Mini Project Report On

OrthoVision AI

Submitted in partial fulfillment of the requirements for the award of the degree of

Bachelor of Technology

in

Computer Science & Engineering

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CERTIFICATE

This is to certify that the mini project report entitled ***"OrthoVision AI"*** *is a bonafide record of the work done by* ***George Bibu (U2103094)****,* ***Jenil Biju (U2103109)****,* ***Justin George Soney (U2103120)****,* ***Kevin Benny Thukkuparambil (U2103125)****, submitted to the APJ Abdul Kalam Technological University in partial fulfillment of the requirements for the award of the degree of Bachelor of Technology (B. Tech.) in Computer Science and Engineering during the academic year 2023-2024.*

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Abstract

The human skeletal system's pivotal role in bodily movement shows the significance of timely and accurate fracture diagnosis. Traditional manual methods, reliant on X-ray imaging, necessitate automation to address potential errors. Leveraging the effectiveness of Deep Neural Networks (DNNs), this project aims to develop a tailored model for bone fracture classification and location in the arm. Augmentation techniques, including rotation, flipping, zooming, and shearing, are applied to the dataset to enhance the DNN's robustness and mitigate overfitting. The model architecture incorporates multiple convolutional layers and max-pooling layers to extract intricate features and manage computational complexity. The integration of advanced deep learning with augmentation strategies aims to enhance diagnostic accuracy and streamline clinical workflows, ultimately improving patient care and treatment outcomes. The proposed model is implemented as a web application where users can log in, upload X-ray images along with relevant details, and receive predictions on fracture presence and location. The web application not only serves as a diagnostic tool but also offers suggestions on specialists and hospital locations based on predictions, providing a comprehensive solution for automated fracture detection in the arm.

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Acronym - Expansion

Chapter 1

Introduction

1.1 Background

About 6.8 million fractures occur annually in India according to a study published in the Indian Journal of Orthopaedics. Thus medical imaging plays a crucial role in diagnosing various conditions including bone fractures.OrthoVision AI aims to develop an automated fracture detection system which utilizes deep learning algorithms to assist healthcare professionals in identifying bone fractures in X-ray images.

The automated detection system can provide preliminary assessments of X-ray images, helping clinicians prioritize cases and make timely treatment decisions. This can lead to more efficient utilization of healthcare resources. Hospitals and healthcare systems can use the insights provided by the system to optimize staffing, equipment allocation, and patient flow, ultimately improving healthcare delivery and resource management.

1.2 Problem Definition

OrthoVision AI aims to develop an automated fracture detection system for the arm using a Deep Neural Network (DNN). This system will analyze X-ray images to detect and locate fractures, and then classify them.

1.3 Scope and Motivation

1.3.1 Scope

Our project aims to develop an automated bone fracture detection system using deep learning techniques, specifically focusing on fractures in the arm region. The system will utilize convolutional neural networks (CNNs) to analyze X-ray images and identify the presence and location of fractures. Additionally, the scope of the project includes building a user-friendly web application where clinicians can upload X-ray images for automated fracture detection. The system will provide accurate and timely results, assisting healthcare professionals in diagnosing bone fractures and making informed treatment decisions.

1.3.2 Motivation

The motivation behind our project stems from the critical need for accurate and efficient diagnosis of bone fractures, which are prevalent injuries worldwide. Manual interpretation of X-ray images is time-consuming and prone to human error, leading to delays in treatment and potential misdiagnoses. By automating the fracture detection process using deep learning algorithms, we aim to streamline the diagnostic workflow, enabling faster and more accurate identification of fractures. Ultimately, our project seeks to enhance patient care by providing clinicians with a reliable tool for early detection and treatment planning of bone fractures, leading to improved treatment outcomes and reduced healthcare costs

1.4 Objectives

1. Develop a deep learning model for automated bone fracture detection in X-ray images.

2. Implement preprocessing techniques to enhance the quality and suitability of input images for model training.

3. Design a user-friendly web application interface for clinicians to upload X-ray images and receive automated fracture detection results.

4. Train the model using a labeled dataset of X-ray images containing various types of bone fractures.

5. Evaluate the performance of the developed model using standard evaluation metrics such as accuracy, precision, recall, and F1 score.

6. Deploy the automated fracture detection system in a real-world clinical setting for testing and validation.

1.5 Challenges

This project faces several challenges, including obtaining a sufficiently large and diverse dataset of arm X-ray images with accurate annotations, optimizing the deep learning model for robust performance across various fracture types, and ensuring the efficient deployment of the automated fracture detection system in real-world clinical settings.

1.6 Assumptions

The project assumes access to a sufficient quantity of high-quality labeled X-ray images for training the deep learning model, availability of computational resources for model training and evaluation, and cooperation from medical professionals for testing and validation of the automated fracture detection system.

1.7 Societal / Industrial Relevance

The automated bone fracture detection system developed in this project holds significant societal and industrial relevance. It can greatly benefit the healthcare industry by improving the efficiency and accuracy of fracture diagnosis, leading to better patient outcomes and reduced healthcare costs. Additionally, it has the potential to positively impact society by enhancing access to timely and accurate medical care for individuals with bone fractures.

1.8 Organization of the Report

The report is structured as follows:

1. **Chapter 1 - Introduction:** Provides background, objectives, and challenges of the project.

2. **Chapter 2 - Software Requirements Specification:** Describes the project's overall description, including system features and nonfunctional requirements.

3. **Chapter 3 - System Architecture and Design:** Presents the project's architecture, user interfaces, and implementation strategies.

Chapter 2

Software Requirements Specification

2.1 Introduction

2.1.1 Purpose

This Software Requirements Specification (SRS) document outlines the requirements for the software associated with "OrthoVision AI," version 1.0. The scope of this document encompasses the entire OrthoVision AI system, covering the automated fracture detection software, its interfaces, and key functionalities. It outlines the essential specifications to guide the development of a robust and efficient software for OrthoVision AI, focusing on automated fracture detection and related features.

2.1.2 Product Scope

The specified software, OrthoVision AI, is designed to revolutionize medical imaging by automating fracture detection in X-ray images. Its primary purpose is to enhance diagnostic accuracy, streamline clinical workflows, and improve patient care outcomes. The software aims to provide healthcare professionals with a reliable tool for efficient and timely fracture identification, aligning with the broader corporate goal of advancing medical technology and fostering innovation in healthcare.

2.2 Overall Description

2.2.1 Product Perspective

The product that is to be developed in this project focuses on developing an automated fracture detection system for the arm using Deep Neural Networks (DNNs). The motivation behind this initiative is to improve the accuracy and efficiency of fracture diagnosis, considering the pivotal role of the human skeletal system in bodily movement. Traditional methods relying on manual inspection of X-ray images are prone to errors, prompting the need for automation.

2.2.2 Product Functions

1. Automated Fracture Detection: Utilizes a Deep Neural Network (DNN) model to automatically detect and classify fractures in X-ray images of the arm.

2. Location Identification: Determines the location of the identified fractures within the arm, providing detailed information for diagnostic purposes.

3. Dataset Augmentation: Applies augmentation techniques, including rotation, flipping, zooming, and shearing, to the dataset. This enhances the DNN's robustness and helps mitigate overfitting

4. Model Architecture: Incorporates multiple convolutional layers and max-pooling layers in the DNN model architecture to extract intricate features from X-ray images, managing computational complexity.

5. Web Application Interface: Implements the model as a user-friendly web application where clinicians can log in, upload X-ray images, and input relevant details for automated fracture predictions.

6. Comprehensive Diagnostic Tool: Beyond fracture detection, the web application offers suggestions on specialists and hospital locations based on predictions, providing a holistic solution for clinicians and potentially improving patient care and treatment outcome

7. Integration of Deep Learning: Integrates advanced deep learning techniques to improve diagnostic accuracy, leveraging the power of DNNs for feature extraction and pattern recognition in X-ray image

8. Streamlined Clinical Workflows: Aims to streamline clinical workflows by providing an automated and efficient tool for fracture detection, ultimately contributing to improved patient care and treatment outcomes

2.2.3 Operating System

Hardware Platform: The software should be compatible with standard computing hardware commonly used in medical facilities or diagnostic centers. It requires sufficient processing power to handle the computational demands of Deep Neural Networks (DNNs) during training and inference. A system with dedicated graphics processing units (GPUs) might be beneficial to accelerate the deep learning computations.

Operating System: The software is developed to be compatible with various operating systems commonly found in medical and clinical environments. Compatibility with both Windows and Linux operating systems is essential to cater to the diverse IT infrastructure in healthcare settings.

Deep Learning Framework: The software relies on a specific deep learning framework for the implementation of the DNN model. Popular frameworks like TensorFlow or PyTorch may be used. Compatibility with the version of the chosen deep learning framework is crucial to ensure proper execution.

Web Application Framework: The web application component of the software is built on the Django framework. Compatibility with the web framework and its version is essential for the proper functioning of the user interface.

Web Browser Compatibility: The web application should be compatible with standard web browsers such as Google Chrome, Mozilla Firefox, and Safari to ensure accessibility for users.

2.2.4 Design and Implementation Constraints

Regulatory Policies: Compliance with healthcare and medical imaging regulations may impose restrictions on data storage, sharing, and security. Standards specified by the NMC (National Medical Commission) must be adhered to.

Hardware Limitations: The choice of hardware may be limited by budget constraints or the availability of specific processing units suitable for deep learning tasks. Memory requirements, especially for handling large datasets and model parameters, could also pose limitations.

Interfaces to Other Applications: Integration with existing hospital systems, Electronic Health Records (EHRs), or Picture Archiving and Communication Systems (PACS) may be constrained by the APIs and compatibility provided by those systems.

Ethical Considerations: The use of AI in medical applications raises ethical concerns. Ethical guidelines, especially when dealing with sensitive health data and decisions affecting patient care must be considered.

2.2.5 Assumption and Dependencies

Availability of Labeled Dataset:

An assumption might be made about the availability of a sufficiently large and well-labeled dataset for training the fracture detection model. If such a dataset is not accessible or lacks quality labels, it could impact the model's effectiveness.

Consistent and Standardized X-ray Imaging:

The effectiveness of the fracture detection system assumes consistent and standardized X-ray imaging procedures across different healthcare facilities. Variations in imaging techniques or equipment may affect the model's performance.

Stability of Deep Learning Frameworks:

The project assumes the stability and reliability of the chosen deep learning framework (e.g., TensorFlow or PyTorch). Changes, updates, or discontinuation of the framework may introduce compatibility issues or require modifications to the code.

Web Application Compatibility:

The web application assumes compatibility with standard web browsers and common user devices. Changes in browser standards or device specifications could affect the application's user experience.

2.3 External Interface Requirements

2.3.1 User Interfaces

The web application interface shall include a user login screen with fields for username and password. Upon successful login, users will be directed to a dashboard displaying options to upload X-ray images and relevant patient details. The GUI shall adhere to standard design principles and may follow product family style guides for consistency.

Error messages will be displayed in a clear and concise manner, providing guidance to users in case of invalid inputs or system errors.

2.3.2 Hardware Interfaces

The software shall be compatible with various hardware components commonly used for image processing, including X-ray scanners and digital imaging devices. Physical characteristics such as supported device types and data interaction protocols will be documented in the system's technical specifications.

2.3.3 Software Interfaces

The software shall integrate with specific software components, including deep learning libraries such as Tensor Flow or PyTorch for model development and training. Data sharing between software components shall occur through defined APIs, specifying the format and purpose of incoming and outgoing data.
Communication with databases storing patient information and image data will be established using standard database connectivity protocols. Integration with external services for specialist recommendations and hospital location Suggestions will be documented, including the nature of data exchange and communication protocols.

2.3.4 Communications Interfaces

The web application shall support communication over standard web protocols such as HTTP and HTTPS. Message formatting for data transfer shall adhere to industry standards to ensure compatibility with different web browsers and servers. Communication security measures, including encryption of sensitive data during transmission, will be implemented to protect user privacy and confidentiality. Data transfer rates and synchronization mechanisms will be optimized to ensure efficient performance, especially during image upload and prediction retrieval processes.

2.4 System Features

2.4.1 Fracture Detection

Description and Priority

This feature aims to detect fractures in uploaded X-ray images of the arm. It is of high priority as it forms the core functionality of the system.

Stimulus/Response Sequences

Stimulus: User uploads an X-ray image of the arm.
Response: System accepts the image and passes it to the fracture detection model.
Stimulus: Fracture detection model processes the image.
Response: The system Classifies the image as a fractured or healthy and localizes the fracture if it is present.

2.4.2 Functional Requirements

REQ-1: The website shall have an interface for users to upload X-ray images with a Minimum size requirement. If the user inputs an image of low resolution the website will respond with a notification stating the input image is of low resolution.
REQ-2: Uploaded images shall undergo preprocessing, including resizing and normalization after which it is handed over to the model to accurately detect.
REQ-3: The Website will give the result to the user if a fracture is detected with the location indicated by a box.

2.4.3 User Authentication

Description and Priority

We need a user authentication and access control to ensure secure access to the system. It is of high priority to safeguard sensitive patient medical data.

Stimulus/Response Sequences

Stimulus: User attempts to log in.
Response: System verifies user credentials against a stored set of information in the

database.

Response: Users are granted access if the credentials are valid and taken to the main page.

Response: Users are denied access if the credentials are invalid and an error message displayed.

Functional Requirements

REQ-4: The website shall provide user registration and login functionality.

REQ-5: Username and passwords shall be securely stored.

2.5 Other Nonfunctional Requirements

2.5.1 Performance Requirements

The Automated Fracture Detection System is expected to process X-ray images efficiently, delivering fracture detection results within 10 seconds under normal operating conditions. In real-time scenarios, the system must maintain a consistent processing time for fracture detection to ensure timely clinical decision-making.

2.5.2 Safety Requirements

The Automated Fracture Detection System prioritizes user safety by delivering clear and unambiguous results, preventing misinterpretation by healthcare professionals. It operates seamlessly without interference with existing medical equipment, includes safeguards for challenging cases, and implements fail-safes to prevent data loss. Compliance with relevant safety standards ensures the system's adherence to established safety protocols in the medical domain.

2.5.3 Security Requirements

Ensuring secure user access, the system requires users to undergo secure authentication using valid login credentials. Patient data, including X-ray images and diagnostic results, must be stored securely with encryption protocols to protect against unauthorized access.

The system must comply with privacy and security standards, such as HIPAA, to ensure the confidentiality and integrity of patient information.

