NOTTINGHAM TRENT UNIVERSITY

School of Science and Technology

Final Year Project Plan

Project Planning Document: Classification of ultrasound images using CNN

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Table of Contents

Classification of ultrasound images using CNN

Introduction

In recent years, machine learning techniques have been developed significantly and successfully in various fields such as 'image analysis, anomaly detection and disease detection' (Noor, et al., 2020). The health care sector can augment specific specialties' performance and diagnose cases more accurately, 'improving patient care' using new techniques and technologies (Yamashita, et al., 2018).

Applications of CNN highlighted in the medial and biological sector explained by the work of Mahmud et al examining the CNN models to predict 'DNA- AND RNA binding proteins ' (Mahmud, et al., 2018). CNN has also been used for the segmentation of muscle perimysium (muscle disease) and the classification of inflammatory muscle disease; this has been completed with the use of '2D spatial clockwork recurrent neural networks' (Lu, et al., 2020). CNN has become such a broad topic in Deep Learning that 'CNN-based segmentation of MRI' scans has brought clinical studies changes regarding the accuracy, efficiency, and safe evaluations becoming a 'key step in delineating contour' (Ali, et al., 2019).

The use of convolutional neural networks has been conducted before with medical images, highlighted by Mahmud et al that the use of Deep Learning (DL) and Reinforcement Learning (RL) has been 'widely used in analysing medical images' (Mahmud, et al., 2018). The applications of DL concepts such as convolutional neural networks can be seen as a pivotal pillar when trying to 'denoise, segment, classify, detect anomalies and diseases' from such images, including ultrasounds.

This project is interested in using modern techniques such as convolution neural networks (CNN) to classify ultrasound images into good and bad images, which can work out several features, including fetal gestation age. Thus, leading to the improvement in the training of new sonographers' and becoming a reference point for all clinicians

attempting to find the best ultrasound image by minimising the ‘intra and interobserver variability’ (Sarris, et al., 2011).

Crown to rum length measurements at the first-trimester scan is a crucial measurement used to date pregnancy. The dating of pregnancy determines 'accurate prenatal visits,' which are essential for a successful pregnancy, and determines the 'timing of certain interventions' (Morgan & Cooper, 2020). It is the choice method for ultrasound assessment of gestational age in the first trimester, but it is susceptible to intra-observer and inter-observer variation. These variations may result from the inconsistent or incorrect acquisition of the appropriate images. For example, a 'parasagittal plane may not contain the entire fetal length,' leading to CRL's underestimation (Ioannou, et al., 2013); conversely, a hyper-extended fetal neck will lead to CRL’s overestimation.

However, there has been a lack of projects that use CNN and ultrasound imaging to minimise the inter and intra-observer variation by providing good and bad ultrasounds, which can help trainee sonographers learn and help people in peripheral areas around the world to read ultrasounds. Currently, clinicians are missing the classification of ultrasound imaging, which can rule out miscommunication and interpterion of ultrasound images, which is the novelty of this project.

Successfully applying this project could see the development of future significant works in optimising CNN models along with more precise feature extraction and compilation of features to diagnose downs-syndrome. The current project is the foundation of a vast field in convolution neural networks in fetal medicine, more precisely in ultrasound imaging. Most importantly, the project will solve observer variations and can act as a reference point when teaching new students how to read ultrasounds. Along with acting as a sole system in peripheral parts of the world where ultrasounds are challenging to read.

Aims & Objectives

The aim of this project is to develop a web program that contains a convolutional neural network that can classify ultrasound images as good and bad images to minimise inter and intra-observer variations.

The secondary aim is to measure the CRL and nuchal translucency (fluid behind the fetus's head) of the fetus and extract features from images to analyse.

Objectives

Objective	Relevancy	Evaluation
Research and construct a project plan.	Initial research for the foundations of this project.	Initial research is essential for the foundations of the project, but research throughout the project is required.
Design of the project including a paper prototype	The design of the program prepares for the implementation of the project.	The design will show the template of the program. However, changes can be made to the design at later stages.
Constructing a Convolutional Neural network.	The construction of the CNN is the main foundation of the program.	CNN construction is vital for the classification of ultrasound images.
Create a backend Prototype	The backend prototype should display the classification of good and bad ultrasound images.	The backend prototype should show the optimised CNN and other aspects of the backend.
Create a frontend Prototype	The frontend prototype should be user friendly and functional.	The frontend should have a neat and user-friendly user interface.
Backend and Frontend integration	The integration of the backend and frontend is key to producing the final version.	The backend and frontend must be integrated so users can enter ultrasounds to be classified.
Testing application and deployment	Testing and deployment of the program are essential for creating a final product.	Testing and deployment are critical for the final product, which can be presented to users.

