COMP3850 Group 23 Project Plan

Revision History

Revision Number	Date	Person(s)	Changes
1.0	28/03/2024	Group 23	Initial version
1.1	29/04/2024	Michael Yee, Sneha Naidu	Added OKS, PCK and distance metrics for comparing models in Quality Management Added information about the main data source for the project to Resource Management Updated project schedule with Deliverable 3 activities Added Handover Requirements section detailing what will be delivered to the client and other training
1.2	16/05/2024	Michael Yee	Added list of files and folders that will be given to the client in Handover Requirements Added section on assets that the client will access themselves instead of being given during handover Added details of user guide structure, including mention of an FAQ section in the user guide

1. Introduction

1.1 Statement of Purpose

The intent of this document is to outline Project Automated Posture Recognition of Ants' (APRA) goals, its objectives, and its scope, including risk analysis and risk management strategies to be employed to mitigate those risks identified. This report will outline management approaches in regard to resources, change and quality. It will also include an overall schedule for the ongoing project, defining all deliverables and tasks whilst taking into consideration any assumptions that may affect the outcome of the project. Correspondingly, since this is a data science project our scoping document will also follow the Cross Industry Standard Process for Data Mining (CRISP-DM) methodology, ensuring a systematic approach to data mining, analysis and model development.

By complying with this framework, our team will be able address the common issues tied to many data mining projects, allowing us to overcome certain obstacles to eventually improve on the project's success. These enhancements will not only benefit our current endeavours, but will also assist in future projects that look to capture and analyse the cooperative behaviour of weaver ants in hopes that the behaviour of one of nature's most collaborative insects can be incorporated into modern robotics systems.

1.2 Scope of project

The scope of Project APRA will include a complete working model for tracking the posture of weaver ants (*Oecophylla smaragdina*) and a user guide for repeated application in future APRA project iterations, that users will be able to adopt in order to train relevant data. This guide will include how to carry out the analysis of rudimentary pulling chain scenarios, such as single ants at the beginning of a chain-forming activity.

The following list comprises software required to carry out Project APRA:

- SLEAP for posture tracking and analysis (data mining) as well as model development.
- Google Docs for developing required documentation.
- GitHub for managing code version changes for ongoing APRA iterations.
- Trello for navigating and organising required tasks.

Project APRA will deliver the following outcomes and resources to the client:

- A document containing simplified and relevant instructions to set up and use SLEAP software.
- A developed model to apply to ongoing APRA projects/iterations, including:
    - Model skeletons and labels
    - Sample data
    - Recorded setup and training of data using the supplied skeletons and labels

- A GitHub repository for ongoing development of the code and user manual, including historical versioned instances of these resources and the capability to manage ongoing change.
- A set of Jupyter notebooks detailing the outcomes and analysis produced as a result of carrying out Project APRA, which will include:
    - Details of analysis we were able to carry out of the posture of at least one weaver ant during the formation of a pulling chain.
    - Details of the posture labels successfully captured and tracked.
    - The outcome of that analysis, if any, to the effect that a conclusion was formed around the contributing factors leading to local decisions made by at least one weaver ant during the formation of a pulling chain.

1.2.1 Items Out of Scope

- Subsequent APRA project iterations that leverage the output of this project.
- Analysis and tracking of complex scenarios, beyond those we have collectively defined (including consultation and agreement with the client) to be reasonably likely to result in our ability to successfully produce a conclusion based on SLEAP driven analysis.
- A bespoke user interface designed to reduce the future complexity of setting up and using SLEAP for the purposes of forming conclusions around weaver ant posture and cooperative localised decision making behaviours

2. Risk Management

2.1 Approach

Our project centres around understanding and comprehending the teamwork of weaver ants to help drive progress in robotics. Various risks could hinder our project, so to combat and manage risks we have adopted a control cycle approach. This method entails a systematic and iterative process of identifying, assessing, mitigating, and monitoring potential risks throughout our project's timeline.

A control cycle allows for constant monitoring, hence allowing us to adapt to scenarios as we become more familiar with each situation. Throughout our execution of the project, we continuously monitor and reassess risks, adapting strategies as needed to ensure proactive management of emerging risks. This control cycle approach improves decision-making, manages risk and ultimately propels the successful completion of our project.