2.5.4 Software Quality Attributes

Usability is a critical aspect of the system's design. The user interface should adhere to established usability principles, allowing healthcare professionals to interpret results intuitively. The software should also provide clear error messages and guidance to users in case of unexpected events. Demonstrating high reliability, the Automated Fracture Detection System aims to minimize occurrences of false positives or false negatives in fracture detection. To facilitate maintenance, the software is designed with modularity, enabling updates, bug fixes, and the integration of new features without significant disruption. Supporting interoperability with standard medical imaging formats, the system seamlessly integrates into existing hospital management systems. Lastly, the software showcases robust performance by gracefully handling variations in X-ray image quality and diverse fracture patterns.

Chapter 3

System Architecture and Design

3.1 System Overview

The project will be an automated system for bone fracture detection and classification in arm X-ray images. Labeled datasets from reliable medical sources are first acquired, followed by preprocessing the images for consistency (resizing, normalization) and potential quality improvement (augmentation). A deep learning model based on Convolutional Neural Networks (CNNs) is then trained on this data, learning to identify and classify fractures. The model's performance is evaluated using separate datasets and metrics like accuracy, precision, recall, and F1 score.

3.2 Architectural Design

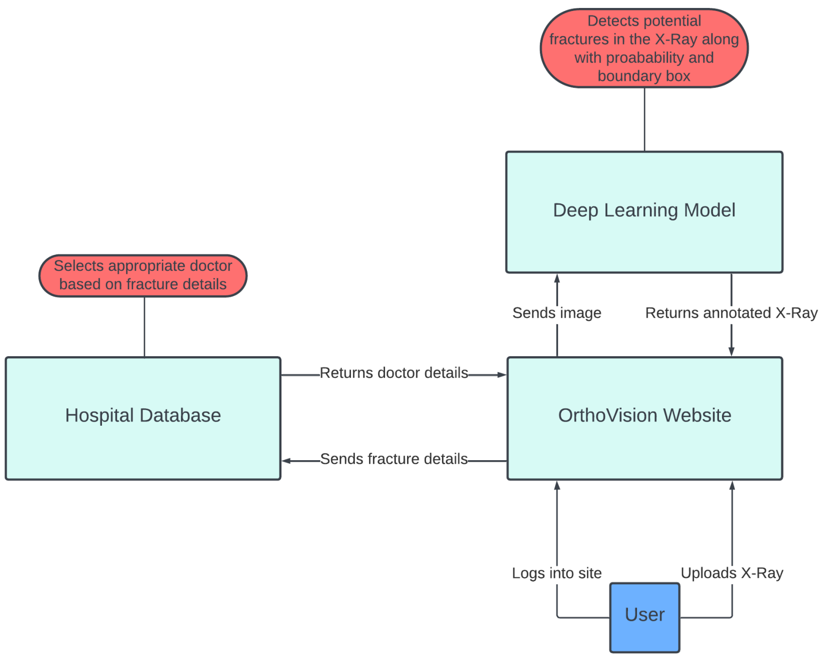

Figure 3.1: Architecture Diagram of the Project

Upon accessing the system, the system displays a login page to the user. The user can either log in to the website using a valid combination of username and password or can sign up for the first time by providing a new username and password along with their email ID. Username and password validity are checked against the user database; if the details are valid, the user is sent to the main page of the website. Otherwise, the user is shown an error message and sent back to the login page. On the main page, users can upload an image of their X-Ray so it can be analyzed for potential fractures. Image resolution must be greater than 640x640 pixels. If the image meets these requirements, it is sent to the YOLO model for analysis. Otherwise, an error message is displayed to the user, and the user remains on the main page. The model analyzes the X-Ray for potential fractures and returns an annotated image with bounding boxes around the regions that have the highest probability of having a fracture, along with the class of the potential fracture detected back to the user. The system then cross-references the identified fracture class with the hospital database to ascertain medical professionals specializing in the pertinent region, and subsequently provides the user with pertinent details of these specialists.

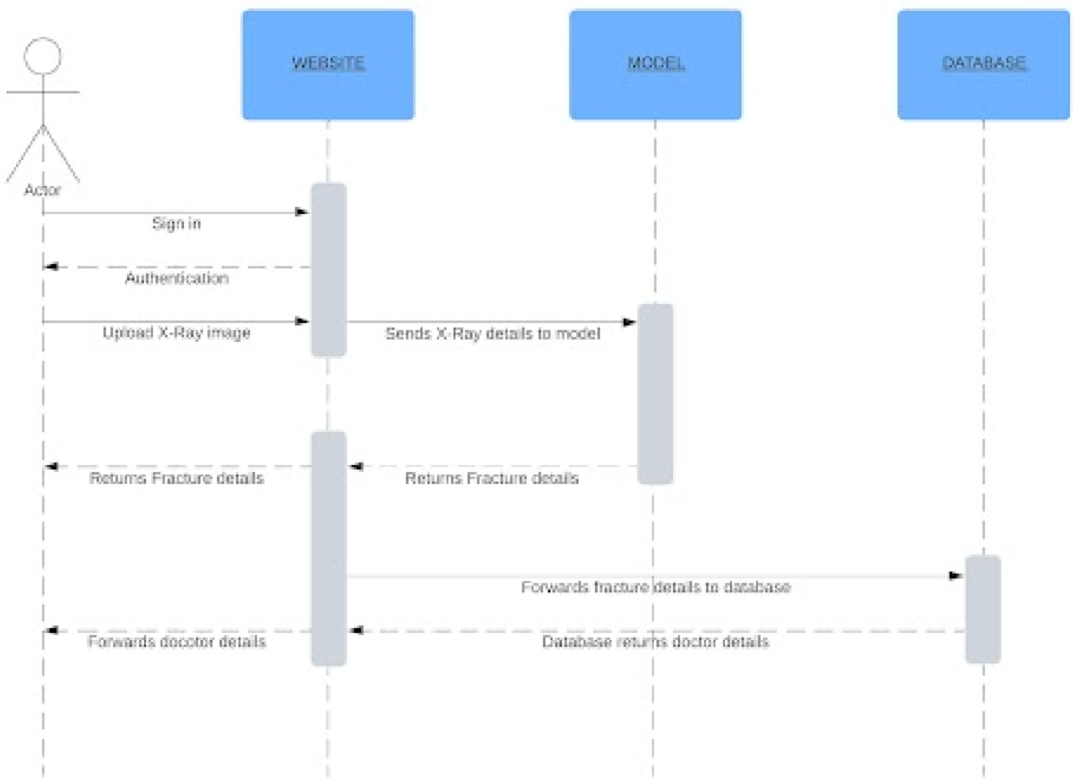

Figure 3.2: Sequence Diagram of the Project

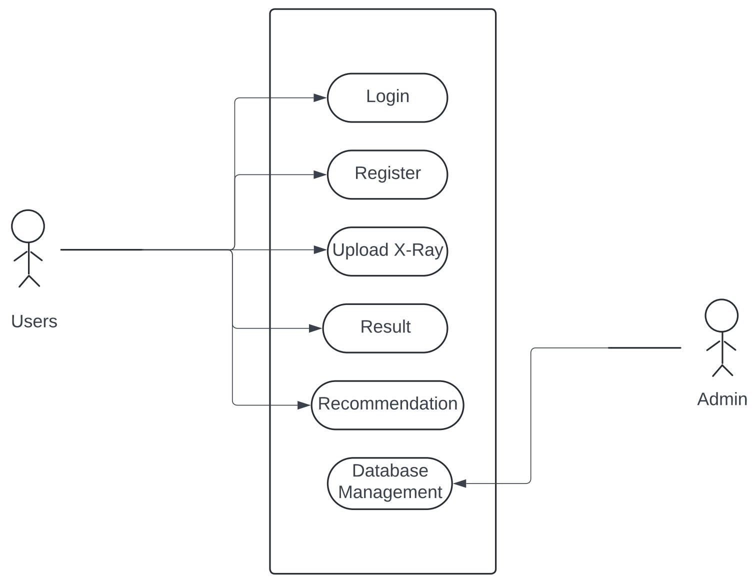

Figure 3.3: Use Case Diagram

3.3 Dataset identified

The training dataset comprises X-Ray images depicting different segments of the human arm. These images exhibit a variety of conditions, including instances with fractures as well as those without. To facilitate the training process of our model, each image in the dataset is accompanied by a set of labels. These labels are structured to include a class number assigned within the range of 0 to 6, with each number signifying a distinct type of fracture.

Moreover, for images depicting fractures, the labels provide additional information crucial for localization. Specifically, these labels encompass a series of coordinate values corresponding to the bounding box delineating the exact location of the fracture within the image. These coordinates include the x position, y-position, x-width, and y-width dimensions, offering precise spatial information essential for training the model to accurately identify and localize fractures within the X-Ray images of the arm.

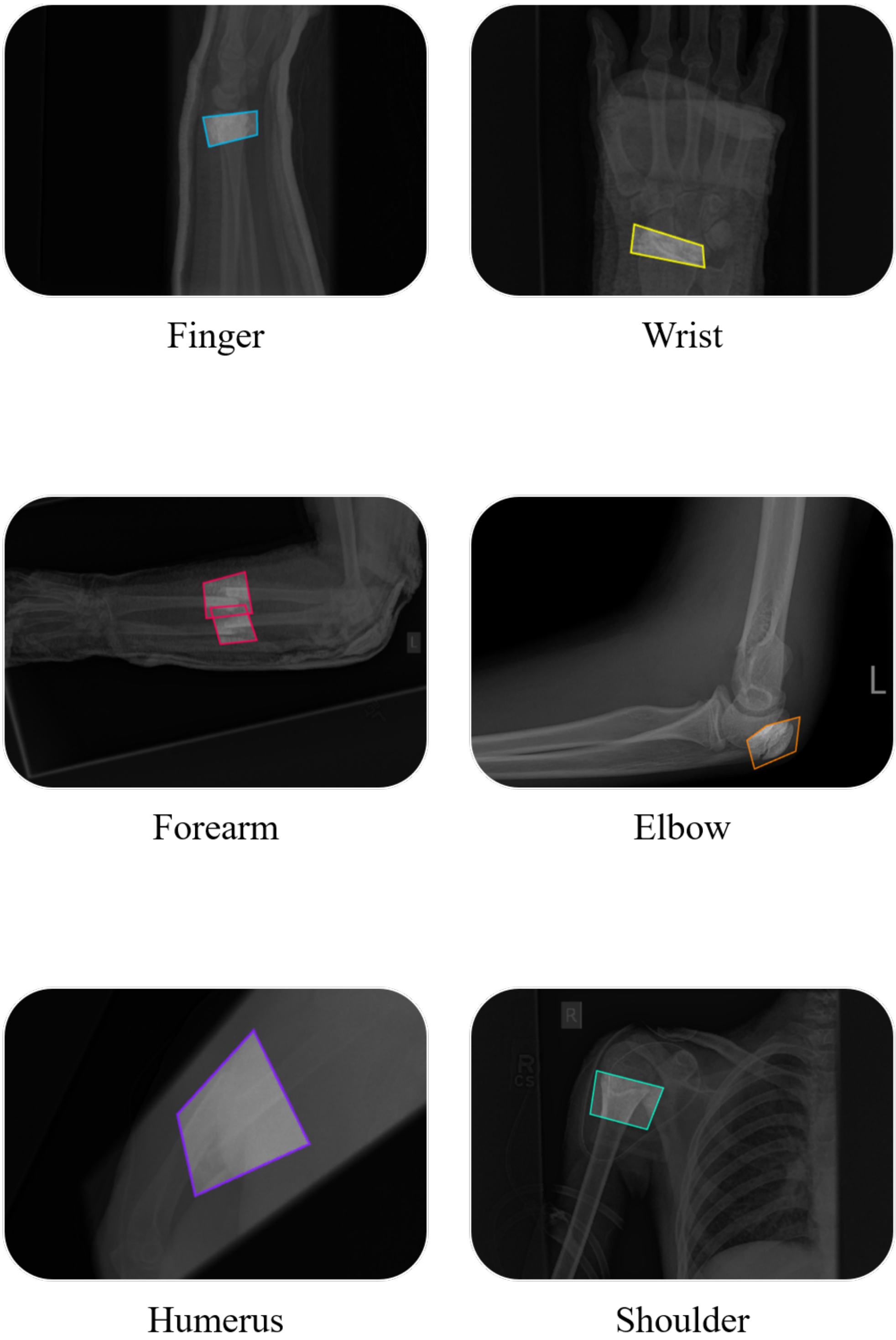

Figure 3.4: Example images of different classes of fractures with bounding boxes

3.4 Proposed Methodology/Algorithms

1. User Authentication
2. Prompt the user to enter their username and password
3. Verify the credentials against the database
4. If the credentials are valid, proceed to step 10
5. If the login credentials are invalid show error and direct the user to registration page
6. New user registration:
7. Prompt user to enter a username and password.
8. Direct user to the main page of the website which will present the user with an interface to upload the image of an X-Ray.
9. If the resolution of the image is too low the user is given an error message and redirected to step 9.
10. If the image is accepted it is sent to the model to make a prediction and user is taken to the result page.
11. The result page will have the uploaded image with annotation box if a fracture is detected, or else no box will be present.
12. The result page contains information of doctors and hospitals for treatment.
13. The result page contains a home button with which a user can be redirected to step 8 for another image upload.