Smart Methodology

To set these objectives, I have used the SMART methodology to generate smart, measurable, realistic, and time-bound objectives. These objectives are specific as they are linked to several tasks, which can be seen in the next section. They are measurable as they can be measured by key milestones set out in the Gantt chart. The objectives are realistic as they are result based requiring documentation or a prototype for each

objective. Finally, these objectives are time-bound as they are time-sensitive, shown on the Gantt chart.

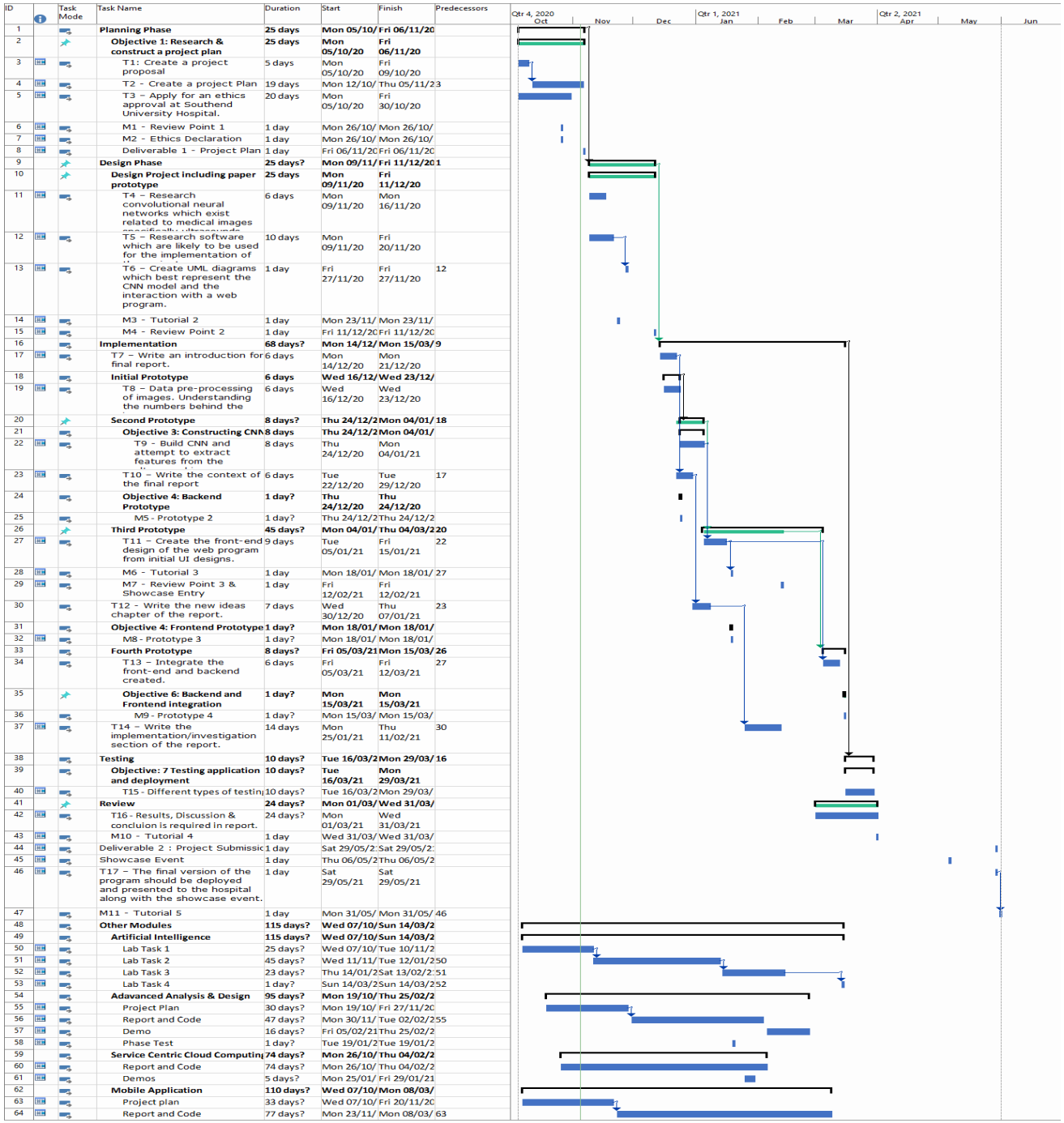
Tasks and deliverables

Task Number	Task	Outcomes/Scope	Dependencies and Time
Planning Phase (P1):			25 days
1	T1: Create a project proposal.	From the initial research interests, a foundation can be formed about the project. By choosing the CNN topic related to ultrasounds imaging, a clear direction is given to the project. By writing a proposal with key objectives, a brief overview of what the project should entail can be shown.	5 days
2	T2 - Create a Project Plan	Project plan should consist of the introduction, aim and objectives, risks, resources, Gantt chart and an ethics section to create a foundation for the project.	T1 19 days
3	T3 – Apply for an ethics approval at Southend University Hospital.	Southend University Hospital requires ethical approval so a dataset of ultrasound images can be used.	20 days
Design Phase (P2):			P1 25 Days
4	T4 – Research convolutional neural networks which exist related to medical images, specifically ultrasounds.	Thorough research of convolutional neural networks is required to help with future problems that can be faced in the implementation stage.	6 Days
5	T5 – Research software that is likely to be used for the implementation of the project.	Thorough research of software is required, so appropriate tools can be used when creating the project without any difficulties.	10 Days
6	T6 – Create UML diagrams which best represent the CNN model and the interaction with a web program.	UML diagrams are required of the system, so a detailed design of the system is available before the implementation stage.	T5 1 Day
Implementation (P3):			P2 68 days
7	T7 – Write an introduction for the final report.	An introduction for the final report must introduce the topic of ultrasounds and CNN explaining the methods and algorithms.	6 days

