Engineering Research Preparation
Task 3 – Research Proposal

Adoption of Face Mask Detection using Artificial Intelligence and Machine Learning

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1. Background

According to estimates from the World Health Organization, the pandemic outbreak of Coronavirus Disease 2019 (Covid-2019) has cataclysmically pushed the world into a catastrophe impacting more than 603 million people and resulting in nearly 7 million deaths worldwide. Covid-19 is an airborne virus that spreads from person to person as well as through human contact and contaminated surfaces. The severity of the crisis can be demonstrated, as the world ground to a standstill during the epidemic, where industrialized and developing nations have experienced detrimental social, public health and economic ramifications. Numerous proposals have been made by governments from many nations to provisionally impose a "No Mask, No Service" policy in order to curb the infection transmission of Covid-19. However, numerous obstacles are associated with implementing these regulations, as a community-wide effort to wear masks correctly in public is required to prevent the spread of the disease. Due to the population density, conventional measures such as human enforcement by law enforcement authorities are not feasible for monitoring an individual wearing a facemask.

Research on face mask detection via artificial intelligence and machine learning opens the possibility of providing a solution to monitoring face masks on faces, thus enforcing these legislations. Face mask detection systems involve a form of object detection algorithm to recognise masks on faces as objects inside photos. There have been multiple conducted studies and proposals on the precision and reliability of face mask recognition algorithms for detection. However, there are many unreliabilities within these studies as they are all dependent on existing research such as the identification of chest radiographs as a continuation of object detection to form suggestions and conclusions about face mask detection. As the detection of chest radiographs and face masks are two distinct paradigms, these conclusions can provide inaccurate outcomes.

Face mask detection systems are not easily accessible in today's society for a variety of reasons. The main reason is due to the system's viability, as it requires certain criteria and regulations to be met before integration into the general public. Face mask identification has proven to be a challenging endeavour due to a combination of factors, these include the absence of technology-based object detection systems and the need for strict compliance with privacy policies. Thus, this section will detail and analyze the social, economic and ethical impacts of adopting face mask detection

1.1 Social Impacts of Face Mask Detection

A social impact of face mask detection includes the notion of social behaviour. Through the adoption of face mask detection, the population is adopting the social behaviour of wearing masks properly in a public setting. Due to population density, implementation of the "No Mask, No Service" regulation is limited, as it is impossible for law enforcement officials to monitor every individual wearing a mask. However, with the help of face mask detection technologies, regulations may be automatically enforced, thereby decreasing the likelihood of covid-19 transmission. The adoption of face mask detection systems can not only aid in the case of preventing covid-19 transmission in public places but also transmission within hospitals. Hospitals have rules that must be followed in order to remain sterile and sanitary, these regulations limit the transmission of infection and diseases within the facilities. In certain healthcare facilities, the social behaviour of mask-wearing can be enforced automatically within restricted areas.

1.2 Economic Impacts of Face Mask Detection

The covid-19 epidemic has negatively impacted Australia's economy. The research of Romano (2020) indicates that between 2019 and 2020, the GDP has declined by more than $280 billion, and the number of businesses investment declined by more than 50 per cent, amounting to $60 billion. In order to finance the covid-19 repayments, the government had to spend $300 billion as indicated by Romano (2020) . Due to the contagious propagation of the covid-19 illness, the Australian economy suffered significant losses. In order to combat and reduce these detrimental impacts to the Australian economy, the adoption of a face mask detection system to enforce the “No mask No service” policy can ultimately reduce the infectious spread of the disease. By reducing the spread of the disease, government expenditures for covid-19 repayments can be significantly reduced saving the Australian economy billions of dollars.

1.3 Ethical Impacts of Face Mask Detection

There are numerous ethical impacts that come from the implementation of face mask detection or any computer vision system within society. Privacy is a major ethical concern for the adoption of face mask detection as complete facial images and videos of individuals are considered biometric data which is a form of personally identifiable information. Current legal restrictions constitute a substantial barrier to the adoption of the technology as it enforces this ethical issue. According to the article by Senior (2005), surveillance of individuals without their consent can result in substantial lawsuits. Hence, for the adoption of face mask detection systems, the system is required to have a warning notice within the proximity of the system to obtain informed consent from individuals. The article by Goldenfein (2019) expresses data protection issues as an ethical issue due to how the data is withheld and analysed, as the data may lead to the likelihood of fraud, inaccuracy, or distortion when individuals are inaccurately transcribed based on computer vision pattern analysis. As a result, for the adoption of face mask detection systems, caution must be taken as these systems are not 100% accurate in their detection. The systems are recommended to be utilised as an indicator/warning for individuals to wear their masks, and not as a device for enforcing the new laws and regulations, due to the unforeseen inaccuracies within the system.

2. Research Question

The adoption of face mask detection systems has proven to be difficult due to the numerous constraints and limits that prevent the devices from being freely accessible to the general public. It has been established that the deployment of a face mask detection system is advantageous for society, as it not only provides a method to restrict the transmission of covid-19 but also a means to enforce the use of masks for sanitary and hygienic purposes in setting such as hospitals. Due to the pandemic, face mask detection has recently been the subject of many studies; yet, there is presently no publicly accessible technology that provides rapid, accurate, and dependable detection in public spaces.

In machine learning and artificial intelligence, there is a multitude of approaches and algorithms that may be used to recognise face masks on faces. However, these methods provide varying results, and further research on these outcomes is required to determine the most optimal face mask detection technique.

Due to the many limits and constraints, there is no adoption strategy in place for a face mask detection system at this current stage. As the varying degrees of constraint, such as cost, law, and social perspective, contribute to the lack of implementation in society. Ultimately, this research proposal will investigate the adoption of face mask detection systems in society by analyzing the variety of face mask detection systems and determining the ideal alternative. The proposal will also address the implementation options accessible for the system throughout society.

