Reflection and Traceability Report on CXR

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[Reflection is an important component of getting the full benefits from a learning experience. Besides the intrinsic benefits of reflection, this document will be used to help the TAs grade how well your team responded to feedback. Therefore, traceability between Revision 0 and Revision 1 is and important part of the reflection exercise. In addition, several CEAB (Canadian Engineering Accreditation Board) Learning Outcomes (LOs) will be assessed based on your reflections. —TPLT]

1 Changes in Response to Feedback

1.1 SRS and Hazard Analysis

Here is the feedback we received on the SRS and Hazard Analysis documents, and the changes we made in response to that feedback.

Table 1: Feedback and Changes for SRS Documentation

Feedback Source	**Feedback Item**	**Response**	**Issue**
TA Feedback	Formatting and Style	Mention figures in paragraphs and fix title	#125
TA Feedback	What not How(Abstract)	Improve constraints details	#126
TA Feedback	Complete, Correct and Unambiguous	Template explanation	#124
TA Feedback	Traceable Requirements	Fix referencing for section 5.2.	#123
TA Feedback	Document Content	Fix functional requirements.	#122

Feedback Source	Feedback Item	Response	Issue
Peer Review	Project Goals	Goal Statements Inconsistency.	#55
Team Feedback	Document Content	Fix FR and NFR to align with the current scope of project	#201
TA Feedback	Document Content	Fixed Citation	#202

1.2 Design and Design Documentation

Here is the feedback we received on the Design and Design Documentation, and the changes we made in response to that feedback.

Feedback Source	Feedback Item	Response	Issue
TA Feedback	Document Content	Formalization	#191
TA Feedback	Document Content	Input represenation	#192
TA Feedback	Document Content	Specific Definition of JSON	#193
TA Feedback	Document Content	HTTP Design	#194

1.3 VnV Plan and Report

Here is the feedback we received on the VNV Plan and VNV Report, and the changes we made in response to that feedback.

Table 3: Feedback and Changes for VNV Plan

Feedback Source	Feedback Item	Response	Issue
TA Feedback	Nondynamic testing used as necessary	Improve Testing	#196
TA Feedback	General Information	Objective mismatching	#195
Team Feedback	System Tests for Functional / Nonfunctional Requirements are specific	Update based on team feedback	#203

2 Challenge Level and Extras

2.1 Challenge Level

[State the challenge level (advanced, general, basic) for your project. Your challenge level should exactly match what is included in your problem statement. This should be the challenge level agreed on between you and the course instructor. —TPLT]

2.2 Extras

[Summarize the extras (if any) that were tackled by this project. Extras can include usability testing, code walkthroughs, user documentation, formal proof, GenderMag personas, Design Thinking, etc. Extras should have already been approved by the course instructor as included in your problem statement. —TPLT]

3 Design Iteration (LO11 (PrototypeIterate))

[Explain how you arrived at your final design and implementation. How did the design evolve from the first version to the final version? —TPLT]

[Don't just say what you changed, say why you changed it. The needs of the client should be part of the explanation. For example, if you made changes in response to usability testing, explain what the testing found and what changes it led to. —TPLT]

4 Design Decisions (LO12)

[Reflect and justify your design decisions. How did limitations, assumptions, and constraints influence your decisions? Discuss each of these separately. —TPLT]

5 Economic Considerations (LO23)

[Is there a market for your product? What would be involved in marketing your product? What is your estimate of the cost to produce a version that you could sell? What would you charge for your product? How many units would you have to sell to make money? If your product isn't something that would be sold, like an open source project, how would you go about attracting users? How many potential users currently exist? —TPLT]

5.1 Market Demand and Opportunity

The market for AI-driven medical imaging analysis is growing rapidly due to increasing healthcare digitization and the global shortage of radiologists. The demand for fast, accurate, and cost-effective diagnostic tools makes this product highly viable. Potential users include hospitals, clinics, telemedicine providers, and government healthcare initiatives. Additionally, developing countries with limited access to radiologists represent a significant market where AI-powered solutions could improve diagnostic capabilities.

5.2 Marketing Strategy

Marketing would involve direct outreach to hospitals and healthcare providers, showcasing the efficiency and accuracy of the model through clinical trials and case studies. Partnerships with electronic health record (EHR) providers could facilitate integration into existing workflows. Furthermore, regulatory approvals such as FDA or Health Canada certification would enhance credibility. However, our team plans more on leveraging via government healthcare programs and partnerships.

