AUTOMATED KNEE DEGENERATIVE ARTHRITIS REPORTS GENERATION THROUGH VISUAL DATA ANALYSIS

COMPUTER SCIENCE AND ENGINEERING
SECTION - C
BATCH NO: C7

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ABSTRACT:

Knee degenerative arthritis is a common medical condition that affects the knee joint .Knee Degenerative arthritis causes major disability in patients all over the world. The computerized reporting procedure requires effort and expertise. Manual diagnosis, segmentation of knee joints are still used in clinical practice. Manual diagnosis of this disease involves observing X-ray images of the knee area and classifying it under five grades using the Kellgren – Lawrence (KL)system. Despite the fact that they are time-consuming and sensitive to user variance. As a result, we have the proposed system employing the CNN model with Computer Vision to increase the clinical workflow efficiency and overcome the constraints of the generally used method. We can also implement the report generation system that generates medical reports based on X-ray image features. By extracting the relevant features such as joint space narrowing, and cartilage degeneration, the system generates detailed and objective reports.

Keywords : Knee Degenerative Arthritis, X-rays, CNN, Computer Vision.

EXISTING SYSTEM:

The Existing System presents a data mining approach for the diagnosis of Knee Degenerative Arthritis using Machine Learning (ML) algorithms.

The system compare the performance of different ML models, including Logistic Naive Bayes, Random Forest, and Support Vector Machines, with varying numbers of features.

The algorithm that achieved the highest accuracy was the Support Vector Machine (SVM).

DISADVANTAGES OF EXISTING SYSTEM:

In the existing system, extracting meaningful features from complex images can be challenging and time-consuming.

Machine learning algorithms do not provide spatial localization of abnormalities in images. For medical imaging, it's essential to provide the exact regions of joint space narrowing.

PROPOSED SYSTEM:

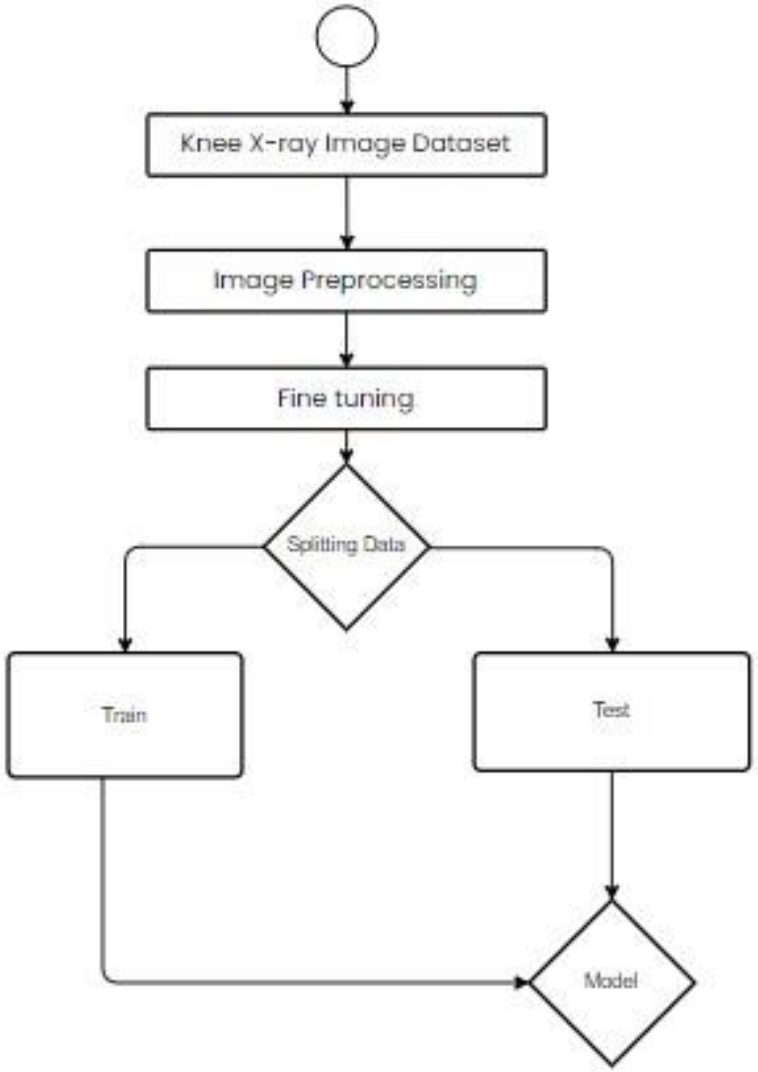
- The proposed system uses computer vision and Convolutional Neural Networks (CNN) for image analysis and for report generation.
- In this system, CNNs are used to extract features from knee joint images, enabling the detection and classification of knee images. These extracted features are then fed into models that generate detailed medical reports in a contextually relevant manner.
- The computer vision and CNN technology not only accelerates the diagnosis process but also reduces the potential for human error, ultimately enhancing the quality of care and improving patient outcomes in the management of knee degenerative arthritis. The generated reports are not only accurate but also follow a logical flow.
- A user interface is created where an image is uploaded and reports are generated with particular detection along with its symptoms and solution.

ALGORITHMS USED:

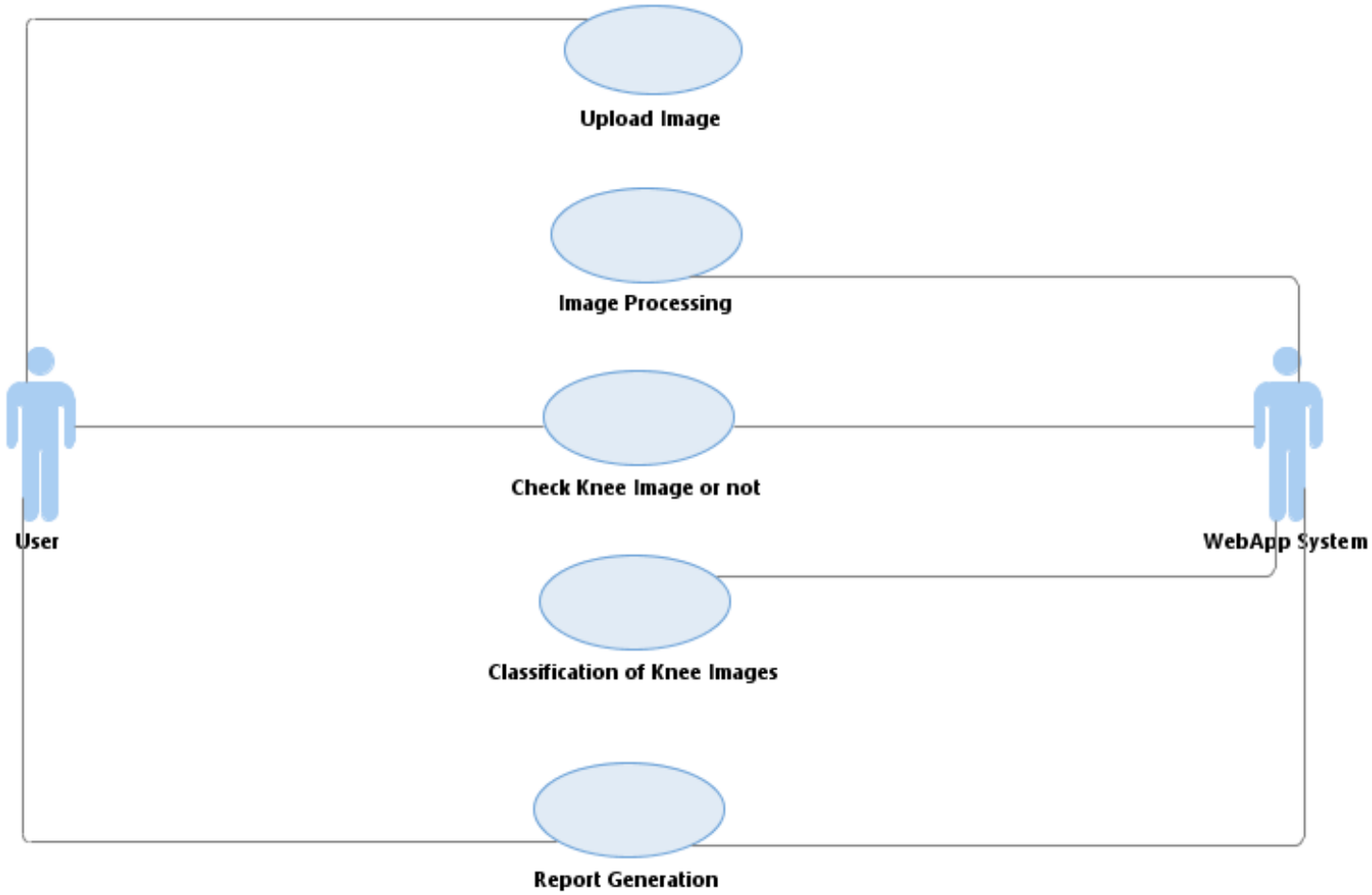
In our project we have implemented CNN algorithm with Inception V3 and Xception Pre-trained models..