The key underlying factors which must be taken into account when determining the most optimal face mask detection technique will be :

- Accuracy
- Reliability
- Cost-effective
- Time
- Computational cost

3. Literature Review

Object detection is generalized as a concept of detecting objects within images or video frames using computer vision. It is currently one of the most popular topics in the field of image processing and computer vision. Object detection is utilized in a vast array of industries, with applications ranging from small-scale personal projects to large-scale industrial projects. Research has demonstrated that there are numerous applications for object detection currently existing, each of which utilizes unique approaches to accomplish detection. As articulated by Nowrin et al. (2021), object detection can be categorized into two major learning concepts; image classification, image localisation or both. Image classification enables object detection to identify objects through categorizing images, for face mask detection these images can be categorized as “Face Mask” and “No Face Mask”. Image locations accomplish object detection by determining the location of the object and drawing bounding boxes around the perimeter. With conventional object detection methods, Nowrin et al. (2021) found that occlusions such as varying camera pixels, varying degrees of obstruction, and variables such as resolution, rotation, angle of view, and lighting can substantially influence the precision of the detection. Due to its capacity to deal with occlusion as well as comprehend contextual information and complicated traits, numerous researchers have used deep learning as a means to enhance object detection.

Deep learning enables the end-to-end learning of features, eliminating the requirement for prior information in the formation of feature extraction. Deep learning is shown to be advantageous in the article by Sethi et al. (2021), since it permits the reduction in the computational resource through training models, reduces process time, and improves accuracy.

Convolutional Neural Network (CNN) is a deep neural network learning-based algorithm that analyzes visual input and executes tasks like segmentation, image classification, and object recognition. The detection process within CNN as described by Islam et al. (2020) utilises unprocessed pixel data within images; the models are then trained to autonomously extract the features based on the pixels from the comprehensive classification. The process of training a model involves inputting datasets through various layers of the CNN architecture. There are typically various layers however the main layers within CNN involve the convolutional layer and the pooling layer. According to Islam et al. (2020), CNN's foundation is the convolutional layer, which computes the convolutional operation of the input image dataset using kernel filters to extract the relevant features. Typically, the pooling layer follows the convolutional layer in order to reduce the size and noise of the feature map generated by the convolutional layer. By processing the inputted dataset through to the CNN layers, the final output of the CNN is a probability vector used to map the probability of a specific feature occurring inside the class. With modern CNN-based object classification algorithms, they are categorized into two groups: one-stage and two-stage object detectors.

3.1 Two-Stage Detector

Two-stage detectors also known as multi-stage detectors utilize two or more neural networks for object detection. R-CNN, which employs one model for extracting and processing a region of interest and a second model for further classifying and refining the localisation of the object, is an example of the intricacies of a two-stage detector. As articulated by Lippert (2020), Two-stage detectors often have a slower rate of detection in exchange for a more precise classification of objects. However, recent advancements in two-stage detectors have shown that they can achieve height performance comparable to single-stage detectors.

3.1.1 R-CNN

R-CNN is a region-based convolutional neural network that significantly outperforms CNN in the categorisation of object detection-related tasks. The R-CNN employs a model that selectively searches and proposes candidate regions that may contain the object. The object region proposal is then processed by a convolutional neural network which further extracts the features and categorizes the object. The act of passing each object region proposal into the convolutional neural network requires a significant amount of computational power due to the quantity of object region proposals that need to be passed. This is also a huge training disadvantage in terms of storage capacity and time. A significant downside of R-CNN algorithms is that the selection of fewer areas for categorisation might have a negative effect on the final results since a key region containing the object may not be detected. The selection of all object region proposals can be processed, but it will demand excessive computer power and time.

3.1.1 SPPNet

SPPNet uses the spatial pyramid pooling (SPP) layer to transform features of varying sizes into the fully connected layer, hence eliminating CNN's fixed-size constraint. The SPP layer functions by applying max pooling to the output at diverse levels proportionate to the size of the image. The object detection pipeline of the SPPNet differs greatly from R-CNN in that it executes a CNN on the provided image dataset prior to gathering the output and cropping out the region identified by the selective search. The SPP layer is applied to each of the cropped identified regions and the classification is completed based on the output of the SPP layer.

3.1.1 Fast R-CNN

Fast R-CNN is a variation of the conventional R-CNN that avoids the passing of individual object region proposals by introducing a region of interest (ROI) layer that merges all object region proposals into one. The article by Lippert (2020) explores the differences between R-CNN and Fast R-CNN and concludes that RCNN has a 58.7% detection accuracy while Fast R-CNN has a 66.9% detection accuracy. In comparison to R-CNN and SPPNet, Fast R-CNN delivers more accurate detection, requires no storage for caching the number of object region detections, and ultimately gives greater flexibility since all CNN layers are updated as opposed to SPPNet, which updates fully connected layer only.

3.2 One-Stage Detector

One-stage detectors, often referred to as single-stage detectors, provide direct object recognition by predicting the image's object-bounding boxes in a single step using a single Convolutional Neural Network. Unlike the multi-stage detector, the single-stage detector omits the region detection stage entirely. In terms of process speed, the one-stage detector is often faster, but at the sacrifice of precision.