5.3 Production Cost Estimate

The cost of production includes:

- **Cloud Services (AWS ECS):** The hosting and management of the backend system will be powered by AWS Elastic Container Service. This service will handle containerized microservices, ensuring scalability. Costs for ECS typically range from x to x dollar per month, depending on traffic, load, and the number of services running.
- **GPU/Server Cost:** To train the AI model efficiently, a dedicated GPU or server instance is required for training and inference tasks. For optimal performance, services like AWS EC2 GPU instances would be suitable, which cost around 3 to 5 dollars per hour, depending on the selected instance type. In our case, using the Mcmaster GPU server, there was no cost for training and inference, but we estimate a cost of 500 to 1,000 dollars per month if we did not have access to the mcmaster GPU server. Note our product is the application not the computer or server it runs on.
- **Cost of API Services:** The integration of ChatGPT for natural language processing tasks, such as generating reports or patient interaction, incurs costs based on the number of API calls. This will vary depending on usage but can be estimated at a few cents per API call, estimating the monthly cost to be the amount of patients divded by 100.

5.4 Pricing Model

- **SaaS Model (Subscription-based):** Hospitals or the government pays a monthly or annual fee per facility or per patient scan. For considerable profit our team would need to charge around $1,237/month per hospital or $2.34 per scan. This model ensures predictable revenue and allows for scaling as more hospitals adopt the technology.

Given these models, the pricing would balance affordability with long-term sustainability while ensuring accessibility for lower-income hospitals.

5.5 Break-even Analysis

THIS SECTION NEEDS TO BE FILLED

5.6 Conclusion

By aligning pricing, marketing, and distribution with the needs of healthcare providers, the AI-powered X-ray tool has strong market potential. A subscription-based model, combined with strategic partnerships, regulatory approvals, and research collaborations, can drive adoption and profitability while improving global healthcare outcomes. Additionally, partnering with government healthcare programs ensures a stable product demand and consistent revenue stream, as governments often prioritize long-term investments in healthcare infrastructure and technology.

6 Reflection on Project Management (LO24)

6.1 How Does Your Project Management Compare to Your Development Plan

[Did you follow your Development plan, with respect to the team meeting plan, team communication plan, team member roles and workflow plan. Did you use the technology you planned on using? —TPLT]

6.2 What Went Well?

[What went well for your project management in terms of processes and technology? —TPLT]

6.3 What Went Wrong?

[What went wrong in terms of processes and technology? —TPLT]

6.4 What Would you Do Differently Next Time?

[What will you do differently for your next project? —TPLT]

7 Reflection on Capstone

[This question focuses on what you learned during the course of the capstone project. —TPLT]

7.1 Which Courses Were Relevant

- **4ML3 Machine Learning and AI:** The principles and techniques from this course provided a foundation for understanding how to train and deploy machine learning models, especially the convolutional neural networks (CNNs) used for image classification in medical X-rays. Key topics such as model validation, overfitting, and the use of pre-trained models were directly applicable to the AI model development for disease prediction.

- **4HC3 Human Computer Interfaces:** The knowledge gained from this course on Norman's principles of design was crucial in designing an intuitive and effective user interface for the capstone project. Understanding the user experience was essential for ensuring that the system is accessible and user-friendly, especially for medical professionals who will interact with the system.

- **4A03 Ethics:** This course allowed our group to have some former background in the ethical implications of using AI in healthcare, especially regarding privacy, consent, and ensuring that the model works equitably across different patient demographics. This understanding guided the way our team handled data and made design decisions for this project.

- **4X03 Scientific Computation:** This course helped the group understand numerical methods and how to implement efficient algorithms for scientific computing. It was particularly useful when optimizing performance for processing large-scale image datasets, such as chest X-rays, and for ensuring that the system was computationally feasible and efficient.

7.2 Knowledge/Skills Outside of Courses

- **Deep Learning Frameworks (PyTorch):** The team collectively enhanced its understanding of PyTorch, a deep learning framework, to implement the AI model for chest X-ray analysis. This involved collaboratively building convolutional neural networks (CNNs), fine-tuning pre-trained models, and developing robust image data pipelines for preprocessing and augmenting the X-ray images.

- **Regulatory Compliance in Healthcare (HIPAA):** Since the project involves medical data and aims to have real-world applications in healthcare, the team researched and gained knowledge about healthcare regulations like Health Insurance Portability and Accountability Act for AI-based medical tools. This included understanding privacy concerns and compliance measures for handling patient data safely and legally.

- **API Integration and Deployment:** To integrate the machine learning model into a production environment, the team learned how to set up RESTful APIs and integrate them with the frontend. This included working with cloud services such as AWS to deploy the system and ensure scalability for real-world use. This was crucial for making the AI model accessible to healthcare professionals and ensuring that it could handle multiple requests simultaneously.

- **Data Annotation and Augmentation for Medical Imaging:** The team acquired knowledge on handling medical image datasets, including proper annotation of X-ray images for training purposes and applying image augmentation techniques to improve model robustness. This was particularly important as public datasets for chest X-rays can be limited and require preprocessing for real-world applications.

- **Performance Monitoring and Model Optimization:** To ensure that the AI system performed well in production, the team explored model optimization techniques, such as hyperparameter tuning, and utilized performance monitoring tools to track the model's real-world effectiveness in detecting lung diseases. This included setting up logging and feedback mechanisms to ensure continuous learning and improvement.