UNIVERSITY of LIMERICK

OLLSCOIL LUIMNIGH

Department of Electronic & Computer Engineering

Final Year Project Interim Report

Melanoma (Skin Cancer) Long-Term Monitoring

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Academic Year:	2017/2018

Introduction

In this report, I will be outlining a method for using Image processing to monitor Melanoma which is a type of Skin cancer. I will give a brief background on Melanoma alongside an outline of what the project will encompass. I will also discuss two published paper which I read that I found useful. I will then discuss the main theory behind the project and the steps required to complete it. Finally, I revealed my design and plan for completing the project.

Contents of Report

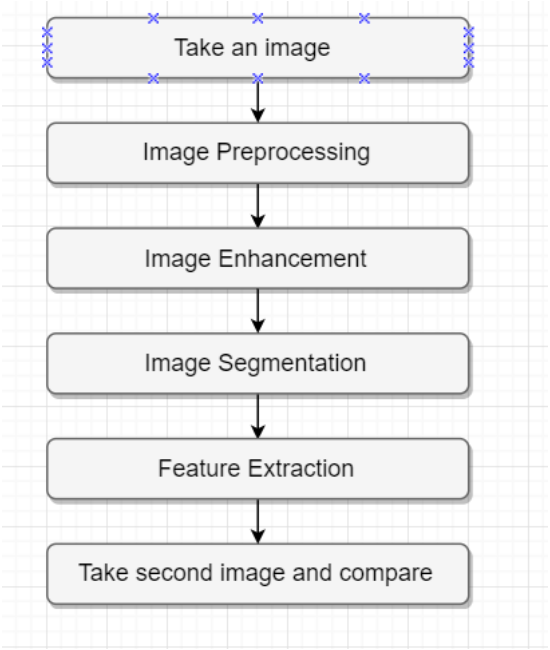

Figure 1: Steps required to analyze an image

Background information on Melanoma (Skin Cancer)

Skin cancer is the most common cancer in Ireland, with 10,304 cases of non-melanoma skin cancer and 1,041 cases of melanoma skin cancer diagnosed in 2014. It is mostly preventable cancer, and early detection of it will drastically improve the outcome of the patient as the treatment will be relatively easy and cheap. Skin cancer is the abnormal, uncontrollable growth of skin cells which is often developed when the genetic material (DNA) inside the skin cells is damaged which causes the cells to multiply rapidly usually because of overexposure to ultraviolet (UV) radiation from the sunlight or sunbeds. There are two main types of skin cancer: Non-melanoma and Melanoma. Non-melanoma skin cancer is a group of skin cancers that affect the upper layers of skin which mostly comprise of basal cell carcinoma and squamous whereas Melanoma skin cancer is a group of cancers that start in pigment cells (melanocytes) in the skin.

Melanoma is the deadliest form of skin cancer. Although it only accounts for 3-4% of all skin cancers, it is responsible for 75% of all skin cancer deaths and 1 in 8 people who are diagnosed with it result in a fatality. It is particularly dangerous as it can spread to other parts of the body beyond the skin usually through the lymphatic system and when it does, it can become hazardous and difficult to treat.

A person is more at risk for Melanoma if they have pale skin that burns easily, many moles, uses tanning beds or has a family history of melanoma. If you have a higher risk of developing skin cancer, it is best to take extra precautions. The best way to prevent melanoma is to avoid overexposure to the sun, seek shade when the sun is strongest, use SPF 30 sunscreen when necessary, dress sensibly, avoid sunbeds and have regular skin checks.

In Ireland, suspicious moles are first examined by a GP who usually decides if the moles require further testing by a dermatologist who a doctor that specializes in skin conditions. A dermatologist will use the ABCD method alongside a questionnaire to determine the severity of the mole. The ABCD method for visually inspecting a mole will inspect if the mole is asymmetrical, has an unusual border, multiple colors and if the mole is large. Often if the mole looks unlike any other mole on the patient's body further inspection might be needed. The questionnaire will involve asking the patient if the mole has recently appeared, is changing over time or if the mole has caused any irritability problems such itchiness or bleeding. A dermatologist may decide from this information to do a biopsy if they think it is necessary which is where a suspect mole is removed from your skin so that it can be studied

under a microscope to check if the mole is cancerous. If the mole is confirmed to be cancerous, a further operation may be done to remove a wider margin of skin around the mole which may remove the melanoma.