3.2.1 YOLO

You only look once (YOLO) first published by Redmon and Farhadi (2017) is one of the most popular single-stage detector algorithms. The algorithm is able to achieve close to real-time object detection, however, this is at the expense of some loss of accuracy. YOLO achieves detection by splitting the images into numerous sections and concurrently predicting the boxes and probabilities of each region. As stated in the article by Jiang et al. 2021, YOLO was tested to be extremely fast at object detection compared to the other two-stage detector algorithms. Through multiple enhancements and iterations, as shown in Jiang et al. 2021, YOLOv3 was designed to improve the flaws within YOLO through a more backbone network and multiscale training to enhance the accuracy and speed of the algorithm. There have been many extensions that have been applied to YOLOv3 to improve the overall performance. An example from the article by Huang et al (2019) includes the utilisation of MobileNet as a replacement for the current DarkNet-53 utilised in YOLOv3 to lessen the computational complexity of the algorithm. The conversion from DarkNet-53 to YOLOv3 has enabled lightweight improvements without compromising of accuracy, ultimately enhancing the YOLO algorithm by two times.

3.2.2 Resnet

The Resnet algorithm is currently the most popular method within the convolutional neural network. Resnet 50 is a variant of the Resnet algorithm that processes and classifies objects using 50 layers. The article by Walia (2021) demonstrates that Resnet 50 consist of 48 convolutional layers, 1 max pool layer and 1 average pool layer. Research from Loey (2021) has demonstrated that Resnet 50 is the most optimal choice for training and building pre-processing models that detect face masks within faces. Although it requires a lot of fine-tuning, the Resnet 50 is proven to be accurate in identifying the scenario, however, there are issues with computational time as it requires a long time to identify the face mask. Hence to achieve real-time detection using Resnet-50, configurations are required to be made to optimise the processing time.

4. Methodology

The study will investigate the implementation of a face mask detection system using information and data primarily from scientific publications, journals and documents acquired within the UTS library's database. Other sources such as literature conducted by software companies, and research organizations relating to face mask detection will also be utilised. The data will be validated and cross-referenced to determine if the source is valid for usage. The data will be categorised into qualitative and quantitative data.

- The qualitative data will be directly related to the face mask detection system, including the type of algorithm utilised, the research and development process, and the outcomes.

- The quantitive data will be about the expenditure of the project to develop face mask detection systems and the primary results that are obtained from the finalized product.

4.1 Data Collection

Data collection will be done through the usage of several scientific publications, journals and documents acquired within the UTS library's database. Information and data can also be gathered from software providers, and research organizations that have conducted research on face mask recognition and have published their findings. The collected data will undergo a screening procedure that verifies the validity of the information. The procedure includes background and source checks to evaluate whether the data is authentic and dependable. Afterwards, the material will be cross-referenced with other scholarly publications to evaluate whether or not the data supplied is from a primary source that could be used for the project. With regard to the research stage, the data will be collected manually through traditional note-taking as it is the most optimal method.

The data will then be stored in a google drive as it is the most convenient method for storing the project. The advantages include

- The ability to store and organize the data as files and folders in a singular platform
- The data stored can be of any type ranging from text to face mask detection program
- Security and version control for the data
- Easy access for research teams located anywhere

4.2 Data Analysis or Interpretation

The research data will offer a detailed illustration of the various object identification techniques that can be employed to identify face masks within faces. Through testing the multitude of object detection algorithms, an analysis can be formed on the benefits and drawbacks of using each of the algorithms. The parameters below will form the basis of the analysis that will be undertaken for the data.

- Accuracy
- Reliability

- Cost-effective
- Time
- Computation power

The following categories will be used to assess the data findings in order to establish the ideal approach for the implementation of a face mask detection system. The Juptyer notebook will be the primary instrument utilised for benchmarking these metrics. The Jupiter notebook provides a vast array of tools for creating the training model and visualising the results in the form of numerous graphs or as simple outputs. Accuracy, dependability, time, and processing power will be the primary metrics analysed in the Jupyter notebook. For the cost analysis, construction on the prototype of the face mask detection system is deemed necessary in order to evaluate the cost-effectiveness of the system.

4.3 Validity of potential results or findings.

The validity of the potential result will be highly dependent on the method that produced the results. Hence, the varying forms of object detection algorithms will be cross-referenced with numerous studies and scientific articles to ensure that the results are consistent throughout providing valid results. The testing will be reproduced at a minimum of 3 times in order to ensure reliability within the results. Hence eliminating outliers from the findings.

5. Project management

5.1 Scope of the Project

5.1.1 Mission Statement

As more than 603 million individuals have been affected by covid-19, resulting in approximately 7 million fatalities globally, a "No mask, no service" policy is essential to limit the spread of the infectious disease. Due to the difficulty of enforcing the policy for the reduction of the disease, face mask detection systems are deemed mandatory in order to enforce these rules.The challenges associated with face mask detection systems include the choice of an object detection algorithm for fast, reliable and accurate detection. This project aims to investigate the adoption of a face mask detection system by analysing the numerous object detection algorithms and determining the most optimal for face mask detection.

5.1.2 Objective And Requirements

The following section will detail the must-haves (Horizon one) and the nice to have (Horizon two) within this project.

5.1.2.1 Horizon One Objectives

- Review literature on the various relevant pilot project on face mask detection and object detection algorithms with the summary of finding.
- Scenarios analysis to determine what it would take to adopt a face mask detection system within society. This includes legislation, social, economic and environmental perspectives.
- Develop an analysis based on the results of the finding to determine the 3 most optimal object detection algorithms
- Develop three prototypes of the most optimal artificial intelligence and machine learning algorithm choices for detection of face mask identification
- Create a cost analysis of the prototype based on the resources required for the project
- Analysis of the result to determine the most optimal prototype

5.1.2.2 Horizon Two Objectives

- Optimise the three prototypes to determine the most preferable results.
- Develop an object detection algorithm most suitable for face mask detection

5.1.3 List of Deliverables

This section will list the finalised deliverables of the project.