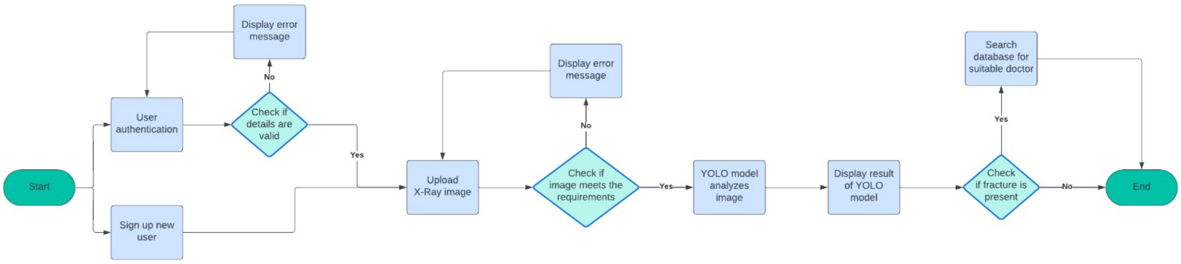

Figure 3.5: Algorithm Flowchart

3.5 User Interface Design

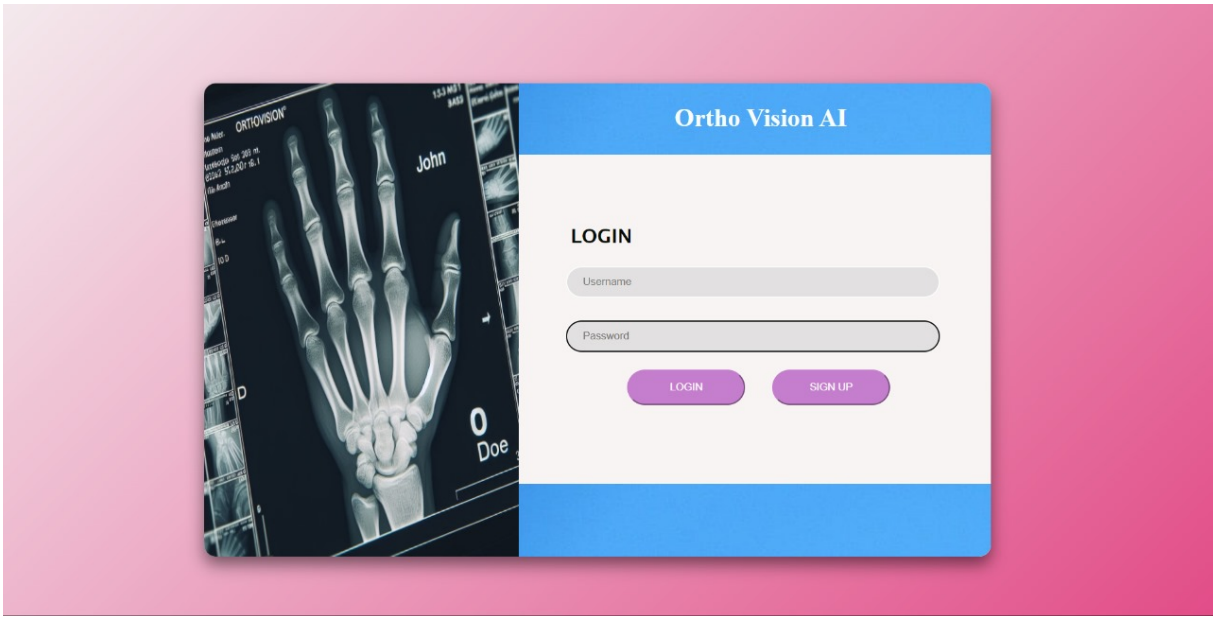

Figure 3.6: Login Page

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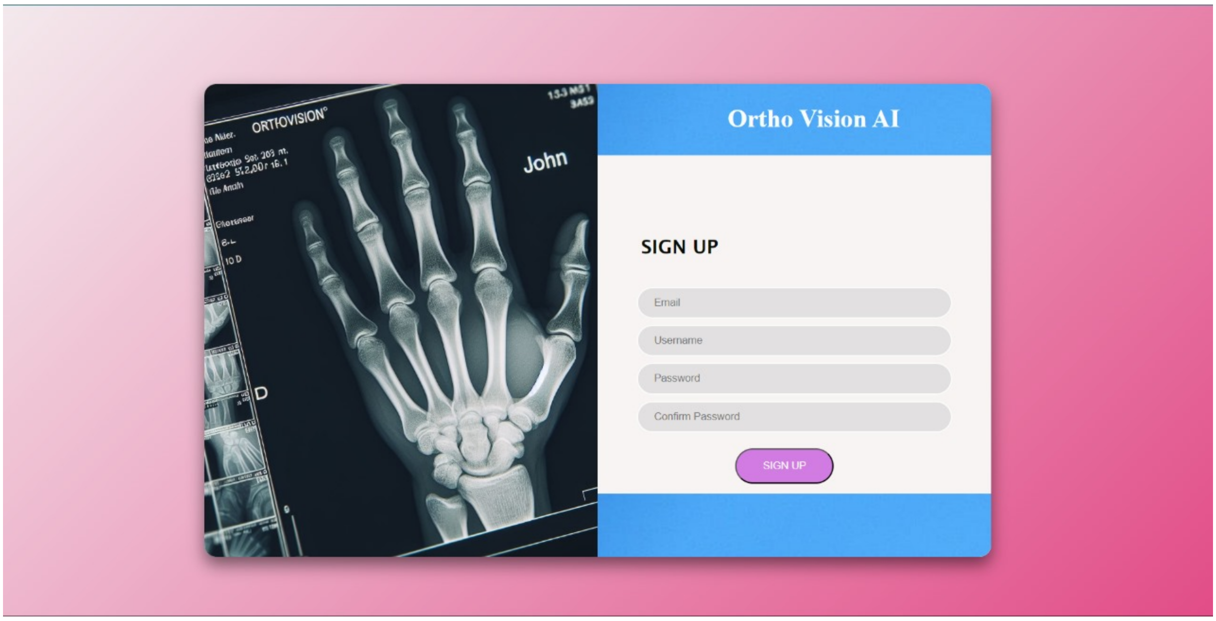

Figure 3.7: Sign-up Page

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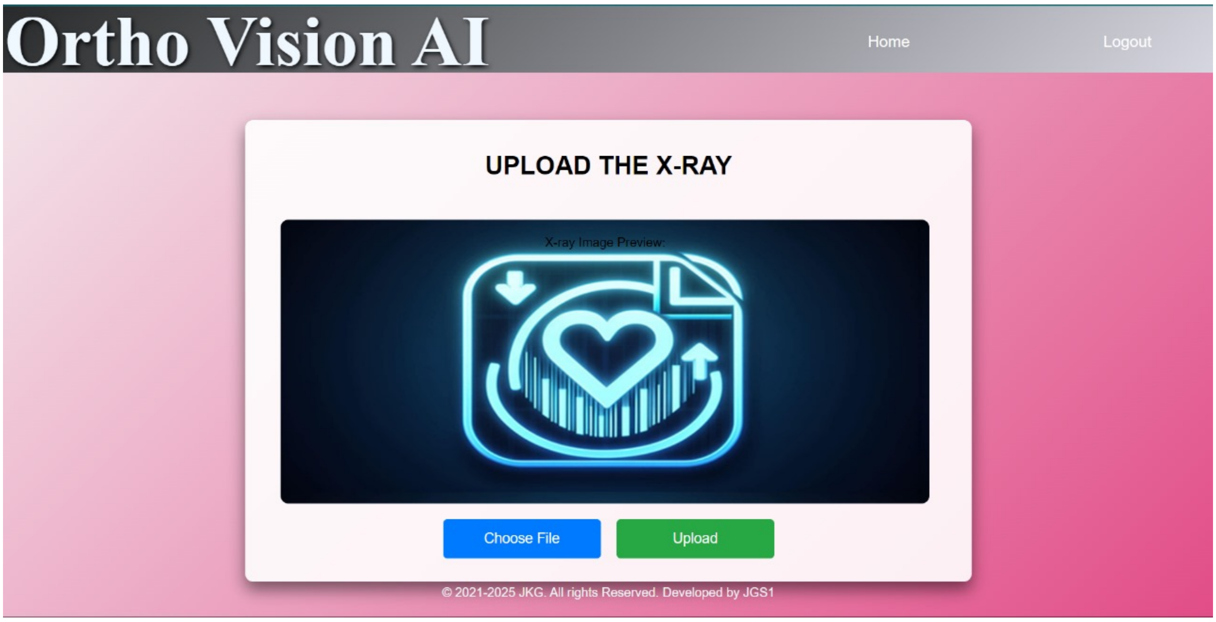

Figure 3.8: Uploading x-ray page

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3.6 Database Design

For this project, we employ Django, a powerful Python web framework renowned for its database management capabilities. In our implementation, we create a database to handle user information effectively.
Django's default database, SQLite, is selected due to its user-friendly nature and straightforward setup process. SQLite's simplicity and suitability for development purposes make it an excellent option for implementing the project.
The database schema design for managing login information and storing the details of doctors is given below:

Field	Data Type	Description
`userid`	`varchar PRIMARY KEY`	Unique identifier for each user
`username`	`varchar`	Username for login
`password`	`varchar`	Securely hashed password
`email`	`varchar`	User's email address for communication

Table 3.1: Users Table Schema

Field	Data Type	Description
`doctorid`	`varchar PRIMARY KEY`	Unique identifier for each doctor
`doctorname`	`varchar`	Name of the doctor
`hospital`	`varchar`	Hospital name
`rating`	`float`	Rating of the doctor out of 5
`speciality`	`varchar`	Speciality of the doctor

Table 3.2: Doctors Table Schema

3.7 Description of Implementation Strategies

In this project, several key implementation strategies are employed to achieve the objectives effectively. Firstly, for image processing and fracture detection tasks, the project utilizes the YOLO (You Only Look Once) model, a deep learning-based model. The implementation is facilitated through Python and deep learning frameworks PyTorch. By leveraging pre-trained YOLO models and fine-tuning them on specific datasets, the project aims to achieve accurate and efficient detection of fractures in arm X-ray images.

Secondly, the project incorporates Django which is a high-level Python web framework, for building the web application interface. Django's features include handling user authentication, file uploads, and data management streamline the development process.

Additionally, to evaluate the performance of the fracture detection model, various metrics such as precision and recall using TensorFlow Libraries. These help provide insights into the model's accuracy and help assess its effectiveness in clinical settings. Overall, by combining cutting-edge deep learning techniques with efficient web development frameworks, the project aims to deliver a solution for automated fracture detection in the arm.

The training code for annotating the images is given below:

Listing 3.1: Python training command

```
python train.py --workers 1 --device 0 --batch-size 8 --epochs 100 --img 640 640 --data data/custom_data.yaml --hyp data/hyp.scratch.custom.yaml --cfg cfg/training/yolov7-custom.yaml --name yolov7-custom --weights yolov7.pt
```

3.8 Module Division

The project is structured into three primary modules, each serving distinct functions within the system:

1. Deep Learning Model: The cornerstone of the project is the development and implementation of a deep learning model. This model is meticulously trained to discern potential fractures within X-ray images presented to it by users. Leveraging advanced machine learning techniques, the model analyzes the input images to identify regions indicative of fractures, thus enabling rapid and accurate detection.

2. Web Application: Integral to the user experience is a web-based interface, accessible via a website. Users engage with this platform by logging in and uploading their X-ray images for fracture detection. This module provides a user-friendly and intuitive means for individuals to interact with the system, facilitating seamless submission of images for analysis.

3. Recommendation System: Complementing the fracture detection functionality is a recommendation system designed to provide users with pertinent information regarding healthcare professionals. Upon identifying a fracture within an X-ray image, the system leverages a database to match the fracture type with suitable medical specialists. This module assists users by furnishing details of doctors proficient in treating specific fracture types, thereby facilitating informed decisions regarding healthcare provider selection.

Module 1: 2 group members, Module 2: 1 group member, Module 3: 1 group member

3.9 Work Schedule - Gantt Chart

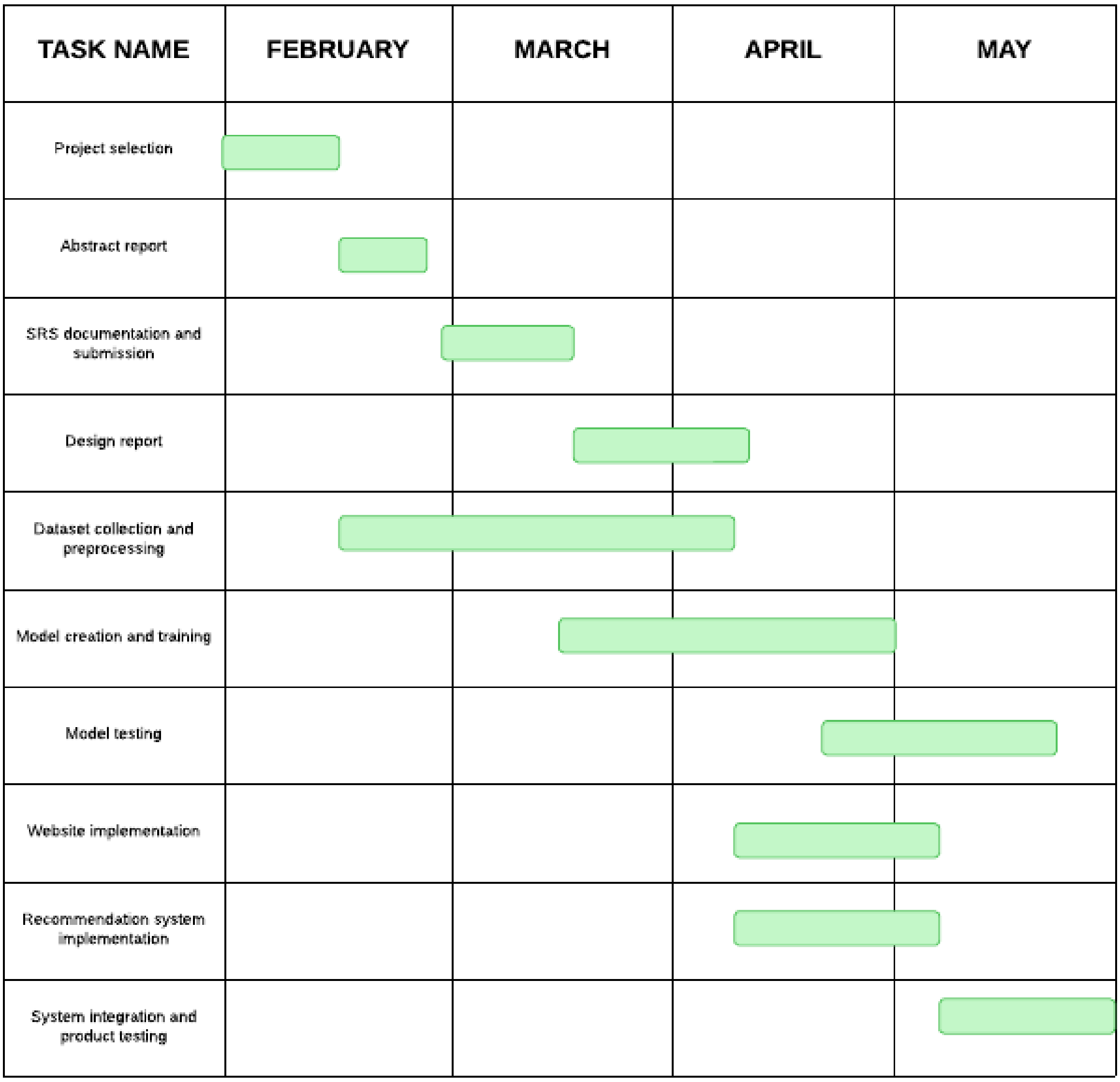

Figure 3.9: Work Schedule - Gantt Chart

Chapter 4

Results and Discussions

4.1 Overview

Users can sign up or log in to the website, OrthoVisionAi. They will be presented with the home page where an X-ray image can be uploaded. The uploaded image is then sent to the model for processing, and the model returns the result. If no fracture is detected by the model, the input image is displayed with the result "No fracture detected." If a fracture is detected by the model, it will return the annotated image with the fracture type and display it on the screen. If a fracture is detected, the result page will also have a list of recommended doctors for fracture treatment.