We have set clear objectives and defined key deliverables while pinpointing potential risks including Technological Risks, People Risks, Organisational Risks, Data Quality Issues and Resource Constraints. Subsequently, we have employed risk assessment techniques to prioritise identified risks based on their impact and devised suitable risk mitigation strategies.

2.2 Risks

2.2.1 Technological Risks

- SLEAP software fails to meet expectations.
- Ant tracking proves to be time-consuming.
    - All members struggling to find a time-effective solution can indicate that the technology is the problem rather than the individual group members.

2.2.2 People Risks

- Tasks assigned to individuals remain unfinished.
- Potential conflicts arise among team members.
    - These mainly occur when communication is poor. i.e. team members consistently do not attend meetings or reply to messages causing them to not be on the same page as the rest of the group.

2.2.3 Organisational Risks

- Members encounter difficulties attending meetings.
- Deadlines are missed.

- These occur if there is a lack of communication by the team leader/Scrum master.

2.2.4 Data Quality Issues

- Overlapping ants disrupt the model.

2.2.5 Resource Constraints

- Limited availability of videos for model training.
- Dependency on a single data tracking software.

2.3 Risk table

The table below showcases the likelihood, effect and priority of the potential risks to our project and how we will go about monitoring them and our current mitigation strategies that may be subject to change later.

Risk No.	Description	Likelihood	Effect	Monitoring Strategy	Mitigation Strategy
1	SLEAP software fails to meet performance expectations.	Medium	Moderate	Posting results into our common Github repository and conducting comparisons	We will continue to compare results to determine if we are producing comparable and effective results
2	Ant tracking proves to be time-consuming.	High	Minor	Comparing the time it takes each individual to train the model	We will research the problem to find a solution, otherwise it's an unavoidable circumstance
3	Tasks assigned to individuals remain unfinished.	Low	Significant	Consistently checking up on each team member’s work completion status	The Scrum master sets a target date that is before the deadline so that we are not rushing and finishing tasks on the day
4	Potential conflicts arise among team members.	Low	Moderate	Consistently checking everyone's perspective on work approaches in meetings or through chats	Resolve conflict by discussing it peacefully or if required team leader steps in

5	Members encounter difficulties attending meetings	Medium	Minor	Using the when2meet software to determine when every member is free	All Zoom meetings are recorded otherwise members who missed out are caught up by the team leader
6	Deadlines are missed	Low	Significant	Consistently communicating and reiterating due dates	The Scrum master continuously reminds us of our pre-set deadline and we have set up an open communication channel to help each other with difficult components
7	Limited availability of videos for model training	Low	Moderate	Assessing if we require more videos through the use of SLEAP	Request more video data from the client if needed
8	Dependency on a single data tracking software	High	Minor	Assessing if results from SLEAP are producing a result	Have been provided with backup software but the client has told us it is not much better than the recommended software

3. Resource Management

This section of the document provides information on all project resources as of the writing of this document.

3.1 People

The Project APRA team is comprised of the following people:

- Julian Teow
- Emma Hodgson
- Michael Yee
- Rijul Khunger
- Sneha Naidu
- Rhys Patton

Additionally there is the project client, the Macquarie University School of Natural Sciences, who is represented by Chris Reid, who we will be consulting with regularly to apprise of all progress and if clarification is needed at any point during the project's development.

3.2 Hardware

The hardware used to develop the Project APRA Guide and train the SLEAP program to recognise the weaver ant pulling chains consists of the personal computers, laptops and Macbooks/Macs owned by the team members. These include:

- Julian Teow
    - Acer Swift Laptop
    - PC with Intel i7 CPU and a Nvidia RTX 2060 Super GPU
- Rijul Khunger
    - Macbook Air Laptop
    - Apple M1
- Rhys Patton
    - Dell XPS 9510 Laptop
    - PC with Intel i7 CPU and Nvidia RTX 3080 GPU
- Emma Hodgson
    - Macbook Pro Laptop
    - Apple M1 Pro
- Michael Yee
    - PC with Intel i7 6-core CPU and Nvidia RTX 2080 GPU
- Sneha Naidu
    - Macbook Pro Laptop

3.3 Software

The software we intend to use to create Project APRA includes the following.