- Three of the most optimal object detection algorithms for face mask detection
- Prototype of trained models for face mask detection using the three most optimal algorithms researched.

- Research report proving the background, methodology and algorithms used, analysis and findings of the project.

5.1.4 Limitation and Exclusion

5.1.4.1 Limitation

- **Dataset access -** To effectively train a model for face mask recognition, agreed datasets encompassing both mask-wearing and mask-free individuals are necessary. The datasets can be found widely available from the GitHub repository by Cabani (2020)
- **Finance -** A video camera and a microprocessor are necessary for the project in order to develop a prototype for testing the face mask detection system. The project's budget should be within the range of $100 to $500, which is considered reasonable for an average student.

5.1.4.1 Exclusion

- **Final Product -** Although it would be good to develop a final physical product of the face mask detection system in order to evaluate its cost, size, and other physical attributes, this is not necessary. As developing a tangible final product of the face mask detection system is not within the scope of this project, the evaluation of the final product's cost will be based on a rough estimate.

5.1.4 Uncertainties and Risk

	Risk	Risk Analysis			Method Of Control
		Likelihood	Consequences	Rating	
Data availability	Delays in training the models for the face mask detection system, delay in project	Unlikely	Major	Medium	The dataset will be chosen from a reputable source online from Cabani (2020)
Computer Failures	Loss in the training model, Delay in the face mask detection system, delay in project	Likely	Moderate	Medium	Training the object detection model will be done on a high-performance computer. Frequent saving of the training model can help avoid the complete loss of the training model.
Code Error	Due to the difficulty of the project, the project is prone to code compiling errors which can delay the project.	Likely	Moderate	Medium	Identify the problem and solves the issue through researching on Google and StackOverflow
Supervisor availability	Delay in the project. Investing time into the	Unlikely	Minor	Low	Frequent meeting schedules organised in advance.

	wrong object detection algorithm				
Inaccurate quality of work	Inaccurate results due to poor quality of work or outliers	Likely	High	Medium	Further investigation and testing on the varying object detection algorithm is required.

5.2 Process and Timeline and Milestones

The subsequent section will describe the four distinct phases of the project's lifespan. The primary purpose of these stages, which range from the Initial Phase to the Submission Phase, is to ensure that the workload is distributed evenly throughout the semester.

5.2.1 Initial phase

This project's commencement will begin at the start of July 2022 when the Initial phase commences. This phase will begin one month prior to the commencement of the Spring semester to allow for reasonable planning, research on literature studies and industry events on the topic. This phase also involves a lot of preparation work like installing the necessary components i.e python, Jyupter notebook for the development of the face mask detection system. The critical part of this section will involve researching details on the topic and connecting with other professionals to gain guidance on the project. The finalization of the project proposal report will complete the first milestone of the project.

5.2.1 Design Phase

The design phase involves in-depth research on the varying object detection algorithms.
This phase will begin in August and last all the way to mid-September. The main deliverables for this phase will include 5 crucial tasks, research, development, optimisation analysis and finalization of the face mask detection system. This phase is the longest phase to ensure that the most optimal parameters and algorithms will be utilised for the face mask detection system. The research will be the second milestone of the project and the development will be the third milestone of the project.

5.2.3 Reporting Phase

The reporting phase will commence early in august as it will run concurrently with the design phase. Researching on the IEEE standard of writing does not have dependencies this allows for the task to run early and concurrently within the design phase. The deliverables for this phase are to produce a formal thesis paper for the adoption of a face mask detection system.

5.2.5 Submission Phase

The submission phase will commence shortly after the reporting phase. The task of the phase is to ensure that the report and face mask detection model system has been finalized before the submission date. The deliverables of this phase are to ensure that there are no errors within the report and model, and the report follows IEEE standards of writing. The completion of this phase will mark the final milestone.

5.3 Gantt Chart

The Gantt Chart in Appendix A displays the duration of the four-month project and the time invested in each task. The project schedule has been adjusted such that, if possible, tasks are executed concurrently. Each figure corresponds to a different month.

5.4 Communication Management

This project will utilise various methods of communication depending on the scenario. The types of communication for this project involve the following:

- Email
- Microsoft Teams
- In-Person Meeting

Attached within Appendix B, the communication management plan details the schedule of meetings using the listed forms of communication above. The meetings will be held with essential project stakeholders such as the main supervisor, industry representative and industry conference. The main progress check meeting will be done via email and teams.

5.5 Work Breakdown Structure

The Work Breakdown Structure attached in Appendix C sections the project into the following four phases.

1. Initial phase
2. Design Phase
3. Reporting Phase
4. Submission Phase

The phase is completed by completing the task within the phase which is listed in the work breakdown structure.

6. Progress Statement

The research proposal has investigated the numerous variety of object detection algorithms for adopting the face mask detection system. These algorithms have been categorised the algorithms into one-stage and two-stage detectors for face mask detection. In accordance with the timeline in section 5.2 of the report, the project is currently in phases three and four, reporting and submission phases. Completing two out of the four milestones is currently an optimistic scenario, as the other milestone may not be completed. This is mainly due to the very tight schedule, given only 3 months of preparation work excluding July 2022 and computer hardware failure due to the computational cost required to train the models (this was identified in section 5.1.4 as a medium risk).

Currently, the main milestones that have been reached are the research proposal and the investigation of the topic. These are important milestones as they signify the completion of the planning section of the project which allows for the progression of the task in the early stages. The estimated time of completion for the research report remains at the end of the semester.

