Bilkent University
Department of Computer Engineering

Senior Design Project
T2407
Lesion Lens

Analysis and Requirement Report

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Analysis and Requirement Report

Lesion Lens

1. Introduction

The Department of Neurology at Hacettepe Hospital (HH) is currently experiencing significant operational challenges due to resource constraints, specifically an insufficient number of medical professionals relative to the increasing patient volume and healthcare demands. To address these challenges, we propose Lesion Lens (LL), an innovative solution designed to optimize clinical workflow by automating the detection and monitoring of lesions in neurological magnetic resonance imaging (MRI) studies.

The current diagnostic process requires neurologists at HH to conduct comprehensive assessments of lesion development, classification, and progression. This involves a labor-intensive evaluation of sequential MRI studies, where physicians must manually compare current and historical imaging data to identify subtle changes and developments. The process demands extensive expertise in evaluating lesion characteristics, including morphology, anatomical location, and dimensional attributes. While this methodology proves adequate for cases with limited lesion burden, it becomes increasingly challenging and time-consuming in complex cases with multiple lesions, potentially impacting diagnostic accuracy and efficiency.

To enhance clinical efficiency and diagnostic precision, Lesion Lens will be implemented as a sophisticated web-based platform that leverages advanced imaging analytics to evaluate lesion progression through longitudinal MRI studies. The system will integrate state-of-the-art machine learning (ML) algorithms to identify and characterize lesions within both cerebral and spinal imaging studies. Additionally, LL will employ advanced computational methods to track temporal changes in lesion characteristics. The platform will synthesize this data to generate comprehensive three-dimensional volumetric representations, providing clinicians with an enhanced visualization tool that complements their expertise and facilitates more informed clinical decision-making.

2. Current System

The current PACS system used at Hacettepe Hospital provides essential functionalities for medical imaging, including opening, closing, and viewing MRI scans slice by slice. This is sufficient for general diagnostic purposes but lacks advanced features such as automatic lesion detection, segmentation, or tracking over time. While PACS supports the storage and retrieval of DICOM files and facilitates basic visualization, it does not provide automated tools for lesion analysis. Doctors relying on the system must manually assess lesions, which is both time-consuming and prone to human error. Additionally, for more advanced features like segmentation or lesion progression tracking, PACS requires integration with external systems or plugins, which can be complex and expensive.

In comparison, Lesion Lens offers an integrated solution that directly addresses these limitations. Unlike the current PACS system, LL incorporates machine learning algorithms to automate lesion detection and segmentation, eliminating the need for manual analysis. Furthermore, it provides temporal tracking capabilities, enabling doctors to monitor lesion progression over time, which is not feasible with the existing PACS setup. LL also offers volumetric analysis of lesions, allowing clinicians to determine changes in lesion size and volume to inform treatment decisions. By integrating these advanced tools within a single application, LL reduces dependency on additional systems and enhances diagnostic efficiency, offering significant improvements over the current PACS system.

3. Proposed System

3.1. Overview

Lesion Lens is a web-based medical imaging application that assists healthcare professionals in analyzing neurological lesions in brain and spine MRI scans. The application was developed in response to increasing workloads in neurology departments, where specialists must review large volumes of patient scans. The system aims to reduce the time required for manual review of multiple MRI slices while maintaining diagnostic accuracy.

The application employs machine learning algorithms to detect potential lesions within MRI scans. These algorithms identify abnormalities that may indicate conditions such as multiple sclerosis or brain tumors. The system processes MRI data to locate lesion structures and analyze their characteristics across multiple scans. This automated detection helps differentiate between closely positioned lesions and provides initial measurements without manual intervention.

The tracking functionality monitors lesion changes across sequential MRI scans taken over time. The software calculates volumetric measurements and tracks changes in lesion size and characteristics. This data is used to document disease progression and treatment response. The system maintains a record of lesion measurements and locations, enabling quantitative comparison between scans from different dates. This temporal analysis helps clinicians assess treatment effectiveness and disease progression patterns.

The visualization system converts 2D MRI slices into 3D representations using WebGL rendering libraries. Users can manipulate these 3D models to examine lesions from different angles, providing additional context for spatial relationships within the brain or spine. The interface displays both current and historical scan data for comparison. These visualization tools help medical professionals understand complex anatomical relationships that may not be apparent in traditional 2D slice views.

The platform operates as a web application, allowing access from hospital workstations. It processes DICOM format medical imaging files using GoLang backend systems, cloud storage, and specialized medical imaging libraries. Machine learning models built with TensorFlow or

PyTorch analyze the scans. The system architecture handles large datasets and multiple concurrent users, facilitating integration into existing clinical workflows.

Security measures comply with healthcare data regulations including GDPR and KVKK. The system implements data encryption, role-based access controls, and audit logging. Patient data is anonymized, and the system maintains records of all access and modifications. These security features ensure patient privacy while maintaining data accessibility for authorized medical personnel.

The technical architecture allows for updates to accommodate new detection models and analysis methods. Initially implemented at Hacettepe Hospital's neurology department, the system can integrate with existing healthcare information systems and databases. The modular design facilitates the addition of new features and improvements to existing functionality as medical imaging technology advances.

The application focuses specifically on longitudinal lesion tracking and volumetric analysis. It combines detection capabilities with temporal comparison tools and 3D visualization features. This functionality supports the monitoring of progressive neurological conditions where tracking lesion changes over time is clinically relevant. The system provides quantitative data to support clinical decision-making while maintaining the physician's role as the primary diagnostic authority.

The development process included consideration of various clinical workflows and use cases. The user interface design prioritizes efficiency and clarity in data presentation. Regular feedback from medical professionals during development helped ensure the system's practical utility in clinical settings. The system continues to evolve based on user experience and advancing medical imaging technologies.

The system includes features for data export and reporting. Users can generate standardized reports including lesion measurements, location data, and progression analysis. These reports can be incorporated into patient records and shared with other healthcare providers. The reporting system supports both detailed technical data and simplified summaries for different use cases.

Research applications of the system include the potential for aggregated data analysis. With appropriate privacy controls and consent, anonymized data could contribute to larger studies of disease progression and treatment effectiveness. The system's standardized measurements and temporal tracking capabilities provide consistent data for research purposes.

3.2. Functional Requirements

3.2.1. MRI Data Upload

The system will enable doctors to upload multiple MRI collections for processing and analysis, providing the capability to manage extensive datasets efficiently. All uploaded MRI data will be securely stored in the database to ensure privacy and facilitate further analysis, complying with all relevant data protection regulations.

3.2.2. Viewing 2D MRI Slices

Doctors will be able to view individual MRI slices, presented as 2D images, through an intuitive web application interface. This functionality will allow for detailed examination and analysis of specific areas within the MRI scans.

3.2.3. Lesion Detection and Analysis

The system will incorporate an advanced machine learning (ML) model designed to detect and outline lesion-like objects in brain and spine MRI data. The model will accurately count the number of lesion-like objects identified and possess the capability to differentiate between closely clustered lesions, ensuring precise and reliable results.

3.2.4. 3D Mapping and Lesion Measurement

The system will include a sophisticated tracking algorithm that generates 3D mappings of lesion-like objects by processing multi-angle MRI data. This functionality will enable comprehensive visualization and analysis. Furthermore, the system will calculate the area and volume of identified lesions, providing quantitative metrics to support clinical decision-making.

3.2.5. Monitoring Lesion Progression

To facilitate monitoring over time, the tracking algorithm will compare current and previous MRI scans, identifying potential lesion growth or the emergence of new developments. This feature will assist doctors in tracking disease progression and evaluating treatment efficacy.

3.2.6. 3D Reconstruction Visualization

Doctors will have access to a 3D reconstruction of lesion-like objects through the web application, allowing for enhanced visualization and a better understanding of complex cases.

3.2.7. Sharing and Collaboration

The system will enable doctors to share their analysis, including both 2D images and 3D visualizations, with other authorized users for collaborative review and consultation.

3.2.8. Exporting Analysis Results

Analysis results can be exported in a standardized format, ensuring compatibility with offline use or integration into other tools and systems. This feature will support a seamless workflow for doctors who may require results outside of the web application environment.

3.2.9. Administrative Tools

For administrative needs, the system will provide a dedicated set of tools for admin users. These tools will include functionalities for user management, system monitoring, and the management of MRI collections. This ensures the system remains secure, well-maintained, and capable of adapting to the evolving requirements of its users.

3.3. Non-functional Requirements

3.3.1. Usability

Even though our application will run on the web, we have a very specific user base and specific desktops to run on—namely neurology doctors at Hacettepe Hospital (HH) and their designated computers. As such, our web application should be intuitive and easily adoptable for our users. To achieve these goals, our usability requirements are as follows: The application must allow multiple users to use the same account simultaneously. It should have an intuitive user interface tailored to the target audience (doctors at HH). Any login process should take at most four steps with valid credentials. All functionalities of the application must be accessible and easily visible from the main page. Furthermore, undo/back buttons should always be placed in the top left corner of the screen, while "exit," "escape," or "X" buttons must be positioned in the top right corner of the corresponding window. The application must handle all network requests asynchronously, enabling users to interact with the frontend continuously. Additionally, all in-progress network requests must be clearly visible to users.

3.3.2. Reliability

Reliability is the most critical requirement since doctors will use our application to make decisions and manage sensitive personal data. To ensure reliability, lesion-like detection must achieve an accuracy of 94% for both brain and spine analyses. It is imperative that no doctor can access another patient’s data without proper authorization. Furthermore, user data must never be vulnerable in the database or during its transfer to and from the database. All user data must be encrypted to prevent unauthorized access. Any DICOM or NII data associated with the user must never contain identifiable user information or any link back to the user. These files should only be accessible via a key and path stored in an encrypted user database.

3.3.3. Performance

While performance and usability are distinct requirements, they are closely interconnected in this application. Doctors at HH typically spend around 15 minutes analyzing a patient's MRI scans. Our application must demonstrate significantly greater speed or accuracy than manual analysis to ensure adoption. Thus, performance requirements include the following: The latency of the server when using the machine learning analysis and tracking feature for lesions must be less than 120 seconds. The 3D model viewer should run smoothly on modern PCs used at HH, maintaining a frame rate of at least 30 fps. Loading an MRI scan into the 3D viewer should take no more than 10 seconds. The application must also support multiple user accounts utilizing the machine learning service simultaneously without performance degradation. Additionally, any part of the user interface must load within five seconds on internet speeds of 9 Mbps or higher.

3.3.4. Scalability

Our system must be designed to handle increasing demands in terms of data, users, and computational requirements without compromising performance or reliability. It should adapt seamlessly to the growing needs of HH, ensuring continued usability and efficiency over time. Scalability requirements include the efficient storage and retrieval of large MRI datasets, supporting up to 100,000 scans. The system must handle at least 100 concurrent users without noticeable performance degradation. It should process high-resolution MRI data and larger datasets without impacting machine learning model accuracy or response time. The infrastructure must dynamically scale resources to handle peak traffic demands. Furthermore, the system should enable easy integration of new technologies, improved machine learning models, or additional imaging modalities. It must also ensure interoperability with external databases or systems for research or regulatory purposes.

3.3.5. Security & Privacy

Our application relies on sensitive data, such as patient information, to deliver accurate lesion detection and ensure reliable results. This data includes training and testing datasets for the machine learning model, making it critical to implement stringent security measures. To balance functionality and privacy, we will adhere to established privacy regulations, including the Kışisel Verilerin Korunması Kanunu (KVKK) and the General Data Protection Regulation (GDPR), while obtaining necessary approvals and user consent as required. Security measures include ensuring that all datasets used for training and testing the machine learning model comply with KVKK and GDPR guidelines. Patient data provided by HH for model training and testing must receive approval from the Ethical Board of HH. All passwords will be securely hashed using the SHA-256 algorithm to prevent unauthorized access. Session tokens will be issued using secure protocols and will remain valid for a maximum of eight hours. Additionally, refresh tokens will be provided to allow users to regenerate session tokens as needed.

3.4. Pseudo Requirements

- GoLang will be used as the language of the backend.
- GoLand will be used as the development environment for the backend.
- PostgreSQL will be used for database management.
- Orthanc will be used for DICOM file management.
- Swagger will be used to test endpoints in the backend.
- Python and tensorflow will be used to develop the model.
- Google Colab will be used to train the model.