3.3.1 Google Docs

Google Docs is a web-based word processor that will allow our team to collectively work together on a single document simultaneously and in real-time. Team members will also be able to edit and view each other's work whilst adding comments and suggestions, improving communication and teamwork.

3.3.2 Git

Git is a distributed version control system that will enhance collaborative aspects of Project APRA by tracking code changes introduced by each team member. The related online platform Github will be used to store the code in an online central repository where we can share and review code changes.

3.3.3 Social LEAP Estimates Animal Poses (SLEAP)

SLEAP is an open source deep-learning based framework designed to analyse animal poses from images or videos. SLEAP will allow us to examine the behaviour of the weaver ants, how they move, and more specifically to the project how their legs are positioned when creating a pulling chain.

3.3.4 Trello

Trello is a project management tool that will assist the team in staying ahead of deadlines through the use of digital lists, boards and cards. Trello will allow us to track the tasks and deliverables of our unit whilst allowing us to plan our method of attack with regards to which tasks have a greater priority.

3.3.5 Jupyter Notebook

Jupyter Notebook is an open-source software application that our team intends to use to further experiment with codes and algorithms, allowing us to run individual lines of code whilst keeping track of their outputs in real time - ultimately allowing us to analyse and improve upon our training models.

3.3.6 Google Colab

Google Colab is a real-time collaborative platform where our team will train machine learning models and experiment with different algorithms that we can use to further analyse the behaviour of weaver ants. The ability to simultaneously run notebooks will allow each other to give each other insights on each other's code and troubleshoot where needed.

3.4 Data sources

The primary data source for the project will be the videos of weaver ants that have been provided by the client for the project. These videos were recorded previously as part of a research project carried out by Madelyne Stewardson as part of Chris Reid's team at the Macquarie University School of Natural Sciences. These videos were recorded in very high resolution and contain a combined total of over 12 hours of footage of ants engaging in nest-building behaviour, which should be sufficient for this project. Hence, there should be no need to acquire further video data and no need for a plan to obtain more data.

4. Change Management

4.1 Managing requirements and scope change

The initial trajectory of the project will be determined during early discussions with the client and, while it is anticipated that the requirements will be further clarified over time, it would be highly undesirable to introduce frequent changes over the course of the project. However, as the project progresses, it is highly likely that the project requirements will evolve for reasons such as issues or blockers arising during the model training process that necessitate a change in approach, such as if the animal model skeleton that was chosen proved to be inappropriate for subsequent analysis, which would in turn increase the development time.

We may also find that developing a computer vision model that can accurately track the positions of large numbers of ants is too difficult to achieve in the time allowed for the project and thus would require more significant changes to the project objectives. In all cases, the team will be encouraged to raise their concerns about the feasibility of achieving the project milestones, whether their own part thereof or as a whole, so that adjustments can be made to the project timeline or discussions can be held with the client to potentially alter the scope and ensure that some product can still be delivered at the project's conclusion.

The client may also request additions or changes to the model or the scope of the project itself in response to various iterations of the ant tracking model(s) over time. While we will always endeavour to accommodate the requests of the client, it will also be important to weigh the time and effort required to make the changes against the time remaining and resources available to avoid "scope creep" and ensure that the project deadlines are not put at risk. Therefore, all requested changes received from the client will be examined as a team to estimate the time and effort required to make them, taking into account the work already performed, available time remaining, and alignment with the goals and objectives of the project as initially discussed. Should it be determined that the changes are too far outside the scope of the project and/or introducing the changes would place unreasonable pressure on the project deadlines, the team will liaise with the client to try and find a more suitable alternative if possible, or explain to the client why it is believed that accommodating the changes would not be feasible.

