INFORMATICS INSTITUTE OF TECHNOLOGY

In Collaboration with

ROBERT GORDON UNIVERSITY ABERDEEN

Multimodal Brain Tumor Detection System

Group 21 Project Proposal Document by

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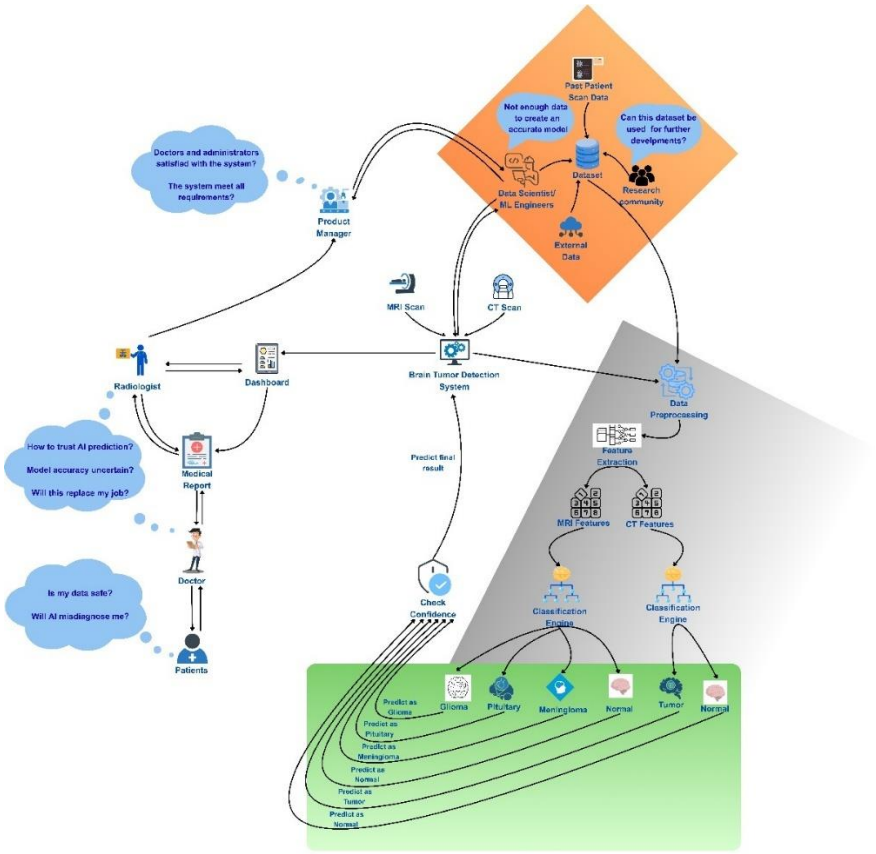
1 Chapter Overview

This chapter outlines the gathering and analysis of system requirements for the multi-model brain tumor detection system. It acknowledges the stakeholders and their responsibilities, explains the methods used to elicit needs (such as expert reviews and literature reviews), and defines both functional and non-functional requirements. Further, it presents visual representations through diagrams such as Rich Pictures, Onion Models, and Use-Case Diagrams to depict relationships of stakeholders and system dynamics.