3.5. System Models

3.5.1. Scenarios

Scenario 1: Automatic Lesion Detection

a) **Actors**: Neurologist, Lesion Lens system

b) **Steps**:

i) The neurologist uploads a patient's MRI scan to the system.

ii) Lesion Lens analyzes the images using ML algorithms.

iii) The system identifies and highlights potential lesions.

iv) A detailed report is generated, showing lesion characteristics and volumetric analysis.

Scenario 2: Temporal Tracking

a) **Actors**: Neurologist, Lesion Lens system

b) **Steps**:

i) The neurologist selects a patient's historical MRI data.

ii) Lesion Lens compares previous and current scans.

iii) The system displays lesion progression over time through a 3D visualization tool.

Scenario 3: Integration With Patient Data

a) **Actors**: Neurologist, Lesion Lens system

b) **Steps**:

i) A neurologist receives a new patient referral with MRI scans provided on a CD.

ii) The neurologist uploads the DICOM files into Lesion Lens.

iii) The system extracts metadata, anonymizes patient details, and organizes the scans in the database.

iv) The neurologist views the patient's lesion history using the timeline feature to assess progression.

Scenario 4: Collaborative Consultation

a) **Actors**: Neurologist, Consulting Specialist, Lesion Lens system

b) **Steps**:

i) A neurologist detects an unusual lesion and decides to consult a specialist.

ii) Using Lesion Lens, the neurologist shares the patient's lesion data with the specialist, granting read-only access.

iii) The consulting specialist logs into the system, reviews the lesion's 3D visualization and volumetric data, and provides feedback.

iv) The primary neurologist updates the patient's treatment plan based on the collaboration.

Scenario 5: Lesion Progression Report Generation

a) **Actors**: Neurologist, Lesion Lens system, Patient

b) **Steps**:

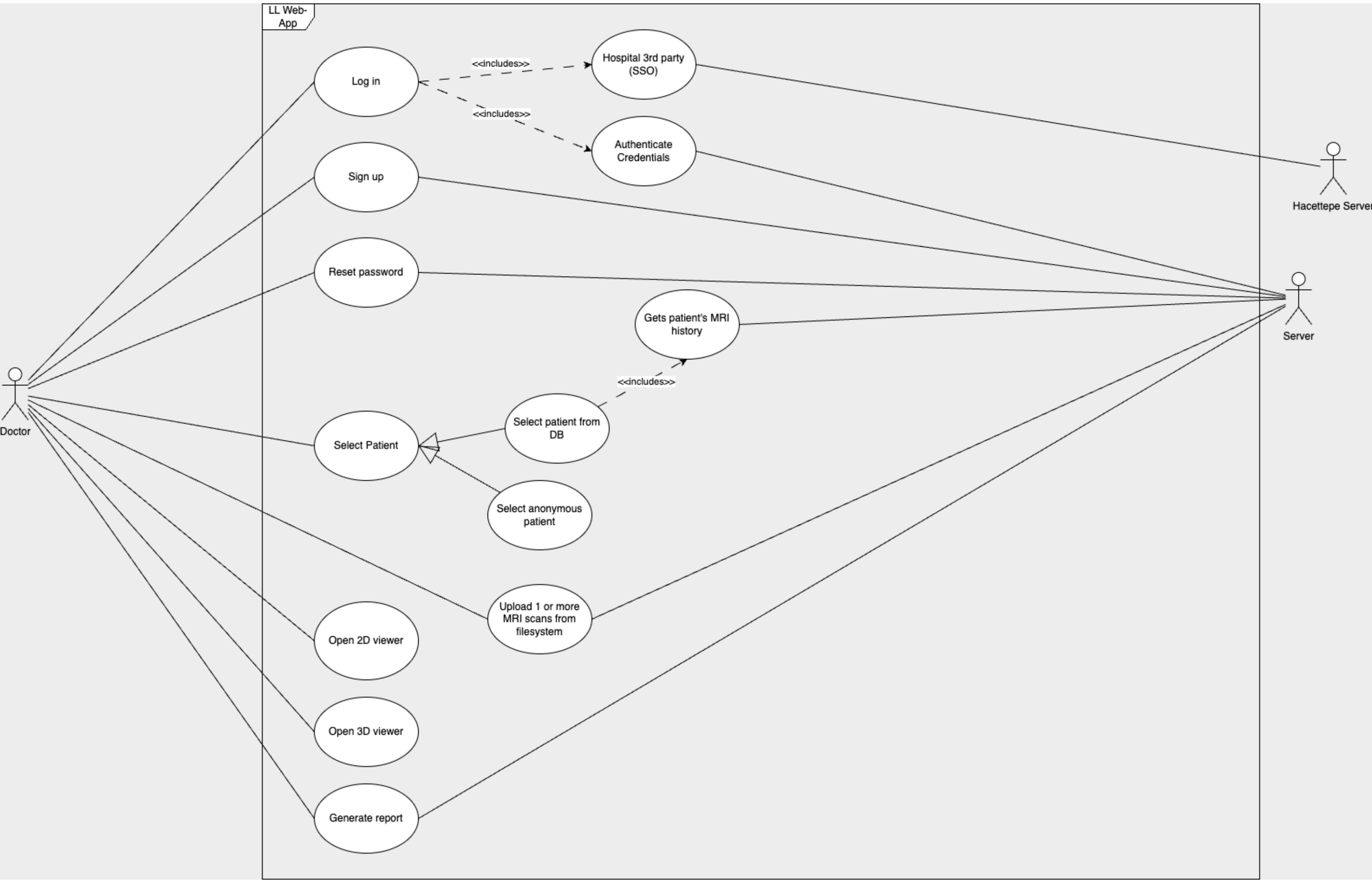
i) A neurologist selects a patient's MRI scans from multiple time points in Lesion Lens.

ii) The system generates a report summarizing lesion count, size, and volumetric changes over time.

iii) The report is exported as a PDF and included in the patient's medical records.

iv) During a follow-up appointment, the neurologist uses the report to explain disease progression and treatment effectiveness to the patient.

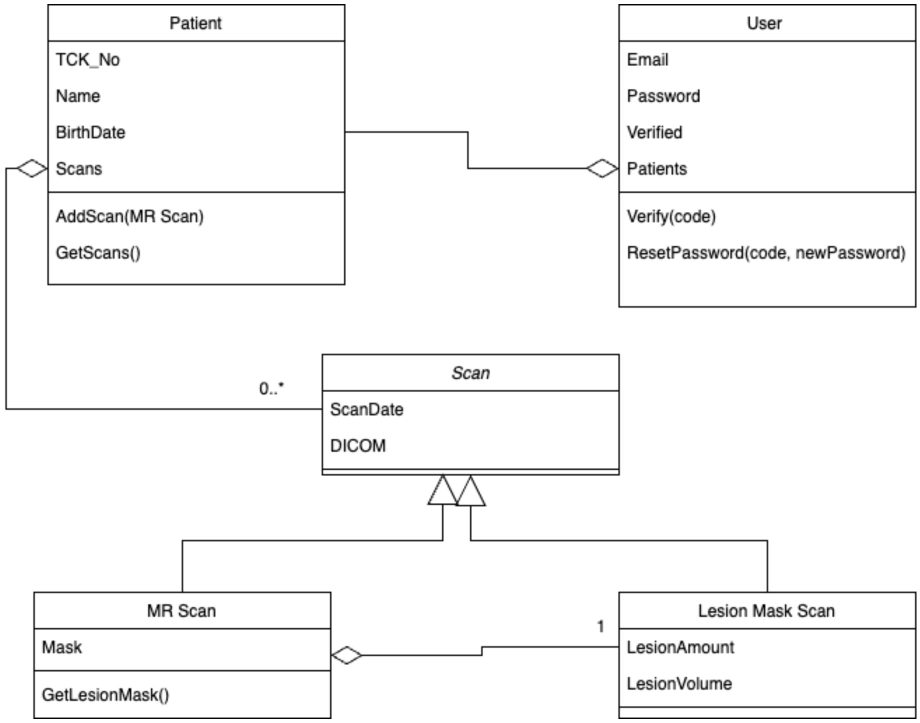
3.5.2. Use-Case Model



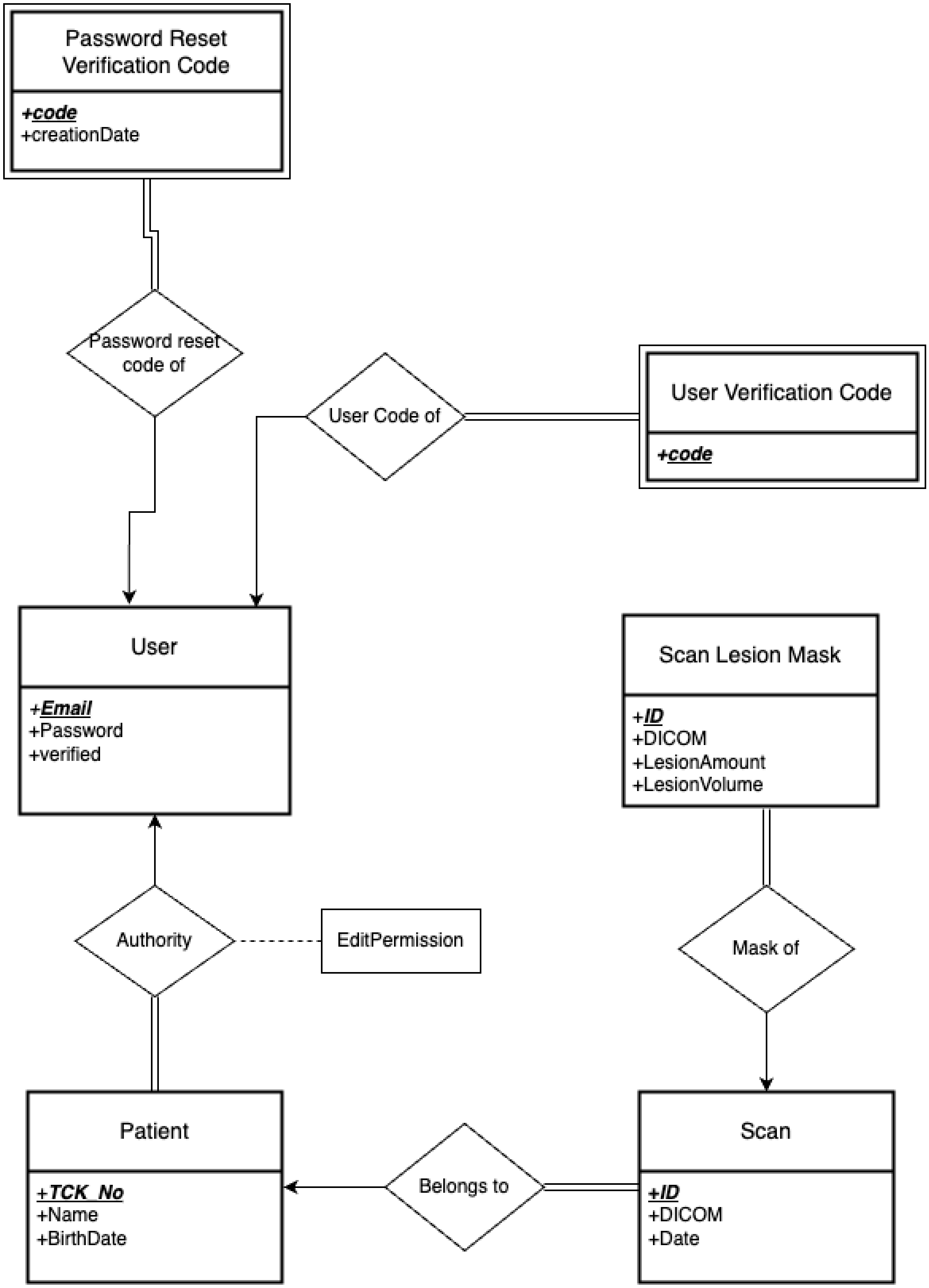

2D Use Case
Uploads MRI scan(s)
Gets historical MRI of patient
Doctor
Server
<<extends>>
No previous data in DB
<<includes>>
View side by side history
<<extends>>
Selects axis
Requests AI analysis
<<extends>>
<<extends>>
<<includes>>
Toggles between T1, T2, and FLAIR
Toggles AI analysis lesion overlay
<<extends>>
<<extends>>
<<extends>>
Selects MRI scan
AI analysis not complete
<<extends>>
Historical overlay