One such potential issue that has already been identified during early discussions with the client is that identifying the specific positions of ants and their body parts in a pulling chain is a challenge, even for a human, due to the significant overlapping of limbs from different ants that can occur when pulling chains form. Therefore, it is possible that we may not be able to build a model with a high degree of accuracy in the available time for this project. To avoid being unable to deliver any suitable model at all to the client, we plan to assess our progress with our client prior to the minimum viable product delivery due date to determine if it is feasible to continue working with the original dataset, or whether it is necessary to pivot to solving a simpler problem using a dataset where the ants are positioned more distinctly. Even if this were to occur, one of the main requests from the client in addition to the creation of an ant position tracking model is the development of a system or process that simplifies building other models for their research in future. Therefore, switching to a different dataset would result in minimal wasted effort in this regard.

4.2 Version control

The primary version control system that will be used throughout this project for code will be the ‘Git’ software. Git is a distributed version control system that will allow team members to maintain a local copy of the code/data repository on their machine for making changes to, while periodically synchronising with a remote repository that integrates changes made by other team members. Conflicts that may arise as a result of work being performed on the same files by different people in the team can be managed during these merges, providing a means to ensure that work is not inadvertently overwritten by other changes. Git is used ubiquitously throughout many companies in information technology and other sectors, and all members in our team are familiar and comfortable with its use.

The repository hosting service Github will be used to store the remote repository with which all team members will synchronise their changes. Since all team members have used Github during other units of study, they already have their own accounts which simplifies set-up and use of the service. The repository itself will store the animal model skeletons, labelled training data and trained models, and other metadata associated with the project. This will provide visibility to all team members over the work of others as well as simplifying the processes of merging the trained datasets and making them available for the team’s use.

To maintain good version control practices and minimise the potential for merge conflicts to arise, each team member will have their own working branch that they will commit their changes to in their local repository. When they are ready to merge their changes into the main branch, they will first synchronise their local repository with the remote repository in Github. They will then open a pull request in Github to merge their personal branch with the main branch. The repository manager (Michael Yee) will then review the changes and merge them if appropriate. Finally, these changes will be merged with each team member’s local repository during the next time that they synchronise with the remote repository.

Documentation version control will be managed using Google Docs. Google Docs is a web-based word processor with a similar feature set to Microsoft Word and allows for collaborative changes to be made in a single file while retaining a comprehensive history of changes made to the document, including the date, time, name of the person who made the changes, and the specific lines that were added, removed or modified. This provides accountability as it is simple to verify that each team member is contributing roughly equally to the documentation. Each team member already has access to Google Docs via their student email account and all documents can be easily shared in the same way.

5. Quality Management

Maintaining a high standard of quality throughout the lifecycle of the project will encourage confidence in the model outputs and subsequent insights. This will be done by performing regular quality assurance reviews at each step of the model creation process to ensure that errors and inaccuracies do not propagate through to the final product. The relevant steps in this project will be checking the labels for consistency and accuracy and validating the model outputs.

The quality of the labelling will have a significant impact on the efficiency of the training process and the performance of each model produced as a result. Due to the large number of video frames that must be labelled to train an accurate model capable of tracking multiple ants in the same frame and the limited time available to the team, this requires that the labelling is shared by multiple people in the team. When the definition of each label is clearly defined and understood by each person performing the labelling, it will be easier for the model to learn appropriate features that identify the labels correctly. However, if the labels are misapplied to the wrong body part or misaligned with the point on the ant representing the particular body part, this may result in a model that takes longer than necessary to train or produces inaccurate inferences. To avoid these situations, the team and the client have agreed on a model skeleton to be used for labelling, with specific definitions for the point on the ant's body that represents a certain body part. The models will also be used to infer labels on random samples of the dataset and consistently incorrect predictions will be examined further to determine if the ground truth label was misapplied.

Additionally, each proposed model that is developed over the course of the project will be evaluated and tested during the training process to confirm that the outputs are consistently accurate and reliable. On a technical level, this will be done by optimising the model loss function to minimise the error rate in terms of the difference between the predicted location of a body part in a frame and the actual position. A lower overall error rate indicates a more accurate and hence higher quality model and SLEAP includes an 'online hard keypoint mining' loss function that can penalise the scores for body parts that are difficult to predict well, resulting in a model that is more capable of predicting the location of these body parts. Other metrics will also be used to compare models, including the Percent of Correct Keypoints and Object Keypoint Similarity scores which measures the overall accuracy of model predictions compared to the ground truth. More granular comparisons can be made by directly measuring the Euclidean distances between the predicted body part positions and the ground truth labels for individual body parts.