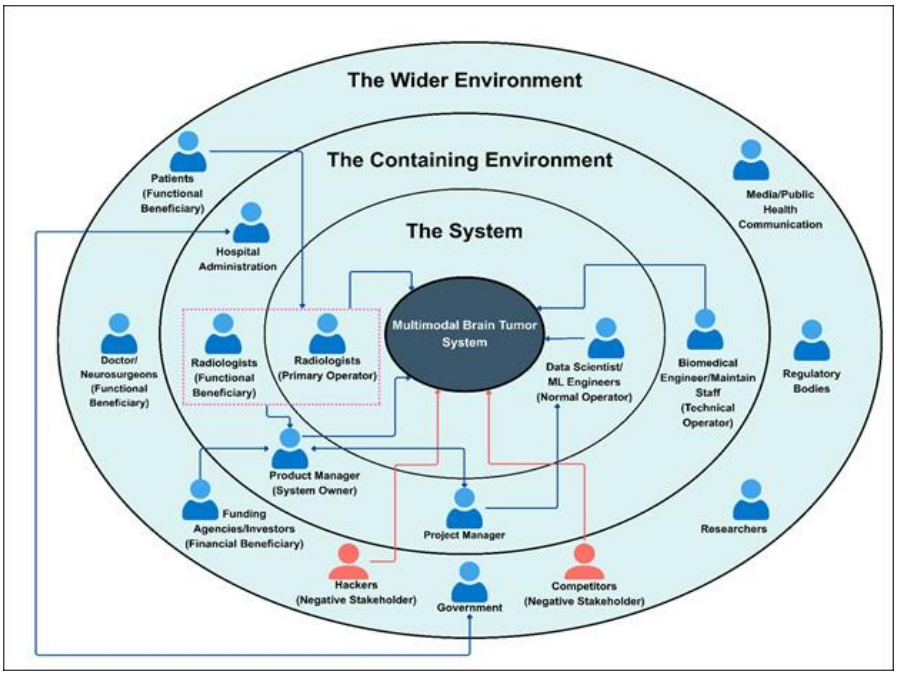
2 Rich Picture



3 Stakeholder Analysis

The onion model presented below demonstrates the Stakeholders that have a relationship to the system. To get an understanding of each stakeholder's role, it is displayed in the figure that follows.

3.1 Onion Model



3.2 Stakeholder Viewpoints

Stakeholders	Roles	Viewpoint
Data Scientist and ML Engineers	Build the Model	Developing and improving the classification and segmentation models.
Radiologist	Analyze Patients and AI Results (Primary Users)	Upload a scan, use the result to support the diagnosis.
Hospital IT Staff	Maintain the System	Maintain servers, storage, and the health system in clinical operations.
Doctors and Neurosurgeons	Make Treatment Plans	Using AI support results in the creation of a treatment plan.
Hospital Administration	Oversee Operations and Approve Resources	Handles budget, procurement, and resource allocation for system initialization.
Medical Director	Define Requirements	The owner of the system that ensures compliance with ethical standards.
Legal and Compliance Team	Ensure Regulations	Ensure medical regulations and privacy data.
Quality Assurance and Testers	Test Performance	Confirm and ensure the model's accuracy is consistent and reliable before deployment.
Biomedical Engineers and Maintain Staff	Maintain Hardware	Maintain servers and equipment.
Patients	Receive Diagnosis	Receives AI-guided care, with concerns for outcomes, privacy, and consent (their scans train model).
Regulatory Bodies	Approve the Device	Verify the safety and approve the AI-based system for clinical purposes.
Researchers	Collaborate Research and	Give research data, basement knowledge, or

	Publish Research	assist in clinical trials to validate the system.
Government	Regulate System	Regulate, monitor, and support the AI system so that it benefits the public healthcare sector safely, ethically, and efficiently.
Funding Agencies and Investors	Provide Funding	Give funds to the system to improve system reliability.
Insurance Company and Payers	Process Claims and Decides Reimbursements	Give funds for patients' medical needs and decide whether to reimburse for diagnoses aided by AI systems.
Media and Public Health Communication	Spread Awareness	Their view of AI impacts funding, public trust, and technology adoption.
Hackers	Threaten System Vulnerability	Pose a risk to data security and model integrity.
Competitors	Compete Market	Implementing similar AI-based analysis systems to give competition.

4 Selection of Requirement Elicitation Techniques/Methods

Requirements of elicitation involves collecting requirements through different methods.This section explores multiple approaches and their respective pros and cons.

4.1 Observing Current System and LR

Among requirement elicitation activities, this technique involves a similar analysis of existing research in the domain of medical image analysis and brain tumor detection.

Advantages	**Disadvantages**
Helps to identify specific limitations of single-modality (MRI or CT only) analysis and this highlights the need for a multi model approach, which is the core of our project.	Published research papers often focus on high accuracy in each model with manageable rich datasets.
Provide a clear understanding about algorithmic models (e.g. VGG19, EfficentNet) and evaluation metrics, which directly represent our proposed research architecture.	High performing research papers omit details of datasets used, such source, image resolutions or preprocessing steps which makes the process difficult to make experiments.