3D Use Case
No previous data in DB
<<extends>>
Gets historical MRI of patient
Doctor
Uploads MRI scan(s)
Server
Toggles between T1, T2, and FLAIR
<<extends>>
Selects MRI scan
<<extends>>
Toggles AI analysis lesion overlay
<<extends>>
<<extends>>
<<extends>>
<<includes>>
Shows 3D volume map
Requests AI analysis
<<includes>>
Selects from lesion list
Scrolls through timeline

3.5.3. Object and Class Model



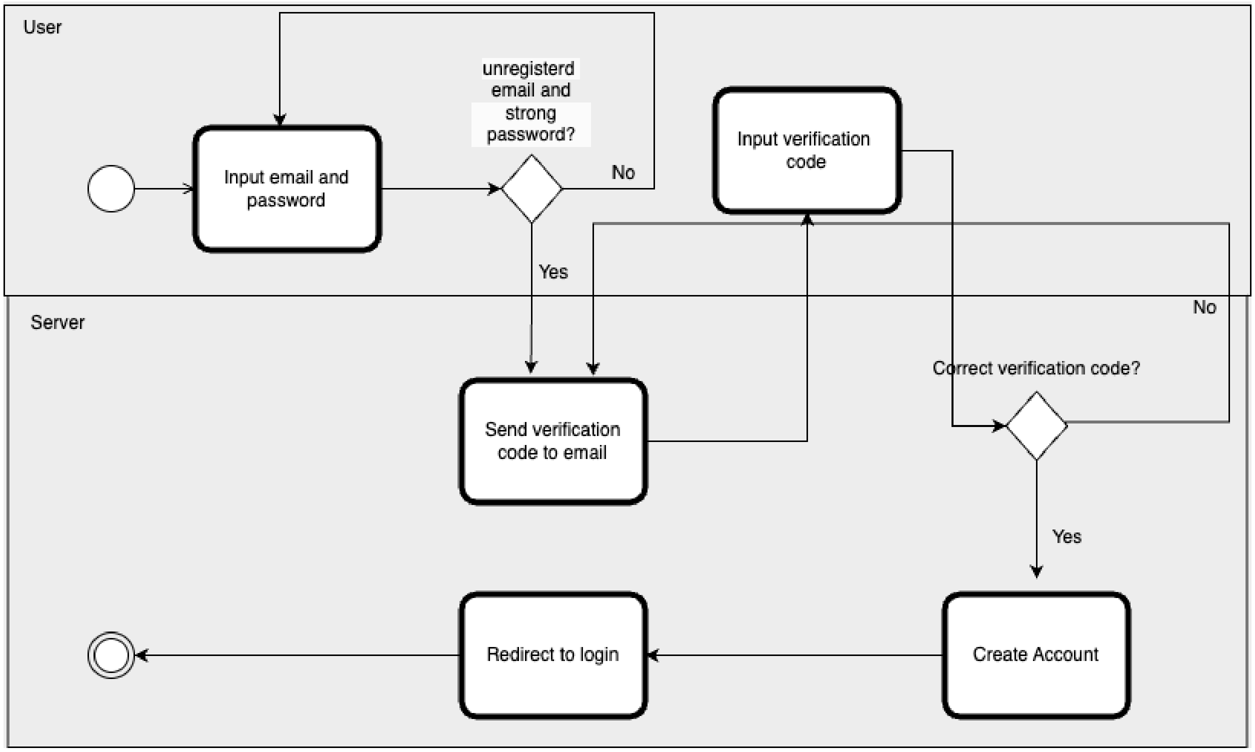
3.5.3.1. SQL Tables



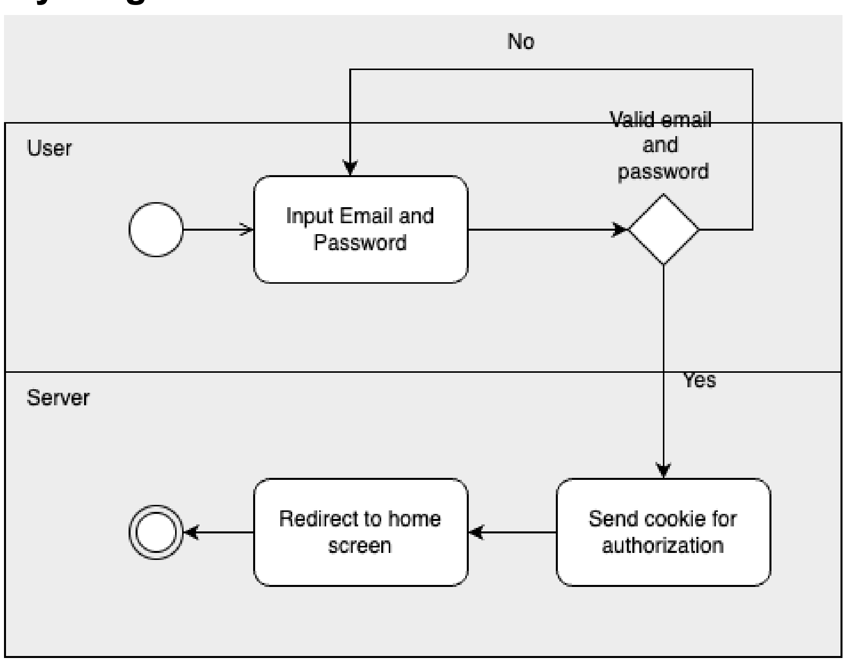
3.5.4. Dynamic Models

3.5.4.1. Activity Diagrams

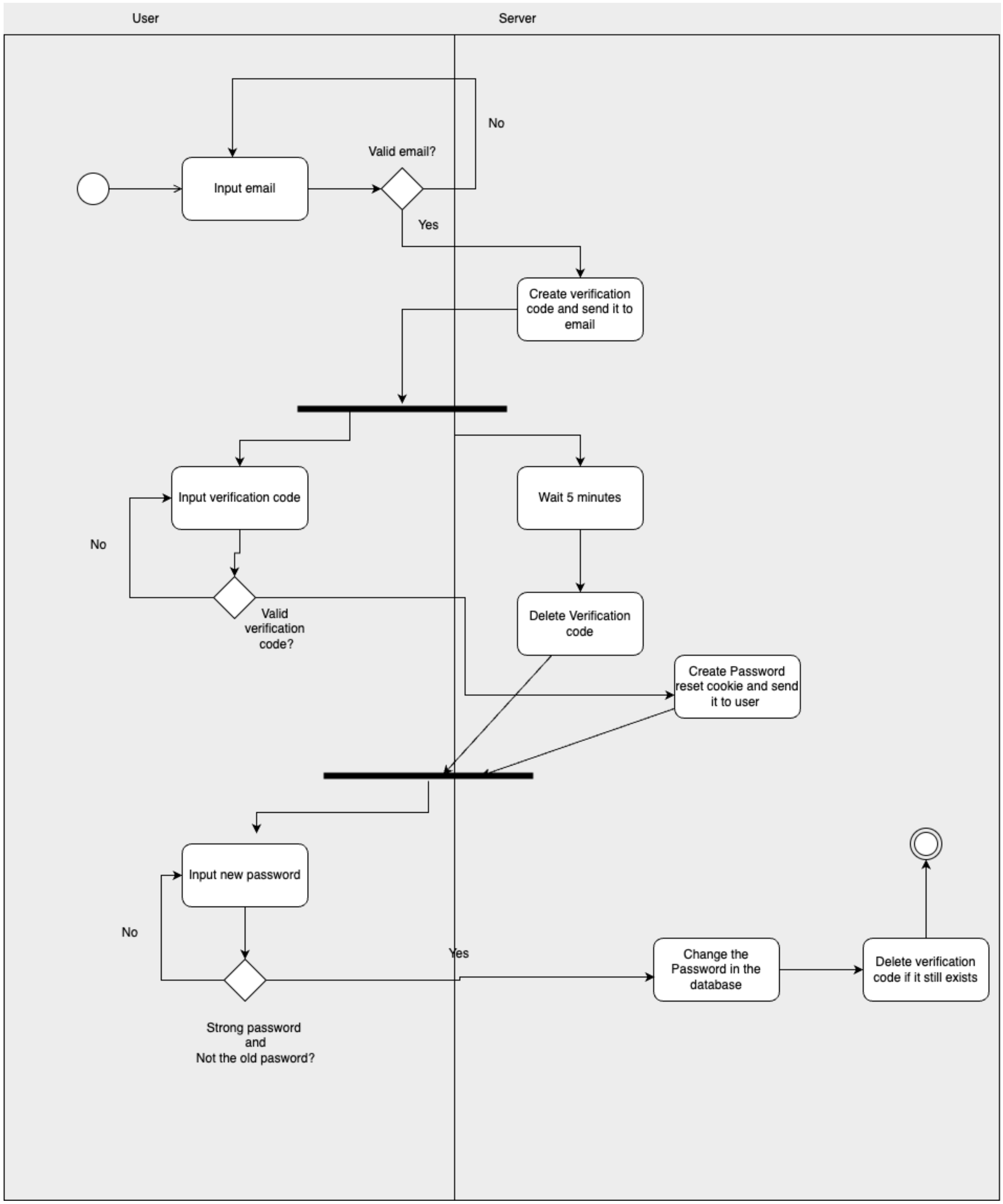
Sign Up Activity Diagram:



Log In Activity Diagram:



Reset Password Activity Diagram:

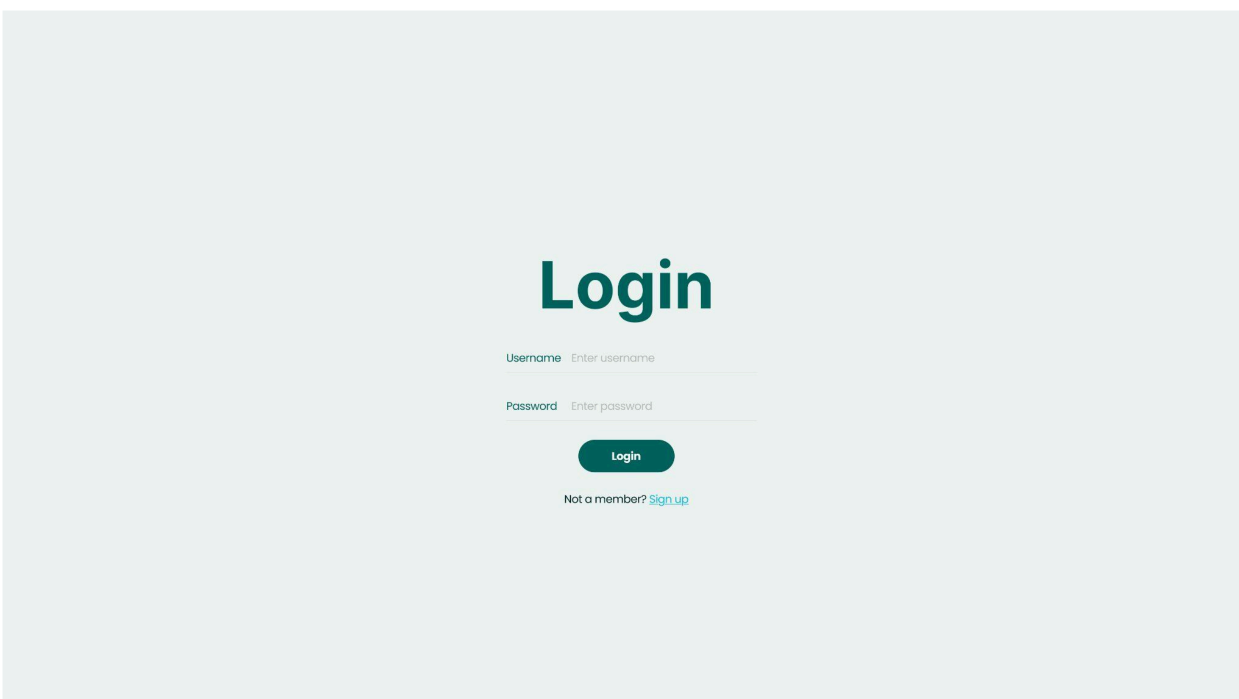


3.5.5. Endpoint Model

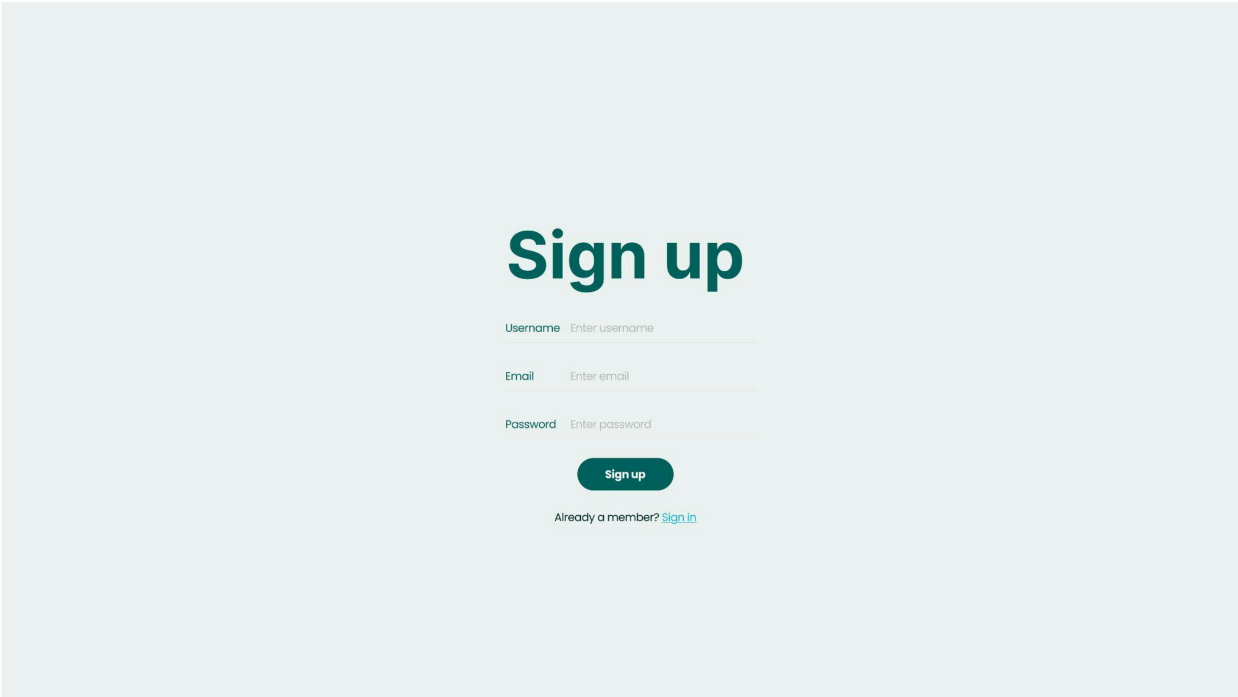
- Signup - Creates a user account in SQL DB as a doctor.
- Verify Email - Verifies a given user if correct verification code is provided
- Login - Logs into account with the login info
- Reset Password Verify (GET) - Sends a verification code to email to reset the password
- Reset Password Verify (POST) - If verification code in header is correct, sends a cookie to authorize the password reset operation
- Reset Password - If valid authority cookie exists, resets the password of a given account
- List patients - Gets patients that the doctor has authority to view
- Select Patient - Displays patient data (clickable studies)
- Get patient data - Return data of patient form Orthanc and SQL
- Get history as thumbnail - Sends thumbnail and AI metadata (such as lesion count) of all previous MRI's of a given patient.
- Get history - Get all scans in the patient's history as DICOM
- Get history by ID - Gets single study
- Upload - Upload singular MRI study or multiple
- Select MRI scan - Send mask and series DICOM
- Request ML - Creates an ML analysis of the MRI and returns a lesion mask
- Share patient - Select which other doctor can view this patient (read/write perms)

3.6. User Interface - Navigational Paths and Screen Mock-ups

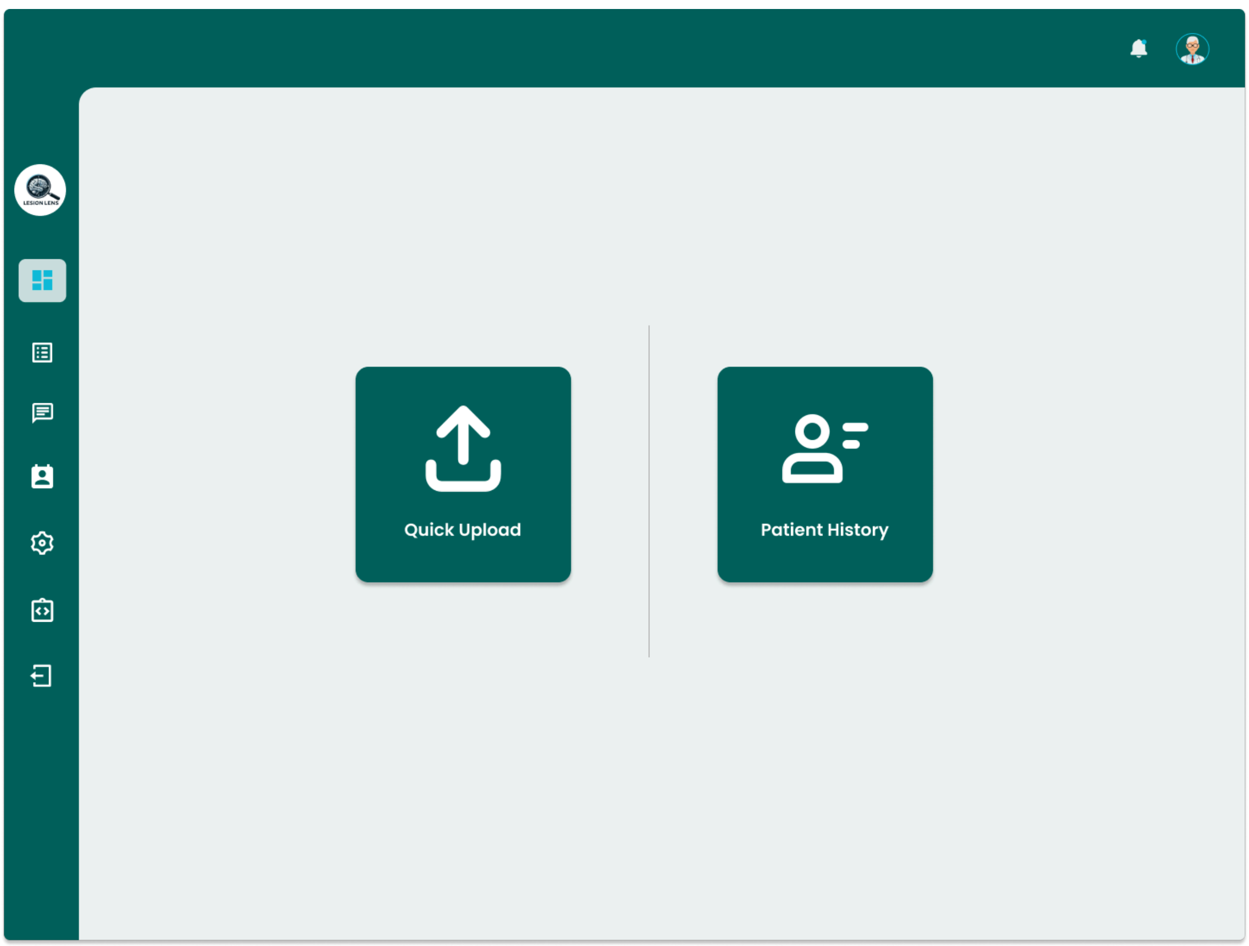
Login:



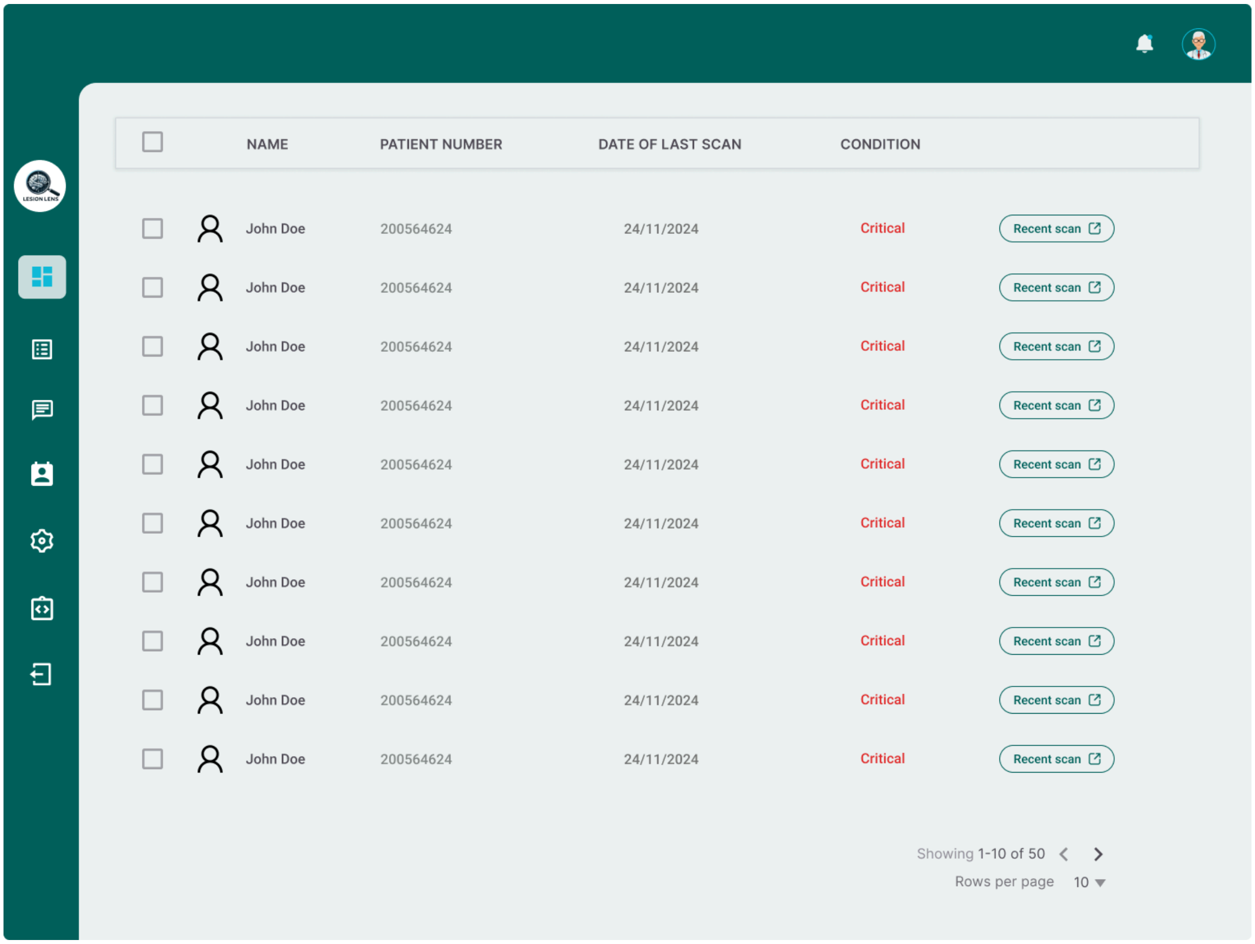
Sign Up:



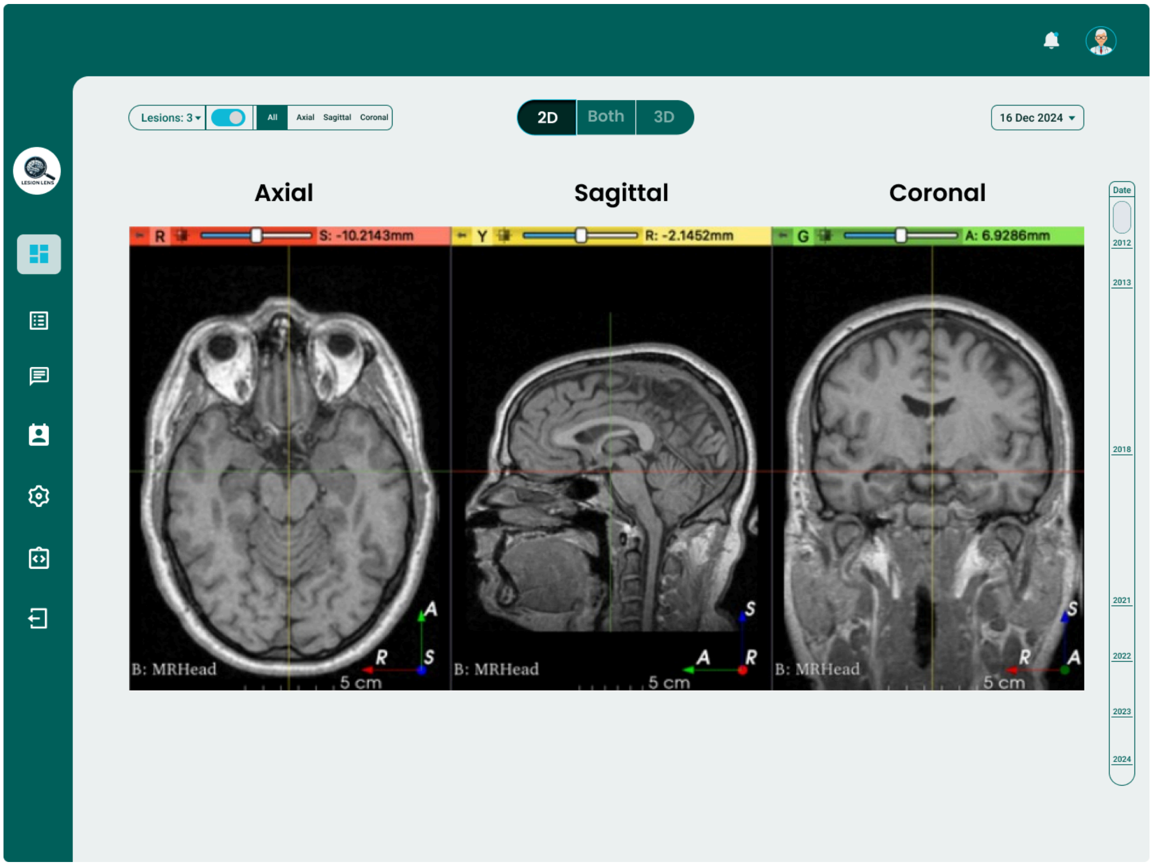
Choose one-time upload (CD) OR Open old patient’s scan:



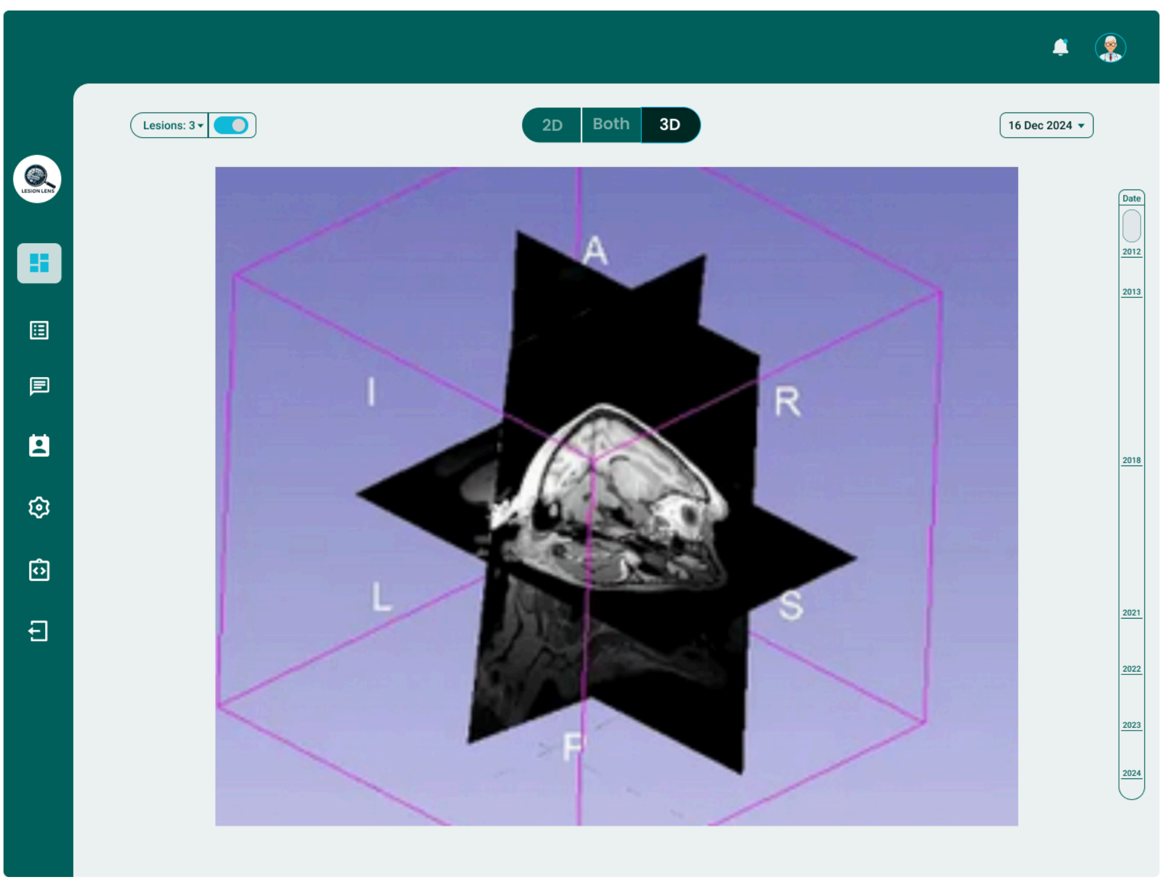
Patients Overview:



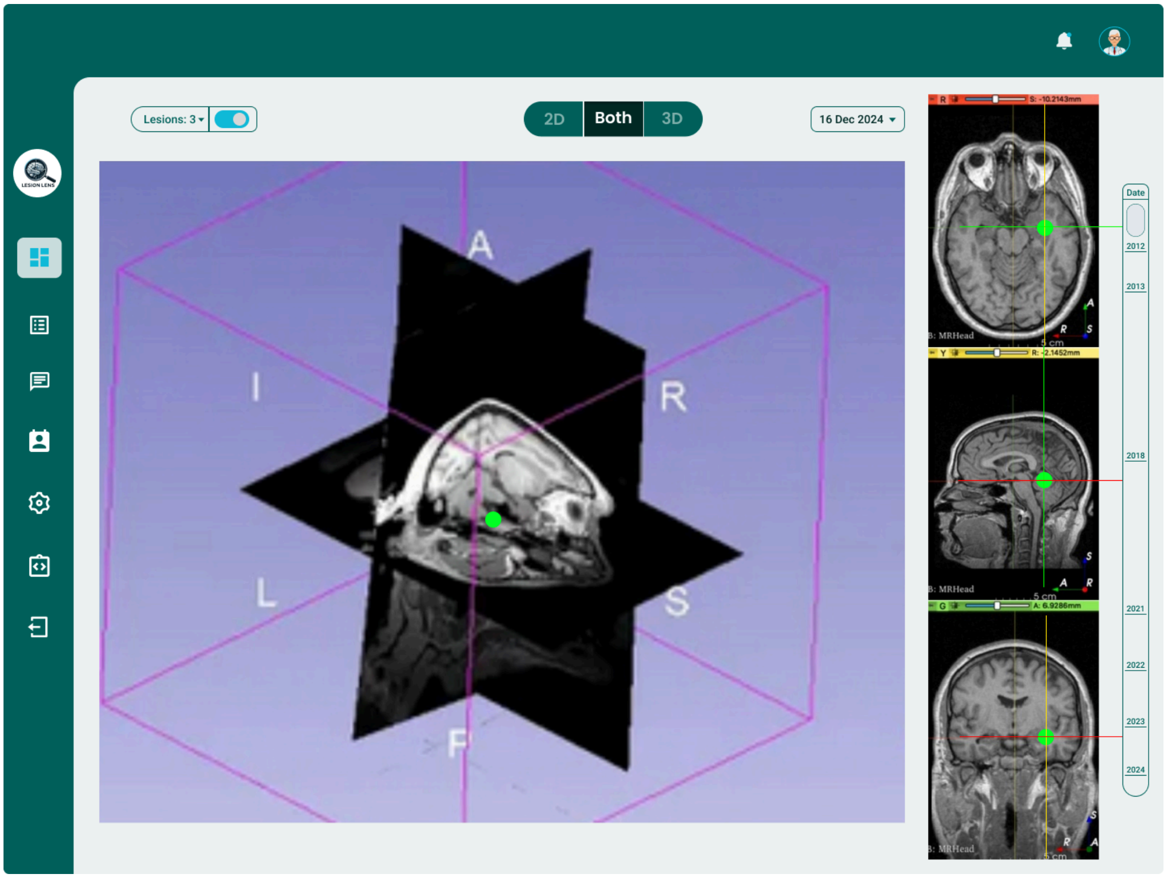
2D View of Current Scan, All axes:



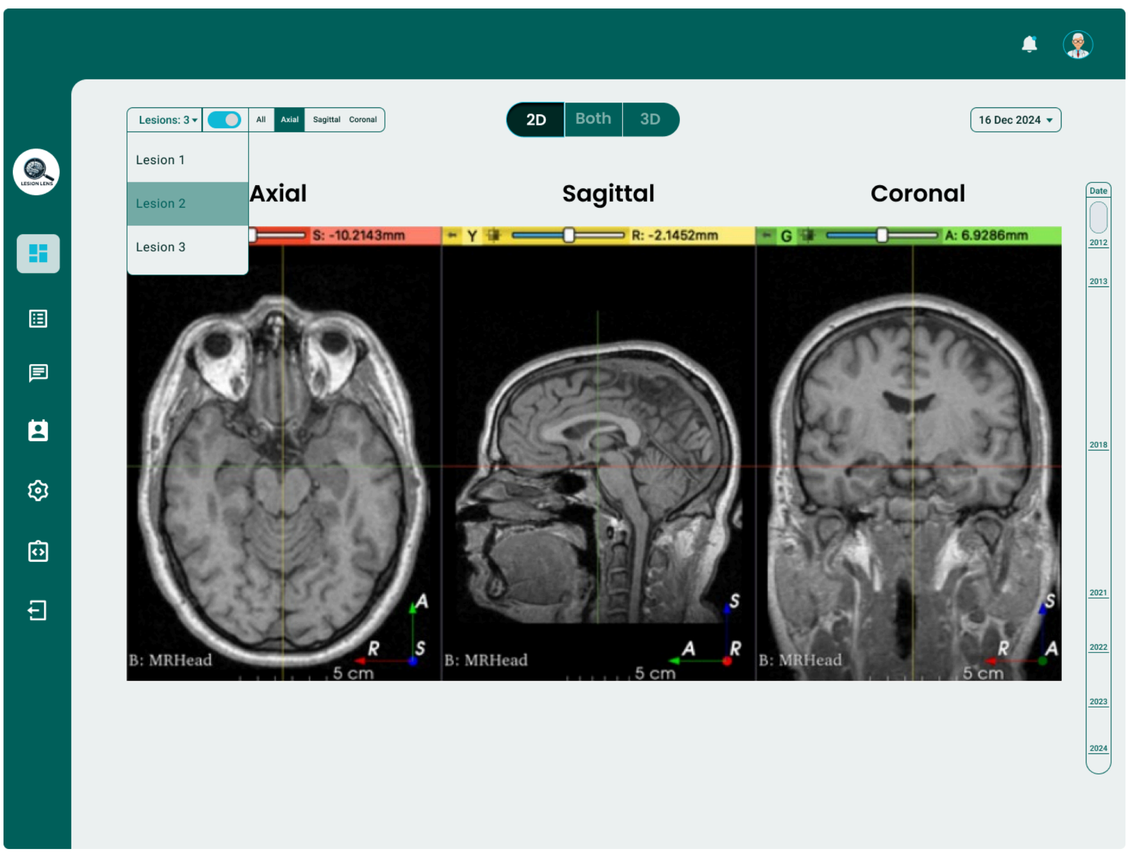
3D View:



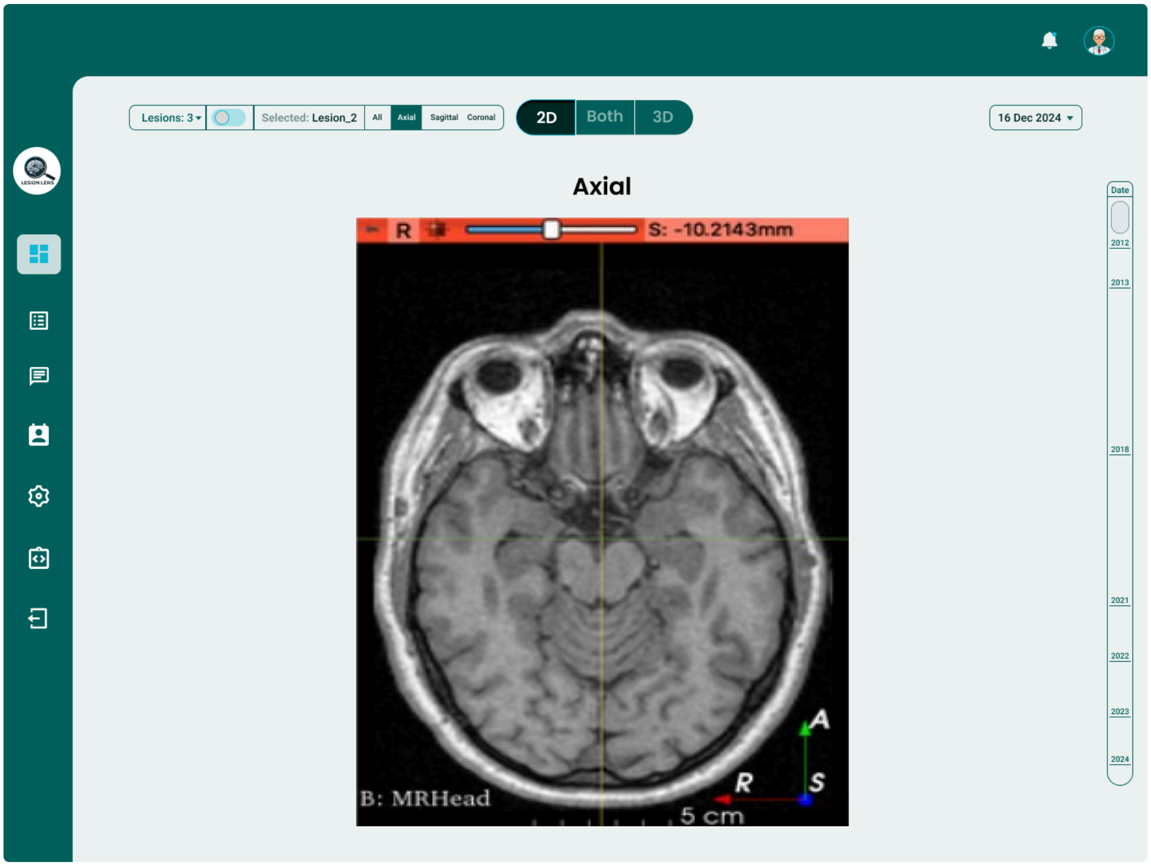
Combined Views, Show Lesions:



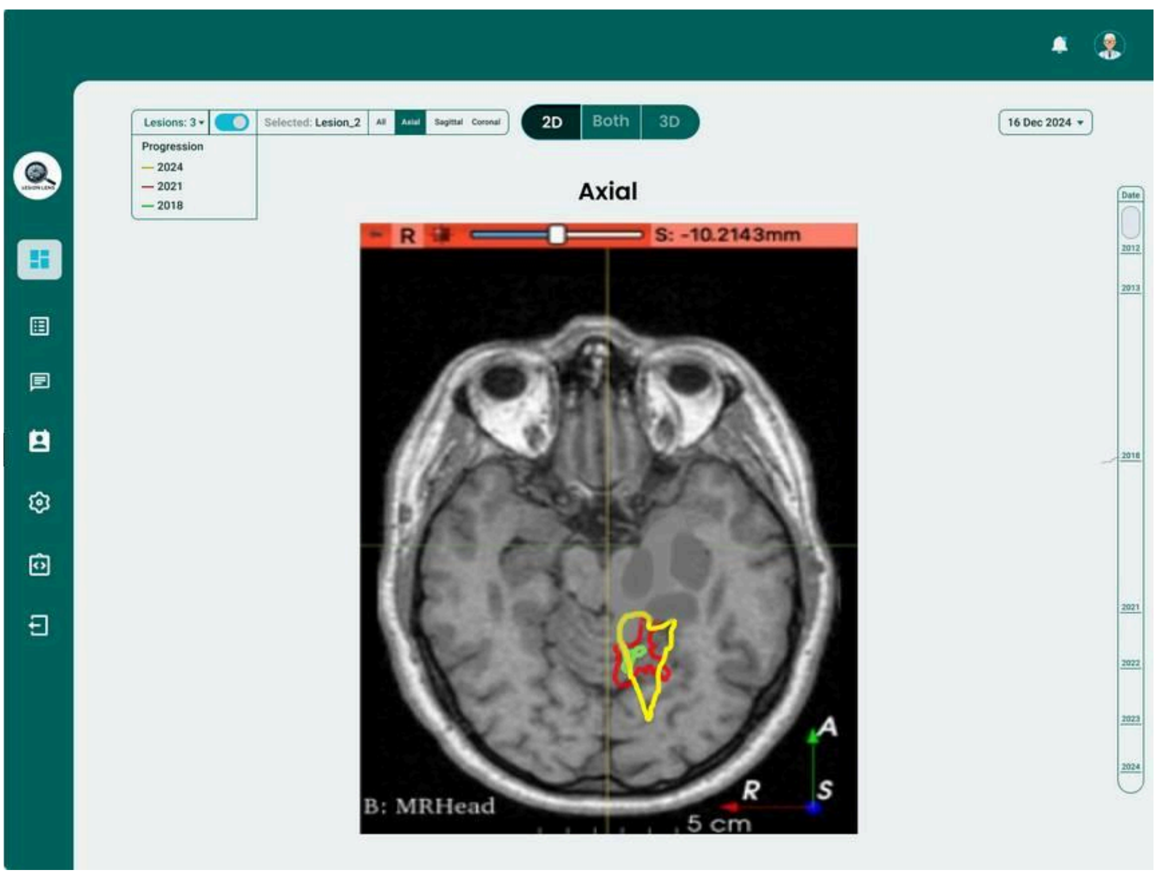
2D View of Current Scan, All Axes. Choose Lesion from List of Lesions:



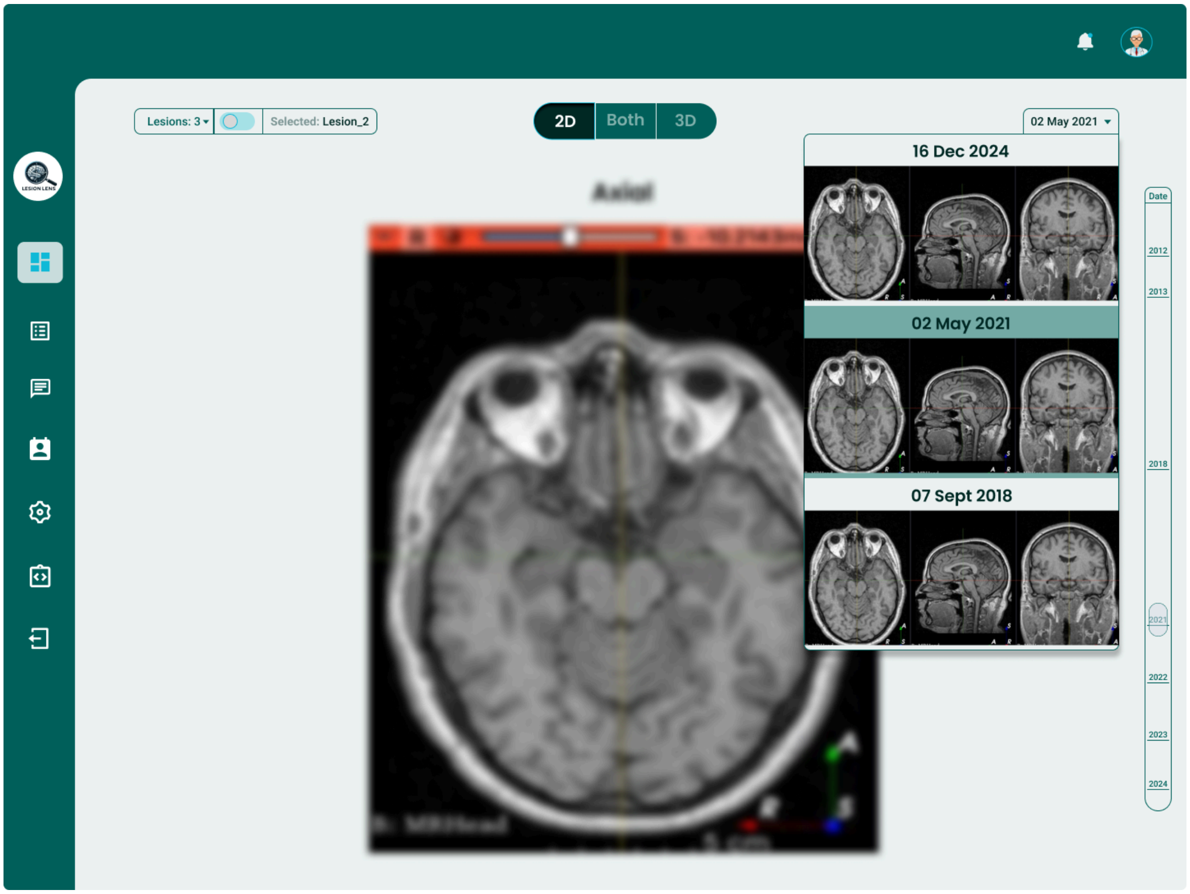
2D View of Single Axis:



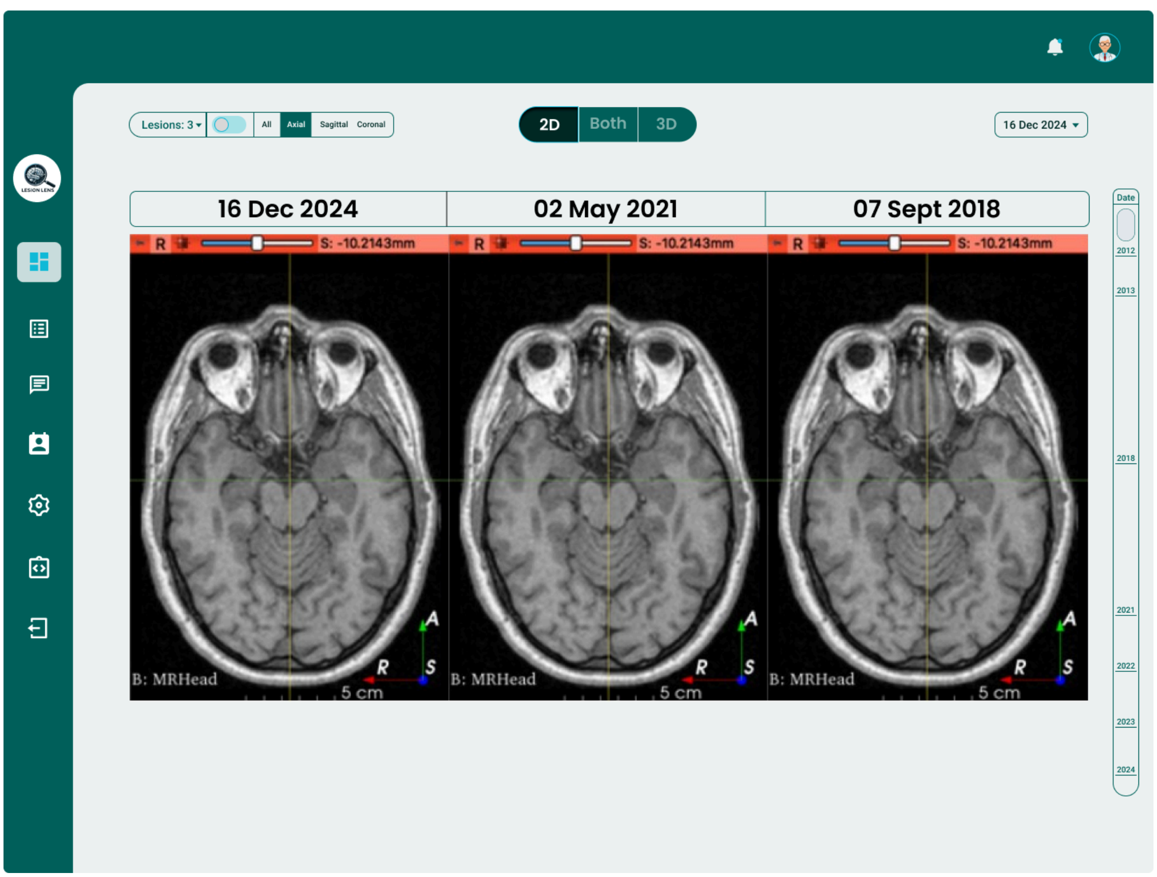
2D View of Single Axis, Shows Lesion Progression:



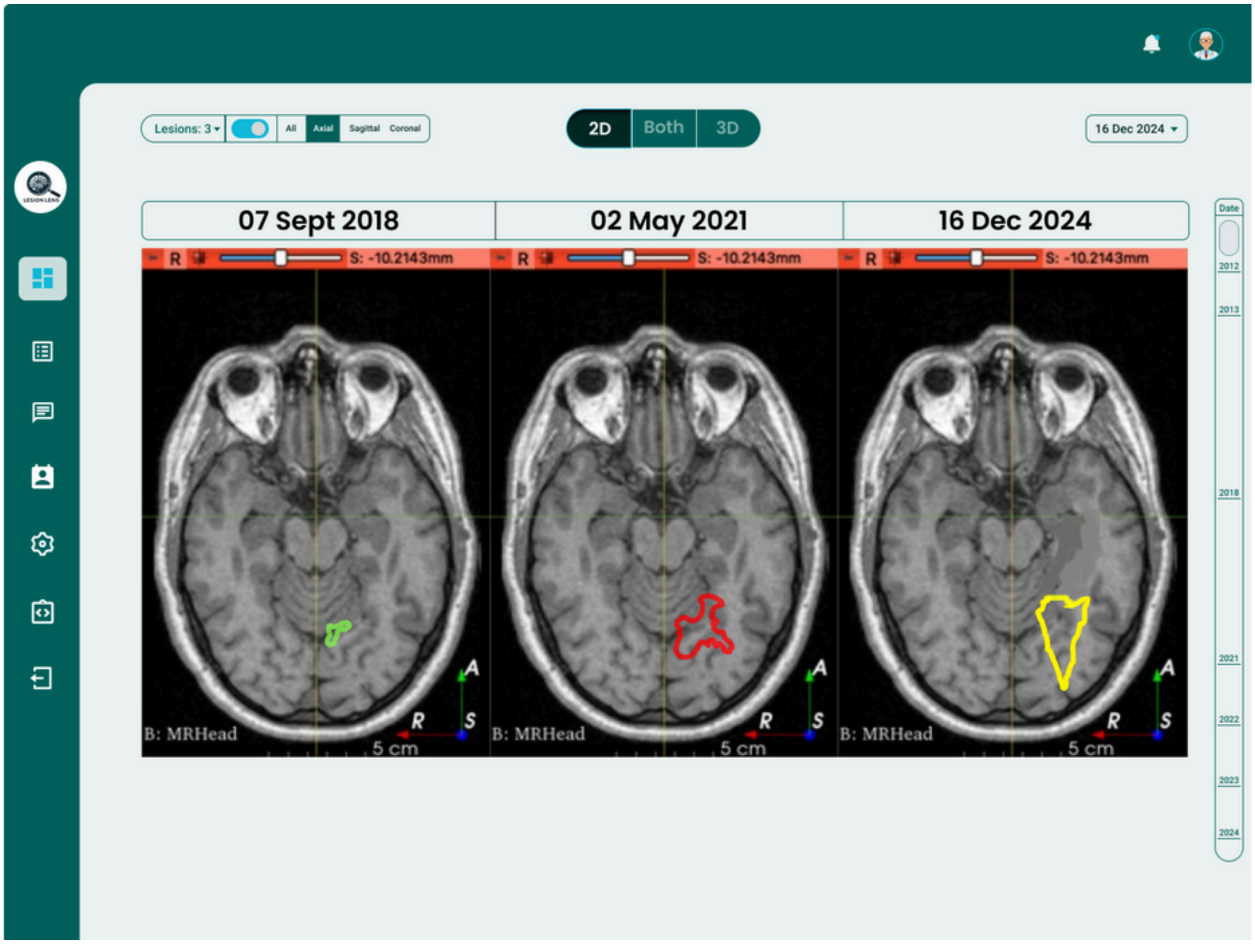
2D View of History of Scans Dropdown:



2D View of Single Axis, Over the Years:



2D view of single axis. Over the years. Show Lesion Progression:



4. Other Analysis Elements

4.1. Consideration of Various Factors in Engineering Design

In this section of the report, we discuss the various design considerations for our project. There are four significant ethical risks with using artificial intelligence in medical imaging: autonomy of patients and clinicians, transparency of clinical performance and limitations, fairness toward marginalized populations, and accountability of physicians and developers [1].

4.1.1. Public Health Considerations

LesionLens aims to improve public health conditions by providing a fast and reliable way for clinicians to analyse MRIs for lesions. While improving the lesion detection process, LsionLens respects the autonomy of doctors. LesionLens doesn't provide diagnosis but rather a tool to make the doctor's job easier. During our visits to Hacettepe University we learned that doctors have a very limited time to analyze each MRI due to a large number of patients. This creates the risk of missing certain lesions. LesionLens serves as a second set of eyes to ensure this doesn't happen.

4.1.2. Public Safety Considerations

LesionLens stores sensitive patient information in the database. Because of this, the consent of patients and a secure database is of utmost importance. To ensure the security of this sensitive information, we provide an option to upload scans anonymously.

4.1.3. Public Welfare Considerations

For LesionLens to be in accordance with the welfare of the public, we need to ensure that our product is fair towards marginalized groups. This means that we need to select our ML datasets carefully to ensure they are representative of all parts of a population. Luckily, we gained access to robust and representative datasets from MICCAI to train our ML models.

4.1.4. Global Considerations

Even though LesionLens originates from the needs of Hacettepe Hospital, it is planned to be deployed in various healthcare systems worldwide, therefore it must be designed to function effectively across diverse settings. The application should support multiple languages to cater to users from different linguistic backgrounds. The machine learning model must adapt to variations in medical imaging techniques and standards used in different regions. Integration with globally recognized healthcare protocols and interoperability with regional hospital systems are essential. The system should also account for differences in infrastructure, such as varying internet speeds, ensuring usability even in areas with limited resources. Through addressing these global considerations, LesionLens can be a universally accessible tool for medical imaging analysis.

4.1.5. Cultural Considerations

Cultural considerations play a key role in making Lesion Lens accessible and acceptable across different regions. The application’s interface and communication materials should be localized for language, medical terminology, and visual cues familiar to local users. Doctors and patients may have varying levels of trust in automated systems, so transparency about the tool’s role and data usage can help build confidence. Compliance with regional laws, ethical guidelines, and hospital protocols ensures that patient privacy and data handling respect local values and regulations. By adapting to cultural norms—such as accommodating different communication styles, workflows, and trust in medical authority—Lesion Lens can integrate seamlessly into diverse healthcare environments.

4.1.6. Social Considerations

Social considerations involve understanding how Lesion Lens fits into existing relationships between patients, doctors, and hospital staff. The tool should support, not replace, the expertise of healthcare professionals, maintaining trust and respecting traditional roles. Training and clear communication ensure that users feel confident adopting the new technology, while patients remain informed and reassured. Additionally, considerations like equitable access—ensuring that all who need the tool can use it—help prevent disparities in care. By integrating smoothly with existing workflows and respecting the social fabric of healthcare settings, Lesion Lens can foster positive collaboration and ultimately improve patient outcomes.

4.1.7. Environmental Considerations

Environmental considerations for Lesion Lens center on responsibly managing resource usage in both development and deployment. Efficient cloud computing strategies, such as using only necessary storage and computing power, help reduce the application's carbon footprint. Hardware optimization—like leveraging existing hospital equipment and avoiding unnecessary hardware upgrades—minimizes waste. Furthermore, proper data management and secure, remote access can reduce the need for physical travel or transfer of information, indirectly lessening environmental impact. By prioritizing energy efficiency, resource conservation, and minimal hardware dependency, Lesion Lens can contribute to a more sustainable healthcare technology ecosystem.

4.1.8. Economic Considerations

Economic considerations for Lesion Lens focus on cost-effectiveness and long-term sustainability. Reducing manual analysis time through automated lesion detection can lower operational expenses and potentially increase patient throughput. Using open-source libraries and publicly available training datasets can minimize initial development costs, while the scalability of cloud-based infrastructure allows for flexible resource allocation as usage grows. Careful balancing of hardware investments, data storage expenses, and maintenance fees ensures that the tool remains affordable, accessible, and provides a return on investment for healthcare providers over time.

Title	Effect Level	Effect
Public Health	9	Improves early detection of lesions, potentially reducing disease progression and improving overall healthcare outcomes.
Public Safety	3	Ensures patient data is secure through anonymized uploads, protecting sensitive information.
Public Welfare	5	Reduces bias by using representative ML datasets, promoting fair and equitable healthcare.
Global	3	Supports diverse healthcare systems by ensuring multilingual support, regional medical imaging standards, and operability in varying infrastructure conditions.
Cultural	1	Builds trust and accessibility

		through localized interfaces, compliance with regional ethics and laws, and respecting cultural medical practices.
Social	1	Maintains harmony in healthcare environments by supporting professionals' expertise, providing training, and ensuring equitable access to all users.
Environmental	2	Reduces environmental impact with efficient computing, hardware reuse, and sustainable data management practices.
Economic	7	Enhances cost-effectiveness by minimizing manual work, leveraging open-source resources, and implementing scalable cloud infrastructure for long-term affordability and ROI.

4.2. Risks and Alternatives

LesionLens' risk arises from system integration rather than implementation. The main components of the software: 3D viewer, Backend API, Frontend, Machine Learning model, and the tracking algorithm on their own are straightforward to implement. Initially, there were worries that lesions would be too hard to detect for our ML model, however, our preliminary tests gave promising results.

The primary risks we anticipate are related to potential disruptions to the user experience. A significant challenge is the integration of patient data from doctors into our system. Typically, hospitals utilize PACS (Picture Archiving and Communication System) to seamlessly connect devices and interfaces within the hospital. For instance, MRI scans are automatically processed and stored in the hospital's database via PACS, enabling other software to retrieve patient data effortlessly. Furthermore, the government's E-Nabız platform supports the transfer of patient data between hospitals. However, we will not have access to these systems, making the process of uploading patient MR scans more labor-intensive for doctors. This could result in reduced adoption and usage of our software.

Risk	Likelihood	Effect	Solution
MR Images are not standardized in Turkey	Low	3D viewer alignments mismatch, tracker struggles to track lesion growth.	Resizing the images is not an issue, our preliminary tests prove they can be standardized on our backend. However, differing number of slices between machines are harder to deal with. Nonetheless, we will use gap filling algorithms for the lesion volumes.
Unable to directly get data from E-Nabız/E-Devlet or PACS		Migration to our software is hindered.	Our solution aims to address a gap not currently fulfilled by existing applications, offering a service that justifies the effort of manually entering patient data. This would be in the form of the tracking algorithm which would track the growth of the lesions over time. Moreover, when patients are referred from hospitals outside Hacettepe, doctors are already required to manually transfer patient data from CDs. We will make it so our software easily extracts DICOM data from the CDs.
DICOM file transfers may take too long	Medium	Software works slowly.	We will optimize the API and database by reducing the size of transferred files, eliminating unused elements to

			streamline data flow. Additionally, we will utilize GPU acceleration for preprocessing tasks to decrease the network load and improve overall performance.

4.3. Project Plan

WP#	WP Title	Leader	Members Involved
0	Market/Customer Analysis	Berk	All Members
1	Requirement Elicitation Report	Berk	All Members
2	Lesion Detecting ML Model	Mert	Mert, Shayan, Arda
3	Lesion Tracker/Analyser	Arda	Mert, Shayan, Arda
4	Backend API	Berk	Berk, Kerem
5	Database Construction	Kerem	Berk, Kerem
6	3D Viewer	Berk	Berk, Shayan
7	Demo Presentation	Shayan	All Members
8	TÜBİTAK 2209-B Project	Mert	All Members
9	Publish Paper	Arda	All Members
10	Frontend	Shayan	Shayan, Arda

Work Packet #0: Market/Customer Analysis Start Date: 01.08.2024 End Data: 01.10.2024 Leader: Berk Members Involved: All Members

Objectives: Prepare for the senior project and understand customer needs.