Treatment of melanoma will depend on how far the melanoma has grown into the skin and whether it has spread to other regions of the body. In the early stages if the cancer is detected early enough treatment will involve surgically removing the cancerous with a small area of the skin surrounding it which is known as surgical excision. If the melanoma has been removed, there is little chance of it returning, and no further treatment should be needed. In the case that the melanoma has spread to another part of the body it may not be possible to cure it so measures may be taken to slow the growth of cancer, reduce the symptoms and possibly extend the life expectancy of the patient. Some of these include Radiotherapy and drug treatments such as Chemotherapy to name a few which can have serious side effects on the patient, so it's better to treat it early at this stage. It is important than melanoma is detected and treated before it spreads as there are better treatments and higher survival rates.

Skin cancer is well suited for image processing techniques as the abnormal moles are visible on the skin. There are many advances in the field of Computer Vision which could dramatically change how we detect and treat Melanoma such as automatic detection of Melanoma from digital and dermoscopic images and new methods of monitoring Melanoma. Computer programs may be developed which could provide non-invasive methods for determining if a mole is benign or malignant.

Figure 2: Benign vs. Malignant mole

Project Outline

In this project, I will develop a system that will be able to monitor the progress skin cancer (Melanoma) on a patient's arm over a couple of months. This project will involve combining hardware and software engineering. I will be able to achieve this by taking an image of the arm with Melanoma in an enclosure with cameras and using aspects of Image processing to extrapolate information from the image. I will be imaging the arm from all angles using multiple cameras and combining the images to get a full representation of the arm.

From the images, I will be able to gather information about the moles from its features such as moles shape, size, color and number of moles on the arm. I will then take a second image of the same arm under the same conditions which I will compare with the previous image. By comparing the two complete images of the arm, I will be able to determine if a mole has evolved, changed in color or if any new mole has appeared which could indicate the Melanoma spreading. Most project in this field can't monitor the progress of a mole, calculate if a mole has increased in size or account for the appearance of new moles which may also be malignant as the information can't be determined from just one image.

Analyzing the images of the arm will involve the following steps: Preprocessing/Enhancement, Image Segmentation, and Feature Extraction. Image preprocessing and Segmentation steps will allow me to remove the parts of the image that serve no purpose such as the background skin, hairs, and any skin lines. It will also separate the moles from the skin as I will only need to focus on the mole. Feature Extraction will allow me to obtain useful information from the image and by comparing the information from the two images, I will be able to make some predictions about the progress of the melanoma.

This project has the potential of becoming an important tool for GPs and dermatologists in the monitoring of melanoma as the GP or dermatologist will be able to represent any change in the moles in a measurable way which could help improve the patient's treatment. It is useful because the GP or dermatologist will be able to measure any changes in the moles of the patient.

Literature Survey

While researching for this project, I read a lot of previously published papers which were relating to Melanoma which had a lot of information on different preprocessing, segmentation techniques and feature extraction methods. I also read books that were relating to the topic such as Digital Image Processing by Gonzalez and Woods which had a lot of great information on Image fundamentals, Image enhancements, Image compression, Segmentation and Object recognition. I will briefly summarize two of the published papers I researched.

Automatic Detection of Malignant Melanoma using Macroscope Images:

In this paper, three Biomedical Engineering students developed a method for detecting malignant melanoma from benign pigmented lesions using macroscopic images. The steps which are necessary to achieve this were Preprocessing, Image segmentation, Feature Extraction, and Classification. The students got the images which they trained their Machine Learning algorithm from a dermatology atlases called Dermnet where they collected 282 RGB images of various sizes (149 benign and 133 malignant). Preprocessing of the images was achieved by applying a median filter to remove impact noise, skin lines, hairs, and reflections. The RGB channels (Red, Green and Blue Channels) of each image was also converted to HSV color space (Hue, Saturation, and Value) to weaken the effect of non-uniform lighting. There were many methods used to segment the lesion from the skin such as K-mean clustering and Otsu thresholding which was used to remove the unhelpful parts of the image. The feature extraction method used was based off ABCD criteria which is like the traditional process of visual inspection. Finally, a Support Vector Machine classifier was used to predict whether a lesion was benign or malignant.