6. Schedule

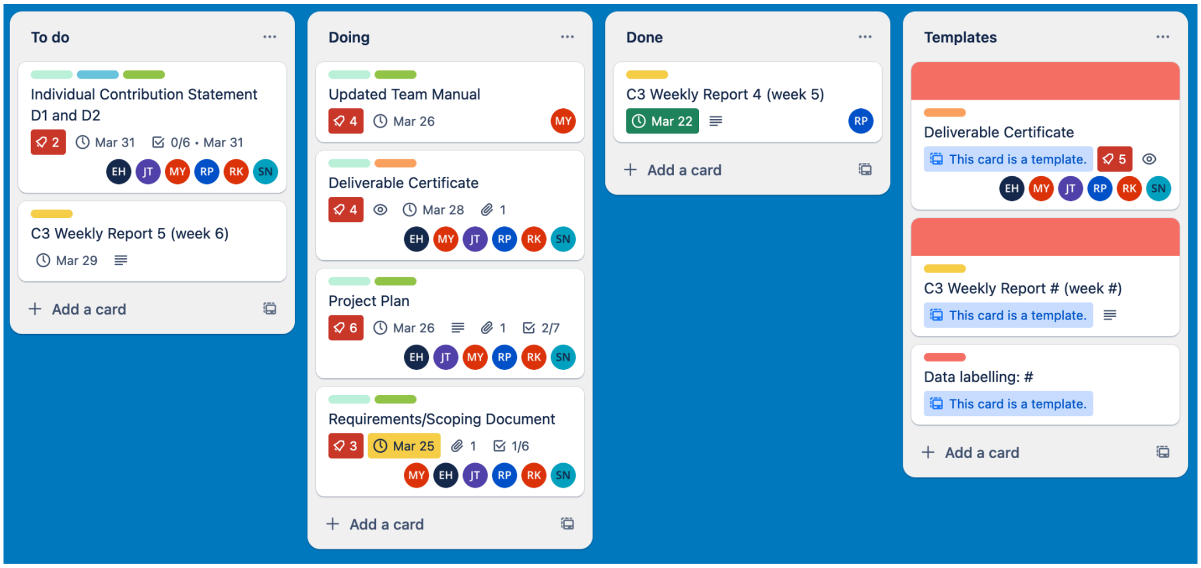
6.1 Tasks/Deliverables/Process

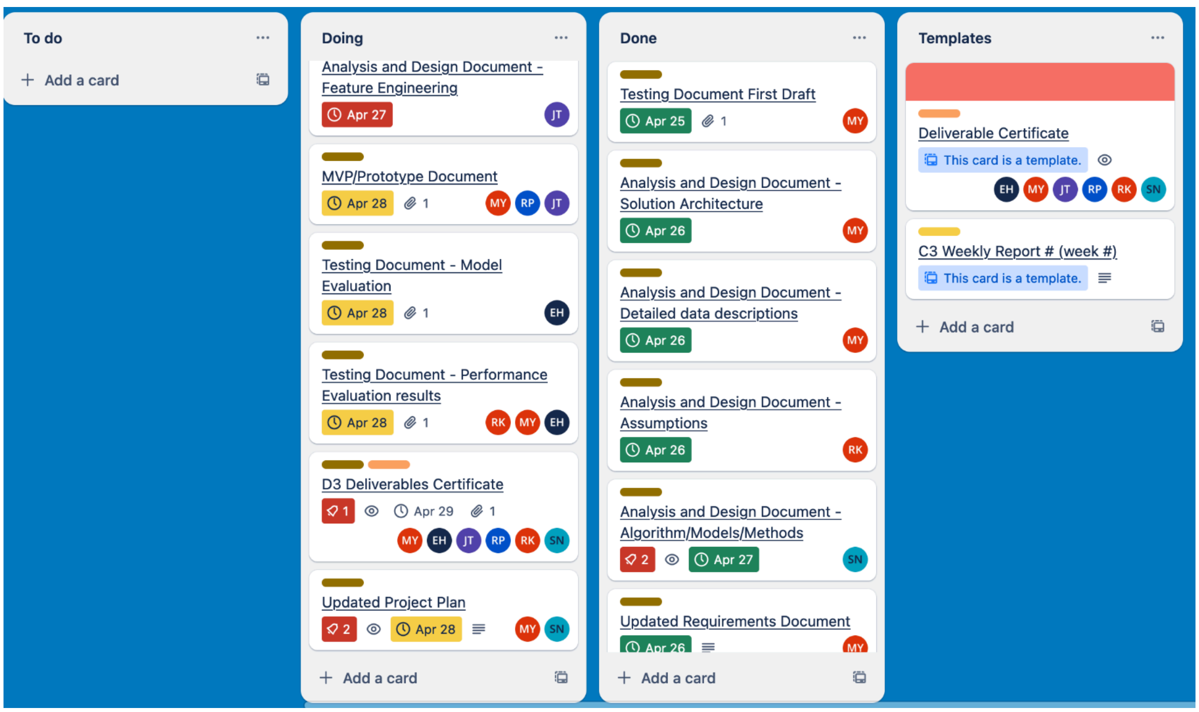
Project APRA has been divided into sections based on the deliverables due. The table below shows the deliverables and their due dates as well as the individual tasks required to complete each deliverable. It is expected that tasks may need to be added or changed in the future as the project progresses.

