Software Requirements Specification for Software Engineering: AI for Chest X-Ray Read

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Contents

Revision History

Date	Developer(s)	Notes
October 1st 2023	Allison Cook, Ibrahim Issa, Mohaansh Pranjal, Nathaniel Hu, Tushar Aggarwal	Initial Draft of SRS document
October 4th 2023	Name	Notes
October 6th 2023	Allison Cook, Ibrahim Issa, Mohaansh Pranjal, Nathaniel Hu, Tushar Aggarwal	Edits to SRS document

1 Purpose of the Project

This project aims to provide a system that will reduce the amount of time radiologists and medical professionals will need to spend reviewing chest x-rays of patients. Users of the completed solution proposed in this project will be able to upload a chest x-ray and receive a generated diagnostic radiology report outlining any abnormalities in the given image.

1.1 User Business

The user businesses are medical institutions (e.g. hospitals) and other medical imaging businesses (e.g. diagnostic centres). These businesses aim to review and analyze patient chest x-rays, perform diagnostics, report their findings and present the results to their patients and/or relevant third parties as soon as possible.

1.2 Goals of the Project

The primary goal of the project is to provide accurate detection of abnormality given an x-ray image and generate a diagnostic radiology report outlining any abnormalities. The project's other goals are to provide secure and remote access to the system while having an intuitive user interface. A further stretch goal of the project is to be able to generate structured or free-formed radiology diagnostic reports using natural language processing (NLP).

2 Stakeholders

This section outlines the various stakeholders of this project's proposed solution, and describes them each in detail with regards to their relevance to this project's success. These include the clients, customers, other stakeholders and hands-on users. Their personas, assigned priorities, user participation and the maintenance users and service technicians are also described in detail.

2.1 Client

The following are the clients of project's proposed solution:

- **Doctors**: want the tedious work of analyzing chest x-rays, performing diagnostics and writing radiology reports to be semi-/fully-automated

- **Patients**: wants chest x-ray results faster with the same accuracy

- **Diagnostics Teams**: wants to maximize the number of chest x-rays performed and processed for patients

These are the people expected to be the primary users of the project's proposed solution. They are expected to use this proposed solution primarily in their daily work as medical professionals, or benefit from it (i.e. the patients).

2.2 Customer

The customers of the project's proposed solution are described as follows:

- **Medical Institutions**: want to process chest x-rays faster to get results for patients in time-critical situations (e.g. detect time-sensitive diseases)

- **Diagnostic Centres**: want to process chest x-rays faster to maximize number of chest x-rays processed for patients, but not necessarily as time-sensitive (e.g. routine checkups)

2.3 Other Stakeholders

The following are the other stakeholders of the project's proposed solution:

- Medical institutions' IT departments

- Developers

These are the other stakeholders' who do not directly use the project's proposed solution, but are involved in supporting it in carrying out its intended functions successfully.

2.4 Hands-On Users of the Project

The following are the hands-on users of the project's proposed solution:

- **Medical professionals** using this software to perform initial analysis of chest x-rays and diagnose diseases and other health conditions

Like as was mentioned earlier, these users are expected to use the project's proposed solution in their daily work lives to support their work.

2.5 Personas

The following are descriptions outlining the personas modelling the respective stakeholders and users of the project's proposed solution:

- **Doctors/Medical Professionals**

  - Stressed, under pressure to analyze chest x-rays, perform diagnoses and present results to patients and all other relevant stakeholders as soon as possible.
  - Want the information presented to them such that they can glance over it quickly and grab the relevant information to present
  - May be looking to verify the position of lines and tubes in patients in the ICU or during/after interventions

- **Patients**

  - May be stressed, worried about chest x-ray results for variety of reasons
  - May be waiting on results for diagnosis of possible cardiac or lung conditions
  - For ruling out diseases for regulatory reasons such as immigration or occupational health assessments

- **Medical Institution IT Department**

  - Want to ensure security of systems to ensure patient privacy of their medical records

2.6 Priorities Assigned to Users

The following are the assigned priorities of the users of this project's proposed solution:

- **Doctor/Medical Professional**: key user, the expected primary user of the proposed solution to assist them in their work

- **Patient**: secondary user, benefits from having radiology analyses and diagnostic reports generated from their chest x-rays with faster results

- **Medical Institution IT Department**: tertiary user, supports the function of the proposed solution

2.7   User Participation

The user participation of the main users of the project's proposed solution are described in further detail below:

- **Doctors/Medical Professionals**

  - User feeds chest x-ray images into the software for analysis and diagnosis
  - User reviews output diagnostic report produced by the software

- **Patients**

  - User is presented the results of the diagnostic report by the doctor/medical professional

- **Medical Institution IT Department**

  - User authorizes the chest X-ray images to taken from the medical institution's medical information systems by authorized users

2.8   Maintenance Users and Service Technicians

The maintenance users and service technicians of the project's proposed solution are described below:

- **Developers/Testers**, those responsible for the development of the project's proposed solution, as well as maintaining it (fixing bugs, adding updates implementing new features/improving existing ones)

3 Mandated Constraints

This section describes the various constraints placed on this project's proposed solution in more detail. These include the solution constraints, the implementation environment of the current system, supporting partner or collaborative applications and existing off-the-shelf software. The anticipated workplace environment and schedule, budget, and enterprise constraints are also described in more detail here.

3.1 Solution Constraints

The following are constraints placed on the project's proposed solution. Each is described in more detail, including its rationale and fit criteria, as shown below:

- The product shall operate as a web application —- **This is a possible answer or something similar**

   Rationale: This will permit the users at different hospitals to use the system without any change to their institutional system

   Fit Criterion: The product will contain

3.2 Implementation Environment of the Current System

The following are constraints resulting from the implementation environment of the current system:

- Model source code is

- **NAME!** library used for model training

-

3.3 Partner or Collaborative Applications

The following are partner or collaborative applications that the project's proposed solution is expected to work with:

- Medical institution's internal IT systems and databases where the patients' chest X-rays and other relevant medical records are stored

3.4 Off-the-Shelf Software

The following are off-the-shelf software with functionality comparable to the project's proposed solution:

- ??? Name ???

3.5 Anticipated Workplace Environment

The anticipated workplace environment for the project's proposed solution is described as follows:

- **Medical Institutions**: chest x-rays taken to diagnose diseases or conditions, verify positions of lines and tubes in ICU patients before/after interventions; more time-critical

- **Diagnostics Offices**: chest x-rays taken to diagnose diseases or conditions, for routine checkups or for regulatory reasons (e.g. immigration, occupational health assessments); less time-critical

3.6 Schedule Constraints

The schedule constraints (i.e. project deadlines) for the project's proposed solution are described as follows:

- **Proof of Concept Demonstration**: November 13 - 24, 2023, demonstrate that key parts of the proposed solution are viable

- **Revision 0 Demonstration**: February 5 - 16, 2024, demonstrate the functionality of the initial version of the proposed solution

- **Final/Revision 1 Demonstration**: March 18 - 24, 2024, demonstrate the functionality of the first revision of the proposed solution

3.7 Budget Constraints

There is a budget constraint of $750 for this project's proposed solution. However, no necessary funding is needed for the project and no additional pieces of hardware or software will be purchased for this project.

3.8 Enterprise Constraints

Given that the project's proposed solution is expected to interface with a medical institution's IT systems, the following enterprise constraints apply:

- **Security**

  - The system handles individual patients health information and must only be accessed by authorized individuals and protected from unauthorized access

- **Computation Utilization**

  - The system should not overload the medical institution's IT systems needed to support its proper functionality

4 Naming Conventions and Terminology

This section describes all of the naming conventions and terminology relevant to documenting this project's proposed solution. This mainly includes the glossary of all terms (including acronyms) that are used by stakeholders involved in the project.

4.1 Glossary of All Terms, Including Acronyms, Used by Stakeholders involved in the Project

N/A: there are no naming conventions and terminology identified as relevant to documenting this project's proposed solution that are used by stakeholders involved in this project.

5 Relevant Facts And Assumptions

This section includes all of the relevant facts, business rules and assumptions relevant to this project's proposed solution, described in further detail below.

5.1 Relevant Facts

The following are facts relevant to the project's proposed solution:

- Chest x-rays are the most common medical imaging modality

- Chest x-rays constitute 40% of the 3.6 billion medical imaging procedures performed worldwide each year

5.2 Business Rules

The business rules relevant to the project's proposed solution are described in detail below:

- proper security protocols are followed when retrieving and storing patients' medical records and data (i.e. chest x-rays)

- proper patient privacy policies are followed when processing and sharing patients' medical information with other parties (i.e. only shared with authorized parties)

- proper patient data protection policies are followed when processing and storing patients' medical information

5.3 Assumptions

The following are assumptions made about the project's proposed solution:

- The system has access to a DICOM server with the required chest X-ray images

- The accuracy of the system will not be 100%

- The model will be trained with a smaller section of the chest X-ray library due to limited computational power

6 The Scope of the Work

This section describes the scope of the work to be done for the project's proposed solution. This includes the current situation, the context of the work, work partitioning and a business use case scenario.