4.2 Surveys and Questionnaire

Since a brain tumor detection system must meet a diverse set of medical experts,a survey or questionnaire is a feasible method to efficiently collect requirements from a broad pool of stakeholders, including radiologists and clinical researchers.

Advantages	**Disadvantages**
Enables us to gather insight from a wide range of participants, which capture diverse perspectives.	Collecting public inputs builds trust and shows own feedback, which is important in a combination of the sensitive healthcare

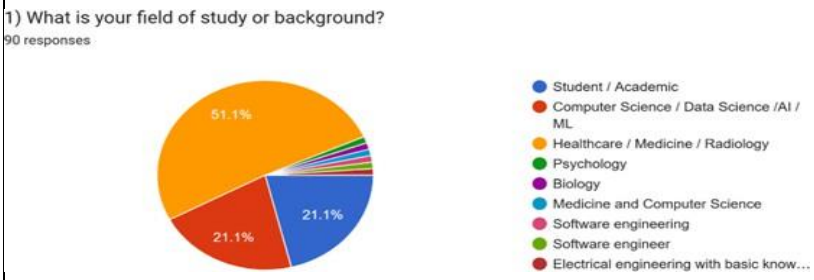
	domain and AI domain.
Technical terms like "multi-modality" might be leading to unreliable responses if we don't phrase them carefully.	Some respondents might have limited knowledge about the topic, which may misinterpret final analysis.

4.3 Interviews

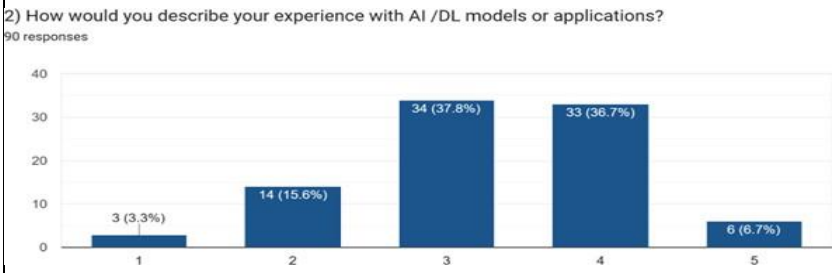
Interviews can be carried out by lead radiologists, neurologists and hospital IT administrators, to know more about the needs, requirements of the system and to manage the data requirements.

Advantages	**Disadvantages**
Enable opportunities to test whether our technical assumptions align with actual clinical preferences.	Allow us to collect diagnostic needs and sort all doubts from a broader pool of medical professionals across different hospitals.
The quality of information is highly dependent on the interviewer's skills and the interviewee's perspective.	Scheduling interviews may be time consuming, when cancellations occur.

5 Discussion of Results

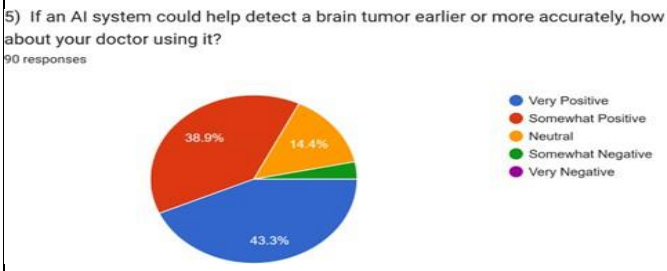
Question	What is your field of study or background?
Aim of Question	To understand the demographics and expertise of the respondents
Observations	
Conclusion	The survey achieved a good mix of AI field and medical domain field expertise, results suggesting both groups who are critical to the development and application of medical AI systems, and also including those from "Other" fields, provides a well-rounded perspective that ensures the system's public general acceptance.