Deliverable	Tasks	Due Date
D1 - Feasibility Study	All members were involved in the creation of the report.	6/03/2024
D2 - Project Plan/Requirements Scope	All members were delegated a section of the Project Plan and Requirements Scope and completed their specified section.	28/03/2024
D3 - Updated Project Plan + Prototype	Update Project Plan - Updating schedule and making minor improvements overall → Michael, Sneha	29/04/2024
	Checking Data Quality - Cropping the videos in order for less ants to be seen to increase tracking accuracy → Michael - Choosing videos that allow for accurate tracking → All members	
	Labelling Data - Defining the key points of the ants that will be labelled (head, thorax, limbs) → Michael - Choosing Frames to label in videos → All members - Using the defined skeleton to label the ants → All members - Quality control throughout the labelling → All members	
	Analysis and Design - All members contributed to the completion of this document.	
	Testing - Relevant features from labelled data needs to be selected and extracted (velocity, angular orientations, spatial relationships, etc) → All	

	members - Choosing an appropriate machine learning algorithm for the task → Emma - Training the selected model using the labelled data as well as monitoring the model's performance on the validation set → All members - Parameters may need to be adjusted to prevent overfitting or underfitting - Evaluating the trained models and recording evaluation in the Testing Document → Michael, Emma, Rhys, Julian - Refining the models → Emma, Rijul	
	Prototype Document - Explain the usage and purpose of the video pre-processing script - Comprehensively explain the SLEAP Labelling and Training process as well as the integration with Jupyter Notebook	
D4 - Updated Project Plan + User/Training Manual	Update Project Plan - Each member will update sections of the Project Plan as the following tasks are completed	16/05/2024
	Deployment of the trained model - Deploy the trained model on video data → Rijul - Implement mechanisms for model monitoring and maintenance to ensure continued reliability and performance over time → Sneha, Rijul, Rhys	
	User Documentation - Introduce the model and its capabilities for analysing the ants → Julian, Rhys, Michael - Usage instructions → Rijul, Sneha, Emma	