6.1 The Current Situation

Chest x-rays, constituting 40% of the 3.6 billion annual medical imaging procedures globally, serve as a primary diagnostic tool for various lung and heart conditions.

Radiologists and healthcare professionals face significant time constraints in analyzing chest X-rays, potentially leading to critical delays with life-threatening implications for patients.

6.2 The Context of the Work

To develop a comprehensive solution addressing the time-intensive nature of chest X-ray analysis for healthcare professionals. **Context diagram??**

6.3 Work Partitioning

The following details how the work will be partitioned for this project:

Figure 1: Table 1: Work Partitioning

Event Name	Input/Output	Summary
input chest x-ray image	chest x-ray image (in), disease/abnormality detection (out)	user inputs chest x-ray image, gets disease/abnormality detection
input chest x-ray image	chest x-ray image (in), diagnostic radiology report information (out)	user inputs chest x-ray image, gets diagnostic radiology report information

- Implementation of a Computer Vision and Neural Network component for automated detection of abnormalities in chest X-rays.

- Development of a User interface component to facilitate user input and display diagnostic reports.

- Integration of a Security component to safeguard sensitive user information.

6.4 Specifying a Business Use Case (BUC)

Business Use Case Scenario:

1. **Patient arrival:** A patient arrives at the emergency room with severe respiratory symptoms, the attending doctor orders a chest X-ray for assessment of the patient's lungs.

2. **AI chest X-ray:** An X-ray of the patient's chest is taken and input into the system. The system identifies key abnormalities in the patient.

3. **Diagnostic report:** The system generates a list of the identified findings and their severity levels. The user interface presents this information in a clear and concise manner.

4. **Treatment:** The doctor quickly reviews the AI-generated report without examining the X-ray and begins treatment.

7 Business Data Model and Data Dictionary

7.1 Business Data Model

Insert your content here.

7.2 Data Dictionary

Insert your content here.

8 The Scope of the Product

8.1 Product Boundary

The application encompasses the entire life cycle of the Automated Chest X-ray Diagnosis System, from the initial input of a chest X-ray image to the generation of a structured radiology report. It includes all components such as the Computer Vision and Neural Network modules, User Interface, and Security.

8.2   Product Use Case Table

Figure 2: Table 2: Product Use Case Table

Use Case ID	Use Case Description
PUC-001	Process chest X-ray image using computer vision module
PUC-002	Generate a list of identified findings
PUC-003	Convert findings into a structured diagnostic report
PUC-004	Display diagnostic report on the user interface

8.3   Individual Product Use Cases (PUC's)

1. PUC-001:

   - Description: the system takes a chest X-ray image as input and processes it to identify abnormalities.
   - Actors: computer vision module, chest x-ray image
   - Preconditions: valid chest x-ray image input is provided
   - Postconditions: processed image with identified abnormalities

2. PUC-002:

   - Description: the system generates a comprehensive list of identified findings based on the processed chest x-ray image
   - Actors: computer vision module, neural network module
   - Preconditions: processed image with abnormalities is provided item Postconditions: list of identified findings is generated

3. PUC-003:

   - Description: The system converts the list of identified findings into a structured radiology report
   - Actors: list of findings
   - Preconditions: list of identified findings is provided

- Postconditions: diagnostic report is generated

4. PUC-004:

- Description: The user interface module displays the diagnostic report for the user
- Actors: user interface module, user
- Preconditions: diagnostic report is provided
- Postconditions: diagnostic report is displayed on the user interface

9   Functional Requirements

9.1   Functional Requirements

Requirement #: 1   **Requirement type:**   **Use case:**
Description: The system shall accept and read jpeg images as input.
Rationale:
Fit Criterion:

Requirement #: 2   **Requirement type:**   **Use case:**
Description: The system shall display jpeg images.
Rationale:
Fit Criterion:

Requirement #: 3   **Requirement type:**   **Use case:**
Description: The system shall generate and display a report outlining the findings.
Rationale:
Fit Criterion:

Requirement #: 4   **Requirement type:**   **Use case:**
Description: The system shall be able to fetch patients' records on retrieval request by the user.
Rationale:
Fit Criterion:

Requirement #: 5   **Requirement type:**   **Use case:**
Description: The system shall accurately detect and classify abnormalities or normality in a given X-ray image.