8	T8 – Data pre-processing of images. Understanding the numbers behind the images.	It is essential to pre-process the images to gain an understanding of the build-up of ultrasound images.	6 days
9	T9 – Build CNN and attempt to extract features from the ultrasound image.	For the best performance of the model optimisation, for example, finding the best batch size.	8 days
10	T10 – Write the context of the final report	This section should highlight a literature review of research that is already completed in the field.	T9
11	T11 – Create the front-end design of the web program from initial UI designs.	The front-end design will give a user interface and allow users to enter ultrasound images.	T10 9 days
12	T12 - Write the new ideas chapter of the report.	The new ideas section should eliminate existing limitations and include a new method for the project.	T11 7 day
13	T13 – Integrate the front-end and backend created.	The integration of the front-end and back-end is key so users can enter their images.	T12 6 days
14	T14 – Write the implementation/investigation section of the report.	The project's implementation should highlight the algorithms used and the algorithms' structure and explanations of the decisions made.	14 days
15	T15 – Different types of testing	Several tests are required to check if the program is accurate and reliable such as. Classification accuracy, Other tests.	10 days
16	T16 – Results, Discussion and a conclusion are required to be documented.	The results section is important to evaluate the results from the project and discuss findings. The conclusion section highlights the final findings and any future work which can be carried.	24 days
17	T17 – The program's final version should be deployed and presented to the hospital along with the showcase event.	The deployment of the project is key, so users can get the opportunity to use the system at the showcase event.	1 day

Key Milestones	Deliverables
M1 – Tutorial 1	**D1 - Project planning Document**
M2 – Ethics Declaration	**D2 - Final Report submission**
M3 – Tutorial 2	
M4 – Review Point 2	
M5 – Prototype 2	
M6 – Tutorial 3	
M7 – Prototype 3	
M8 – Prototype 4	
M9 – Review point 3 and showcase entry	
M10 – Tutorial 4	
M11 – Tutorial 5	