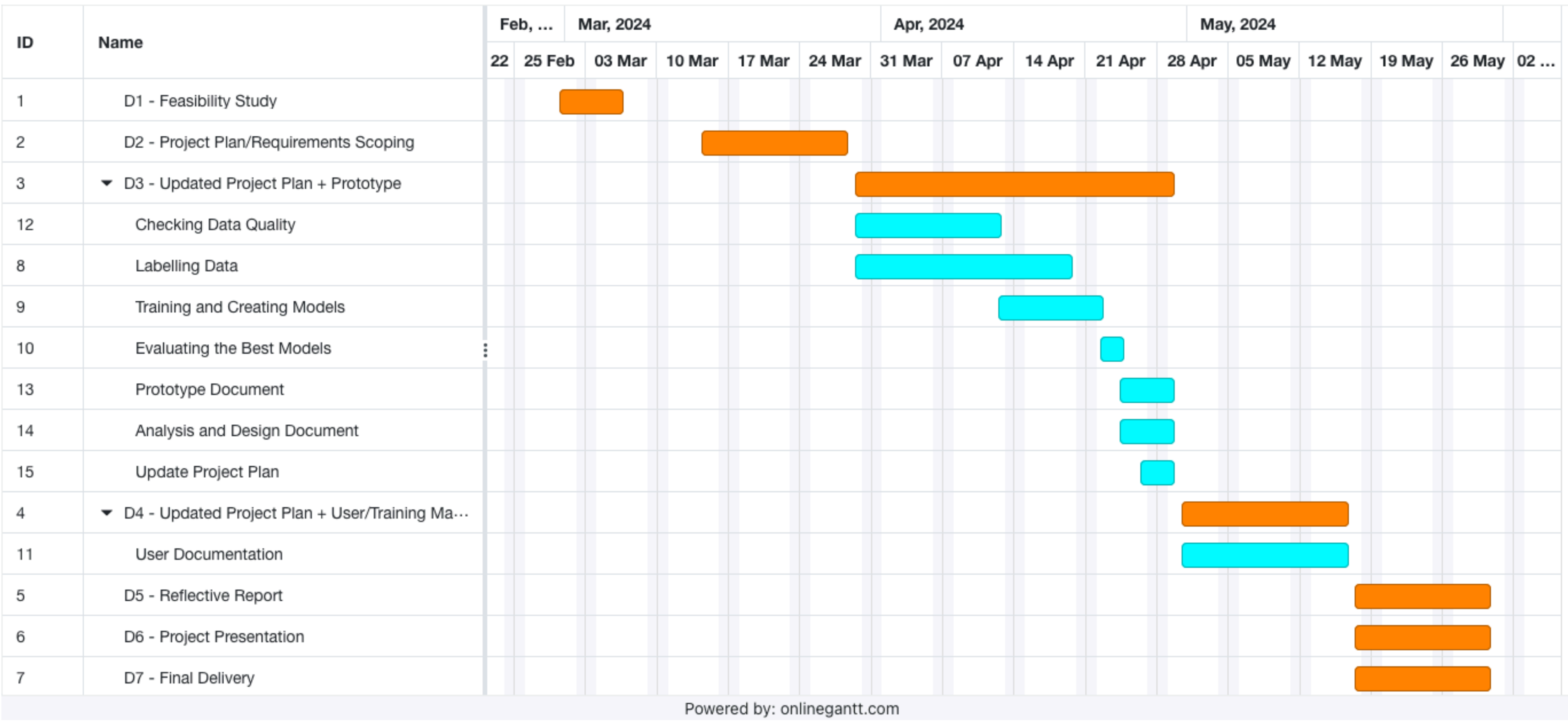
In order to organise tasks, Project APRA has been using Trello workspace as can be seen below.


To do
Individual Contribution Statement D1 and D2
2
Mar 31
0/6 • Mar 31
EH JT MY RP RK SN
C3 Weekly Report 5 (week 6)
Mar 29
Add a card
Doing
Updated Team Manual
4
Mar 26
MY
Deliverable Certificate
4
Mar 28
1
EH MY JT RP RK SN
Project Plan
6
Mar 26
1
2/7
EH JT MY RP RK SN
Requirements/Scoping Document
3
Mar 25
1
1/6
MY EH JT RP RK SN
Add a card
Done
C3 Weekly Report 4 (week 5)
Mar 22
RP
Add a card
Templates
Deliverable Certificate
This card is a template.
5
EH MY JT RP RK SN
C3 Weekly Report # (week #)
This card is a template.
Data labelling: #
This card is a template.
Add a card