Rationale:
Fit Criterion:

Requirement #: 6   **Requirement type:**   **Use case:**
Description: The system shall be accessible remotely via a web interface.
Rationale:
Fit Criterion:

Requirement #: 7   **Requirement type:**   **Use case:**
Description: The system shall convert images from a DICOM file to a jpeg, jpg or other suitable image format to be processed by the ML algorithm.
Rationale:
Fit Criterion:

10   Look and Feel Requirements

10.1   Appearance Requirements

The

10.2   Style Requirements

Insert your content here.

11   Usability and Humanity Requirements

11.1   Ease of Use Requirements

Insert your content here.

11.2   Personalization and Internationalization Requirements

Insert your content here.

11.3   Learning Requirements

Insert your content here.

11.4 Understandability and Politeness Requirements

Insert your content here.

11.5 Accessibility Requirements

Insert your content here.

12 Performance Requirements

12.1 Speed and Latency Requirements

Insert your content here.

12.2 Safety-Critical Requirements

Insert your content here.

12.3 Precision or Accuracy Requirements

Insert your content here.

12.4 Robustness or Fault-Tolerance Requirements

Insert your content here.

12.5 Capacity Requirements

Insert your content here.

12.6 Scalability or Extensibility Requirements

Insert your content here.

12.7 Longevity Requirements

Insert your content here.

13 Operational and Environmental Requirements

13.1 Expected Physical Environment

Insert your content here.

13.2 Wider Environment Requirements

Insert your content here.

13.3 Requirements for Interfacing with Adjacent Systems

Insert your content here.

13.4 Productization Requirements

Insert your content here.

13.5 Release Requirements

Insert your content here.

14 Maintainability and Support Requirements

14.1 Maintenance Requirements

Insert your content here.

14.2 Supportability Requirements

Insert your content here.

14.3 Adaptability Requirements

Insert your content here.

15 Security Requirements

15.1 Access Requirements

Insert your content here.

15.2 Integrity Requirements

Insert your content here.

15.3 Privacy Requirements

Insert your content here.

15.4 Audit Requirements

Insert your content here.

15.5 Immunity Requirements

Insert your content here.

16 Cultural Requirements

16.1 Cultural Requirements

Insert your content here.

17 Compliance Requirements

17.1 Legal Requirements

Insert your content here.

17.2 Standards Compliance Requirements

Insert your content here.

18 Open Issues

Insert your content here.

19 Off-the-Shelf Solutions

19.1 Ready-Made Products

Insert your content here.

19.2 Reusable Components

Insert your content here.

19.3 Products That Can Be Copied

Insert your content here.

20 New Problems

20.1 Effects on the Current Environment

Insert your content here.

20.2 Effects on the Installed Systems

Insert your content here.

20.3 Potential User Problems

Insert your content here.

20.4 Limitations in the Anticipated Implementation Environment That May Inhibit the New Product

Insert your content here.

20.5 Follow-Up Problems

Insert your content here.

21 Tasks

21.1 Project Planning

Insert your content here.

21.2 Planning of the Development Phases

Insert your content here.

22 Migration to the New Product

22.1 Requirements for Migration to the New Product

Insert your content here.

22.2 Data That Has to be Modified or Translated for the New System

Insert your content here.

23 Costs

Insert your content here.

24 User Documentation and Training

24.1 User Documentation Requirements

Insert your content here.

24.2 Training Requirements

Insert your content here.

25 Waiting Room

Insert your content here.

26 Ideas for Solution

Insert your content here.

Appendix — Reflection

The information in this section will be used to evaluate the team members on the graduate attribute of Lifelong Learning. Please answer the following questions:

1. What knowledge and skills will the team collectively need to acquire to successfully complete this capstone project? Examples of possible knowledge to acquire include domain specific knowledge from the domain of your application, or software engineering knowledge, mechatronics knowledge or computer science knowledge. Skills may be related to technology, or writing, or presentation, or team management, etc. You should look to identify at least one item for each team member.

2. For each of the knowledge areas and skills identified in the previous question, what are at least two approaches to acquiring the knowledge or mastering the skill? Of the identified approaches, which will each team member pursue, and why did they make this choice?