7. References

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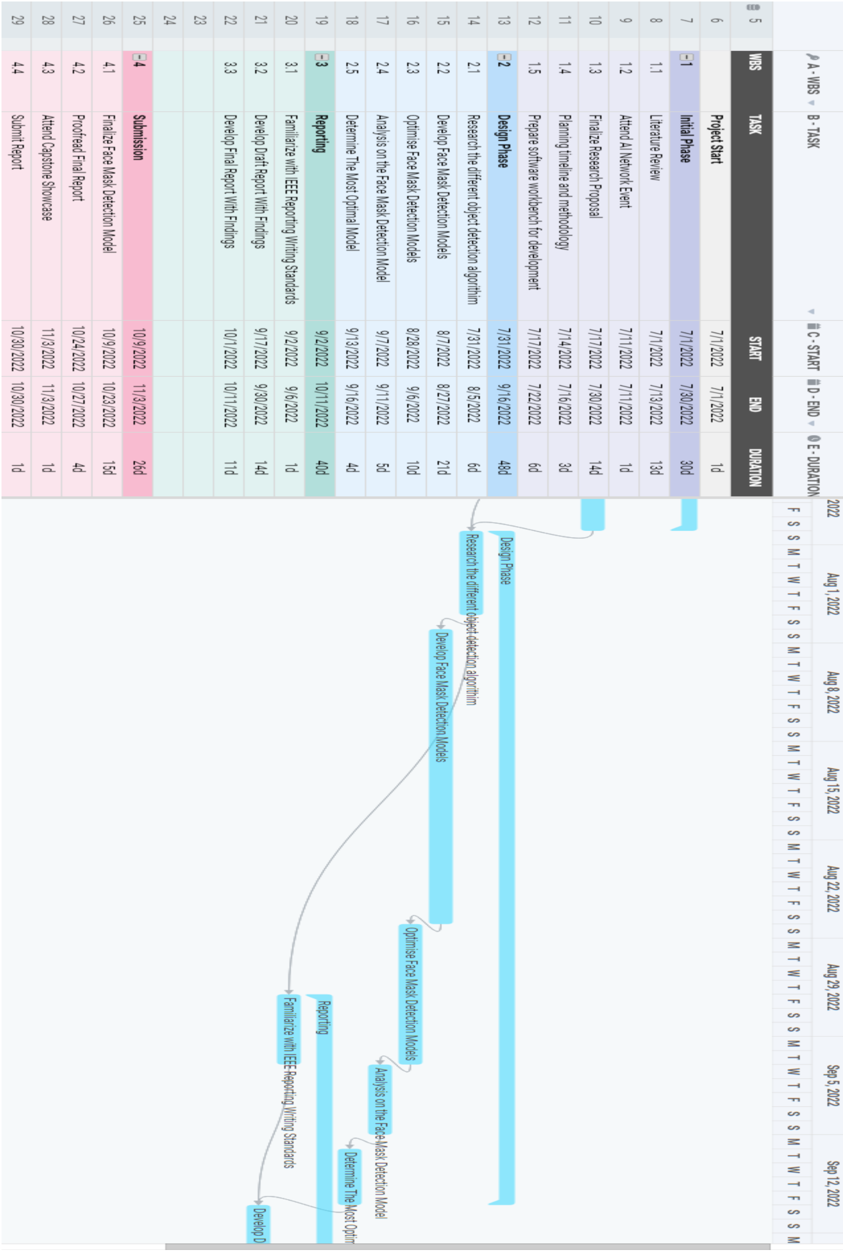
Appendix

Appendix A

	WBS	TASK	START	END	DURATION
6		Project Start	7/1/2022	7/1/2022	1d
7	1	**Initial Phase**	7/1/2022	7/30/2022	30d
8	1.1	Literature Review	7/1/2022	7/13/2022	13d
9	1.2	Attend AI Network Event	7/11/2022	7/11/2022	1d
10	1.3	Finalize Research Proposal	7/17/2022	7/30/2022	14d
11	1.4	Planning timeline and methodology	7/14/2022	7/16/2022	3d
12	1.5	Prepare software workbench for development	7/17/2022	7/22/2022	6d
13	2	**Design Phase**	7/31/2022	9/16/2022	48d
14	2.1	Research the different object detection algorithm	7/31/2022	8/5/2022	6d
15	2.2	Develop Face Mask Detection Models	8/7/2022	8/27/2022	21d
16	2.3	Optimise Face Mask Detection Models	8/28/2022	9/6/2022	10d
17	2.4	Analysis on the Face Mask Detection Model	9/7/2022	9/11/2022	5d
18	2.5	Determine The Most Optimal Model	9/13/2022	9/16/2022	4d
19	3	**Reporting**	9/2/2022	10/11/2022	40d
20	3.1	Familiarize with EEE Reporting Writing Standards	9/2/2022	9/6/2022	1d
21	3.2	Develop Draft Report With Findings	9/17/2022	9/30/2022	14d
22	3.3	Develop Final Report With Findings	10/1/2022	10/11/2022	11d
23					
24					
25	4	**Submission**	10/9/2022	11/3/2022	26d
26	4.1	Finalize Face Mask Detection Model	10/9/2022	10/23/2022	15d
27	4.2	Proofread Final Report	10/24/2022	10/27/2022	4d
28	4.3	Attend Capstone Showcase	11/3/2022	11/3/2022	1d
29	4.4	Submit Report	10/30/2022	10/30/2022	1d