The dataset taken from Parisa Karimi Darabi has the following data:

Slno	**Class**	**No of Images**
0	Elbow	164
1	Finger	143
2	Forearm	285
3	Humerus	367
4	Shoulder	68
5	Wrist	154
Total		**1181**

Table 4.1: Image Distribution by Class

4.2 Testing

4.2.1 Login Page

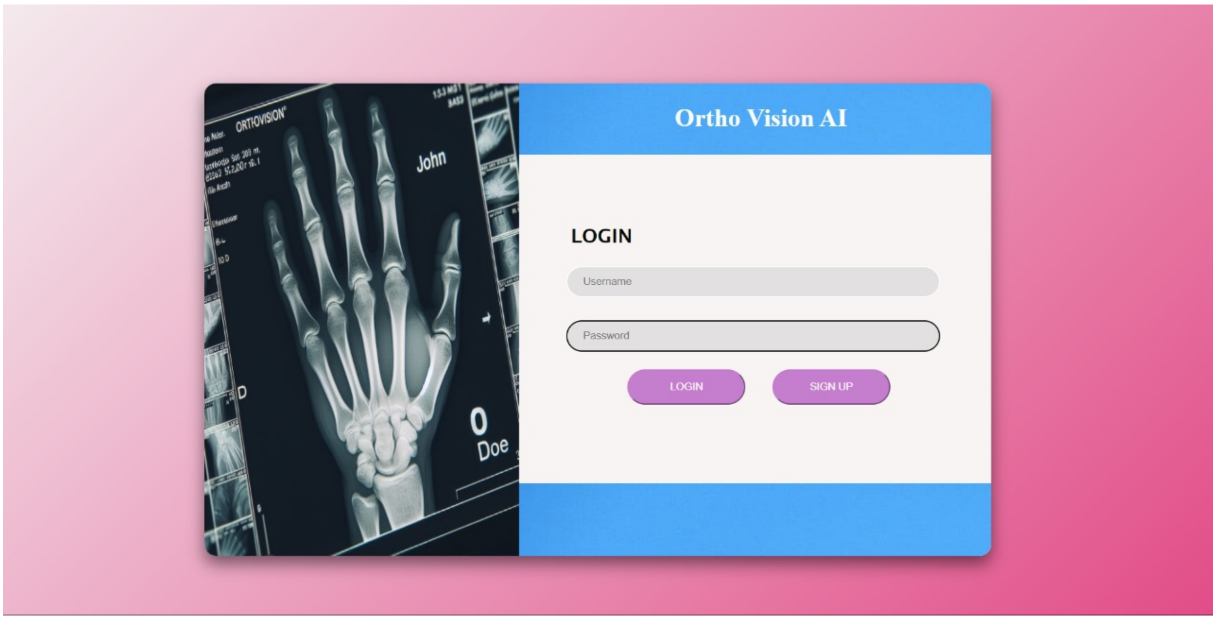

Figure 4.1: Login Page

4.2.2 Sign-up page

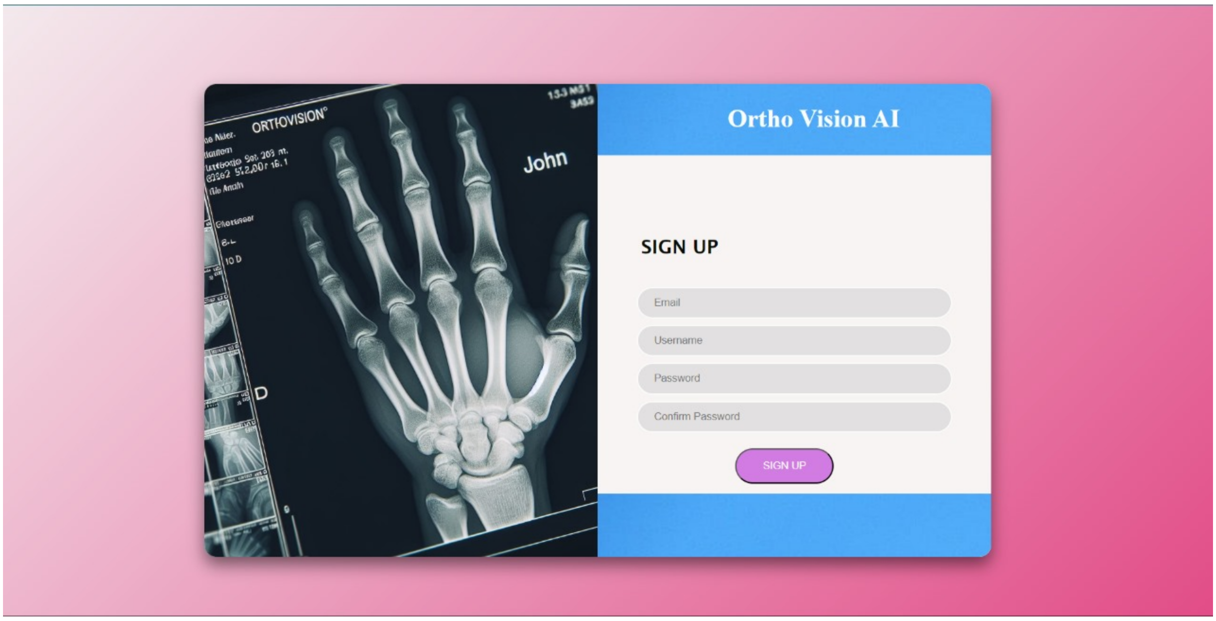

Figure 4.2: Sign-up Page

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4.2.3 Upload page

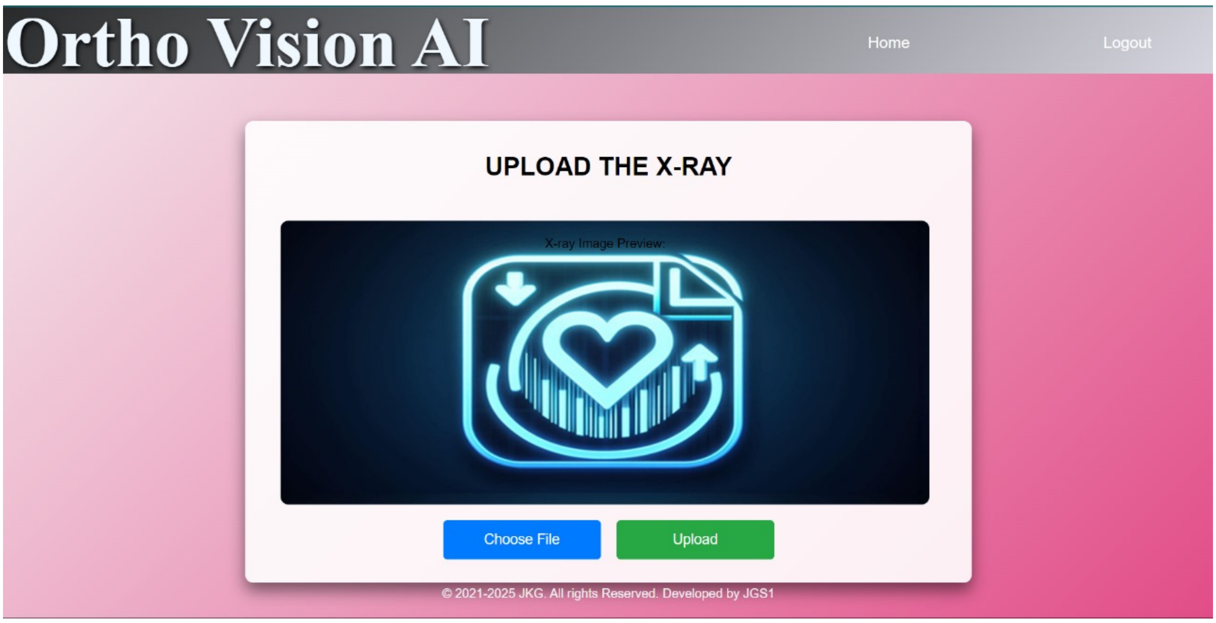

Figure 4.3: Uploading x-ray page

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4.2.4 Various fracture detection

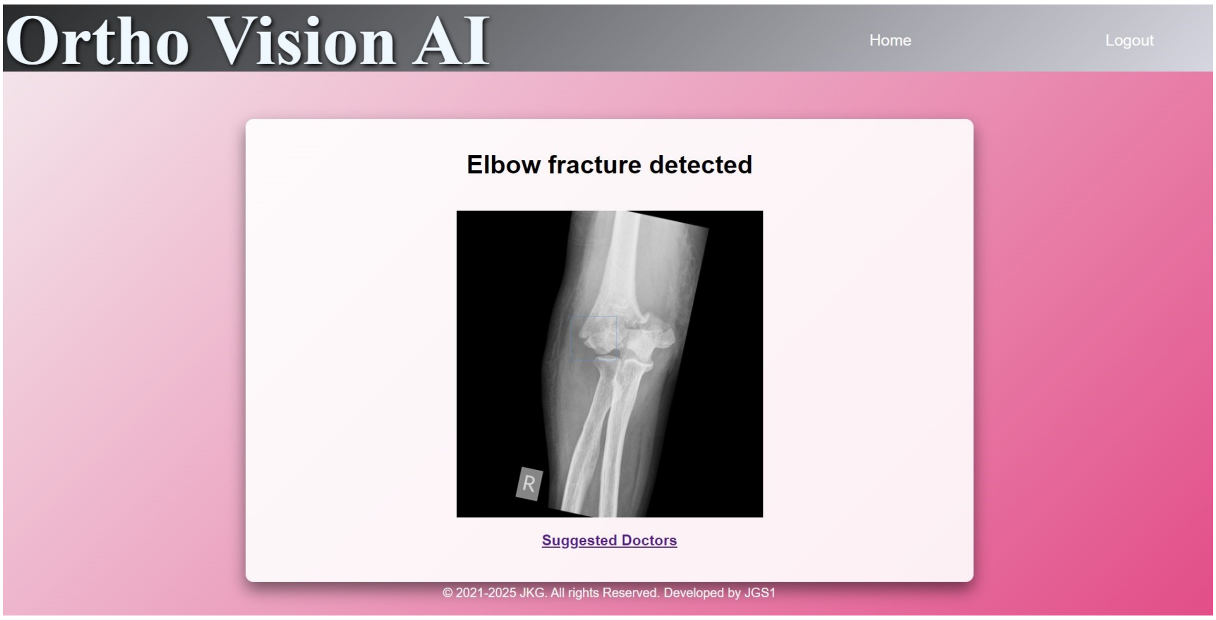

Figure 4.4: Elbow fracture

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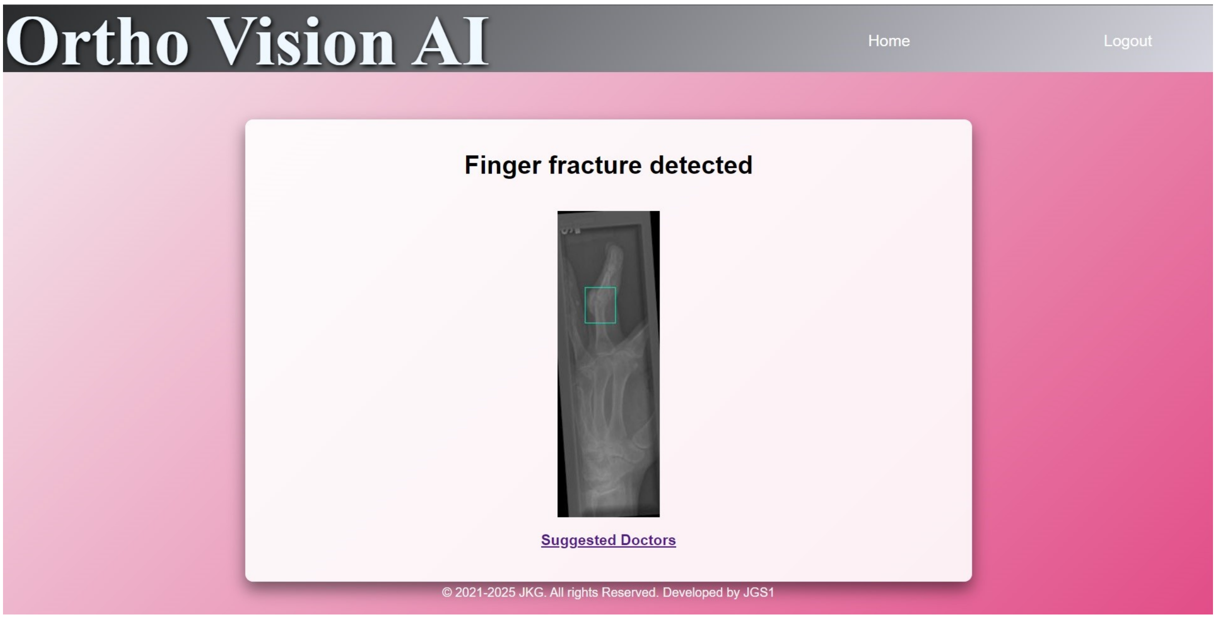

Figure 4.5: Finger fracture

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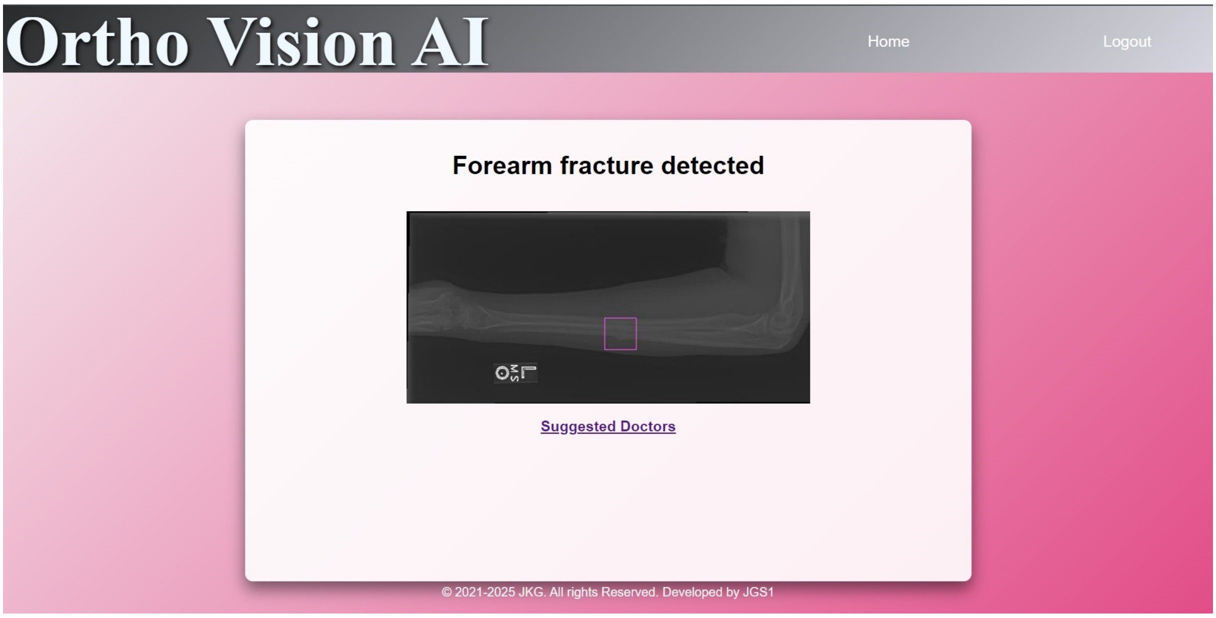