- **Convolutional Neural Networks (CNNs):** A convolutional neural network (CNN) typically comprises multiple convolutional and sub-sampling layers, optionally followed by fully-connected layers like a standard multi-layer neural network. A CNN exploits the 2D spatial structure images to learn translation invariant features. The main advantage of CNN over fully connected networks is that they are easier to train and have fewer parameters with the same number of hidden units.
- **InceptionV3**:It is a convolutional neural network for assisting in image analysis and object detection, and got its start as a module for GoogLeNet. It is the third edition of Google's Inception Convolutional Neural Network, originally introduced during the ImageNet Recognition Challenge.
- **Xception:** Xception, short for "Extreme Inception," is another convolutional neural network architecture.Xception replaces the standard convolutional layers in traditional CNN architectures with depth wise separable convolutions, which significantly reduces the number of parameters while maintaining or improving performance.

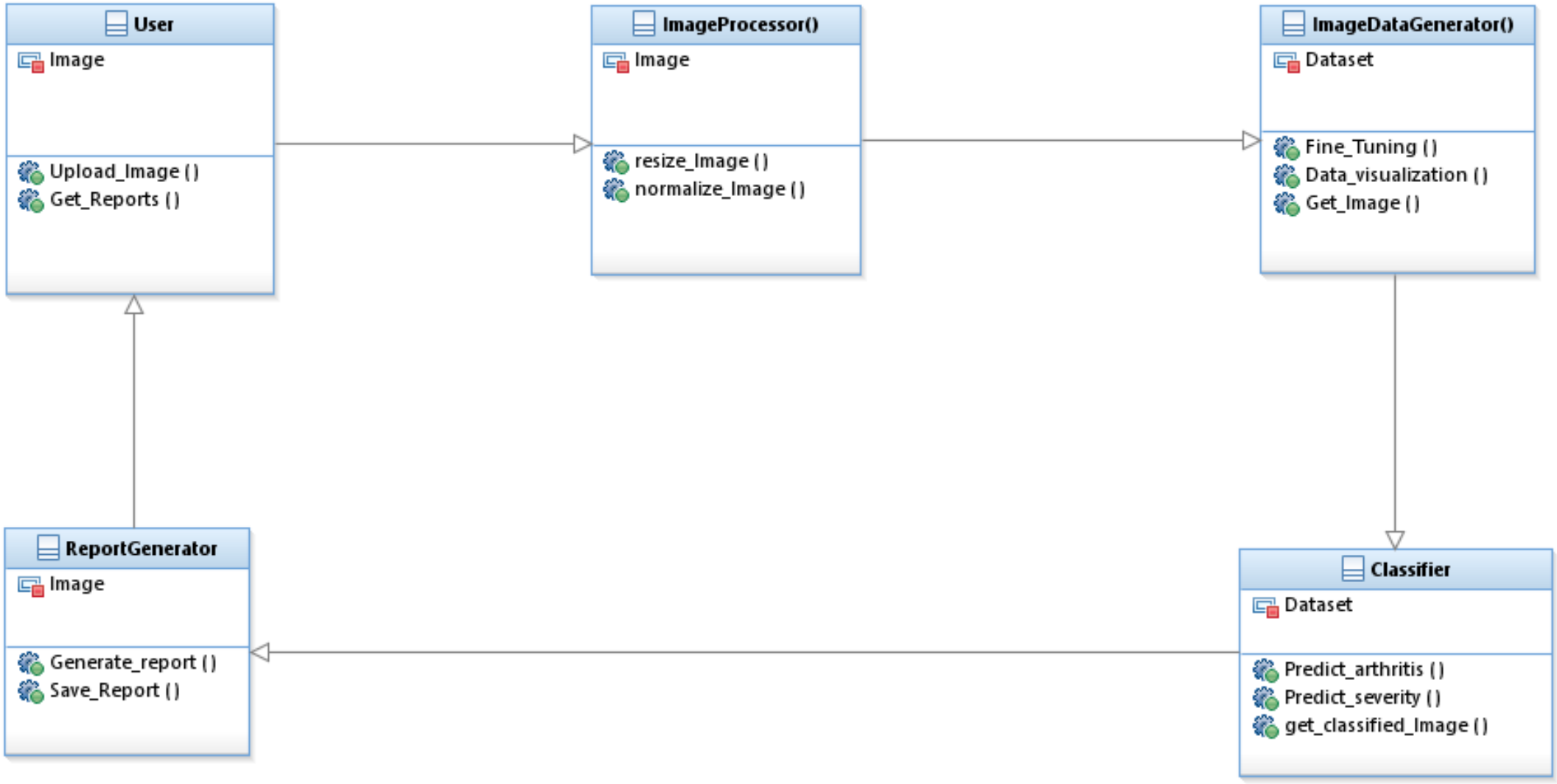
Flow Chart:


Knee X-ray Image Dataset
Image Preprocessing
Fine tuning
Splitting Data
Train
Test
Model

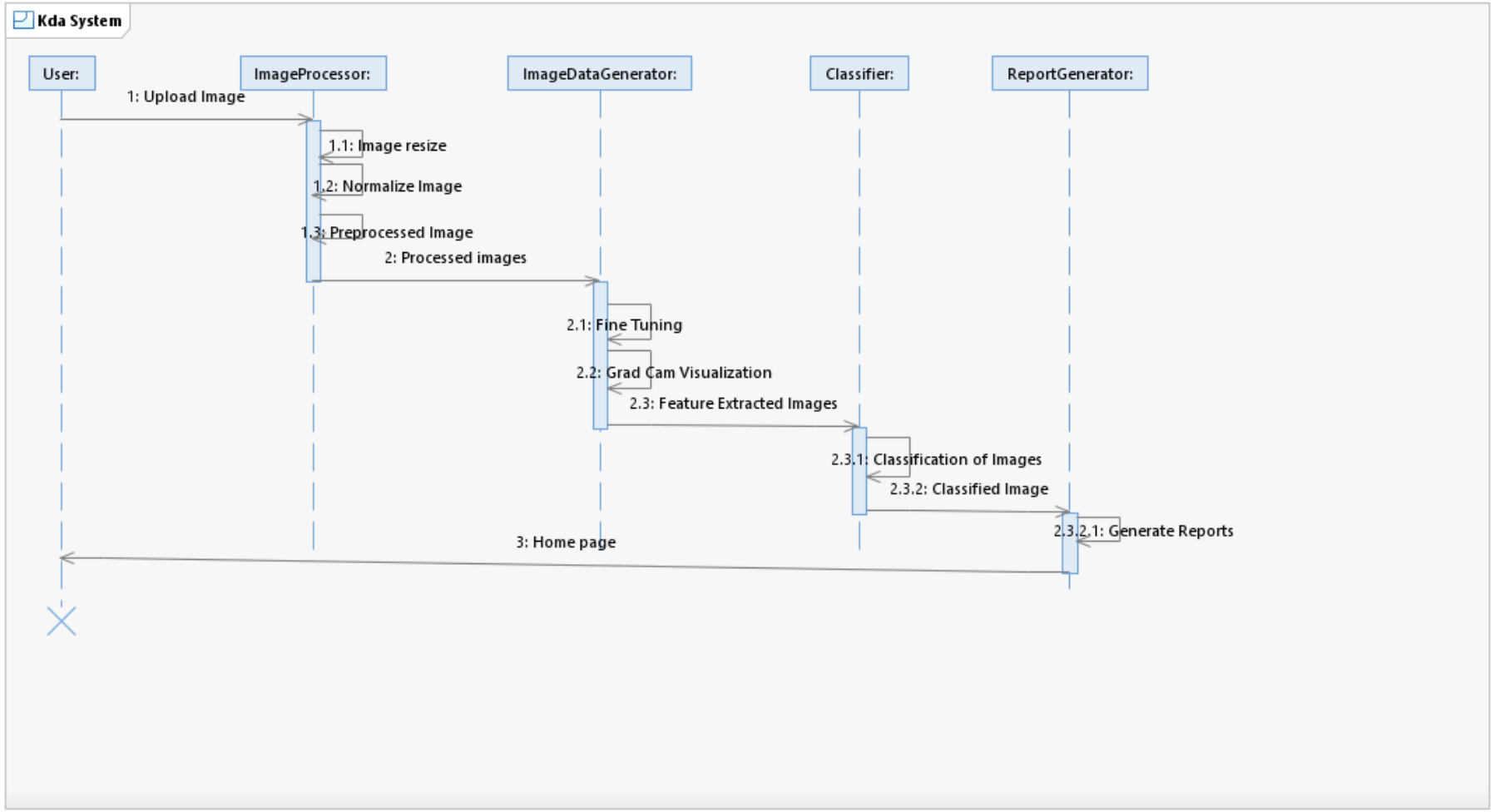
USE CASE DIAGRAM:



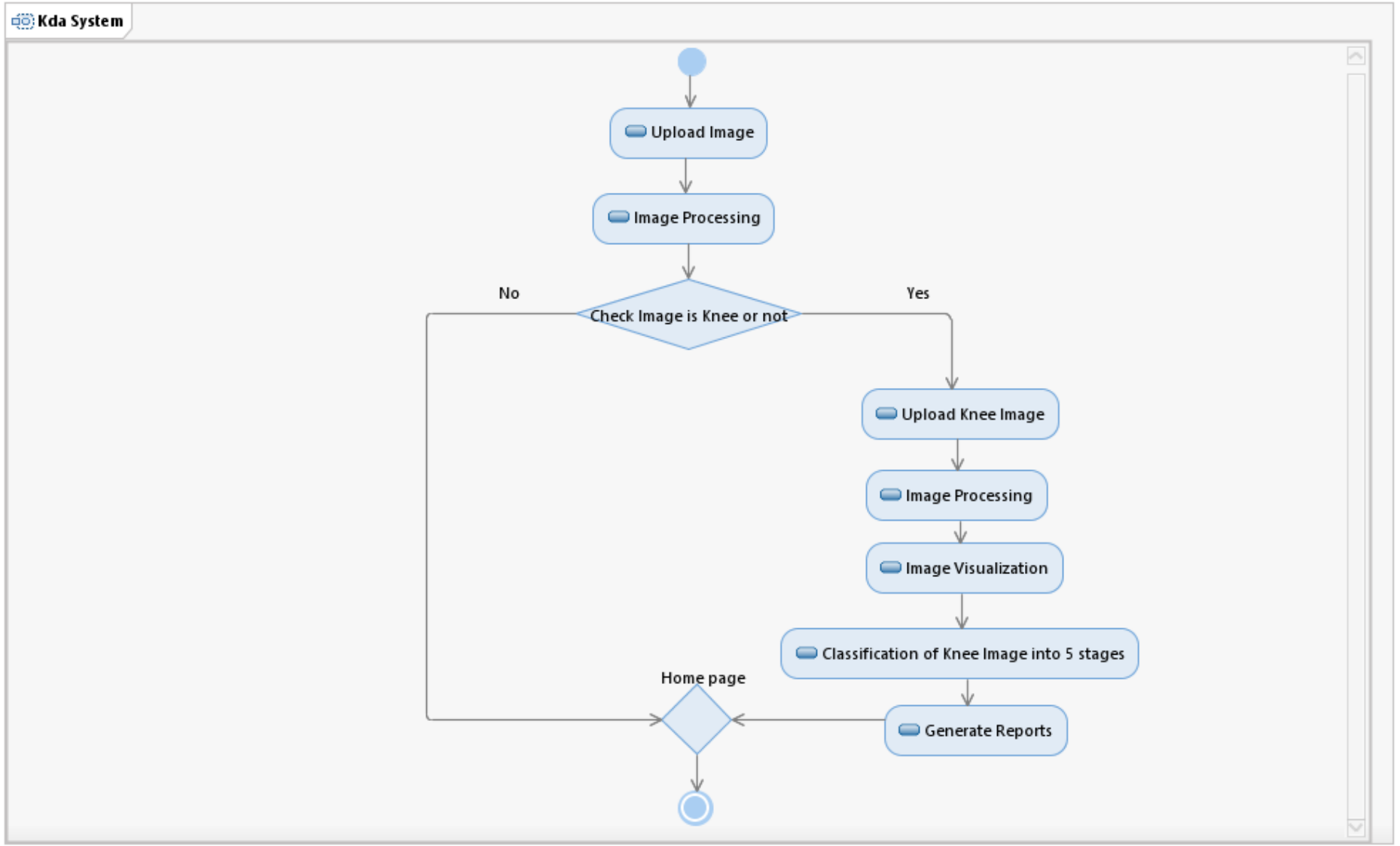
CLASS DIAGRAM:



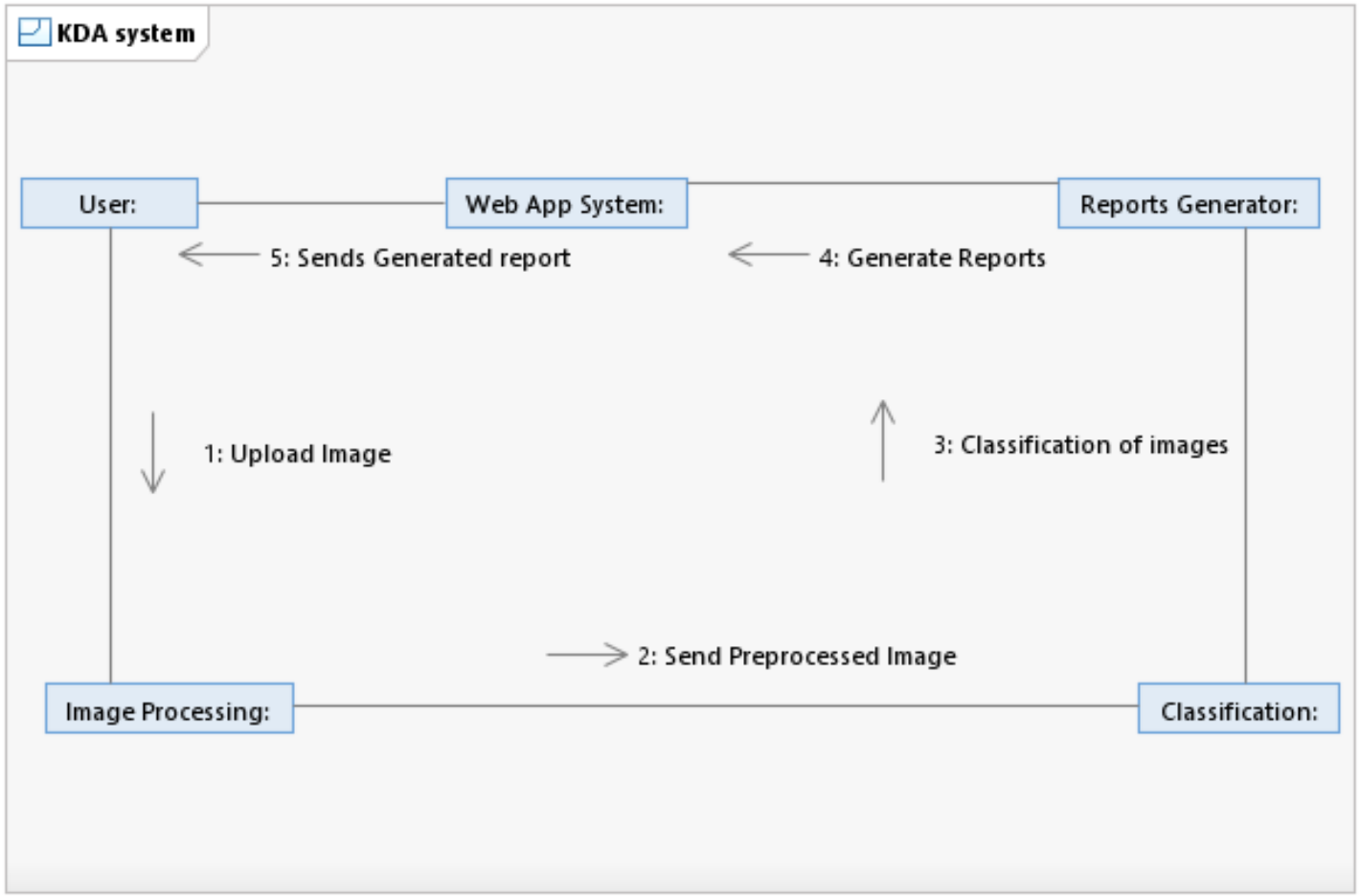
SEQUENCE DIAGRAM:



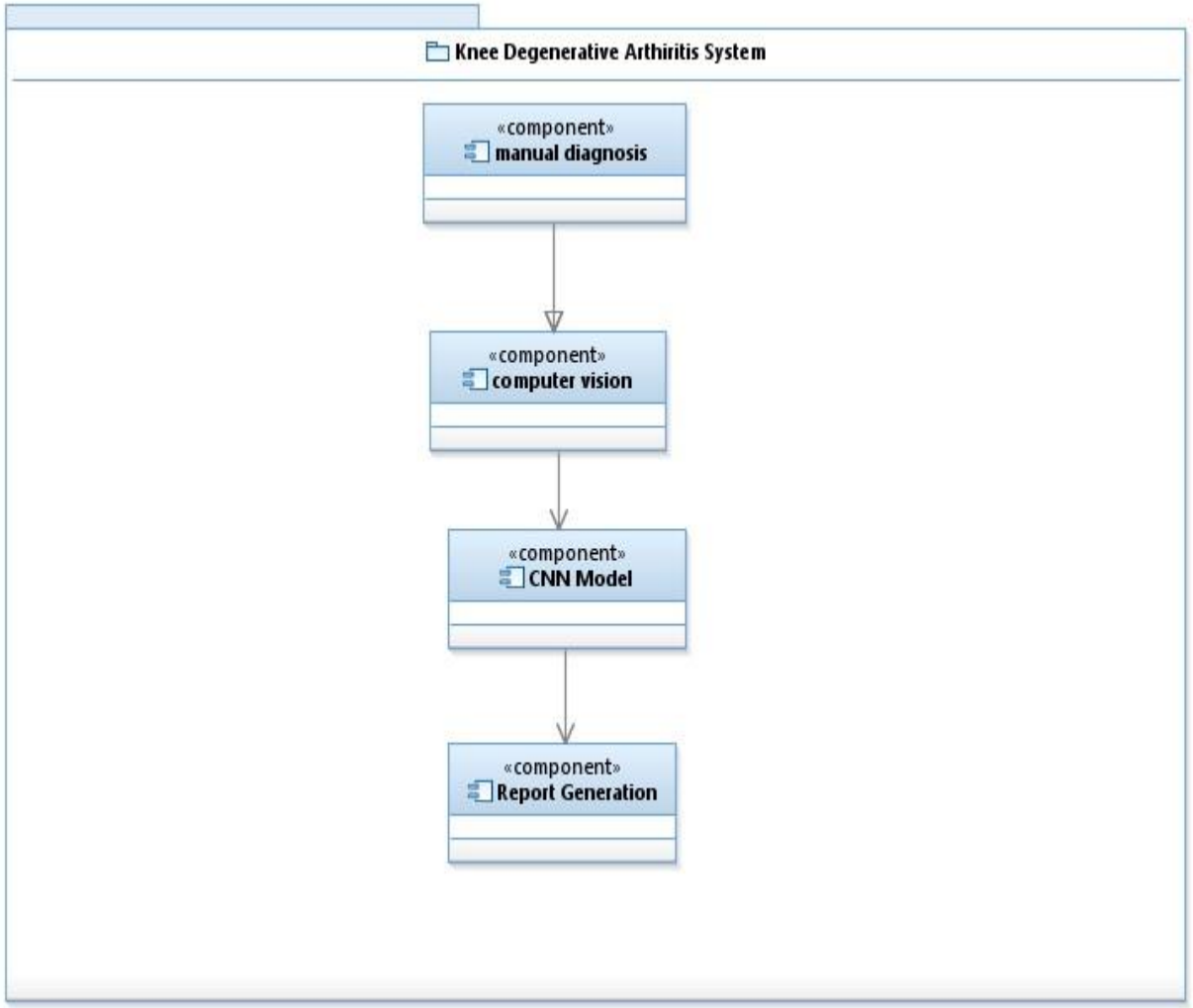
ACTIVITY DIAGRAM:



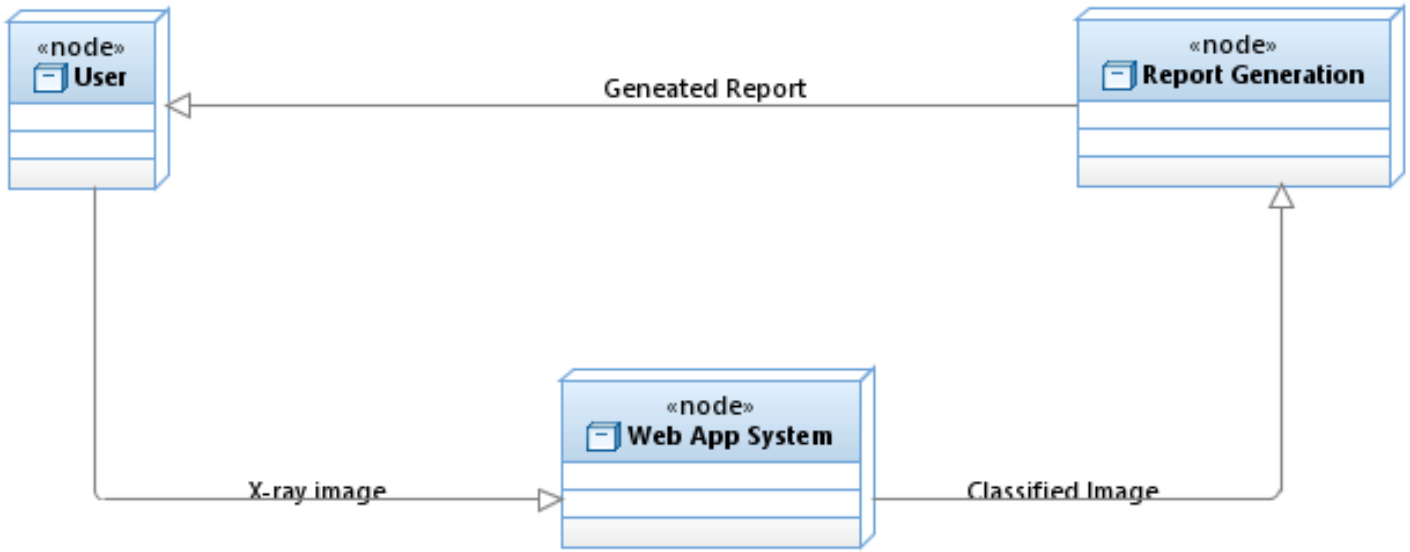
COLLABRATION DIAGRAM:



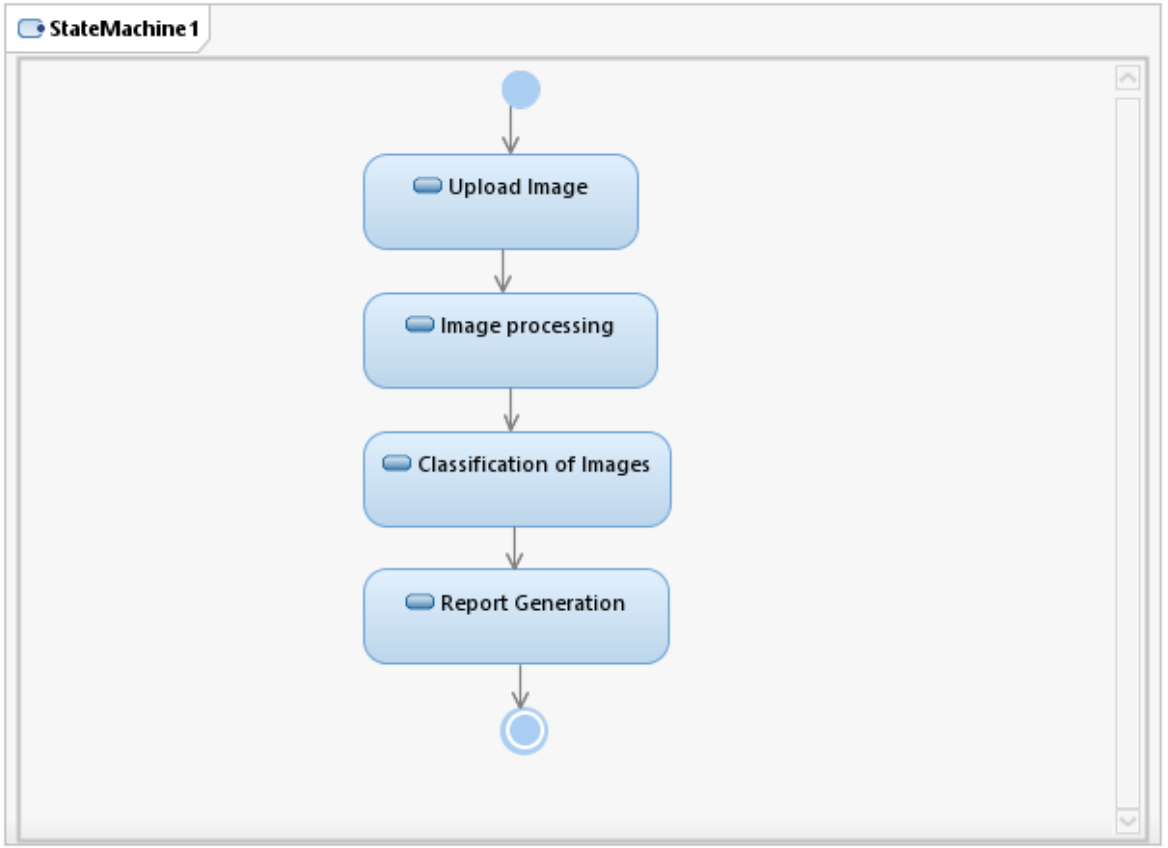
COMPONENT DIAGRAM:



DEPLOYMENT DIAGRAM:



STATE CHART DIAGRAM:



SYSTEM REQUIREMENTS:

SOFTWARE REQUIREMENTS:

1.Programming Languages:
Frontend: HTML,CSS,JAVASCRIPT
2 .CNN
4.Python Libraries
5.Open CV
6.Operating System: Windows
7.Text Editor
8.Web Browser

HARDWARE REQUIREMENTS:

1.Computer or Server
2.Storage
3.Internet Connection
4. Hard Disk

ALGORITHMS

CNN ALGORITHM:

CNN Convolutional Neural Networks (CNNs) are a type of deep learning neural network architecture specifically designed for image and video recognition tasks.They have been actively utilized for a variety of computer vision applications, including segmentation, object identification, and image classification. The convolutional layer, which applies the mathematical operation of convolution to the input data, is the fundamental component of a CNN. The convolution operation involves sliding a small filter (also called a kernel or weight matrix) across the input data, element-wise multiplying each part of the input by the filter, and summing the results to produce a single output value. For each position of the filter across the input data, this operation is repeated numerous times, producing a feature map, or set of output values. A CNN can extract progressively complicated features from the input data by stacking many convolutional layers on top of one another.

INCEPTION V3

Inception-v3 is a architecture of convolutional neural network (CNN) that was developed by Google researchers by combining convolutional layers with various filter sizes to collect features at different scales, it is intended to increase the efficiency and accuracy of image classification tasks. Each module in the Inception v3 architecture is made up of a number of convolutional layers, pooling layers, and other types of layers. These modules are set up in a hierarchy, with lower-level modules concentrating on the capture of low-level features like edges and textures and higher-level modules concentrating on the capture of more complex features like object components and complete objects.The modules of this network is made up of parallel convolutional layers with various filter sizes and a max-pooling layer that helps in reducing the output's dimensionality. Each module's output is then combined and passed into the next module.Inception-v3 additionally employs batch normalisation and dropout regularisation. Overall, it has been demonstrated that Inception v3 performs at the cutting edge on a variety of image recognition tasks, including object detection, image classification, and visual question answering.Additionally, this has been utilised to extract features that have proven to be highly effective for tasks related to transfer learning.

Classifying the Knee Degenerative Arthritis

Steps:

1.**Importing Libraries**

2.Setting Up Image Data Generators:

Rescaling:rescaled_pixel_value=original_pixel_value/255 and

Rotation, Shifting, Shearing, Zooming, Horizontal Flip

3.**Loading Pre-Trained InceptionV3 Model:**

output=Conv(input,filters,kernel_size,activation)

Activation function (ReLU):ReLU(x)=max(0,x)

4.Constructing Custom CNN Model:

Dense Layer:output=activation(input·weights+bias), where the activation function is ReLU.

Output Layer:output=sigmoid(input·weights+bias)

5.Training the Model

6.Evaluating Model Performance:

1.Accuracy:TP+TN/TP+TN+FP+FN

2.Precision:TP/TP+FP

3.Loss:TP/TP+FN

4.F1-score:2.precision.recall/precision+recall

7.Performing Predictions

XCEPTION

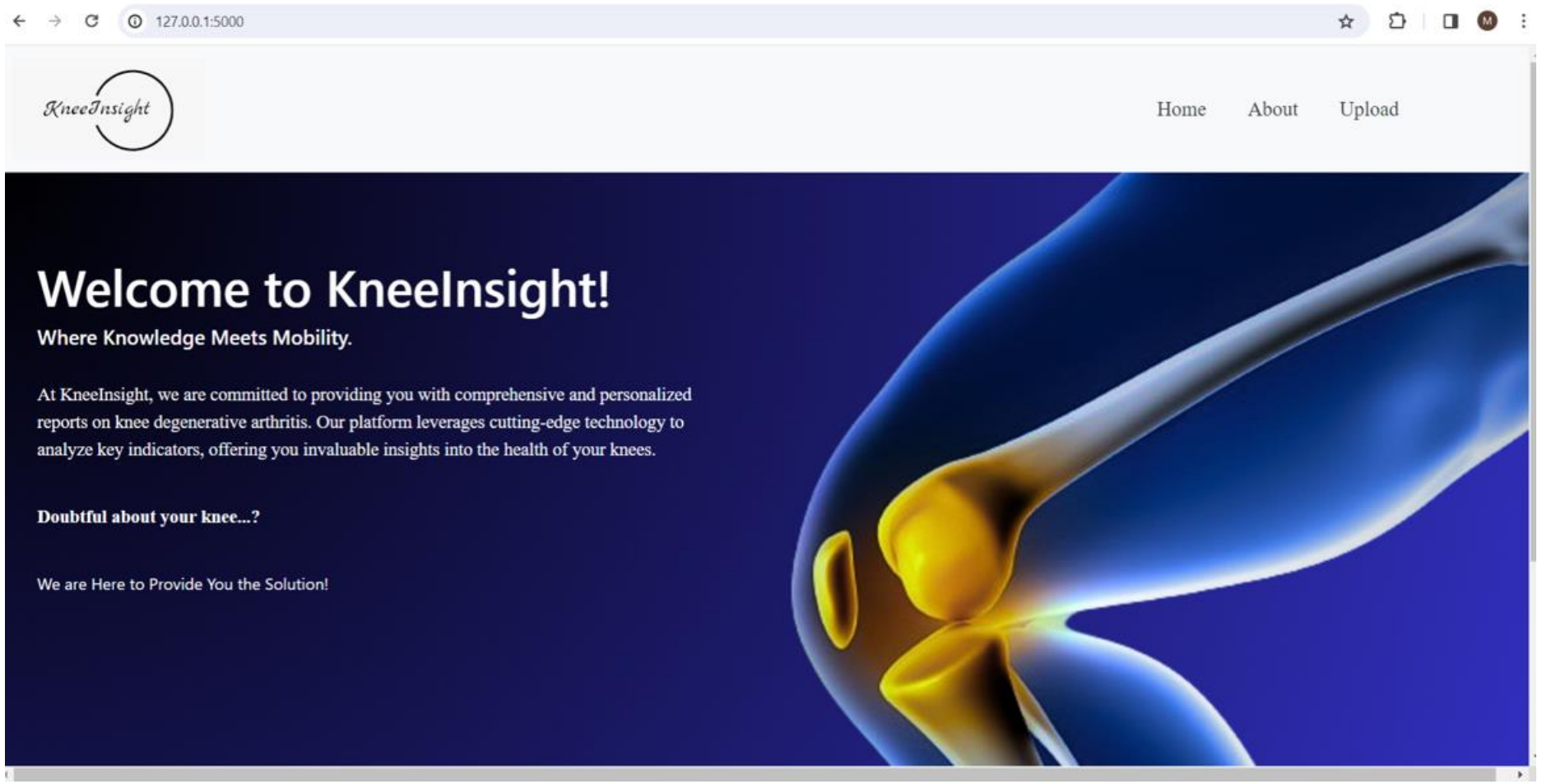
Xception, short for "Extreme Inception," is a convolutional neural network architecture proposed by François Chollet in 2017 as an advancement over the Inception architecture. It is designed to achieve better performance and efficiency by introducing a novel approach called depthwise separable convolutions. Xception follows the same fundamental idea as the Inception architecture, which involves extracting features at multiple spatial scales using convolutional filters of different sizes. However, instead of using traditional convolutional layers, Xception employs depthwise separable convolutions, which decompose the standard convolution operation into two separate operations: depthwise convolution and pointwise convolution. This separation significantly reduces the number of parameters while maintaining or even improving the model's representational capacity. By decoupling spatial and channel-wise dependencies, Xception allows for more efficient use of computational resources and enables deeper and more complex network architectures. Xception has been shown to achieve state-of-the-art performance on various computer vision tasks, including image classification, object detection, and image segmentation.

Reports Generation on Knee Degenerative Arthritis:

Steps:

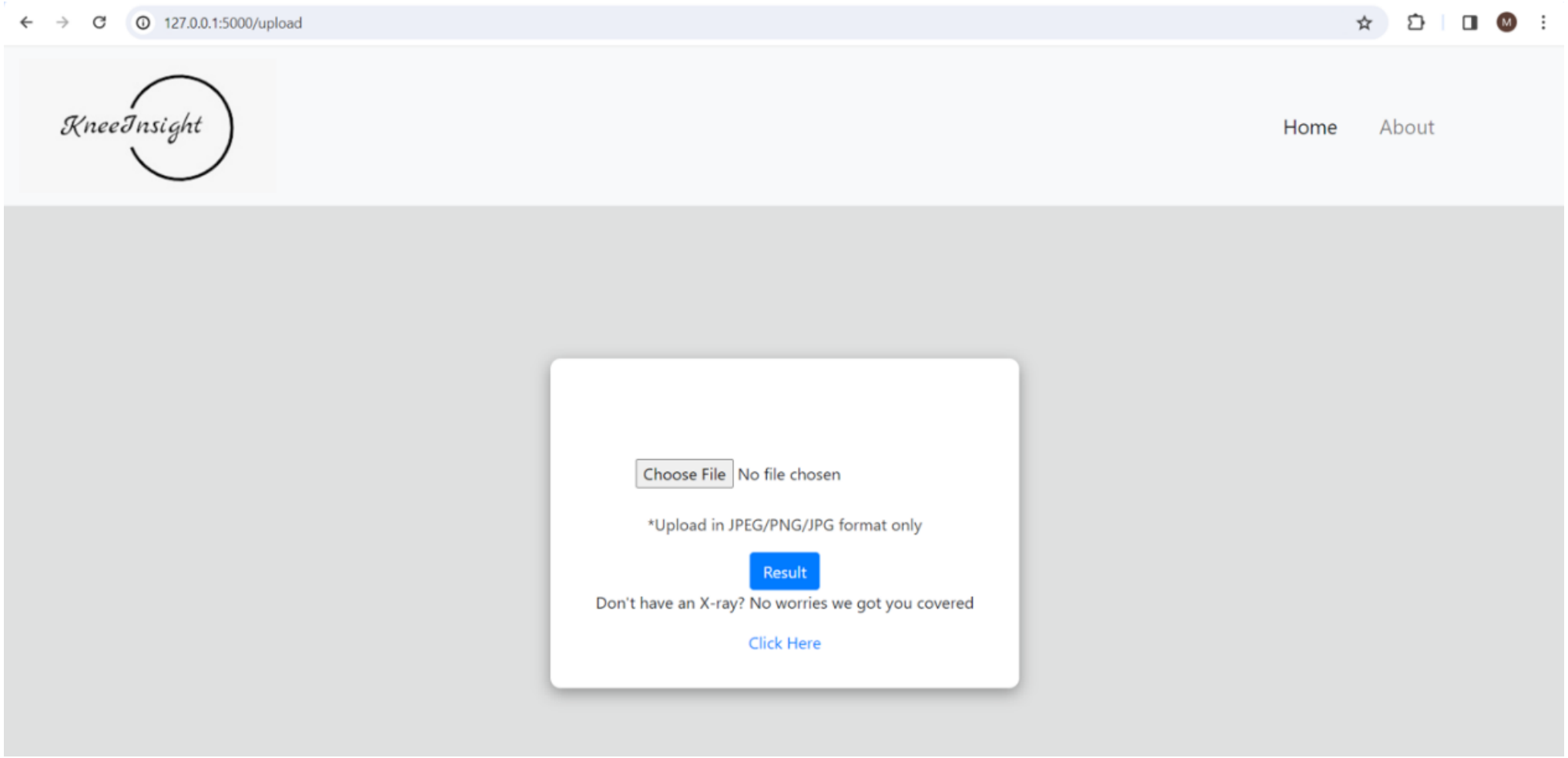
1 .Data Preparation and Augmentation
2.Model Training
3.Evaluation
4.Metrics Computation
5.Grad-CAM Visualization
6.Analysis and Interpretation

TECHNICAL DESIGN:



TECHNICAL DESIGN

TECHNICAL DESIGN



SOFTWARE TESTING:

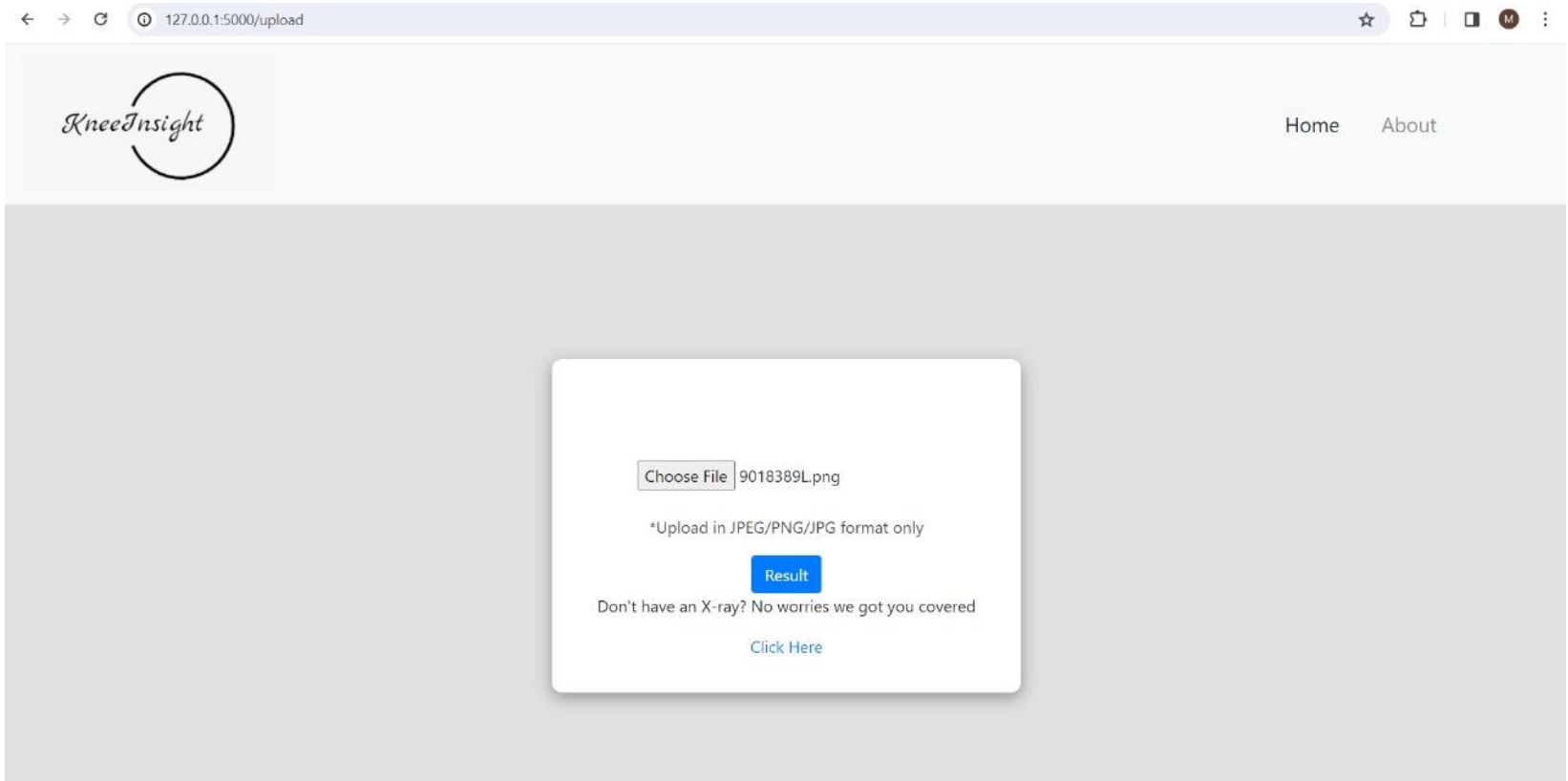
The process of checking a software program to make sure it performs as expected and satisfies with requirements is known as software testing. It includes running the program under well regulated circumstances and analyzing the output to find errors or differences between the intended and actual outcomes. Software testing is to verify the program's operation, dependability, and quality before end users are allowed to use it.

Software testing approaches are available in many forms, each with a specific role in assuring the dependability and quality of the program. These are a few typical categories of software testing:

- **Unit Testing**
- **Functional Testing**
- **System Testing**
- **Acceptance Testing**
- **Integration Testing**
- **Performance Testing**

UNIT TESTING:

Unit testing involves the design of test cases that validate that the internal program logic is functioning properly, and that program input produces valid outputs. All decision branches and internal code flow should be validated. It is the testing of individual software units of the application .



TEST CASES:

Test case Number	1
Test case Name	Unit Test Case for uploading images by the user.
Feature to be tested	Image upload
Description	A knee X ray images with classification based on 5 grades
Sample Input	Example.jpg, Example.jpeg, Example.png
Expected output	The model accurately identifies the knee image.
Actual output	The image is classified into normal stage[class_0]
Remarks	Success

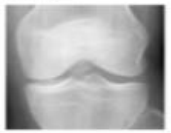
127.0.0.1:5000/upload

Generated Reports

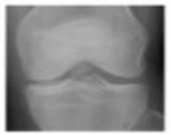
Reports generated for the knee image:

Reports on knee image:

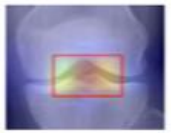
Input Image:



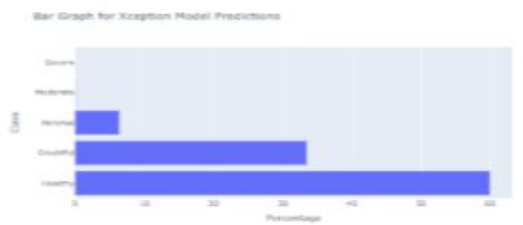
Preprocessed Image:



Grad CAM Visualization with Bounding Box:



Prediction: Healthy with 60.02%



Knee Health Description:

Stage 0 OA is classified as "normal" knee health. The knee joint shows no signs of OA and the joint functions without any impairment or pain. Congrats you are perfectly fine.

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Test case Number	2
Test case Name	Unit Test Case for uploading images by the user.
Feature to be tested	Image upload
Description	A knee X ray image with classification based on 5 grades
Sample Input	Example.jpg, Example.jpeg, Example.png
Expected output	The model accurately identifies the knee image.
Actual output	The image is classified into Doubtful stage[class_1]
Remarks	Success

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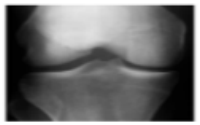
Generated Reports

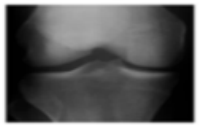
Reports generated for the knee image:

Reports on knee image:

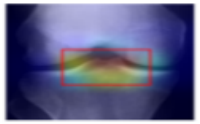
Input Image:



Preprocessed Image:



Grad CAM Visualization with Bounding Box:



Prediction: Doubtful with 53.99%

Knee Health Description:

Stage 1 OA: A person with stage 1 OA is showing very minor bone spur growth. Bone spurs are bonay growths that often develop where bones meet each other in the joint. Someone with stage 1 OA will usually not experience any pain or discomfort as a result of the very minor wear on the components of the joint.

Go to Home Page

Test case Number	3
Test case Name	Unit Test Case for uploading image by the user.
Feature to be tested	Image upload
Description	A knee X ray image with classification based on 5 grades
Sample Input	Example.jpg, Example.jpeg, Example.png
Expected output	The model accurately identifies the knee image.
Actual output	The image is classified into Minimal stage[class_2]
Remarks	Success

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Generated Reports

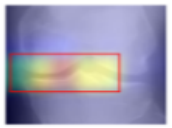
Reports generated for the knee image:

Reports on knee image:

Input Image:

Preprocessed Image:

Grad CAM Visualization with Bounding Box:



Prediction: Minimal with 47.65%

Bar Graph for Xception Model Predictions

Knee Health Description:

Stage 2 OA of the knee is considered a "mild" stage of the condition. X-rays of knee joints in this stage will reveal greater bone spur growth, but the cartilage is usually still at a healthy size, i.e. the space between the bones is normal, and the bones are not rubbing or scraping one another. At this stage, synovial fluid is also typically still present at sufficient levels for normal joint motion.