Question	How familiar are you with the use of Artificial Intelligence (AI) in healthcare (e.g., assisting doctors in analyzing medical scans)?
Aim of Question	To determine the respondents' medical domain specific awareness of AI application usage, mainly the process of identifying diagnostics.
Observations	



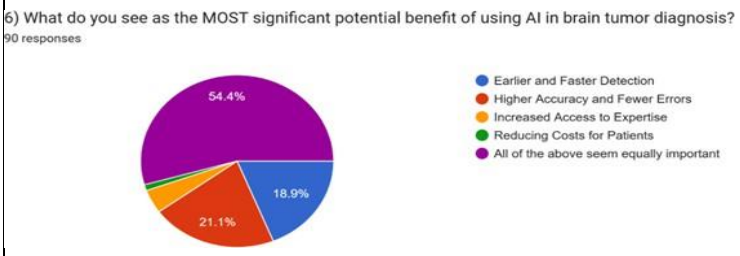
Conclusion	Overall domain- specific knowledge of AI in healthcare is at a moderate level. This indicates the proposed system needs to include clear educational components to ensure the user's understanding (e.g. visual explainers).

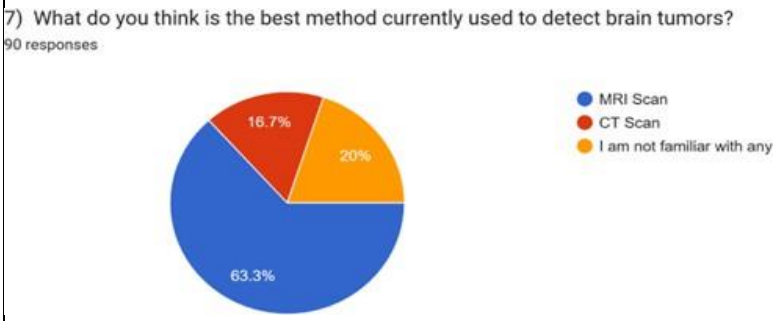
Question	If an AI system could help detect a brain tumor earlier or more accurately, how would you feel about your doctor using it?
Aim of Question	To determine the level of acceptance of the AI technology.
Observations	



Conclusion	There is strong acceptance for the accurate AI system. Specifically the majority of users are highly willing for their doctor to use the technology and get help from that.

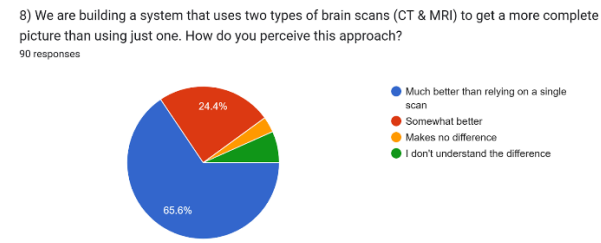
Question	What do you see as the MOST significant potential benefit of using AI in brain tumor diagnosis?

Aim of Question	To identify the prioritized requirements of the AI system from the stakeholder perspective.
Observations	
Conclusion	The majority overall strongly focus on" All of the above seems equally important". It indicates proposed method must have higher accuracy, earlier and faster detection, and reduce costs for patients, which are emphasized in the system's stated benefits and overall confidence.

Question	What do you think is the best method currently used to detect brain tumors?
Aim of Question	To determine the knowledge of medical procedures and validate the proposed method MRI and CT scans as the input.
Observations	

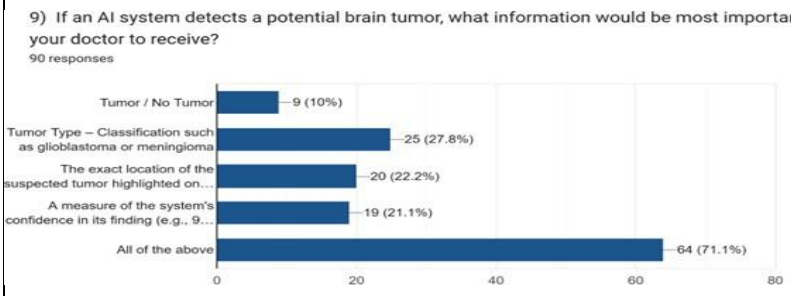
Conclusion	Most widely, MRI scan plays a crucial role in brain tumor detection.However overall most respondents are unfamiliar with current detection methods, but majority respondents understand the MRI strength.However target of the check high level of general knowledge about tumor diagnostic procedures is positive. It shows awareness of the different roles of different imaging modalities and it directly supports the novel scan approach.