Gantt Chart



ID	Task Mode	Task Name	Duration	Start	Finish	Predecessors
1		**Planning Phase**	**25 days**	**Mon 05/10/**	**Fri 06/11/20**	
2		**Objective 1: Research & construct a project plan**	**25 days**	**Mon 05/10/20**	**Fri 06/11/20**	
3		T1: Create a project proposal	5 days	Mon 05/10/20	Fri 09/10/20	
4		T2 - Create a project Plan	19 days	Mon 12/10/	Thu 05/11/2	3
5		T3 – Apply for an ethics approval at Southend University Hospital.	20 days	Mon 05/10/20	Fri 30/10/20	
6		M1 - Review Point 1	1 day	Mon 26/10/	Mon 26/10/	
7		M2 - Ethics Declaration	1 day	Mon 26/10/	Mon 26/10/	
8		Deliverable 1 - Project Plan	1 day	Fri 06/11/2	Fri 06/11/2	
9		**Design Phase**	**25 days?**	**Mon 09/11/**	**Fri 11/12/2**	1
10		**Design Project including paper prototype**	**25 days**	**Mon 09/11/20**	**Fri 11/12/20**	
11		T4 – Research convolutional neural networks which exist related to medical images	6 days	Mon 09/11/20	Mon 16/11/20	
12		T5 – Research software which are likely to be used for the implementation of	10 days	Mon 09/11/20	Fri 20/11/20	
13		T6 – Create UML diagrams which best represent the CNN model and the interaction with a web program.	1 day	Fri 27/11/20	Fri 27/11/20	12
14		M3 - Tutorial 2	1 day	Mon 23/11/	Mon 23/11/	
15		M4 - Review Point 2	1 day	Fri 11/12/2	Fri 11/12/2	
16		**Implementation**	**68 days?**	**Mon 14/12/**	**Mon 15/03/**	9
17		T7 – Write an introduction for final report.	6 days	Mon 14/12/20	Mon 21/12/20	
18		**Initial Prototype**	**6 days**	**Wed 16/12/**	**Wed 23/12/**	
19		T8 – Data pre-processing of images. Understanding the numbers behind the	6 days	Wed 16/12/20	Wed 23/12/20	
20		**Second Prototype**	**8 days?**	**Thu 24/12/2**	**Mon 04/01/**	18
21		**Objective 3: Constructing CNN**	**8 days**	**Thu 24/12/2**	**Mon 04/01/**	
22		T9 - Build CNN and attempt to extract features from the	8 days	Thu 24/12/20	Mon 04/01/21	
23		T10 – Write the context of the final report	6 days	Tue 22/12/20	Tue 29/12/20	17
24		**Objective 4: Backend Prototype**	**1 day?**	**Thu 24/12/20**	**Thu 24/12/20**	
25		M5 - Prototype 2	1 day?	Thu 24/12/2	Thu 24/12/2	
26		**Third Prototype**	**45 days?**	**Mon 04/01/**	**Thu 04/03/2**	20
27		T11 – Create the front-end design of the web program from initial UI designs.	9 days	Tue 05/01/21	Fri 15/01/21	22
28		M6 - Tutorial 3	1 day	Mon 18/01/	Mon 18/01/	27
29		M7 - Review Point 3 & Showcase Entry	1 day	Fri 12/02/21	Fri 12/02/21	
30		T12 - Write the new ideas chapter of the report.	7 days	Wed 30/12/20	Thu 07/01/21	23
31		**Objective 4: Frontend Prototype**	**1 day?**	**Mon 18/01/**	**Mon 18/01/**	
32		M8 - Prototype 3	1 day?	Mon 18/01/	Mon 18/01/	
33		**Fourth Prototype**	**8 days?**	**Fri 05/03/21**	**Mon 15/03/**	26
34		T13 – Integrate the front-end and backend created.	6 days	Fri 05/03/21	Fri 12/03/21	27
35		**Objective 6: Backend and Frontend integration**	**1 day?**	**Mon 15/03/21**	**Mon 15/03/21**	
36		M9 - Prototype 4	1 day?	Mon 15/03/	Mon 15/03/	
37		T14 – Write the implementation/investigation section of the report.	14 days	Mon 25/01/21	Thu 11/02/21	30
38		**Testing**	**10 days?**	**Tue 16/03/2**	**Mon 29/03/**	16
39		**Objective: 7 Testing application and deployment**	**10 days?**	**Tue 16/03/21**	**Mon 29/03/21**	
40		T15 - Different types of testin	10 days?	Tue 16/03/2	Mon 29/03/	
41		**Review**	**24 days?**	**Mon 01/03/**	**Wed 31/03/**	
42		T16 - Results, Discussion & concluion is required in report.	24 days?	Mon 01/03/21	Wed 31/03/21	
43		M10 - Tutorial 4	1 day	Wed 31/03/	Wed 31/03/	
44		Deliverable 2 : Project Submissic	1 day	Sat 29/05/2	Sat 29/05/2	
45		Showcase Event	1 day	Thu 06/05/2	Thu 06/05/2	
46		T17 – The final version of the program should be deployed and presented to the hospital along with the showcase event.	1 day	Sat 29/05/21	Sat 29/05/21	
47		M11 - Tutorial 5	1 day	Mon 31/05/	Mon 31/05/	46
48		**Other Modules**	**115 days?**	**Wed 07/10/**	**Sun 14/03/2**	
49		**Artificial Intelligence**	**115 days?**	**Wed 07/10/**	**Sun 14/03/2**	
50		Lab Task 1	25 days?	Wed 07/10/	Tue 10/11/2	
51		Lab Task 2	45 days?	Wed 11/11/	Tue 12/01/2	50
52		Lab Task 3	23 days?	Thu 14/01/2	Sat 13/02/2	51
53		Lab Task 4	1 day?	Sun 14/03/2	Sun 14/03/2	52
54		**Adavanced Analysis & Design**	**95 days?**	**Mon 19/10/**	**Thu 25/02/2**	
55		Project Plan	30 days?	Mon 19/10/	Fri 27/11/2	
56		Report and Code	47 days?	Mon 30/11/	Tue 02/02/2	55
57		Demo	16 days?	Fri 05/02/21	Thu 25/02/2	
58		Phase Test	1 day?	Tue 19/01/2	Tue 19/01/2	
59		**Service Centric Cloud Computin**	**74 days?**	**Mon 26/10/**	**Thu 04/02/2**	
60		Report and Code	74 days?	Mon 26/10/	Thu 04/02/2	
61		Demos	5 days?	Mon 25/01/	Fri 29/01/21	
62		**Mobile Application**	**110 days?**	**Wed 07/10/**	**Mon 08/03/**	
63		Project plan	33 days?	Wed 07/10/	Fri 20/11/2	
64		Report and Code	77 days?	Mon 23/11/	Mon 08/03/	63