Figure 4.6: Forearm fracture

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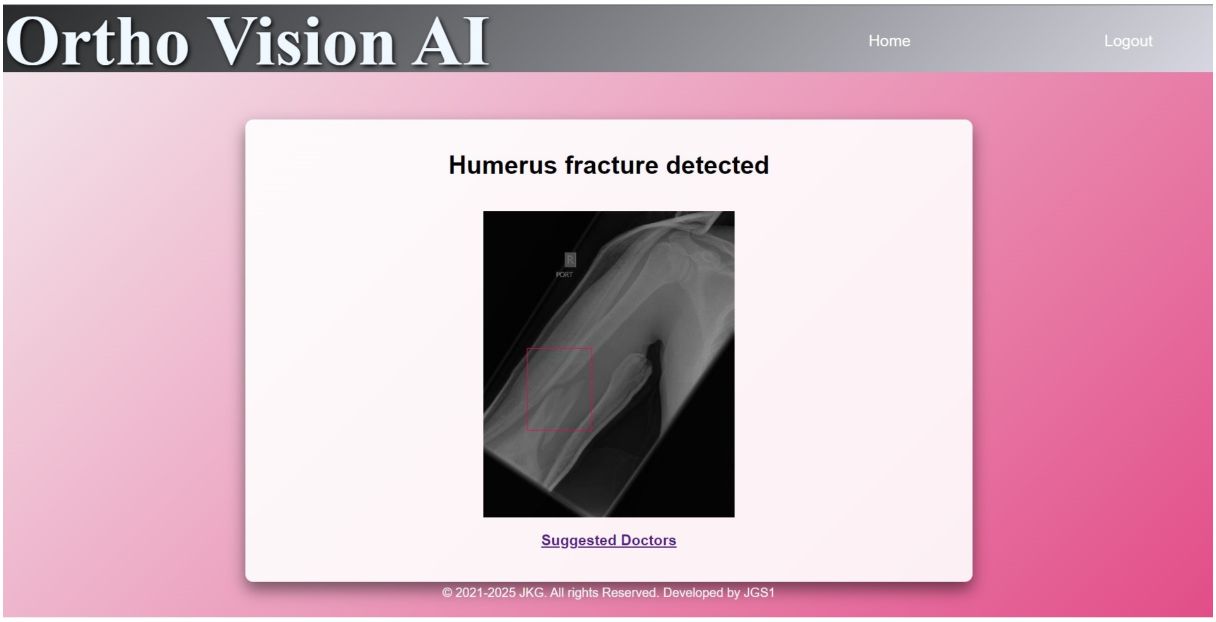

Figure 4.7: Humerus fracture

.

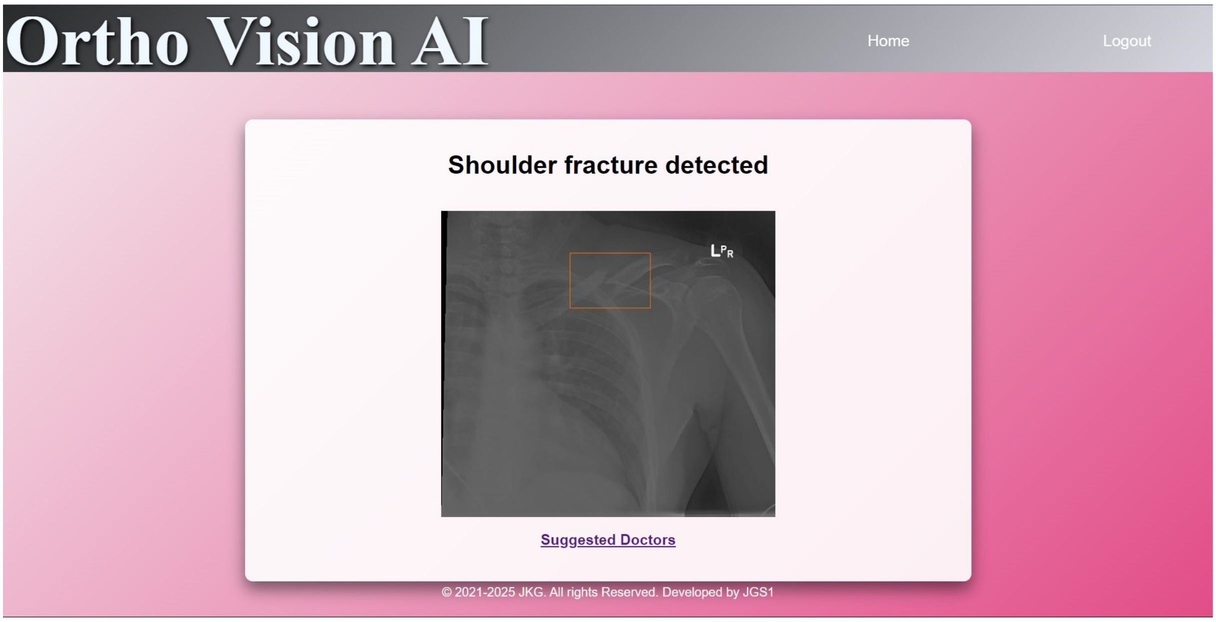

Figure 4.8: Shoulder fracture

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Figure 4.9: Wrist fracture

.

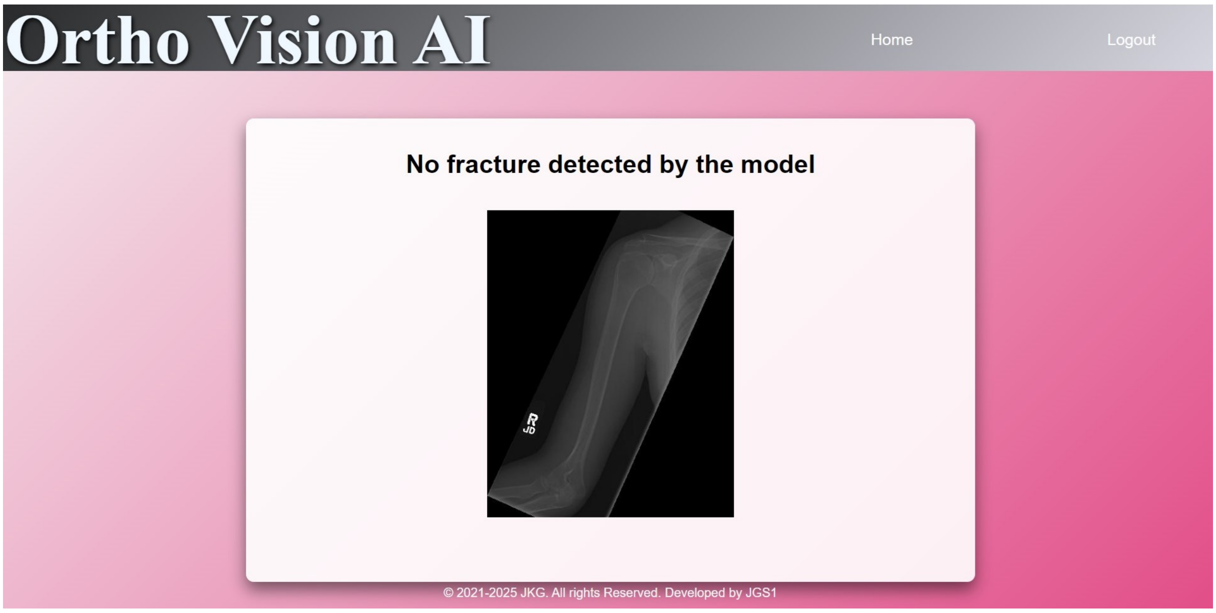

Figure 4.10: No fracture detected page

.

4.2.5 Recommendation page

Figure 4.11: Recommendation page

.

4.3 Quantitative Results

4.3.1 Confusion Matrix

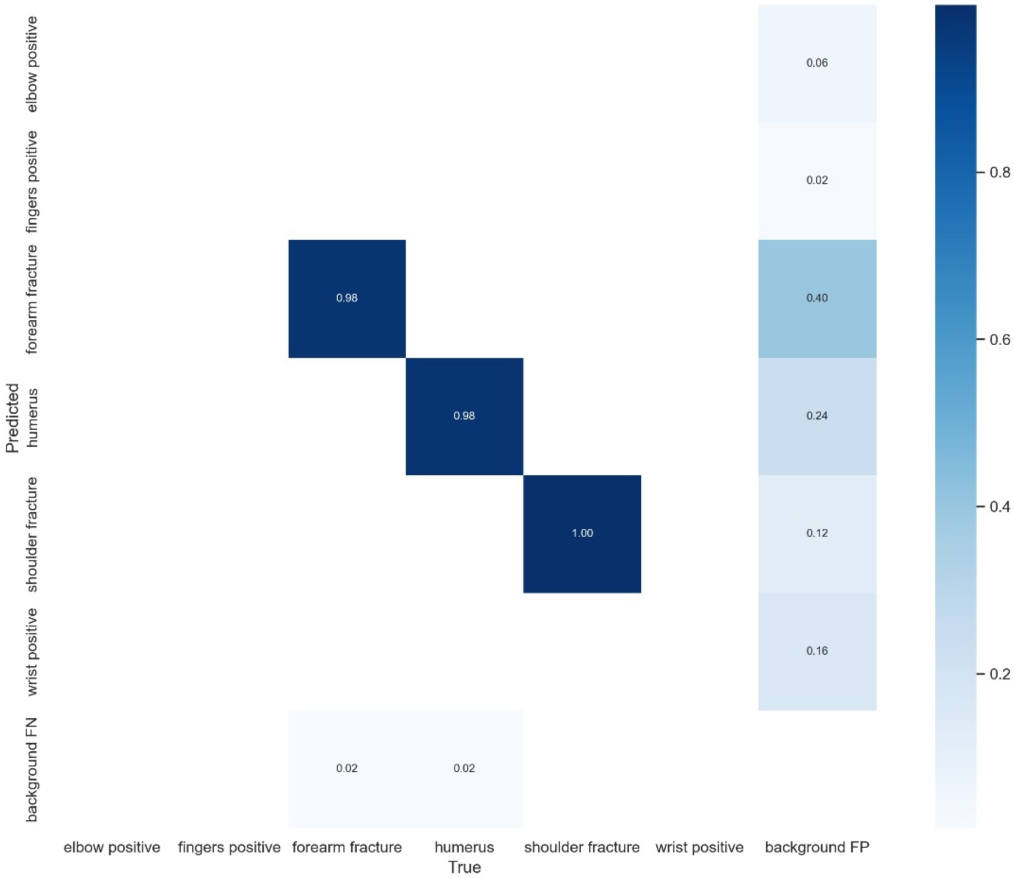

Figure 4.12: Confusion Matrix

. The confusion matrix provides a visual representation of the performance of the YOLO-V7 object detection model trained on the fracture dataset. It illustrates how accurately the model classifies defects and how frequently it misclassify them. In this matrix, rows represent the ground truth labels, which primarily include Background, Elbow, Finger, Forearm, Humerus, Shoulder, and Wrist. Columns, on the other hand, depict the model's predicted labels, encompassing the same categories of Background, Elbow, Finger, Forearm, Humerus, Shoulder, and Wrist.

Diagonal cells The diagonal cells, running from the top left corner to the bottom right corner, represent the number of times the model correctly classified a defect class. A high value (close to 1.0) in a diagonal cell indicates the model performed well for that particular defect class

- Background: 1.00 - The model correctly classified all background images (presumably normal areas of the PCB).
- Wrist: 0.92 - The model correctly classified 92% of wrist defects.
- Humerus: 0.94 - The model correctly classified 94% of humerus defects.
- Shoulder: 0.89 - The model correctly classified 89% of shoulder defects.
- Forearm: 0.86 - The model correctly classified 86% of forearm defects.
- Finger: 0.79 - The model correctly classified 79% of finger defects.
- Elbow: 0.91 - The model correctly classified 91% of elbow defects.

Non-diagonal cells The non-diagonal cells represent the number of times the model incorrectly classified a class. A low value (close to 0.0) in a non-diagonal cell is desirable.

- Background misclassified as Humerus: 0.02 - The model incorrectly classified 2% of background images (presumably normal areas of the PCB) as humerus defects.
- Wrist misclassified as Humerus: 0.04 - The model misclassified 4% of wrist defects as humerus defects.
- Humerus misclassified as Wrist: 0.02 - The model misclassified 2% of humerus defects as wrist defects.
- Shoulder misclassified as Humerus: 0.06 - The model misclassified 6% of shoulder defects as humerus defects.
- Forearm misclassified as Humerus: 0.07 - The model misclassified 7% of forearm defects as humerus defects.
- Finger misclassified as Humerus: 0.08 - The model misclassified 8% of finger defects as humerus defects.

- Elbow misclassified as Humerus: 0.03 - The model misclassified 3% of elbow defects as humerus defects.

4.3.2 Model Metrics

Model Metrics	**Percentage**
Model Precision	89.8%
Model Recall	81.0%
Mean Average Precision	87.9%

Table 4.2: Model Evaluation Metrics

Model Precision This metric mainly focuses on the positives the model predicted and aims to measure how many of these predictions were actually correct.It essentially answers the question: "Out of all the defects the model said it found, how many were truly defects?".In this case the precision is 89.8 ,that is out of all the defects the model flagged, roughly 90 were indeed true defects.

Model Recall This metric focuses on the actual defects that were present in the data. It essentially answers the question: "Out of all the actual defects that exist, how many did the model correctly identify?".In this case the recall is 81.0,that is he model captured about 81 of the actual defects present in the data.

Mean Average Precision This metric provides a single value that summarizes the model's performance across all defect classes. It takes into account both precision and recall and is particularly useful when dealing with multiple classes. In this case the mAP is 87.9,that is the model's performance across all defect classes is around 88.