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Test case Number	4
Test case Name	Unit Test Case for uploading images by the user.
Feature to be tested	Image upload
Description	A knee X ray image with classification based on 5 grades
Sample Input	Example.jpg, Example.jpeg, Example.png
Expected output	The model accurately identifies the knee image.
Actual output	The image is classified into Moderate stage[class_3]
Remarks	Success


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Generated Reports
Reports generated for the knee image:
Reports on knee image:
Input Image:
Preprocessed Image:
Grad CAM Visualization with Bounding Box:
Prediction: Moderate with 95.33%
Bar Graph for Xception Model Predictions
Knee Health Description:
Stage 3 OA is classified as "moderate" OA. In this stage, the cartilage between bones shows obvious damage, and the space between the bones begins to narrow. People with stage 3 OA of the knee are likely to experience frequent pain when walking, running, bending, or kneeling. They also may experience joint stiffness after sitting for long periods of time or when waking up in the morning. Joint swelling may be present after extended periods of motion, as well.
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Test case Number	5
Test case Name	Unit Test Case for uploading images by the user.
Feature to be tested	Image upload
Description	A knee X ray image with classification based on 5 grades
Sample Input	Example.jpg, Example.jpeg, Example.png
Expected output	The model accurately identifies the knee image.
Actual output	The image is classified into Severe stage[class_4]
Remarks	Success

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Generated Reports

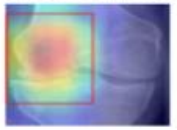
Reports generated for the knee image:

Reports on knee image:

Input Image:

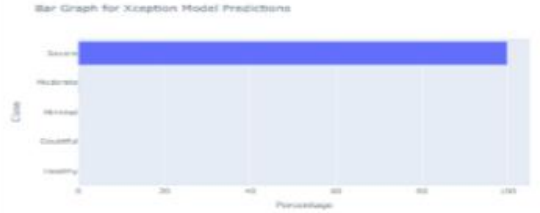
Preprocessed Image:

Grad CAM Visualization with Bounding Box:



Prediction: Severe with 99.88%

Bar Graph for Xception Model Predictions



Knee Health Description:

Stage 4 OA is considered "severe." People in stage 4 OA of the knee experience great pain and discomfort when they walk or move the joint. That's because the joint space between bones is dramatically reduced—the cartilage is almost completely gone, leaving the joint stiff and possibly immobile. The synovial fluid is decreased dramatically, and it no longer helps reduce the friction among the moving parts of a joint.

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ACCEPTANCE TESTING :

User Acceptance Testing is a critical phase of any project and requires significant participation by the end user. It also ensures that the system meets the functional requirements.

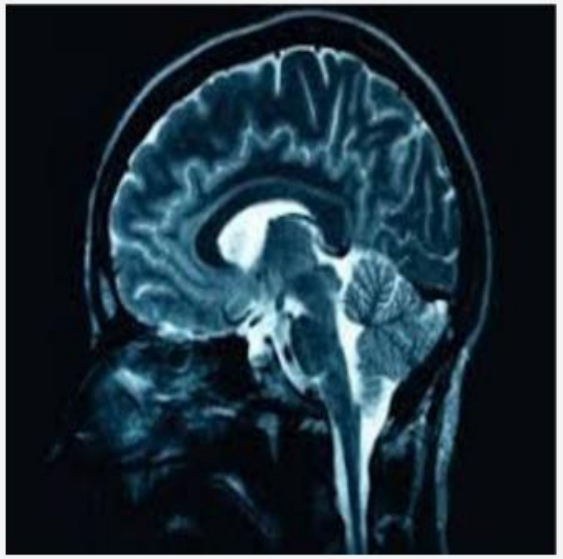
S-NO	Test-case scenario	Expected result	Actual result
1	Invalid image	Prompt for “Insert Correct Knee Image”.	Focus on image.

127.0.0.1:5000/upload

Incorrect Image

The uploaded image is not a knee image.

Please insert a correct knee image.



Go back to Upload Page

FUNCTIONAL TESTING:

Functional testing is a type of software testing that focuses on verifying that the software functions correctly according to the specified requirements and design. It involves testing the functional aspects of the software, such as its features, functionality, and behavior, to ensure that it performs the intended tasks accurately.

- **Valid Input** : identified classes of valid input must be accepted.
- **Invalid Input**: identified classes of invalid input must be rejected.
- **Functions**: identified functions must be exercised.
- **Output:** identified classes of application outputs must be exercised.
- **Systems/Procedures**: Interfacing systems or procedures must be invoked.

SYSTEM TESTING:

System testing ensures that the entire integrated software system meets requirements. It tests a configuration to ensure known and predictable results. The purpose is to ensure that all components work together seamlessly and that the system behaves as expected under various scenarios and conditions.System testing is based on process descriptions and flows, emphasizing pre-driven process links and integration points .

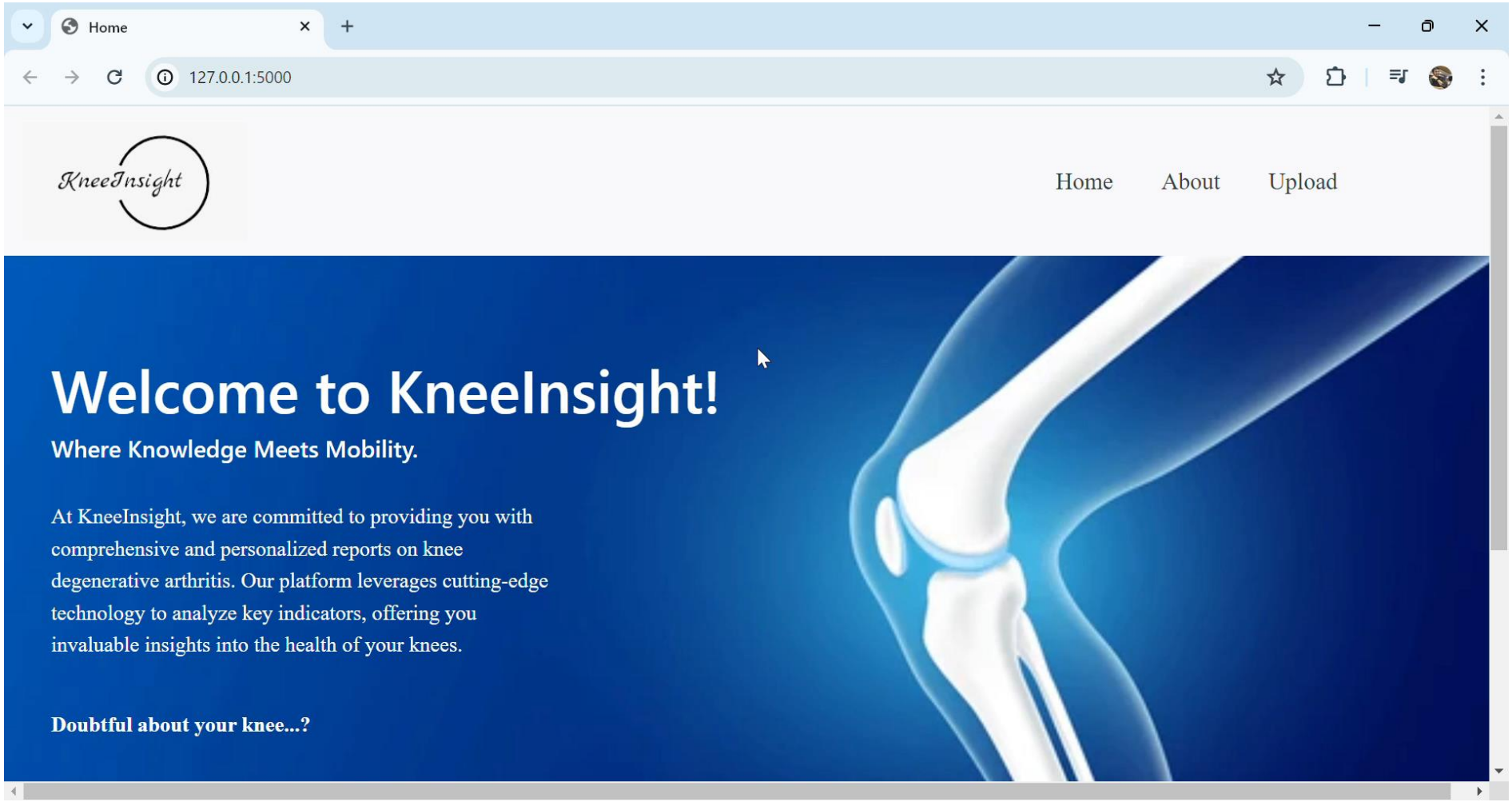
PERFORMANCE TESTING

Performance testing is a type of software testing that evaluates the speed, responsiveness, scalability, and stability of a software application under various workload conditions. The primary objective of performance testing is to ensure that the software performs well and meets performance requirements when subjected to different levels of user activity or system load.

INTEGRATION TESTING

In integration testing, individual modules or components are combined and tested as a group to identify any defects or issues that may arise due to interactions between them. This involves testing the flow of data, control, and communication between modules to ensure that they function correctly and produce the expected results.

PROJECT EXCUTION:



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Thank You!