Resources

Resource Number	Resource	Details/Evaluation of resources.
1	Laptop	A laptop is essential for this project because the main algorithms and the fundamental research should be completed on the laptop.
2	Anaconda	Free, open-source distribution is required to have a variety of IDE's to choose from.
3	Juypter Notebook	Jypter notebook will be required for writing the python code for the backend side of this project.
4	Flask	Flask is a software tool that can be used to create the frontend for this project.
5	Django	Django is a software tool that can be used to create the frontend for this project.
6	MongoDB	MongoDB is a database program that can be used to store images for the model.

Source Number	Source	Details/Evaluations of sources.
1	Udemy	Tutorials to increase knowledge about deep learning.
2	Coursera	Courses to understand theoretical knowledge about machine learning models.
3	Youtube videos	Information and tutorials on how to solve specific problems.
4	Supervisor (Mufti Mahmud)	Advice and guidance on the report and any problems the project is facing.
5	Artificial Intelligence Lab tutor (David Adama)	Gain advice on convolution neural network problems and find solutions to solve specific problems.
6	Library	Literature for research.
7	Google Scholar	Literature for research.
8	Southend University Hospital	Advice on theoretical knowledge regarding the subject. Supplying clarity on aims and objectives.

Risks

Risk Number	Risk Description	Status	Probability	Impact	Rating	Risk Category	Mitigation Plan	Recommended actions
Technical Risks								
1	Loss of source code.	Unacceptable	7	9	63%	High	Source code must be pushed to the git repository.	Regularly save source code to a personal machine. Backup source code to external hard drive for emergencies.
2	Integration problems of front-end and back-end.	Reasonably unacceptable.	6	9	54%	Medium	The code must be clean, and a plan should be formed on how to integrate.	Integration problems must be taken into when designing the project. Any problems should be consulted with the supervisor for advice or other university faculty.
3	Failure to build an optimum CNN model.	Reasonably Acceptable	6	9	54%	Medium	Basic knowledge should be gained before making the model. Sources should be used to understand CNN.	Use sources such as Udemy, Coursera, and Google to build a CNN model. Consult with the supervisor as soon as possible and ask for advice.
4	Loss of accuracy of the model.	Reasonably Acceptable	7	6	42%	Medium	Batch size must be considered if there is a loss in the accuracy of the model.	If there is a loss in the accuracy, then the batch size must be considered in the case of overfitting. Consult with AI lab tutor if there are further questions.
5	An issue with the format of images.	Reasonably Acceptable	7	8	56%	Medium	Corrupted images must be discarded appropriately, and Southend University	Any images which are corrupted should be noted and taken out of the data set. Southend University hospital should be contacted for a