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	Project Start	7/1/2022	7/1/2022	1d
1	Initial Phase	7/1/2022	7/30/2022	30d
1.1	Literature Review	7/1/2022	7/13/2022	13d
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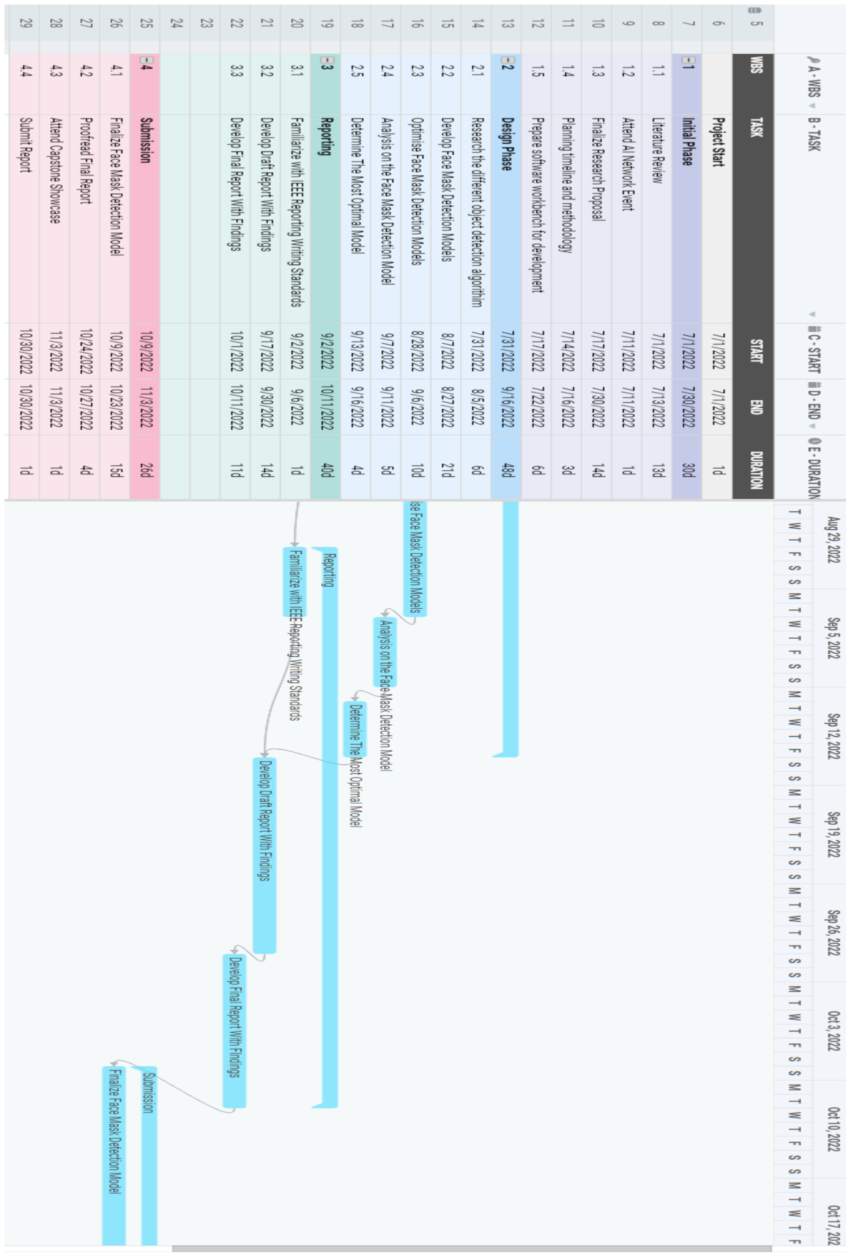
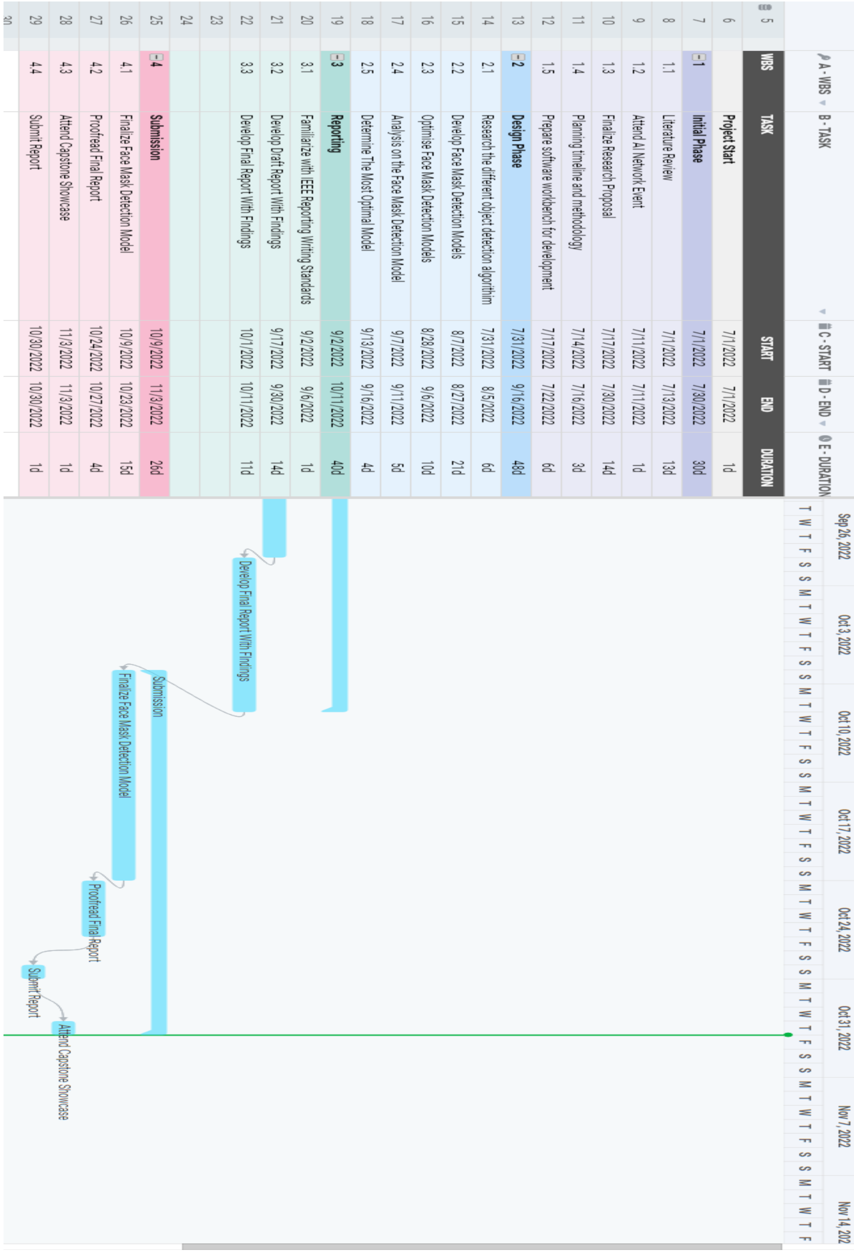
2.4	Analysis on the Face Mask Detection Model	9/7/2022	9/11/2022	5d
2.5	Determine The Most Optimal Model	9/13/2022	9/16/2022	4d
3	Reporting	9/2/2022	10/11/2022	40d
3.1	Familiarize with IEEE Reporting Writing Standards	9/2/2022	9/6/2022	1d
3.2	Develop Draft Report With Findings	9/17/2022	9/30/2022	14d
3.3	Develop Final Report With Findings	10/1/2022	10/11/2022	11d
4	Submission	10/9/2022	11/3/2022	26d
4.1	Finalize Face Mask Detection Model	10/9/2022	10/23/2022	15d
4.2	Proofread Final Report	10/24/2022	10/27/2022	4d
4.3	Attend Capstone Showcase	11/3/2022	11/3/2022	1d
4.4	Submit Report	10/30/2022	10/30/2022	1d