4.4 Graphical Analysis

4.4.1 Model Precision

Precision is a metric that measures the proportion of true positive predictions among all positive predictions made by the model. The graph illustrates the trend of precision across epochs during the training process of the model. The x-axis represents the epochs, which are iterations through the entire dataset during the training phase, while the y-axis depicts the precision score achieved by the model. We can observe that as the number of epochs completed during training increases, the precision of the model increases. At the start of the training process, during the first hundred epochs, precision increases rapidly and begins to smooth out at around 89 percent precision at the end of training at 300 epochs.

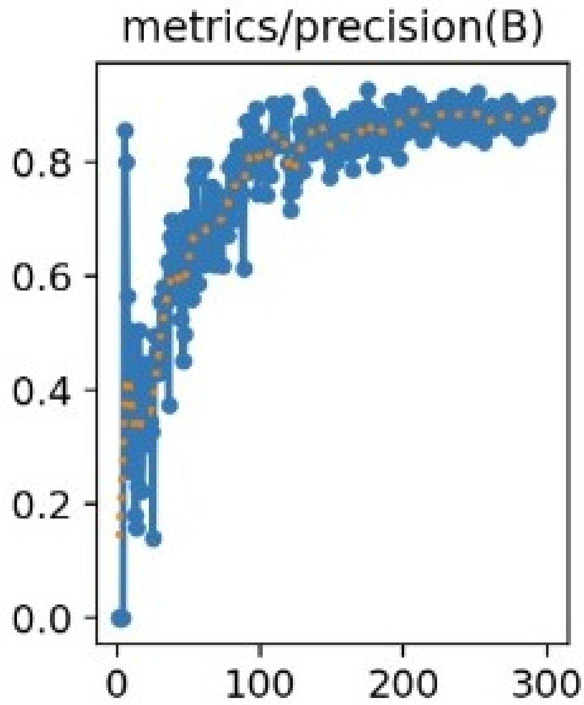

Figure 4.13: Precision vs Epochs

4.4.2 Model Recall

Recall is a metric that measures the proportion of true positive predictions identified correctly among all actual positive instances. The graph depicts the relationship between recall and epochs throughout the training process of the machine learning model. The x-axis represents the epochs, indicating the iterations through the dataset during training, while the y-axis denotes the recall score achieved by the model. We observe that initially the recall of the model increases rapidly through the first hundred epochs and begins to smooth out at around 81 percent recall at the end of training at 300 epochs.

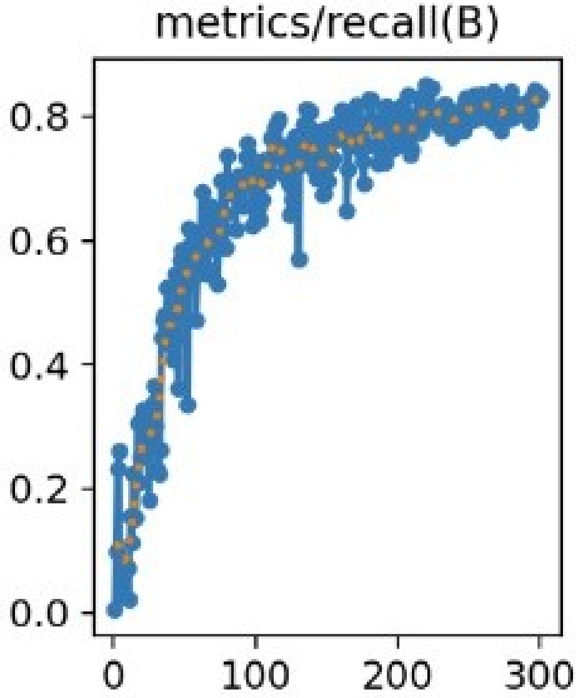

Figure 4.14: Recall vs Epochs

4.4.3 Model Mean Average Precision

Mean Average Precision or mAP is a widely used metric to evaluate the performance of object detection and instance segmentation models. It measures the average precision across multiple classes or categories in the dataset. A higher mAP value indicates better performance in detecting and localizing objects or instances across various classes. mAP can be of different types depending on the Intersection over Union (IoU) threshold of the model. IoU measures the overlap between the predicted bounding boxes and the ground truth bounding boxes. in the following graphs in which the x-axis represents epochs and y-axis represents mean average precision we observe the changes in mAP50 and mAP50-95 with respect to the number of epochs processed during training. mAP50 indicates the mean average precision when IoU threshold is set to 0.5 and mAP50-95 indicates mean average precision over a range of IoU thresholds from 0.5 to 0.95. We observe that, similar to precision and recall earlier, that the both types of mAPs increase sharply towards the beginning of training and later on smooth out at around 87 percent at epoch 300.

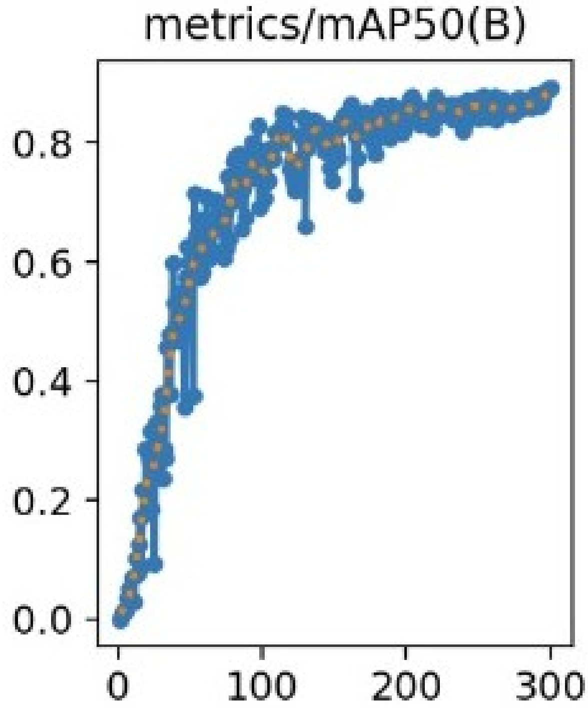

Figure 4.15: mAP50 vs Epochs

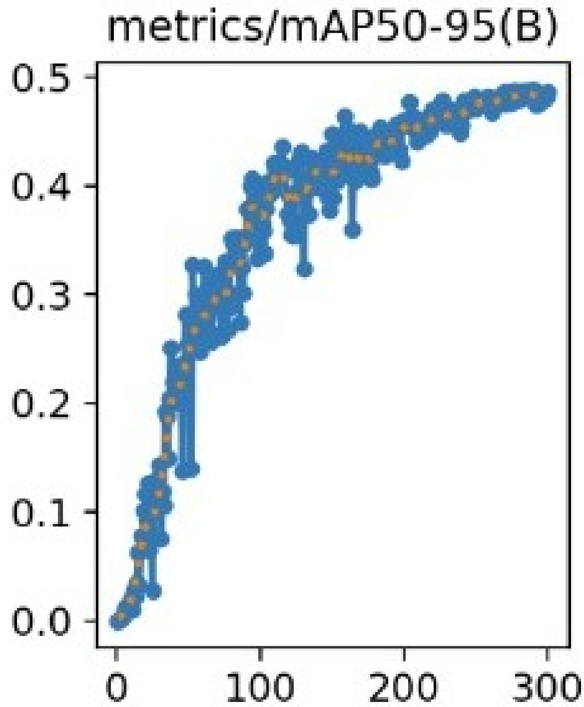

Figure 4.16: mAP50-95 vs Epochs

4.5 Discussion

The model, constructed using YOLO-v7 and trained on a meticulously labeled dataset of X-ray images comprising 1150 samples over a training duration of 3 hours spanning 300 epochs, demonstrated commendable performance metrics. Achieving a precision of 89.8%, a recall rate of 81%, and a mean average precision (mAP) of 87.9% on our test data, the model exhibited proficient capabilities in detecting fractures within X-ray images, effectively delineating them with bounding boxes.

However, upon application to X-ray images beyond those included in the training dataset, the model's performance revealed limitations. Instances where fractures were visibly evident in the images were not consistently detected, suggesting a shortfall in model generalization. This discrepancy likely stems from the dataset's size and composition, insufficiently representing the diverse range of fracture types encountered in clinical settings.

On the implementation front, the model was seamlessly integrated into a web-based application developed using Django, HTML, and CSS. This robust application facilitates user authentication and streamlined image upload functionality, enabling users to submit their X-ray images for analysis. Leveraging third-party APIs, the application orchestrates the model's inference process, generating annotated images with detected fractures where applicable. Furthermore, the application serves as a resource hub, furnishing users with a curated list of recommended healthcare professionals specialized in fracture treatment, leveraging a comprehensive database

Chapter 5

Conclusion

5.1 Conclusion

OrthoVisionAi is a powerful tool that individuals can use to get results for fractures. It allows users in remote areas to get details about the uploaded X-ray. This is particularly helpful in areas where there are no specialist doctors. OrthoVisionAI also aims to bridge the gap in healthcare disparities by offering a reliable solution that can be accessed from anywhere with an internet connection.

5.2 Future Scope

The project aims to transition from using a third-party API plugin to a local model, enhancing data security and reliability. By incorporating larger amounts of data, the model's accuracy will significantly improve. Additionally, broadening the dataset to include diverse images of body fractures will enable the model to detect all types of fractures effectively. Furthermore, the doctor recommendation system will be improved to include multiple doctors from various hospitals in the locality, providing users with comprehensive and accessible medical assistance.

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[1] Ahmed, Kosrat Dlshad, and Roojwan Hawezi. "Detection of bone fracture based on machine learning techniques." Measurement: Sensors 27 (2023): 100723.

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[3] Hardalaç, Fırat, Fatih Uysal, Ozan Peker, Murat Çiçeklidağ, Tolga Tolunay, Nil Tokgöz, Uğurhan Kutbay, Boran Demirciler, and Fatih Mert. "Fracture detection in wrist X-ray images using deep learning-based object detection models." Sensors 22, no. 3 (2022): 1285.

[4] Thian, Yee Liang, Yiting Li, Pooja Jagmohan, David Sia, Vincent Ern Yao Chan, and Robby T. Tan. "Convolutional neural networks for automated fracture detection and localization on wrist radiographs." Radiology: Artificial Intelligence 1, no. 1 (2019): e180001.

[5] Krogue, Justin D., Kaiyang V. Cheng, Kevin M. Hwang, Paul Toogood, Eric G. Meinberg, Erik J. Geiger, Musa Zaid et al. "Automatic hip fracture identification and functional subclassification with deep learning." Radiology: Artificial Intelligence 2, no. 2 (2020): e190023.

[6] Website referred on 16-05-2024 :https://www.kaggle.com/datasets/pkdarabi/bone-fracture-detection-computer-vision-project

Appendix A: Presentation

OrthoVision AI
FINAL PRESENTATION

Guide

Dr. Saritha S

Members

George Bibu
Jenil Biju
Justin George Soney
Kevin Benny Thukkuparambil

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Contents

Introduction

- About 6.8 million fractures occur annually in India according to a study published in the Indian Journal of Orthopaedics. Thus medical imaging plays a crucial role in diagnosing various conditions including bone fractures.

- OrthoVision AI aims to develop an automated fracture detection system which utilizes deep learning algorithms to assist healthcare professionals in identifying bone fractures in X-ray images.

- The automated detection system can provide preliminary assessments of X-ray images, helping clinicians prioritize cases and make timely treatment decisions.

- This can lead to more efficient utilization of healthcare resources. Hospitals and healthcare systems can use the insights provided by the system to optimize staffing, equipment allocation, and patient flow, ultimately improving healthcare delivery and resource management.

Problem Definition

- OrthoVision AI aims to develop an automated fracture detection system for the arm using a Deep Neural Network (DNN). The system needs to be able to analyze X-ray images of the arm and detect and locate fractures, and then classify them. The system should also provide a recommendation of suitable doctors for treatment with the help of databases.

Objectives

- Train and utilize Deep Neural Network to automatically detect, locate and classify potential fractures in X-ray images of the arm.
- Develop a user-friendly web application that allows users to log in, upload X-ray images, and receive automated fracture predictions.
- Implement a recommendations system that provides details of specialists based on the fracture.

Scope and Relevance

- OrthoVision AI is designed to revolutionize medical imaging by automating fracture detection in X-ray images.
- Its primary purpose is to enhance diagnostic accuracy, streamline clinical workflows, and improve patient care outcomes.
- Our project seeks to enhance patient care by providing clinicians with a reliable tool for early detection and treatment planning of bone fractures, leading to improved treatment outcomes and reduced healthcare costs.

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System Design

System Overview

- The project will have an automated detection system for bone fractures using YOLO model
- The model is trained using labeled datasets from reliable medical sources
- The project will implement a user friendly website to login and upload the X-Ray images
- Include a database to store the data of users and healthcare specialists

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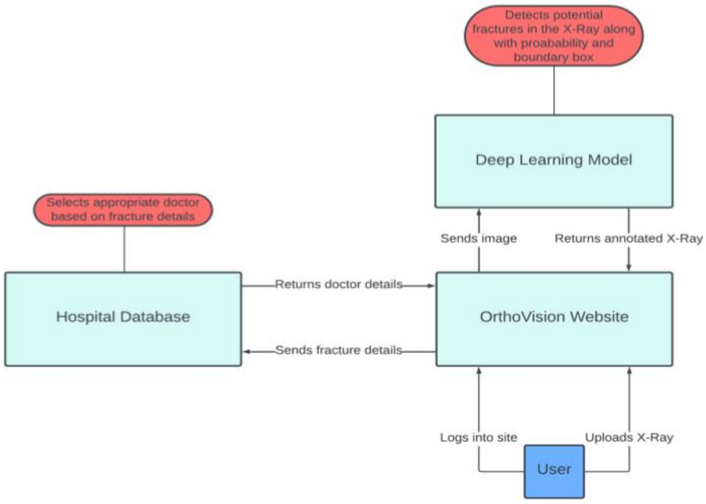
System Design



Architecture diagram

System Design

Modules

YOLO Model

- YOLO's architecture leverages convolutional neural networks (CNNs) for object detection.
- Works on a pre-trained CNN Backbone that is trained on the dataset.
- Following the pre-trained backbone, YOLO adds additional convolutional layers to further refine the extracted features.
- Input image is fed into the the YOLO model which utilizes the pre-trained CNN to extract features.

System Design

- Each image is divided into a grid of size SxS cells.
- Each cell predicts the class probabilities, bounding boxes and confidence score.
- YOLO uses non-max suppression to eliminate redundant bounding boxes. It keeps the most confident prediction for each object.
- The final layers of YOLO are responsible for making predictions.
- Convolutional Layers: These predict bounding boxes and confidence scores for objects within each cell
- Fully Connected Layers: These predict class probabilities for each cell, indicating the likelihood of each object class (e.g., car, person) being present in that cell.