							hospital must be contacted for replacement.	replacement, so the data set size remains the same as projected.
6	Problem in the deployment of the website.	Unacceptable	7	9	63%	High	Use online resources to understand the problem with deployment.	Consult with advisor on the problem with deployment or any lab tutors.
7	Problems with programming tools being used to build the program.	Reasonably Acceptable	6	6	36%	Medium	Keep backup tools that can be used to do similar operations.	Research similar tools that could have been used and use them as a substitute.
Non-Technical Risk								
8	Supervisor's absence for a period of time.	Reasonably Acceptable	6	6	36%	Medium	Regular updates to the supervisor must be sent for clear communication.	Small updates every two weeks should be sent to the supervisor. A plan should be made before the supervisor does go on absence for a period of time.
9	Contracting COVID-19.	Unacceptable	8	8	64%	High	Follow NHS guidelines if contracting COVID-19. Inform supervisor and university.	If COVID-19 is contracted, readjust the schedule so time can be made to finish any work that has been left incomplete. Inform the supervisor and university of isolation dates.
10	Other modules and exams require attention.	Reasonably Acceptable	7	7	49%	Medium	A thorough project schedule is required to organise key dates.	Modules and exams must be given priority. A clear plan should be made with timeframes allocated to each module.

11	University and job applications.	Reasonably Acceptable	8	7	56%	Medium	Applications must be considered when making the project plan. Priority must be given to university work.	University work (project) must be given priority to job and university applications. The project plan must be updated regularly so that time can be made for other activities.
12	Poor time management.	Unacceptable	8	8	64%	High	The project scheduling tool must be continuously updated weekly.	Use other tools like Trello or Asana to help in managing tasks.
13	Poor project design.	Unacceptable	7	9	63%	High	A clear project plan must be created in the design section.	Any problems met in the implementation phase regarding the design must be documented, and the design of the project must be updated.
14	Project too complex to meet final aims and requirements.	Reasonably Acceptable	7	7	49%	Medium	Strong communication with the supervisor is required to avoid problems of complexity.	Seek continuous communication with the supervisor explains problems that are being faced.
15	Loss of planning documentation.	Reasonably Acceptable	6	8	48%	Medium	Regular back-ups must be taken during the	Regularly save source code to personal machine. Backup source code to external hard drive for emergencies.

Legal, Social, Ethical and Professional Issues

There are various legal, socially ethical, and professional issues required to be identified for the development of the project to maintain integrity. The project, which is researching the classification of good and bad ultrasound images, is required to comply with the guidelines set out by the British Computer Society and IEEE-CE (Institute of Electrical and Electronics Engineers Computer Society), which followed by professionals working in the current computing sector. For this project, there are a few examples of guidelines required to be followed to ensure the research that is to be undergone is needed to uphold the highest possible standard to avoid any legal, social, ethical, and professional issues.

Legal

For this project, legality is an important issue as the data which is to be used in this project has to be used correctly. In this project, we will be collecting several ultrasound images to be the foundation dataset of the project. The Data Protection Act of 2018 shows the importance of personal data as the act states several 'data protection principles' (Government Digital Service, 2011). To avoid misusing the act, Southend University Hospital will be providing a dataset of ultrasound images that have personal information of patients redacted, and all the images chosen are to be randomised. This highlights this project following guidelines to avoid any legal issues. Hence the model which is to be created will only contain randomised ultrasound images.

Social

The BCS code of conduct states that projects must be 'acting in the public interest' (BCS, 2015); this suggests that the research outcomes must benefit society in some respects. The project aims to classify ultrasound images into good and bad categories leading to the minimisation of inter and intra-observer variations, which can help train new sonographers; the aims also help in parts of the world where people cannot understand

how to date pregnancies. Thus, this software can be regarded as a reference point benefitting society.

Ethical

Throughout the project, some areas of concern in the code might require the project to entail existing code already published; in this case, any code that can be found online or used in any existing projects will be clearly and correctly referenced. Furthermore, it is essential to 'have due regard for legitimate rights of Third Parties' (BCS, 2015), which indicates that ultrasound images will not be passed on to any Third Party and any images entered into the web program will not be stored but just passed through the CNN model. To follow the BCS code of conduct, all of the images which are to be used in this project will have personal patient information redacted, and the set of data will be randomised.

Professional

It is essential for the web program and the CNN model to hold up most professional qualities and not reflect any flaws in its design and implementation. In this project, it is key to understand the medical aspect; ultrasounds are not easy medical images that can be read. Thus, it is important to act professionally by giving 'respect and value to alternative viewpoints' (BCS, 2015), which will help create an error-free web program. Significant amount of research must be done before the commencement of the project so work which is undertaken in the project is 'within your professional competence' (BCS, 2015). This shows that it is important to be competent with the work which is being conducted; regarding this project significant research has been completed and individuals from Southend Hospital University have been selected to aid with any issues along with a supervisor from Nottingham Trent University, thus increasing my professional competence to a good standard.

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