Question	We are building a system that uses two types of brain scans (CT and MRI) to get a more complete picture than using just one. How do you perceive this approach?
Aim of Question	To understand the public opinion regarding proposed method of the combined CT and MRI AI system.
Observations	



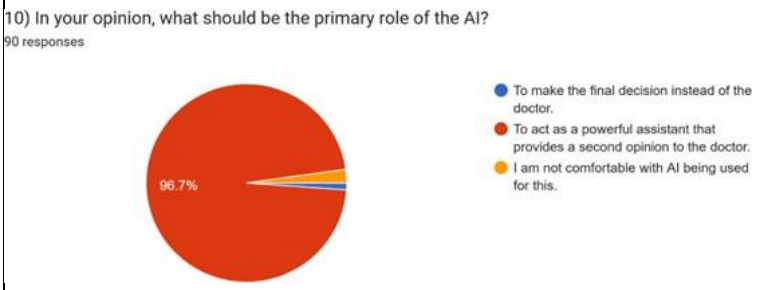
Conclusion	According to the result, the proposed system is overwhelmingly positive, with the highest majority trusting it is much better than relying on a single scan. However, it confirms the goal of a multi-model approach is perceived as a significant clinical advantage for the proposed AI system.

Question	If an AI system detects a potential brain tumor, what information would be most important for your doctor to receive?
Aim of Question	To identify the what kind of output are most valuable for doctors.
Observations	



Conclusion	The majority has a strong preference for detailed information such as tumor type, classification,exact location and confidence measure. However this result transforms a simple detector to a robust diagnostic partner.

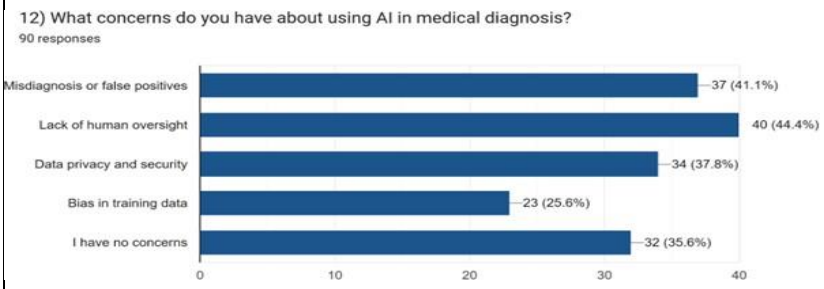
Question	In your opinion, what should be the primary role of the AI?
Aim of Question	To understand how people view AI's engagement in medical workflow.
Observations	



Conclusion	Results clearly indicate the proposed system's primary role should be to act as a powerful assistant that provides a second opinion to the doctor. However, they are highly comfortable with the AI as a supporter for the human expert, enhancing diagnostic capability without replacing the clinician.

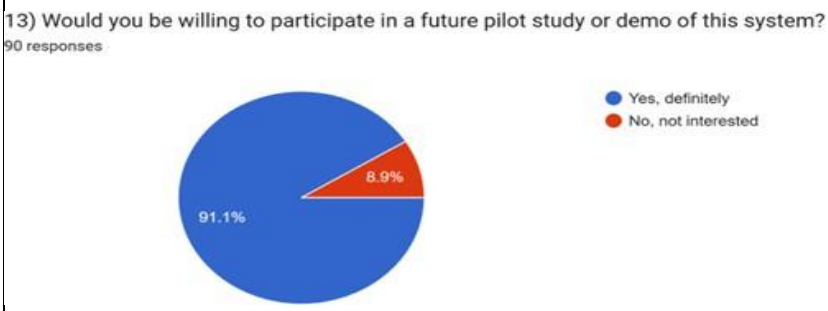
Question	What concerns do you have about using AI in medical diagnosis?

Aim of Question	To identify the risks and hesitation of engaging AI with the medical domain.
Observations	



Conclusion	Respondents raised potential concerns.Specifically, highlighting misdiagnosis or false positives and lack of human oversight. These concerns are raising typically engagement with new technology. However project must prioritize these robust data security protocols, minimize the false positive rates and high accuracy as mandatory requirements.