Mole Investigator - Detecting Cancerous Skin Moles Through Computer Vision:

In this paper, three Computer and Information Science students developed an iOS app that allowed the users to take a picture of a mole and the app will estimate the probability of the mole being malignant based on information from the machine learning model. The app has an easy to use User Interface, so it is accessible to anybody. The steps which are necessary to achieve this involve Preprocessing, Feature extraction, and Machine learning. Preprocessing was used to separating the background skin from the mole region using K-mean clustering which captures the main components of the image (i.e., moles). The Feature Extraction method used was based on ABCD (Asymmetry, Border Irregularity, Color Variation, and

Diameter) criteria and was completed by using the Python library OpenCV with image manipulation. Asymmetry is calculated by splitting the image of the mole in half and comparing each image with each other by orientation. Border Irregularity was calculated by using the OpenCV library to fit curves to the mole and assess the error between the curve of best fit. Color Variation was calculated by using k-mean segmentation to measure the RGB values of the different areas of the mole. The information from the feature extraction was inputted into a machine learning model. The Machine Learning model used was trained with 200 images (100 benign images and 100 melanoma images) which were gathered from the internet. The app asked the user to take a picture which was sent to a more powerful computer where the machine learning was performed. This app utilizes a random forest machine learning model that evaluated the user's image of a mole on the features of asymmetry, border irregularity, and color variation to estimate if the mole is malignant or not. There was also a questionnaire developed to improve the results of the app by highlighting the most concerning characteristics of a mole.

Although the papers I read didn't directly monitor Melanoma, I learned a lot about the different steps necessary for analyzing information from an image of a mole. I was also able to see different approaches for these steps such as Preprocessing, Image Segmentation, and Feature Extraction.

Theory

Monitoring Melanoma is important as it will identify if a malignant mole has evolved, changed color or if a new mole has appeared. If a mole is evolving, it could be an indicator of the melanoma spreading to other parts of the body. Color changes could be a result of a chemical change of the Melanoma, and any new moles that have appeared after being diagnosed could also be Malignant. Digital Image processing techniques are useful for monitoring melanoma because there is a visual representation of the effect of melanoma visible on the skin and by using different applications it is possible to gather information about the melanoma which would be impossible otherwise. Computer vision is an area in digital image processing that would lead itself to this project.

A digital image to a computer is just an array of numbers with each dot (PIXEL) in the image represented as a number in the array. A colored image (RGB image) will have 24 bits per pixel (8 bits each for Red, Green and Blue Channel). Computer vision is the processing and analyzing of images to obtain information from the image. It could also be described as a method of recreating human vision on a computer to interpret images. An image of an arm will be captured in an enclosure which will be compared with an image of the same arm in the same position to check if there is any change in the appearance of the Melanoma from one image to the next.

A program will be written to extract the information needed from the arm which will require the following steps: Image Preprocessing/Enhancing, Image Segmentation and Feature Extraction. Another image will be taken from the same arm and position to be compared with the first image to compare information and gather facts about the melanoma on the arm.

Python is the most useful programming language for Computer vision projects because of all the libraries available such as OpenCV which make prototyping an idea easier. OpenCV is an open source library that covers many areas of computer vision. Python is a powerful open source language with many volunteers constantly improving it. It is an easy language to learn, and the projects built in it are scalable. For this project, it will be best to write all the program on the Linux operating system Ubuntu as the program will easily be able to be transferred to an embedded device such as a Raspberry Pi which uses Raspbian OS which is also based on the Debian architecture.

The images of the arm in this project will be captured in an enclosure which will be connected to a Raspberry Pi. An enclosure will make the lighting of the images of the arm controllable, and it will also minimize external variables which could affect the image quality. Connecting the enclosure to an embedded device such as a Raspberry Pi will allow the project to be portable. The enclosure will be built with a material which will block external light. It will contain a handle and an armrest which will help ensure that the image is captured in a constant position. The enclosure will be fitted with multiple cameras which will take images of the arm from multiple angles to get a full representation of the arm. An image of the arm which will be taken before the program is written and compared with an image of the same arm after the program is complete.

