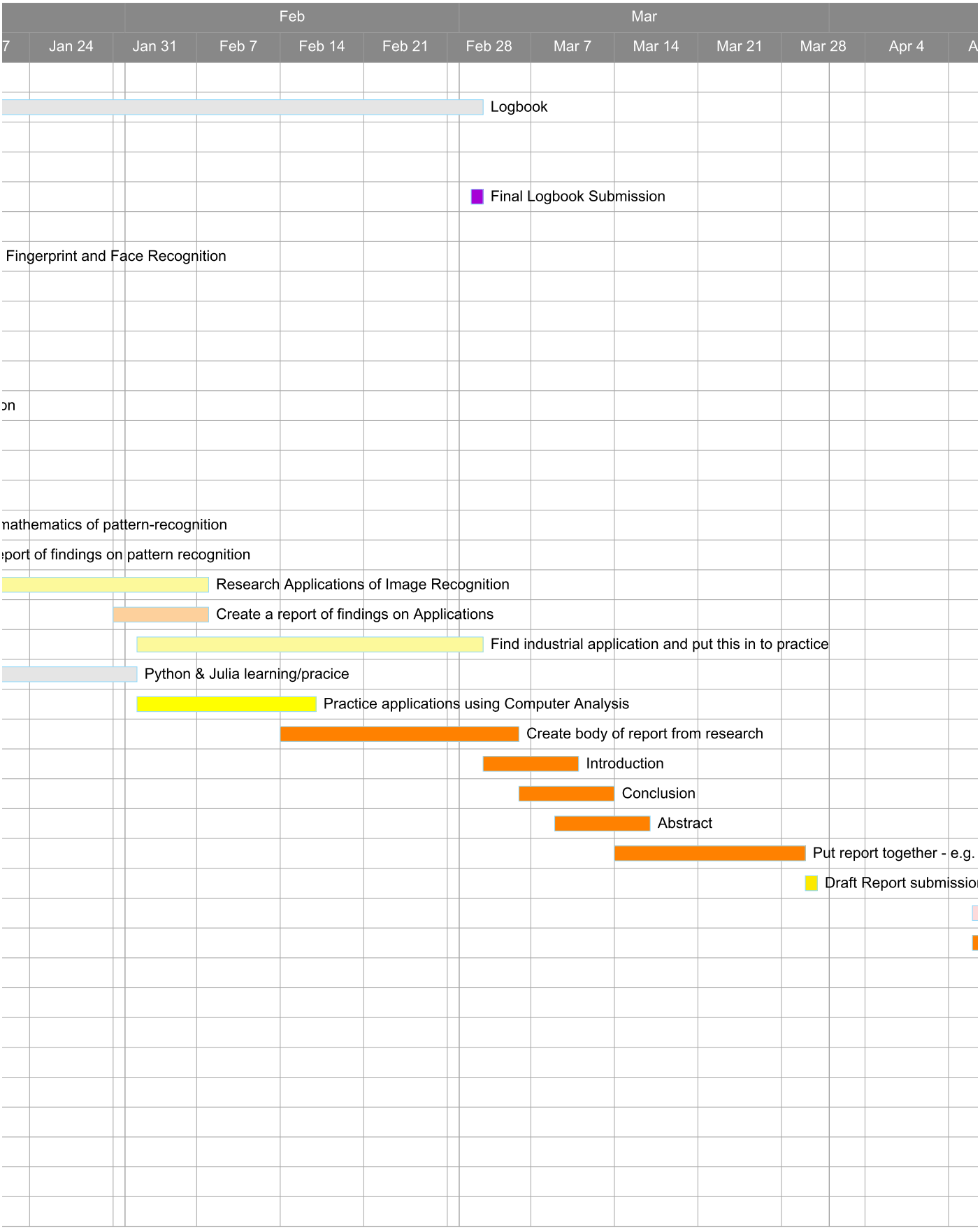
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Conclusion
Abstract
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