Problem Statement and Goals
CXR

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Table 1: Revision History

Date	**Developer(s)**	**Change**
Date1	Name(s)	Description of changes
Date2	Name(s)	Description of changes
...	...	...

1 Problem Statement

1.1 Problem

The rapid and accurate detection of lung and cardiac conditions using chest X-rays is critical in clinical settings. However, current methods for disease detection and monitoring rely heavily on manual interpretation and patient monitoring by radiologists, leading to inconsistent assessments and time delays, particularly when evaluating disease progression over time.To address this challenge, our team aims to develop an automated system that not only detects the presence of diseases in chest X-rays but also tracks changes in patient health across a series of X-rays. This system will enable early detection of decline or improvement in a patient's condition, allowing clinicians to make more informed treatment decisions. This is essential because conventional AI models are limited to binary classifications of disease presence, without providing insights into the progression or regression of conditions.

1.2 Inputs and Outputs

1.2.1 Inputs

- **Medical Images:** A set of chest X-rays provided over time for analysis.
- **Patient Information:** Basic information such as patient ID and scan dates to track progression.
- **Patient/Physician Input:** Additional inputs from patients or doctors describing symptoms like cough, chest pain, or fever.

1.2.2 Outputs

- **Disease Detection:** The system outputs whether a particular disease is present or absent in the X-rays.
- **Progression Analysis:** The system tracks changes over time, indicating if the patient's condition has improved, worsened, or remained stable.
- **Visual Aids:** Graphical representation of affected areas on the X-ray images.
- **Structured Report Generation:** A summary report with key findings, disease detection results, progression status, and confidence levels.

1.3 Stakeholders

1. Physicians
Physicians are experts in interpreting X-ray images and their background knowledge can help validate the AI model's accuracy. They will be the primary users of the application as it would help them enhance efficiency and reduce error in

analysing chest X-ray images.

2. Patients
Patients are the end-users of the AI model as they undergo X-ray examinations.They can upload the X-ray by themselves as well to the application for self-diagnosing purposes. This would provide patients with fast and high-accuaracy diagnoses which ensures that they get timely treatment, improving their health outcome.

3. Healthcare provider
This refers to hospitals, clinics, and other medical facilities that will implement the AI model. Adapting this AI model to their system will provide a more streamlined workflow, providing patients a better experience and ease the work for physicians.

4. Technical support
This refers to people who provide maintenance and suppport for the application throughout its lifespan, ensuring a smooth user experience and integration into existing systems.

1.4 Environment

This software will be compatible with Windows 10 or higher and macOS 12 or higher. Compatibiity with other version of Windows, macOS is likely but will not be guaranteed nor tested.

2 Goals

3 Stretch Goals

4 Challenge Level and Extras

[State your expected challenge level (advanced, general or basic). The challenge can come through the required domain knowledge, the implementation or something else. Usually the greater the novelty of a project the greater its challenge level. You should include your rationale for the selected level. Approval of the level will be part of the discussion with the instructor for approving the project. The challenge level, with the approval (or request) of the instructor, can be modified over the course of the term. —SS]

[Teams may wish to include extras as either potential bonus grades, or to make up for a less advanced challenge level. Potential extras include usability testing, code walkthroughs, user documentation, formal proof, GenderMag personas, Design Thinking, etc. Normally the maximum number of extras will be

two. Approval of the extras will be part of the discussion with the instructor for approving the project. The extras, with the approval (or request) of the instructor, can be modified over the course of the term. —SS]

Challenge Level: Advanced

We believe the challenge level of this project to be advanced due to the complexity of domain knowledge and implementation required for this project. Firstly, to work with chest X-ray images for disease diagnosis it requires a deep understanding of medical imaging. Interpreting radiological data, dealing with imbalanced datasets, and ensuring proper data labelling are significant obstacles. Also, estimating patient demographics such as race, age, and gender introduces further complexity, as these features may present subtle visual cues that could risk introducing bias into the model. Addressing disease prediction and demographic classification from X-ray images requires careful handling and validation, making the task more challenging. Furthermore, using PyTorch to build deep learning models for multi-task classification adds to the difficulty. Preprocessing medical images, as we need to understand a pattern and handle large datasets, to design a well-designed model. The project also faces technical hurdles such as multi-label classification, where the model needs to predict multiple outputs simultaneously (disease, race, age, gender), increasing the complexity of training and fine-tuning the network. Additionally, addressing ethical concerns, such as ensuring fairness and minimizing bias in predictions related to race and gender, adds another layer of difficulty to the project, making it a highly challenging and nuanced task.

Appendix — Reflection

[Not required for CAS 741 —SS]

1. What went well while writing this deliverable?

   While writing this deliverable our Team was able to get a better understanding of the project's technical requirements and create a helpful time management system. Identifying the challenges related to multi-label classification, transfer learning, and ethical considerations helped outline the advanced nature of the project. Furthermore, PyTorch as a framework for implementing neural networks was a strong choice, as it provided flexibility for the complex modelling tasks at hand. We find that is very well documented and learning PyTorch comprehensively will be a great asset in this project.

2. What pain points did you experience during this deliverable, and how

   The biggest challenge our team encountered was to limit and understand the scope of the project to ensure it remained feasible within the constraints of a Capstone while maintaining sufficient complexity. Initially, the project was overly ambitious, especially regarding the number of tasks (disease detection, demographic predictions) and the potential data processing workload. This was addressed by narrowing the focus to the most critical diseases and using existing datasets to avoid time-consuming data collection. We also considered using transfer learning to aide our models to reduce the training time and improve performance on small medical datasets. did you resolve them?

3. How did you and your team adjust the scope of your goals to ensure they are suitable for a Capstone project (not overly ambitious but also of appropriate complexity for a senior design project)?

   Our team ensured our scope for our Capstone was appropriate by scaling down to the diseases that are highly prevalent in chest X-rays and focusing on obtaining accuracy in one dataset. Through this decision, we can reduce the dataset complexity and the workload required for both training and model validation substantially. In addition, including the demographic predictions (age, race, and gender) as a secondary goal, and prioritizing disease classification would ensure we maintain a challenging and comprehensive project. By setting clear milestones and focusing on realistic, high-impact deliverables, we made sure the project was ambitious enough but also achievable within the given timeframe.