Image preprocessing and enhancement are the first steps in preparing the image for analysis. Image preprocessing is an operation on the image before it is processed such noise removal and color transform. Image enhancement is an operation on the image which is meant to improve the quality of the image which will improve the manipulation ability of the image such as median filtering and image smoothing. The aim for preprocessing and segmentation in this project will be to prepare the image for the preprocessing step and to remove the effect of hairs, skin lines, and other variables that will affect the quality of the image. Image Segmentation is the partitioning the image into meaningful regions to improve its analysis. It is done by separating the objects within the image by finding the boundary regions of connecting pixels and removing the unwanted regions. The aim for segmenting the image in this project will be to remove the skin and background from the image.

Feature extraction is the final step before the images can be compared. Feature extraction is the transformation of the input image into features of distinct properties. The feature extraction method used in this project will be based on the ABCDE mnemonic which is commonly used by dermatologists. The ABCDE mnemonic stands for Asymmetry, Border Irregularity, Color Variation, Diameter, and Evolution. Asymmetry refers to the symmetry of the mole, Border Irregularity refers to the border of the mole being rough or unclear, and Color Variation refers to any difference in color in the mole from one area to another. Diameter refers to the size of the mole (over 6mm is concerning), and Evolution refers to any change in the mole which could be a result of the melanoma spreading. The more of these features a mole has, the higher the risk of the mole is cancerous. The feature extraction for this project will be implemented using formulas in Python. The feature extraction step aims to gather the important information from the images of the arm.

Comparing the image of the arm before the program was written with another image of the same arm in the same position will be the key step in monitoring melanoma. This step is where the usefulness of the project will be observed. By comparing the images, any changes in the arm will be measured. Information from the feature extraction step will be compared with both images, and the differences will be measured. The most important features that will be compared with the images is the mole shape, size, and color. If a mole has changed in shape, size or color, it would indicate that the melanoma is evolving in some way which would be concerning.

This project will be a proof of concept and will outline areas where Computer Vision can be used in a real-world situation. Melanoma is a big problem in our society and once the concepts behind this project get fully utilized it will be able to help GPs and dermatologists more effectively monitor and treat the condition. Melanoma can appear any part of the body not just the arms so the ideas from this project could be used in the future to make an enclosure which could fit an entire body and monitor Melanoma on any part of the body. Classification methods could be implemented to a similar Computer Vision project to potentials diagnose melanoma in a non-invasive way.

Outline Design

For this project, I will design and develop a system which will allow me to monitor the progress of moles on an arm of a patient. I will spend my first couple of weeks researching the topic and developing a plan on how the project can be done. I will then build an enclosure to provide a place to take the images and a program to complete the aims of the project. I will use a lot of Image Processing and Computer Vision techniques to make this possible.

I will write the entire program for this project in Python on the Linux based operating system Ubuntu. I will write the program needed on the text editor Atom, and I will use the Anaconda distribution and Jupyter notebook if necessary. I will utilize many of the libraries which are available in the Python community which will include OpenCV, Numpy, Scipy and Scikit-image which will make writing the program a lot easier. My python program for this project will involve the following steps for processing the image: Combining the images of each section of the arm to make 2-4 complete images, Image Preprocessing, Image Enhancing, Image Segmentation, Feature Extraction techniques and a method for comparing the two images.

The project will require me to build an enclosure which will allow me to control the lighting of the images of the arm. The enclosure will be made from wooden materials which I will gather from the materials lab in the college. I will include a handle and an arm-rest into the design of the enclosure which should help the patient align their arm in the same position for multiple images. I will position the cameras in the most convenient position which should minimize the amount manipulation of the I will have complete. I will connect the enclosure to a Raspberry Pi to run all the program for the images analysis and images comparison.

In this project, I will have to process two or more images simultaneously to get a full representation of the arm. I will capture two images from the top of the patient's arm and another two from the bottom of the patient's arm. I will have to combine two images of the top of the arm and likewise with the bottom part of the arm. To prepare the images for the Segmentation step, I will remove any noise, skin line, hair and the effect of lighting. I will achieve by converting the RGB color model to HSV and applying a median filter. I might change my method if I find a better method. I will begin segmenting the image by using Otsu thresholding, and I will continue implementing different segmentation methods until I get an acceptable result. The image is segmented in this project to separate the mole from the skin and background.