To do
Add a card
Doing
Analysis and Design Document - Feature Engineering
Apr 27
JT
MVP/Prototype Document
Apr 28
1
MY RP JT
Testing Document - Model Evaluation
Apr 28
1
EH
Testing Document - Performance Evaluation results
Apr 28
1
RK MY EH
D3 Deliverables Certificate
1
Apr 29
1
MY EH JT RP RK SN
Updated Project Plan
2
Apr 28
MY SN
Add a card
Done
Testing Document First Draft
Apr 25
1
MY
Analysis and Design Document - Solution Architecture
Apr 26
MY
Analysis and Design Document - Detailed data descriptions
Apr 26
MY
Analysis and Design Document - Assumptions
Apr 26
RK
Analysis and Design Document - Algorithm/Models/Methods
2
Apr 27
SN
Updated Requirements Document
Apr 26
MY
Add a card
Templates
Deliverable Certificate
This card is a template.
EH MY JT RP RK SN
C3 Weekly Report # (week #)
This card is a template.
Add a card

6.2 Timeline

The Gantt chart below shows the timeline of completion for all deliverables and tasks. The deliverables are orange and the tasks are blue.



7. Handover Requirements

At the conclusion of the project, all materials developed as part of the project will be handed over to the client, Chris Reid, and his team. This will be inclusive of all models trained and the best performing model, which will be transferred to the client using Google Drive due to the large size of the model weights files. All scripts, Jupyter notebooks and user documentation will be committed to the project's Github repository, and ownership of the repository will be transferred to the client for their future reference.

Specifically, the Github repository and Google Drive assets transferred to the client during handover will include the following,

- 'antSkeleton.json' SLEAP skeleton file
- 'datasets/' folder containing labelled SLEAP dataset files
- 'models/' folder containing trained UNet model folders
- 'notebooks/' folder containing the following Jupyter notebooks,
    - 'Video pre-processing.ipynb'
    - 'Dataset merging.ipynb'
    - 'Label analysis.ipynb'
    - 'Model analysis.ipynb'
    - 'Data export.ipynb'

The video files will not be provided as the client already has the unprocessed video files stored in their cloud storage environment and the processed videos can be recreated using the video pre-processing notebook. The third-party applications (SLEAP and Jupyter) that form part of the solution architecture will also not be provided directly by the project team. Instead, the user documentation will provide detailed steps to download and install the third-party applications as this will help ensure that the client is not being provided with an out-dated version of these applications.

The user documentation will include a detailed step-by-step manual for installing, using, and maintaining all of the scripts, Jupyter notebooks, and applications developed and used throughout the project, with a focus on the most important and commonly used functionality. This will include a frequently asked questions (FAQ) section for common errors and issues such as poor model accuracy to quickly resolve such issues if/when they arise. To ensure that the client is fully comfortable with the use of all of the software and material being delivered, an in-person training session will be arranged prior to the handover date between the project team and the client to guide them through the setup and use of the software components and confirm that there are no gaps in any of the documentation that will be provided.

8. Assumptions

There are assumptions that the SLEAP software chosen by the client will be adequate to deliver the scope and purpose of this project. Additionally we are assuming that subsequent APRA projects will be scheduled, and the people carrying out those projects will have access to computers with the computer system specifications required to follow the user guide we will deliver as a component of this APRA project.

With regards to the scope included and excluded from this project, the team understand and agree with the client that the requirements listed adhere to the expectations and boundary of deliverables unless explicitly raised by the client during collaborative meetings and frequently scheduled check-ins, or by email to our team lead or team representative responsible for such client communication. As such we are assuming the client will proactively communicate when any of the expectations within this document change, with a reasonable amount of time to address or accommodate these changes.

We will also be assuming that the client is available on a weekly basis for the described frequent check-ins and that we can continue to carry out this form of collaboration either in person or via electronic video conferencing software, for the duration of the APRA project.
We are also assuming the team will continue to make adequate time available throughout the life of the project to meet their project commitments.

The team will be practising agile development techniques and delivering to the quality standard continuously demonstrated to the client throughout the life of the project. We are assuming that the client will also continue to communicate when these standards are not meeting expectations. We are additionally assuming that the technique of measuring and analysing the posture of ants that has been discussed and demonstrated to date is the technique we will apply throughout the project and as the basis of producing conclusive determinations (if any are reached during this project) as part of the assets delivered by the project undertaking.