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System Design

Backend

- Incorporates user authentication mechanisms to ensure secure access to the system.
- Manage user sessions and access control to ensure secure access to system resources.
- Handle image storage, retrieval, and deletion using Django's file handling capabilities.
- Process uploaded images to detect fractures using Roboflow's API
- Integrate a recommendation system to provide users with pertinent information regarding suitable doctors to treat the fracture.

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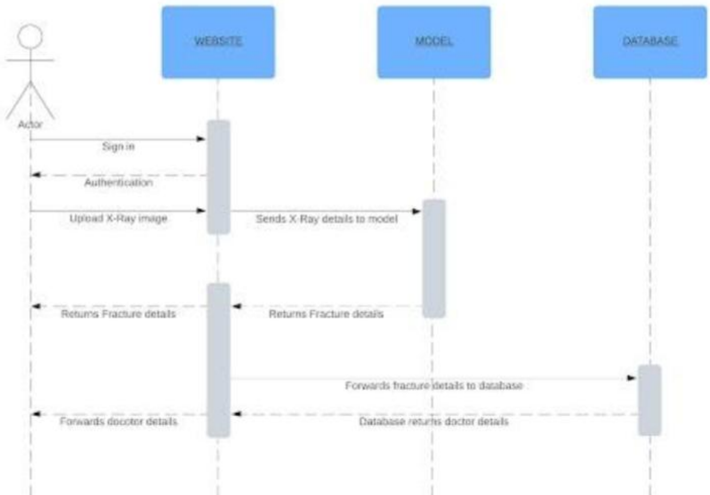
System Design

Front end

- The frontend of the project uses a web-based interface accessible through a standard web browser.
- Incorporates user authentication mechanisms with Backend
- The main page allows users to upload X-ray images directly from their devices.
- Presents fracture detection results to users in a clear and concise manner.
- Provides information about suitable medical specialists or healthcare professionals for the identified fracture

System Design



Sequence Diagram

Datasets

- Dataset by **Parisa Karimi Darabi** on **Kaggle**.
- Images of different class
- Classes are **Elbow Positive, Fingers Positive, Forearm Fracture, Humerus Fracture, Shoulder Fracture, and Wrist Positive**.
- Each image is annotated with a **bounding box.**

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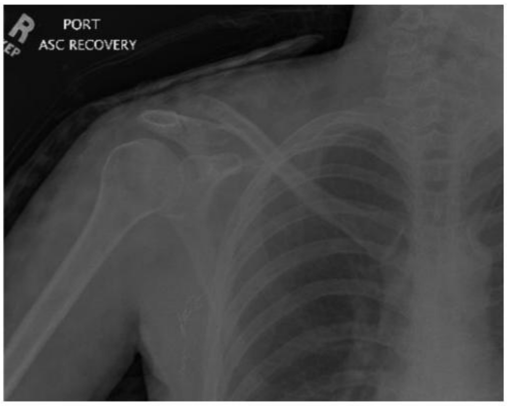
Datasets

- Sample dataset image and corresponding text file

Sample X-Ray Image



X-Ray image data

4 0.565430

0.540039

0.166016

0.130859

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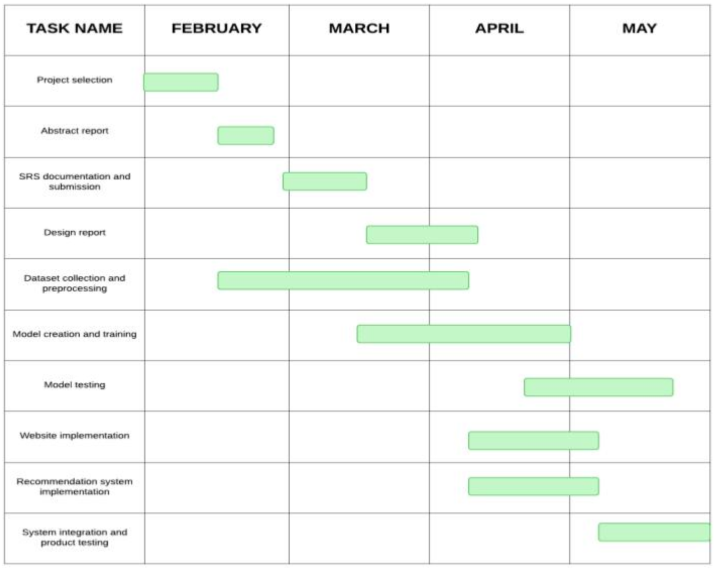
Work Division



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Software/ Hardware Requirements

- **Hardware Required for Product Development:**

  Core i7 10750H (10th Gen), 16GB ram, Nvidia RTX 2060 Max-Q 6GB
- **Software Required For Product Development:**

  Roboflow, Google Colab, GitHub, Django framework, HTML, CSS, JS
- **Hardware Requirement for users:**

  Intel Pentium 4 or later, 4GB ram or Higher and a stable Internet Connection
- **Operating system:**

  Compatible with Windows 8 or later, macOS, Android 8 or later, iOS 10 or later.
- **Web browser:**

  Google Chrome, Firefox, Safari, Edge, Brave.

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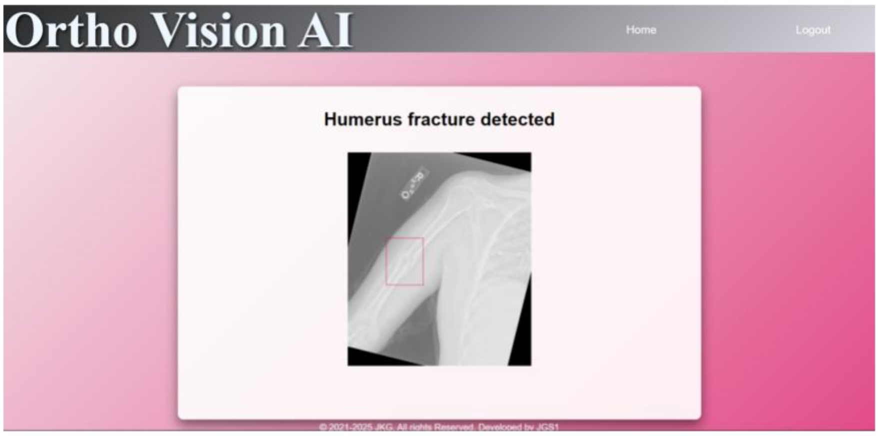
Results

- Successful fracture detection



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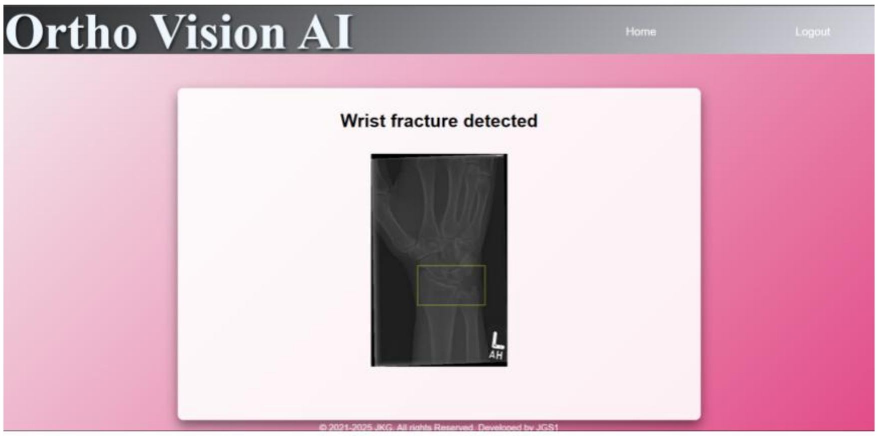
Results

- Successful fracture detection



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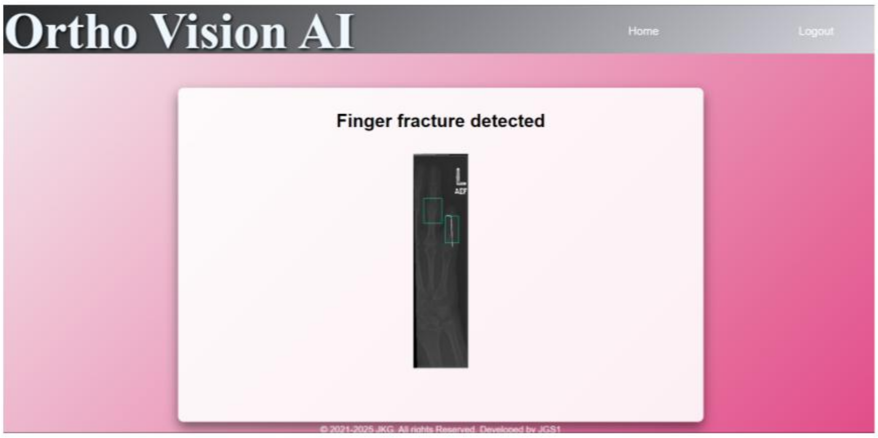
Results

- Successful fracture detection



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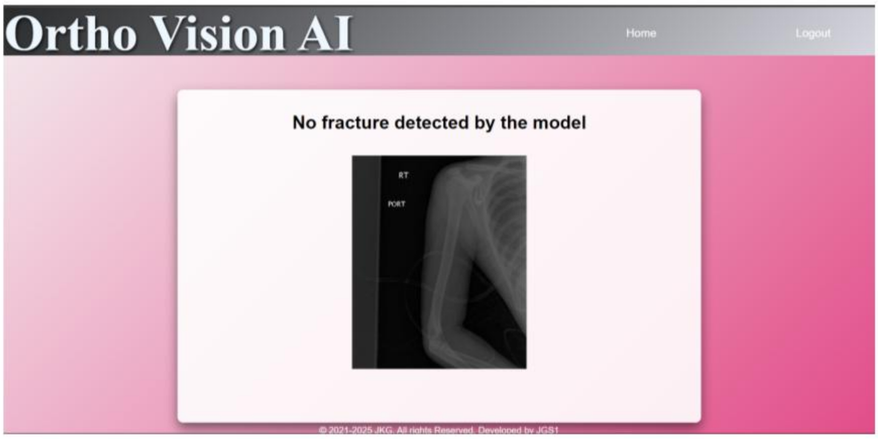
Results

- No fracture detected



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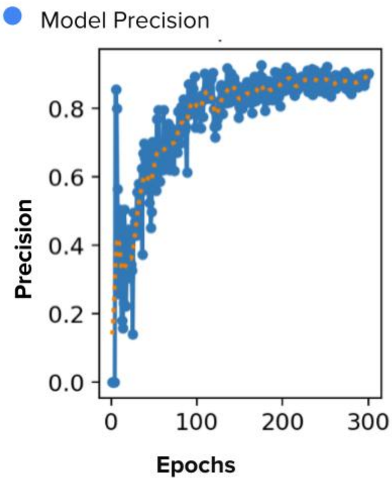
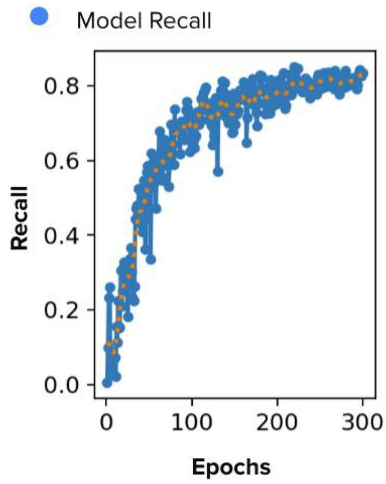
Results



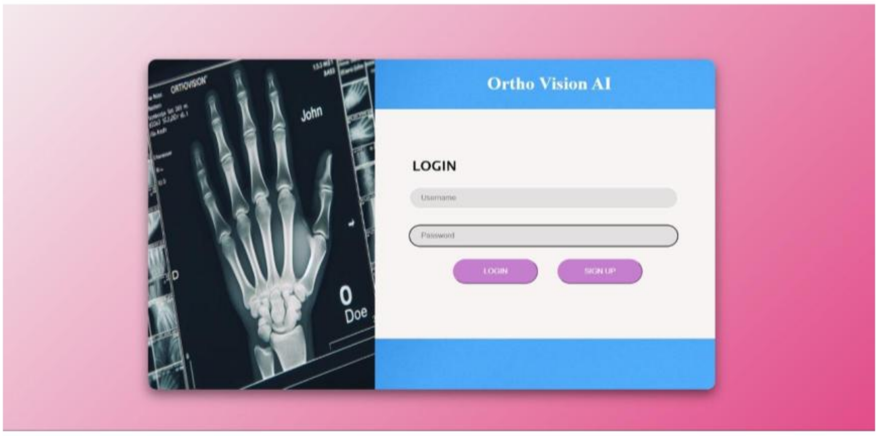


Results

Model Metrics	Percentage
Model Precision	89.8
Model Recall	81.0
Mean Average Precision	87.9

Results

- Login page



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Results

- Sign-Up page

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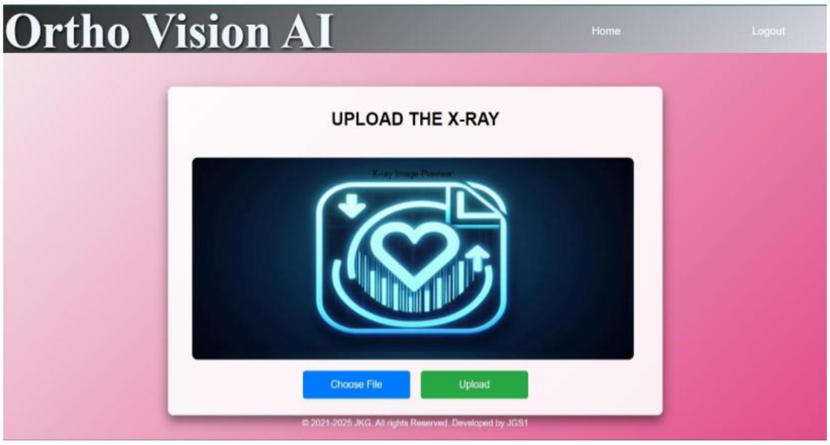
Results

- Upload page



Conclusion

- OrthoVision AI is an automated fracture detection system that leverages advanced artificial intelligence for accurate and efficient analysis of X-ray images.
- This project aims at allowing all users whether it be common man or a medical professional to upload an X-ray and get an accurate result and seek further medical assistance.

Future Enhancements

- Transition from using 3rd party API plugin to a local model .
- Improving model accuracy by incorporating larger amounts of data.
- Broaden dataset to include diverse images of body fractures for a model that can detect all types of fractures.
- Improving the doctor recommendation system to include multiple doctors in various hospitals in the locality.