Feature extraction is completed to gather the most useful information from the image of the mole. My Feature Extraction method will be based on the ABCDE criteria. I will compare two methods of Feature Extraction and used both methods to test which will give me the best results. I will write a program that will manipulate the images of the moles using the Python library OpenCV by comparing each half of the image and fitting shapes to the moles. I will also write a Python program that will extract information from the moles using formulas I will create. I will test each method to see which one is best for the project.

I will write a program to compare the information from the feature extraction step and the number of moles in each image which were taken at two different stage of the melanoma. As well as the size, shape, and color for all the moles on the diameter and if there is any change in any of these, I will report in the output of the program. I will use these results to base my conclusions from the project.

Detailed action plan/Gantt chart

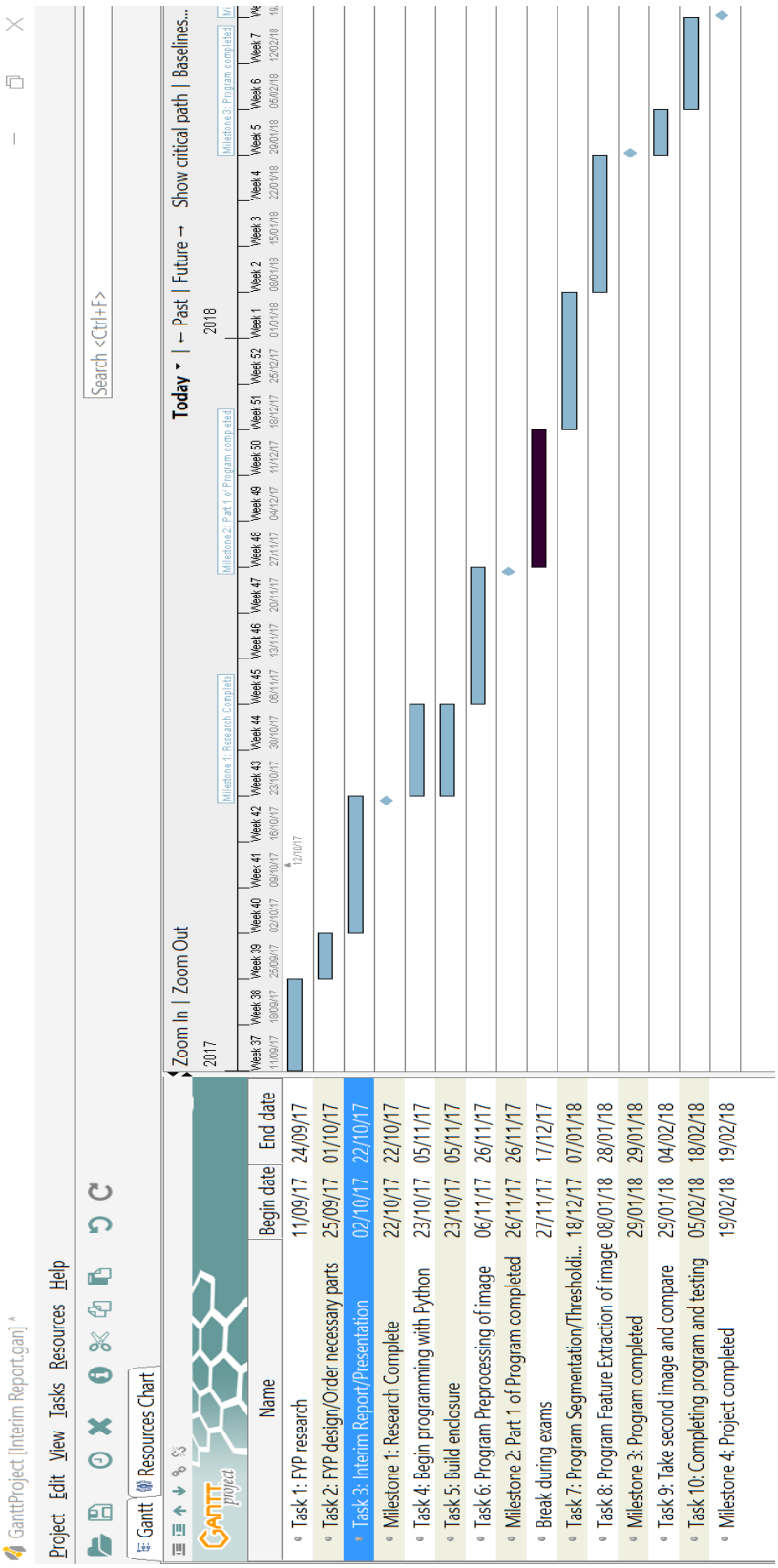

Figure 3: Gantt chart for the project

Task 1: FYP Research

- Spent two weeks researching Melanoma, Computer Vision and Image processing.
- Read relevant published papers and books such as Digital Image Processing.
- Watched various videos and talks about Computer Vision.

Start date: September Week 2 (11/09/17) **Duration:** 2 weeks **Dependencies:** None

Task 2: FYP Design/Order necessary parts

- Designed a plan for the Final Year Project which will involve assessing different methods of preprocessing, image segmentation and feature extraction
- Order all the parts necessary to build the enclosure including four cameras and a Raspberry Pi.

Start date: September Week 4 (25/09/17) **Duration:** 1 weeks **Dependencies:** Task 1

Task 3: Interim Report/Presentation

- Focused on writing my Interim report which is due on Friday of Week 7.
- Prepare a presentation which I will be given in Week 8.

Start date: October Week 1 (02/10/17) **Duration:** 3 weeks **Dependencies:** Task 1,2

Task 4: Begin programming with Python

- Set up the Raspberry Pi with cameras
- Install all the necessary software for the project which will be necessary to run my Python program.
- Install Atom IDE, Anaconda distribution and Jupyter notebook with all the necessary libraries such as OpenCV, Numpy, and Scikit-Learn.
- Spend some time researching and writing various Computer Vision projects to familiarize me with what is necessary to program a Computer Vision project.

Start date: October Week 4 (23/10/17) **Duration:** 2 weeks **Dependencies:** None