WBS	TASK	START	END	DURATION
	Project Start	7/1/2022	7/1/2022	1d
1	Initial Phase	7/1/2022	7/30/2022	30d
1.1	Literature Review	7/1/2022	7/13/2022	13d
1.2	Attend AI Network Event	7/11/2022	7/11/2022	1d
1.3	Finalize Research Proposal	7/17/2022	7/30/2022	14d
1.4	Planning timeline and methodology	7/14/2022	7/16/2022	3d
1.5	Prepare software workbench for development	7/17/2022	7/22/2022	6d
2	Design Phase	7/31/2022	9/16/2022	48d
2.1	Research the different object detection algorithim	7/31/2022	8/5/2022	6d
2.2	Develop Face Mask Detection Models	8/7/2022	8/27/2022	21d
2.3	Optimise Face Mask Detection Models	8/28/2022	9/6/2022	10d
2.4	Analysis on the Face Mask Detection Model	9/7/2022	9/11/2022	5d
2.5	Determine The Most Optimal Model	9/13/2022	9/16/2022	4d
3	Reporting	9/2/2022	10/11/2022	40d
3.1	Familiarize with IEEE Reporting Writing Standards	9/2/2022	9/6/2022	1d
3.2	Develop Draft Report With Findings	9/17/2022	9/30/2022	14d
3.3	Develop Final Report With Findings	10/1/2022	10/11/2022	11d
4	Submission	10/9/2022	11/3/2022	26d
4.1	Finalize Face Mask Detection Model	10/9/2022	10/23/2022	15d
4.2	Proofread Final Report	10/24/2022	10/27/2022	4d
4.3	Attend Capstone Showcase	11/3/2022	11/3/2022	1d
4.4	Submit Report	10/30/2022	10/30/2022	1d