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- Thian, Yee Liang, Yiting Li, Pooja Jagmohan, David Sia, Vincent Ern Yao Chan, and Robby T. Tan. "Convolutional neural networks for automated fracture detection and localization on wrist radiographs." Radiology: Artificial Intelligence 1, no. 1 (2019): e180001.
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Appendix B: Vision, Mission, Programme Outcomes and Course Outcomes

DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING

RAJAGIRI SCHOOL OF ENGINEERING & TECHNOLOGY (AUTONOMOUS)

RAJAGIRI VALLEY, KAKKANAD, KOCHI, 682039

(Affiliated to APJ Abdul Kalam Technological University)

RSET

RAJAGIRI SCHOOL OF ENGINEERING & TECHNOLOGY (AUTONOMOUS)

Vision, Mission, Programme Outcomes and Course Outcomes

Institute Vision

To evolve into a premier technological institution, moulding eminent professionals with creative minds, innovative ideas and sound practical skill, and to shape a future where technology works for the enrichment of mankind.

Institute Mission

To impart state-of-the-art knowledge to individuals in various technological disciplines and to inculcate in them a high degree of social consciousness and human values, thereby enabling them to face the challenges of life with courage and conviction.

Department Vision

To become a centre of excellence in Computer Science and Engineering, moulding professionals catering to the research and professional needs of national and international organizations.

Department Mission

To inspire and nurture students, with up-to-date knowledge in Computer Science and Engineering, ethics, team spirit, leadership abilities, innovation and creativity to come out with solutions meeting societal needs.

Programme Outcomes (PO)

Engineering Graduates will be able to:

1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

2. Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

3. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

4. Conduct investigations of complex problems: Use research-based knowledge including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

6. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

7. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

9. Individual and Team work: Function effectively as an individual, and as a member or leader in teams, and in multidisciplinary settings.

10. Communication: Communicate effectively with the engineering community and with society at large. Be able to comprehend and write effective reports documentation. Make effective presentations, and give and receive clear instructions.

11. Project management and finance: Demonstrate knowledge and understanding of engineering and management principles and apply these to one's own work, as a member and leader in a team. Manage projects in multidisciplinary environments.

12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and lifelong learning in the broadest context of technological change.

Programme Specific Outcomes (PSO)

A graduate of the Computer Science and Engineering Program will demonstrate:

PSO1: Computer Science Specific Skills

The ability to identify, analyze and design solutions for complex engineering problems in multidisciplinary areas by understanding the core principles and concepts of computer science and thereby engage in national grand challenges.

PSO2: Programming and Software Development Skills

The ability to acquire programming efficiency by designing algorithms and applying standard practices in software project development to deliver quality software products meeting the demands of the industry.

PSO3: Professional Skills

The ability to apply the fundamentals of computer science in competitive research and to develop innovative products to meet the societal needs thereby evolving as an eminent researcher and entrepreneur.

Course Outcomes

After the completion of the course the student will be able to:

CO1:

Identify technically and economically feasible problems (Cognitive Knowledge Level: Apply)

CO2:
Identify and survey the relevant literature for getting exposed to related solutions and get familiarized with software development processes (Cognitive Knowledge Level: Apply)

CO3:
Perform requirement analysis, identify design methodologies and develop adaptable & reusable solutions of minimal complexity by using modern tools & advanced programming techniques (Cognitive Knowledge Level: Apply)

CO4:
Prepare technical report and deliver presentation (Cognitive Knowledge Level: Apply)

CO5:
Apply engineering and management principles to achieve the goal of the project (Cognitive Knowledge Level: Apply)

Appendix C: CO-PO-PSO Mapping

COURSE OUTCOMES:

After completion of the course the student will be able to

SL. NO	**DESCRIPTION**	**Blooms' Taxonomy Level**
CO1	Identify technically and economically feasible problems (Cognitive Knowledge Level: Apply)	Level 3: Apply
CO2	Identify and survey the relevant literature for getting exposed to related solutions and get familiarized with software development processes (Cognitive Knowledge Level: Apply)	Level 3: Apply
CO3	Perform requirement analysis, identify design methodologies and develop adaptable & reusable solutions of minimal complexity by using modern tools & advanced programming techniques (Cognitive Knowledge Level: Apply)	Level 3: Apply
CO4	Prepare technical report and deliver presentation (Cognitive Knowledge Level: Apply)	Level 3: Apply
CO5	Apply engineering and management principles to achieve the goal of the project (Cognitive Knowledge Level: Apply)	Level 3: Apply

CO-PO AND CO-PSO MAPPING

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO3
CO1	3	3	3	3		2	2	3	2	2	2	3	2	2	2
CO2	3	3	3	3	3	2		3	2	3	2	3	2	2	2
CO3	3	3	3	3	3	2	2	3	2	2	2	3			2
CO4	2	3	2	2	2			3	3	3	2	3	2	2	2
CO5	3	3	3	2	2	2	2	3	2		2	3	2	2	2

3/2/1: high/medium/low

JUSTIFICATIONS FOR CO-PO MAPPING

MAPPING	LOW/ MEDIUM/ HIGH	JUSTIFICATION
101003/CS622T.1-PO1	**HIGH**	Identify technically and economically feasible problems by applying the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
101003/CS622T.1-PO2	**HIGH**	Identify technically and economically feasible problems by analysing complex engineering problems reaching substantiated conclusions using first principles of mathematics.
101003/CS622T.1-PO3	**HIGH**	Design solutions for complex engineering problems by identifying technically and economically feasible problems.
101003/CS622T.1-PO4	**HIGH**	Identify technically and economically feasible problems by analysis and interpretation of data.
101003/CS622T.1-PO6	**MEDIUM**	Responsibilities relevant to the professional engineering practice by identifying the problem.
101003/CS622T.1-PO7	**MEDIUM**	Identify technically and economically feasible problems by understanding the impact of the professional engineering solutions.
101003/CS622T.1-PO8	**HIGH**	Apply ethical principles and commit to professional ethics to identify technically and economically feasible problems.
101003/CS622T.1-PO9	**MEDIUM**	Identify technically and economically feasible problems by working as a team.
101003/CS622T.1-PO10	**MEDIUM**	Communicate effectively with the engineering community by identifying technically and economically feasible problems.
101003/CS622T.1-P011	**MEDIUM**	Demonstrate knowledge and understanding of engineering and management principles by selecting the technically and economically feasible problems.
101003/CS622T.1-PO12	**HIGH**	Identify technically and economically feasible problems for long term learning.
101003/CS622T.1-PSO1	**MEDIUM**	Ability to identify, analyze and design solutions to identify technically and economically feasible problems.
101003/CS622T.1-PSO2	**MEDIUM**	By designing algorithms and applying standard practices in software project development and Identifying technically and economically feasible problems.
101003/CS622T.1-PSO3	**MEDIUM**	Fundamentals of computer science in competitive research can be applied to Identify technically and economically feasible problems.
101003/CS622T.2-PO1	**HIGH**	Identify and survey the relevant by applying the knowledge of mathematics, science, engineering fundamentals.

101003/CS622T.2-PO2	**HIGH**	Identify, formulate, review research literature, and analyze complex engineering problems get familiarized with software development processes.
101003/CS622T.2-PO3	**HIGH**	Design solutions for complex engineering problems and design based on the relevant literature.
101003/CS622T.2-PO4	**HIGH**	Use research-based knowledge including design of experiments based on relevant literature.
101003/CS622T.2-PO5	**HIGH**	Identify and survey the relevant literature for getting exposed to related solutions and get familiarized with software development processes by using modern tools.
101003/CS622T.2-PO6	**MEDIUM**	Create, select, and apply appropriate techniques, resources, by identifying and surveying the relevant literature.
101003/CS622T.2-PO8	**HIGH**	Apply ethical principles and commit to professional ethics based on the relevant literature.
101003/CS622T.2-PO9	**MEDIUM**	Identify and survey the relevant literature as a team.
101003/CS622T.2-PO10	**HIGH**	Identify and survey the relevant literature for a good communication to the engineering fraternity.
101003/CS622T.2-PO11	**MEDIUM**	Identify and survey the relevant literature to demonstrate knowledge and understanding of engineering and management principles.
101003/CS622T.2-PO12	**HIGH**	Identify and survey the relevant literature for independent and lifelong learning.
101003/CS622T.2-PSO1	**MEDIUM**	Design solutions for complex engineering problems by Identifying and survey the relevant literature.
101003/CS622T.2-PSO2	**MEDIUM**	Identify and survey the relevant literature for acquiring programming efficiency by designing algorithms and applying standard practices.
101003/CS622T.2-PSO3	**MEDIUM**	Identify and survey the relevant literature to apply the fundamentals of computer science in competitive research.
101003/CS622T.3-PO1	**HIGH**	Perform requirement analysis, identify design methodologies by using modern tools & advanced programming techniques and by applying the knowledge of mathematics, science, engineering fundamentals.
101003/CS622T.3-PO2	**HIGH**	Identify, formulate, review research literature for requirement analysis, identify design methodologies and develop adaptable & reusable solutions.

101003/CS622T.3-PO3	**HIGH**	Design solutions for complex engineering problems and perform requirement analysis, identify design methodologies.
101003/CS622T.3-PO4	**HIGH**	Use research-based knowledge including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
101003/CS622T.3-PO5	**HIGH**	Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools.
101003/CS622T.3-PO6	**MEDIUM**	Perform requirement analysis, identify design methodologies and assess societal, health, safety, legal, and cultural issues.
101003/CS622T.3-PO7	**MEDIUM**	Understand the impact of the professional engineering solutions in societal and environmental contexts and Perform requirement analysis, identify design methodologies and develop adaptable & reusable solutions.
101003/CS622T.3-PO8	**HIGH**	Perform requirement analysis, identify design methodologies and develop adaptable & reusable solutions by applying ethical principles and commit to professional ethics.
101003/CS622T.3-PO9	**MEDIUM**	Function effectively as an individual, and as a member or leader in teams, and in multidisciplinary settings.
101003/CS622T.3-PO10	**MEDIUM**	Communicate effectively with the engineering community and with society at large to perform requirement analysis, identify design methodologies.
101003/CS622T.3-PO11	**MEDIUM**	Demonstrate knowledge and understanding of engineering requirement analysis by identifying design methodologies.
101003/CS622T.3-PO12	**HIGH**	Recognize the need for, and have the preparation and ability to engage in independent and lifelong learning in the broadest context of technological change by analysis, identify design methodologies and develop adaptable & reusable solutions.
101003/CS622T.3-PSO3	**MEDIUM**	The ability to apply the fundamentals of computer science in competitive research and prior to that perform requirement analysis, identify design methodologies.
101003/CS622T.4-PO1	**MEDIUM**	Prepare technical report and deliver presentation by applying the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
101003/CS622T.4-PO2	**HIGH**	Identify, formulate, review research literature, and analyze complex engineering problems by preparing technical report and deliver presentation.

101003/CS622T.4-PO3	**MEDIUM**	Prepare Design solutions for complex engineering problems and create technical report and deliver presentation.
101003/CS622T.4-PO4	**MEDIUM**	Use research-based knowledge including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions and prepare technical report and deliver presentation.
101003/CS622T.4-PO5	**MEDIUM**	Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools and Prepare technical report and deliver presentation.
101003/CS622T.4-PO8	**HIGH**	Prepare technical report and deliver presentation by applying ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
101003/CS622T.4-PO9	**HIGH**	Prepare technical report and deliver presentation effectively as an individual, and as a member or leader in teams, and in multidisciplinary settings.
101003/CS622T.4-PO10	**HIGH**	Communicate effectively with the engineering community and with society at large by prepare technical report and deliver presentation.
101003/CS622T.4-PO11	**MEDIUM**	Demonstrate knowledge and understanding of engineering and management principles and apply these to one's own work by prepare technical report and deliver presentation.
101003/CS622T.4-PO12	**HIGH**	Recognize the need for, and have the preparation and ability to engage in independent and lifelong learning in the broadest context of technological change by prepare technical report and deliver presentation.
101003/CS622T.4-PSO1	**MEDIUM**	Prepare a technical report and deliver presentation to identify, analyze and design solutions for complex engineering problems in multidisciplinary areas.
101003/CS622T.4-PSO2	**MEDIUM**	To acquire programming efficiency by designing algorithms and applying standard practices in software project development and to prepare technical report and deliver presentation.
101003/CS622T.4-PSO3	**MEDIUM**	To apply the fundamentals of computer science in competitive research and to develop innovative products to meet the societal needs by preparing technical report and deliver presentation.
101003/CS622T.5-PO1	**HIGH**	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
101003/CS622T.5-PO2	**HIGH**	Identify, formulate, review research literature, and analyze complex engineering problems by applying engineering and management principles to achieve the goal of the project.

101003/CS622T.5-PO3	**HIGH**	Apply engineering and management principles to achieve the goal of the project and to design solutions for complex engineering problems and design system components or processes that meet the specified needs.
101003/CS622T.5-PO4	**MEDIUM**	Apply engineering and management principles to achieve the goal of the project and use research-based knowledge including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
101003/CS622T.5-PO5	**MEDIUM**	Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools and to apply engineering and management principles to achieve the goal of the project.
101003/CS622T.5-PO6	**MEDIUM**	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities by applying engineering and management principles to achieve the goal of the project.
101003/CS622T.5-PO7	**MEDIUM**	Understand the impact of the professional engineering solutions in societal and environmental contexts, and apply engineering and management principles to achieve the goal of the project.
101003/CS622T.5-PO8	**HIGH**	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice and to use the engineering and management principles to achieve the goal of the project.
101003/CS622T.5-PO9	**MEDIUM**	Function effectively as an individual, and as a member or leader in teams, and in multidisciplinary settings and to apply engineering and management principles to achieve the goal of the project.
101003/CS622T.5-PO11	**MEDIUM**	Demonstrate knowledge and understanding of engineering and management principles and apply these to one's own work, as a member and leader in a team. Manage projects in multidisciplinary environments and to apply engineering and management principles to achieve the goal of the project.
101003/CS622T.5-PO12	**HIGH**	Recognize the need for, and have the preparation and ability to engage in independent and lifelong learning in the broadest context of technological change and to apply engineering and management principles to achieve the goal of the project.
101003/CS622T.5-PSO1	**MEDIUM**	The ability to identify, analyze and design solutions for complex engineering problems in multidisciplinary areas. Apply engineering and management principles to achieve the goal of the project.

101003/CS622T.5-PSO2	**MEDIUM**	The ability to acquire programming efficiency by designing algorithms and applying standard practices in software project development to deliver quality software products meeting the demands of the industry and to apply engineering and management principles to achieve the goal of the project.
101003/CS622T.5-PSO3	**MEDIUM**	The ability to apply the fundamentals of computer science in competitive research and to develop innovative products to meet the societal needs thereby evolving as an eminent researcher and entrepreneur and apply engineering and management principles to achieve the goal of the project.