Task 5: Build enclosure

- Design and build the enclosure.
- Spend two days designing the enclosure
- The enclosure will comprise of a wooden box with room to fit a hand and multiple cameras. It will also have a handle and an armrest to ensure that the user can keep their arm in a constant position.

Start date: October Week 4 (23/10/17) **Duration:** 2 weeks **Dependencies:** None

Task 6: Program Preprocessing/Enhancement of image

- Program code to convert an RGB color model to HSV color model of the images.
- Program a median filter to apply to the images.
- Test other preprocessing and enhancing methods to try and improve efficiency.

Start date: November Week 1 (06/11/17) **Duration:** 3 weeks **Dependencies:** Task 5

Break during exam period:

Start date: November Week 4 (21/11/17) **Duration:** 4 weeks **Dependencies:** None

Task 7: Program Segmentation/Thresholding of image

- Program an Otsu thresholding to segment the image.
- Modify the method to try and improve results.
- Test other segmentation methods to try and improve efficiency

Start date: December Week 3 (18/12/17) **Duration:** 3 weeks **Dependencies:** Task 6

Task 8: Program Feature Extraction of Image

- Program code that implements the ABCDE criteria using OpenCV to manipulate images.
- Separately program code that implements the ABCDE criteria using formulas to calculate each feature in the ABCDE mnemonic.
- Modify both methods to try and improve results.
- Compare both methods and choose the method that performs the best.

Start date: January Week 2 (08/01/17) **Duration:** 3 weeks **Dependencies:** Task 7

Task 9: Take the second image of the same arm and compare

- Program code to compare two images of an arm
- Take a second image of the arm in the enclosure in the same position.
- Process both images and compare.
- Analyze the result and interpret information from images.

Start date: January Week 4 (29/01/17) **Duration:** 1-week **Dependencies:** Task 8

Task 10: Testing

- Test the entire project to ensure that the project is fully functional.

Start date: February Week 5 (05/02/17) **Duration:** 2 weeks **Dependencies:** Task 9

Project complete: (26/02/17)

This project is due to be completed on the 26th of February which will allow one week extra in case any task takes longer than expected as I want the project to be finished on the 4th of March.

Requirements of facilities and materials

During my Final Year Project, I will require contact hours with my supervisors. I will also need materials to build the enclosure and a Raspberry Pi to create a complete system.

References

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