Question	Would you be willing to participate in a future pilot study or demo of this system?
Aim of Question	To measure interest to engage in future testing and validating of the AI system.
Observations	

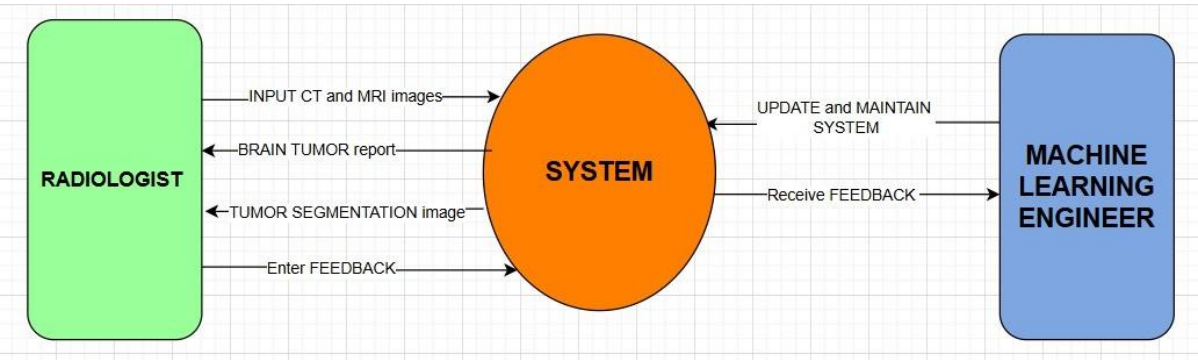


Conclusion	The survey results clearly demonstrate that the majority of participants are willing to use his proposed system. That positive reaction serves as a powerful indicator of the system's reliability. And also, by incorporating respondents' suggested requirements, the overall project demonstrates responsiveness to stakeholder input.