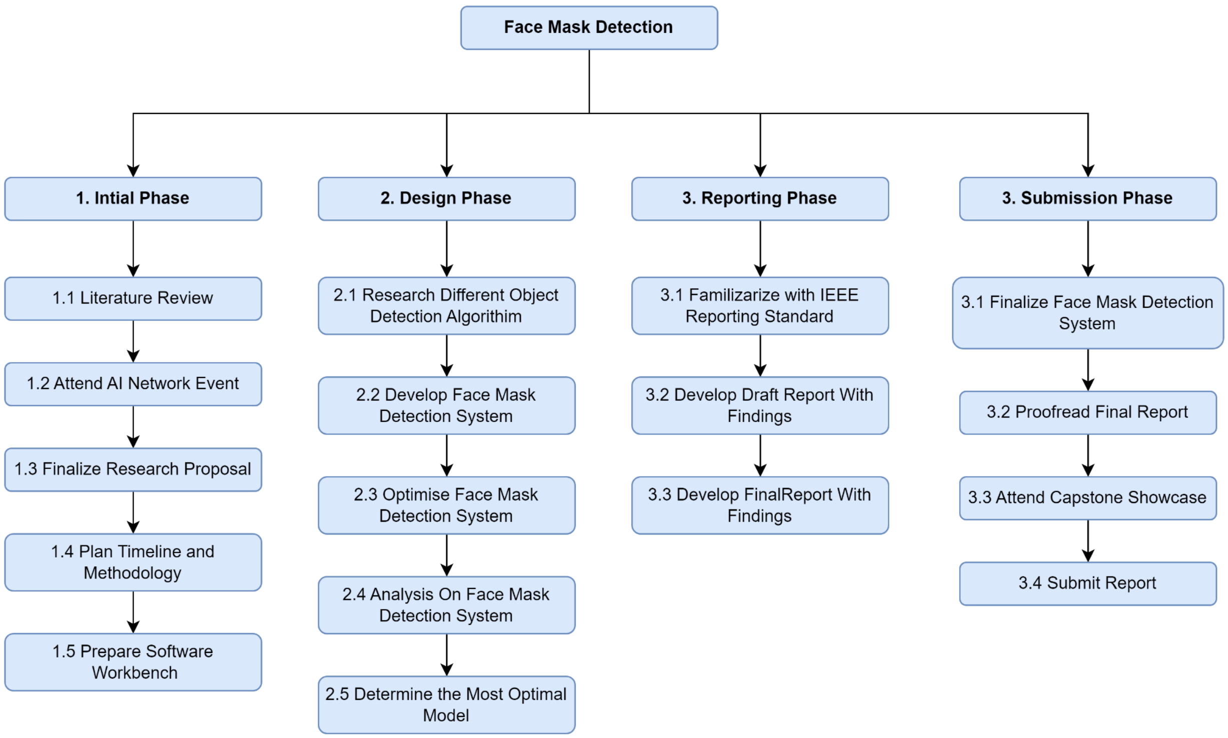


WBS	TASK	START	END	DURATION
	Project Start	7/1/2022	7/1/2022	1d
1	Initial Phase	7/1/2022	7/30/2022	30d
1.1	Literature Review	7/1/2022	7/13/2022	13d
1.2	Attend AI Network Event	7/11/2022	7/11/2022	1d
1.3	Finalize Research Proposal	7/17/2022	7/30/2022	14d
1.4	Planning timeline and methodology	7/14/2022	7/16/2022	3d
1.5	Prepare software workbench for development	7/17/2022	7/22/2022	6d
2	Design Phase	7/31/2022	9/16/2022	48d
2.1	Research the different object detection algorithim	7/31/2022	8/5/2022	6d
2.2	Develop Face Mask Detection Models	8/7/2022	8/27/2022	21d
2.3	Optimise Face Mask Detection Models	8/28/2022	9/6/2022	10d
2.4	Analysis on the Face Mask Detection Model	9/7/2022	9/11/2022	5d
2.5	Determine The Most Optimal Model	9/13/2022	9/16/2022	4d
3	Reporting	9/2/2022	10/11/2022	40d
3.1	Familiarize with IEEE Reporting Writing Standards	9/2/2022	9/6/2022	1d
3.2	Develop Draft Report With Findings	9/17/2022	9/30/2022	14d
3.3	Develop Final Report With Findings	10/1/2022	10/11/2022	11d
4	Submission	10/9/2022	11/3/2022	26d
4.1	Finalize Face Mask Detection Model	10/9/2022	10/23/2022	15d
4.2	Proofread Final Report	10/24/2022	10/27/2022	4d
4.3	Attend Capstone Showcase	11/3/2022	11/3/2022	1d
4.4	Submit Report	10/30/2022	10/30/2022	1d

Appendix B

Subject	Channel	Purpose	Ideal time	Actual Time
Initial Meeting with Supervisor	Email	Initial meeting with supervisor to discuss future Plans	1/07/2022	TBD
Initial Meeting with Picnet representative	Email	Initial meeting with Picnet supervisor Guido Tapia on machine learning and computer visions	2/07/2022	TBD
Meeting Invitation for Picnet Representative	Email	Allocate time to discuss over teams with the Picnet representative	12/07/2022	TBD
Meeting with Picnet Representative	Teams	Identify the potential object detection algorithm techniques used for face mask detection	15/07/2022	TBD
Attend Artificial intelligence conference event	In Person	Seek guidance on the topic of adopting face mask detection system and object identification algorithm used.	21/07/2022	TBD
Meeting invitation for supervisor	Email	Allocate time to discuss with supervisor on teams	26/07/2022	TBD
Meeting with supervisor	Teams	Identify the different varying object detection algorithms	27/07/2022	TBD
Meeting Invitation for Picnet Representative	Email	Schedule meeting with picnet representative	7/06/2022	TBD
Meeting with Picnet Representative	Teams	Discussed the finding of the different object detection algorithm and ask for further recommendation	8/07/2022	TBD
Meeting invitation for supervisor	Email	Schedule team meeting with supervisor	2/8/2022	TBD
Meeting with supervisor	Teams	Development of face mask detection system and how to identify the most optimal model	15/08/2022	TBD
Meeting Invitation for Picnet Representative	Email	Schedule meeting with picnet representative	21/08/2022	TBD
Meeting with Picnet Representative	Teams	Discussion on the result and finding	8/09/2022	TBD
Meeting invitation for supervisor	Email	Allocate time to discuss with supervisor on teams	18/10/2022	TBD
Meeting with supervisor	Teams	Meeting with supervisor on the final Research proposal report	19/10/2022	TBD

Appendix C


Face Mask Detection
1. Intial Phase
1.1 Literature Review
1.2 Attend AI Network Event
1.3 Finalize Research Proposal
1.4 Plan Timeline and Methodology
1.5 Prepare Software Workbench
2. Design Phase
2.1 Research Different Object Detection Algorithim
2.2 Develop Face Mask Detection System
2.3 Optimise Face Mask Detection System
2.4 Analysis On Face Mask Detection System
2.5 Determine the Most Optimal Model
3. Reporting Phase
3.1 Familizarize with IEEE Reporting Standard
3.2 Develop Draft Report With Findings
3.3 Develop FinalReport With Findings
3. Submission Phase
3.1 Finalize Face Mask Detection System
3.2 Proofread Final Report
3.3 Attend Capstone Showcase
3.4 Submit Report