Tasks:
Task 1.1 Select a project topic, innovation expert, supervisor.
Task 1.2 Understand customer needs.
Task 1.3 Research current solutions.

Work Packet #1: Requirement Elicitation Report
Start Date: 16.09.2024
End Data: 22.11.2024
Leader: Berk
Members Involved: All Members

Objectives: Successfully submit Analysis Report, Project Specification Report, Assessment of Innovation form, and Project Information form at their respective deadlines.

Tasks:
Task 1.1 Submit Project Information form.
Task 1.2 Find an Innovation expert and submit Innovation evaluation form.
Task 1.3 Write Project Specification report

Deliverables
D1.1: Project Information form
D1.2: Project Specification document
D1.3: Innovation Expert Evaluation form
D1.4: Analysis and Requirements Report

Work Packet #2: Lesion Detecting ML Model
Start Date: 16.09.2024
End Data: 01.05.2025
Leader: Mert
Members Involved: Mert, Shayan, Arda

Objectives: Successfully train a machine learning model that detects lesions on brain and spine MRIs.

Tasks:
Task 1.1 Identify which ML model to build
Task 1.2 Select which pre-processing steps to follow
Task 1.3 Perform literature review
Task 1.4 Collect data
Task 1.5 Train and refine model

Deliverables
D1.1: Demo

Work Packet #3: Lesion Tracker/Analyser Start Date: 01.01.2025 End Data: 01.05.2025 Leader: Arda Members Involved: Mert, Shayan, Arda Objectives: Develop an algorithm to consolidate results from the ML model and history of the patient. Tasks: Task 1.1: Define input and output requirements for the algorithm, including ML model outputs and patient history data format. Task 1.2: Collect and preprocess patient history data to ensure compatibility with the ML model results. Task 1.3: Design a data structure to store and integrate ML model outputs and patient history. Task 1.4: Develop the algorithm to merge and prioritize data based on predefined criteria (e.g., relevance, accuracy, or temporal order). Task 1.5: Validate the algorithm using test cases that include diverse ML results and patient histories. Task 1.6: Optimize the algorithm for speed and efficiency, considering scalability for larger datasets. Task 1.7: Implement logging and error-handling mechanisms for tracking and debugging. Task 1.8: Deploy the algorithm into the existing system and test its integration with other modules.
Deliverables None

Work Packet #4: Backend API Start Date: 16.09.2024 End Data: 01.02.2025 Leader: Berk Members Involved: Berk, Kerem Objectives: Develop a backend API to interface between frontend and database and run tracker and ML model. Tasks: Task 1.1 Identify frameworks and tools for implementation Task 1.2 Design an Architecture Task 1.3 Using requirement elicitation, identify endpoints Task 1.4 Connect Frontend and Database Task 1.5 Optimize data transfer
Deliverables None

Work Packet #5: Database Construction
Start Date: 16.09.2024
End Data: 01.02.2025
Leader: Kerem
Members Involved: Berk, Kerem

Objectives: Construct a relation database and store DICOM files

Tasks:
Task 1.1 Identify how to store DICOM files
Task 1.2 Draw an ERD diagram
Task 1.3 Optimize data transfer

Deliverables
None

Work Packet #6: 3D Viewer
Start Date: 01.02.2025
End Data: 01.05.2025
Leader: Berk
Members Involved: Berk, Shayan

Objectives: make an online 3D DICOM viewer meeting project needs.

Tasks:
Task 1.1 Learn WebGL
Task 1.2 Implement viewer
Task 1.3 Connect to backend

Deliverables
None

Work Packet #7: Demo Presentation
Start Date: 23.12.2024
End Data: 23.12.2024
Leader: Shayan
Members Involved: All Members

Objectives: Present first demo

Tasks:
Task 1.1 Present progress so far
Task 1.2 Present business research

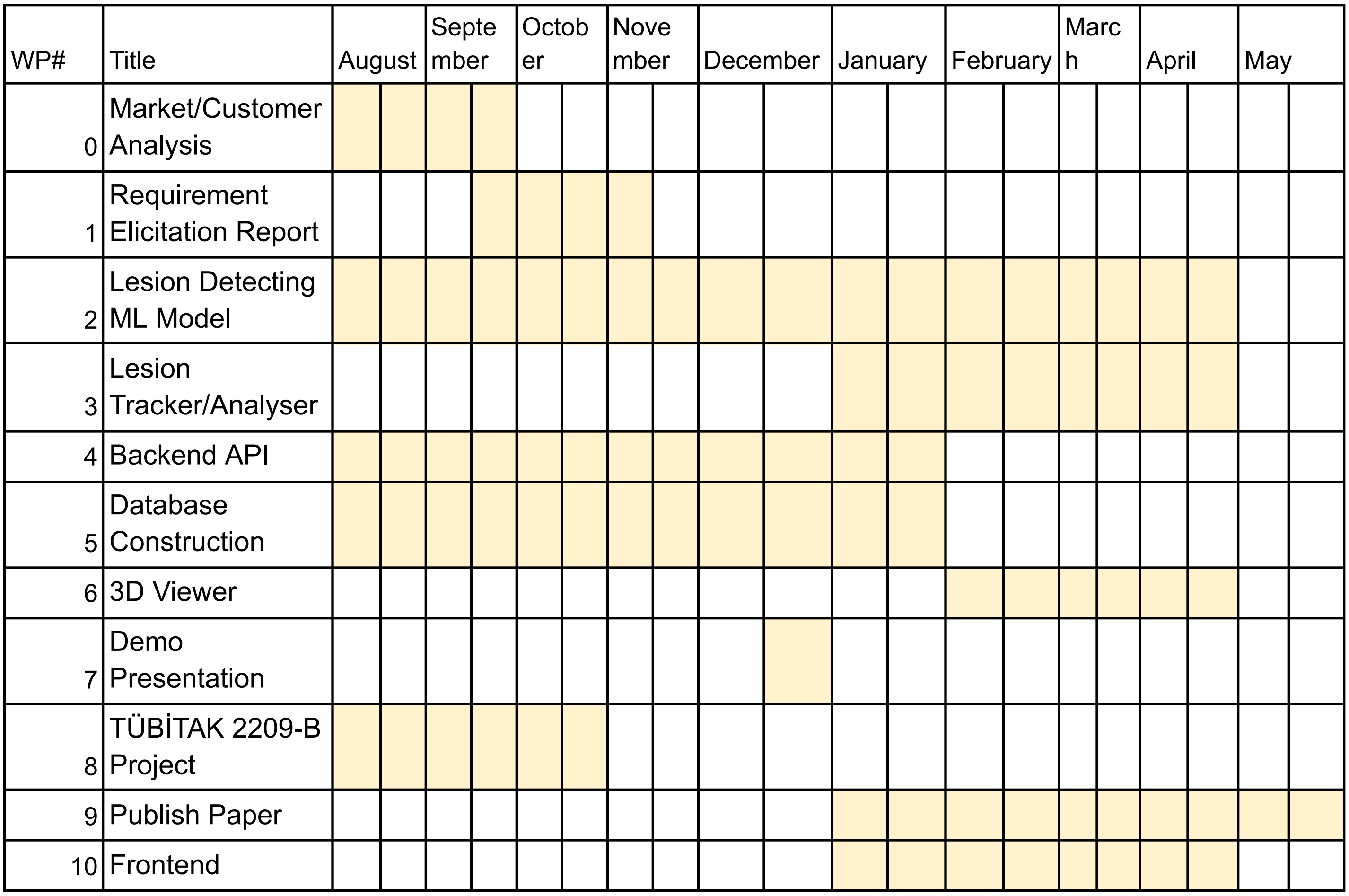
Deliverables
D 1.1 Demo #1

Work Packet #8: TÜBİTAK 2209-B Project Start Date: 16.09.2024 End Data: 01.11.2024 Leader: Mert Members Involved: All Members Objectives: Submit report for TÜBİTAK 2209-B Project Tasks: Same as WP 0 & 1
Deliverables None

Work Packet #9: Publish Paper Start Date: 01.01.2025 End Data: 01.05.2025 Leader: Arda Members Involved: All Members Objectives: Write research paper ready for publishing Tasks: Same as WP 0 & 1 Task 1.1 Get guidance from supervisor Task 1.2 Write paper Task 1.3 Publish paper
Deliverables None

Work Packet #10: Frontend Start Date: 01.01.2025 End Data: 01.05.2025 Leader: Shayan Members Involved: Shayan, Arda Objectives: Develop a frontend for the backend interface. Tasks: Task 1.1 Identify tools to use Task 1.2 Design a UI Task 1.3 Connect to backend
Deliverables None

Gantt Chart



4.4. Ensuring Proper Teamwork

Each member of the group is required to attend weekly meetings and actively participate in the project development lifecycle and decision-making process. It is essential that each member conducts research related to their specific tasks, seeking guidance from both their peers and the supervisor when needed. The division of work should reflect each member's interests and skills, ensuring that responsibilities are distributed fairly and equitably across the team. Collaboration and mutual support among members will be crucial for the successful completion of the project.

4.5. Ethics and Professional Responsibilities

All software frameworks and libraries used must be properly acknowledged in accordance with their respective license requirements. Weekly meetings with the team and supervisor will be scheduled preferably on Fridays, either in person or virtually. These meetings are intended not only for collaboration and guidance but also to uphold high ethical standards and prevent any form of intellectual dishonesty. It is important that every member contributes responsibly and avoids any form of cheating or plagiarism.

4.6. Planning for New Knowledge and Learning Strategies

Planning for new knowledge acquisition and learning strategies requires a multifaceted approach to ensure a comprehensive understanding of the subject. A key method is reading research papers, which provides insights into the latest advancements and methodologies in the field. By critically analyzing these papers, one can identify gaps in existing knowledge and adapt these findings to personal projects. Additionally, consulting experts at Hacettepe Hospital will offer a practical perspective, especially for projects requiring real-world medical insights, such as those involving healthcare applications or medical data analysis. Their expertise can bridge the gap between theoretical knowledge and practical implementation.

Collaboration with professors, particularly those specializing in machine learning (ML) development, is another essential strategy. Professors can guide the learning process, offer constructive feedback, and suggest advanced resources or techniques tailored to specific goals. Moreover, experiential learning—by actively engaging in projects, experiments, or case studies—reinforces theoretical knowledge and builds problem-solving skills. Supplementing these strategies with other types of research, such as participating in workshops, attending conferences, or joining online forums, fosters a well-rounded and dynamic learning experience. Combining these approaches ensures the development of deep expertise and the ability to adapt to evolving challenges.

To build the necessary technical expertise, our team will adopt a structured approach to learning based on the project's requirements. Some members will enroll in courses tailored to their specific tasks. For example, team members focusing on the 3D modeling aspect will take *Graphics I* to gain proficiency in WebGL, enabling the creation of dynamic and interactive visualizations. Meanwhile, others will take Computer Vision courses to strengthen their understanding of machine learning (ML) concepts and techniques relevant to our project. Our technical workflow includes leveraging GitHub to track progress and maintain version control. We will write and train ML models in Jupyter Notebooks, ensuring clear documentation and collaboration. For the backend, we plan to utilize Orthanc for file storage, implement a RESTful API in Go (a new skill we will acquire), and use SQL for database management.

To ensure a robust ML implementation, we will experiment with both U-Net and CNN architectures to determine which performs best for our goals before refining the selected model. Additionally, we aim to develop expertise in lesion identification and segmentation to enhance the medical imaging component of the project. By integrating these specialized learning paths with collaborative tools and a rigorous testing approach, we aim to equip our team with the skills and knowledge required for a successful project outcome.

5. References

[1] J. Herington *et al.*, “Ethical Considerations for Artificial intelligence in Medical Imaging: Deployment and governance,” *Journal of Nuclear Medicine*, vol. 64, no. 10, pp. 1509–1515, Aug. 2023, doi: 10.2967/jnumed.123.266110. [Accessed: Dec. 15, 2024].