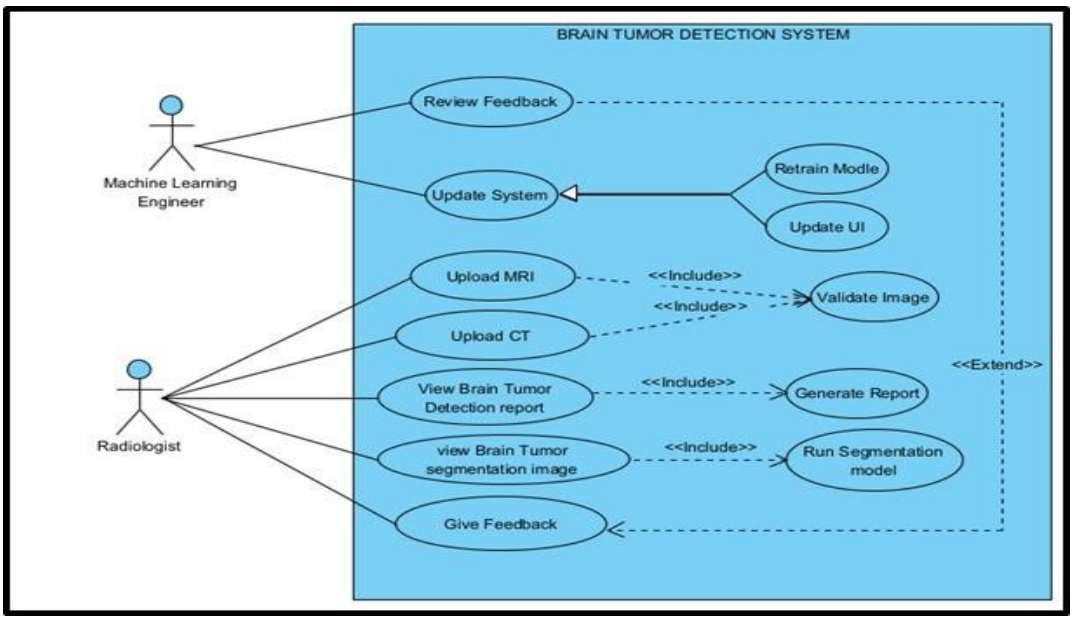
6 Summary of Findings

Findings	**LR**	**Questionnaire**	**Existing Systems**
Limited structured processes exist for processing and interpreting CT and MRI scans simultaneously.	X	X	
There is a need for automated detection tools to identify tumors in CT and MRI images.	X		X
Existing systems often lack modality-specific segmentation models optimized for CT or MRI.		X	
Visualization of results is critical for radiologists to interpret detection and segmentation outcomes.		X	
Strong demand exists for a system that provides, clearer and faster, detection and segmentation results.		X	

7 Context Diagram



8 Use Case Diagram



8.1 Use Case Descriptions

Use Case:	Review Feedback
Section:	Main
Actors:	Machine Learning Engineer
Purpose:	View the feedback from the radiologist.
Preconditions:	The radiologist has given feedback.
Typical course of actions	1. The ML engineer requests for the feedback. 2. The System loads the feedback saved in the storage. 3. The System displays the feedbacks to the ML engineer. 4. The ML engineer reviews the feedback to modify or upgrade the system.
Postconditions:	ML engineer has gotten the feedback
Alternative Course:	If there are no feedbacks stored the system displays a message that no feedbacks are available and the process ends.
Exceptional Fault:	If there was an error when loading the feedbacks the system displays a prompt to retry and the process ends
Related Use Cases:	None

Use Case:	Update System
Section:	Main
Actors:	Machine Learning Engineer
Purpose:	Updating or making changes to the System to improve it.
Preconditions:	None
Typical course of actions	1. ML engineer selects the option to update the system. 2. System loads current configuration and system modules. 3. ML engineer updates or redesigns the required components of the system 4. ML engineer saves the updated version.
Postconditions:	The system is updated

Alternative Course:	System detects incompatible or incorrect updates and instructs the engineer to correct them.
Exceptional Fault:	If the system fails while saving, it shows an error and requests a retry.
Related Use Cases:	None

Use Case:	Upload MRI
Section:	Main
Actors:	Radiologist
Purpose:	Uploading the MRI scan images for brain tumor detection
Preconditions:	The ML model is already created, trained and tested
Typical course of actions	1. Radiologist initiates the process to upload The MRI scan 2. The System Requests for the MRI scan. 3. The Radiologist Uploads the MRI images 4. The System Validates and processes the image
Postconditions:	The MRI scan image is successfully processed
Alternative Course:	If the image is in incomplete or invalid format, the system requests to re-upload the image.
Exceptional Fault:	If the upload fails, a prompt is displayed and the process is stopped.
Related Use Cases:	Includes: Validate Image

Use Case:	Upload CT
Section:	Main
Actors:	Radiologist
Purpose:	Uploading the CT scan images for brain tumor detection
Preconditions:	The ML model is already created, trained and tested
Typical course of actions	1. Radiologist initiates the process to upload The CT scan 2. The System Requests for the CT scan. 3. The Radiologist Uploads the CT images 4. The System Validates and processes the image
Postconditions:	The CT scan image is successfully processed
Alternative Course:	If the image is in incomplete or invalid format, the system requests to re-upload the image.
Exceptional Fault:	If the upload fails, a prompt is displayed and the process is stopped.
Related Use Cases:	Includes: Validate Image

Use Case:	View Brain Tumor Detection Report
Section:	Main
Actors:	Radiologist
Purpose:	Viewing the generated Brain tumor detection report
Preconditions:	MRI or CT images are uploaded
Typical course of actions	1. The Radiologist requests the system to perform tumor detection and generate a report. 2. The system processes MRI or CT to detect any tumors. 3. The system generates and displays the tumor detection report. 4. The Radiologist reviews the report and confirms the findings
Postconditions:	Brain tumor report has been successful generated
Alternative Course:	If tumor is not detected it the system displays that there is no tumor and ends the process.
Exceptional Fault:	If both the MRI or CT images are missing or corrupted, the fusion process is halted, and an error message is displayed.
Related Use Cases:	Includes: Generate Report

Use Case:	View brain tumor segmentation image
Section:	Main
Actors:	Radiologist
Purpose:	Displaying the generated brain tumor segmentation image
Preconditions:	Tumor is detected in the MRI or CT images
Typical course of actions	1. The radiologist requests the system for the brain tumor segmentation image. 2. The system generates and displays the tumor Segmentation report. 3. The radiologist reviews the image and confirms the findings
Postconditions:	Brain tumor segmented image has been successful displayed
Alternative Course:	If tumor is not detected, the system displays that there is no tumor and ends the process
Exceptional Fault:	None
Related Use Cases:	Includes: Run Segmentation Model

Use Case:	Giving Feedback
Section:	Main
Actors:	Radiologist
Purpose:	Giving feedback on the tumor detection report and segmentation image.
Preconditions:	The Fused imaged and Tumor detection report are reviewed by the Radiologist.
Typical course of actions	1. The Radiologist initiates the process to give the feedback. 2. The System provides a feedback interface. 3. The System collects and stores the feedback. 4. The System displays a conformation message.
Postconditions:	Feedback has been successfully given and stored by the system
Alternative Course:	If the Radiologist skips the feedback, the process ends.
Exceptional Fault:	If the feedback cannot be saved due to a system issue, the system requests the Radiologist to resubmit the feedback.
Related Use Cases:	Extends: Review Feedback

9 Functional Requirements

FR No.	Functional Requirement	Description	Priority
FR-01	Uploading Data	The system allows the users to upload MRI/CT scans in jpg form	High
FR-02	Pre-processing	The system performs many image pre-processing techniques such as noise reduction, image resizing, image normalization, image formatting, contrast enhancement, edge detection, image segmentation and data augmentation.	High
FR-03	Multimodal Data Integration	The system combines inputs from multiple imaging modalities to improve brain tumor detection accuracy.	High
FR-04	Tumor Detection	The system will automatically detect tumor regions in the uploaded scans.	High
FR-05	Tumor Segmentation	The system generates segmented tumor regions.	High
FR-06	Tumor Classifica-tion	The system classifies tumors into types (glioma, meningioma, pituitary tumor) using Machine learning	High

		and Deep learning models.	
FR-07	Confidence Score Display	The system provides confidence scores for detection and classification results.	Medium
FR-08	Report Generation	The system generates a diagnostic report summarizing the classification, tumor size, and location of tumor.	High
FR-09	User Account Management	The system allows users to register, log in, and manage their profiles securely.	Medium
FR-10	Download Results	The system shall allow users to download segmentation masks, annotated images, and reports.	Medium
FR-11	Error Handling	The system notifies the users if the uploaded scan is corrupted, unsupported, or missing critical data.	High

10 Non-Functional Requirements

NFR No.	**Non-Functional Requirement**	**Description**	**Priority**
NFR-01	Performance	The system will process and analyze the fused image of MRI and CT quickly	High
NFR-02	Accuracy	The model will achieve a minimum accuracy of 90%+ for tumor classification and segmentation tasks.	High
NFR-03	Reliability	The system will have a 95%+ uptime other than any maintanence problems and ensure consistent results.	High
NFR-04	Security	All patient data will be encrypted.	High
NFR-05	Privacy and Compliance	The system will comply with medical data privacy standards and laws.	High
NFR-06	Scalability	The system will be able to handle more image uploads without dropping any performance.	Medium
NFR-07	Usability	The system interface will be easy to navigate and interpret results for clinicians.	Medium
NFR-11	Response Time	User interfaces and dashboards will load under 5 - 10 seconds in normal network conditions.	Medium
NFR-15	Robustness	The system will handle invalid, corrupted, or incomplete imaging data without crashing.	High

11 Chapter Summary

This chapter identifies the overall requirements analysis for the multi-model brain tumor detection and classification system. It outlines the problem using a rich picture, identifies the stakeholders through the onion model and stakeholder viewpoints, and also explains the elicitation techniques used to gather system requirements from our clients. Context and use case diagrams provide a visual understanding of the system interactions, and it also defines what the system must do and what standards it must meet.