An Automated System for Predicting Knee Osteoarthritis from X-ray Images Using Neural Networks Approach

A project report submitted to

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY, ANANTAPUR

In partial fulfillment of the requirements
for the award of the degree of

BACHELOR OF TECHNOLOGY
IN
COMPUTER SCIENCE AND ENGINEERING

Submitted by

IV B. Tech II Semester

R. NANDINI	20KH1A0589
N. KAVYA	20KH1A0567
Y. NAMITHA SREE	20KH1A05C1
P. HIMA PRIYA	20KH1A0584
T. THARUNA SREE	20KH1A05B1

Under the Esteemed Guidance of

Ms. P. MANVITHA VARSHA, M. Tech,MSW.,
ASSISTANT PROFESSOR

Department of Computer Science and Engineering

Sri Venkateswara College of Engineering
(Affiliated to JNTUA, Anantapuramu and Approved by AICTE, New Delhi)
Balaji Nagar, Kadapa-516003.

(2020-2024)

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Department of Computer Science and Engineering
SV COLLEGE OF ENGINEERING
Approved by AICTE, New Delhi, Affiliated to JNTUA, Anantapuram
Website: www.svck.edu.in

Sri Venkateswara College of Engineering

(Affiliated to JNTUA, Anantapuramu and Approved by AICTE, New Delhi)
Balaji Nagar, Kadapa-516003.

Department of Computer Science and Engineering

Certificate

This is to certify that the project work entitled

An Automated System for Predicting Knee Osteoarthritis from X-ray Images Using Neural Networks Approach

is the bonafide work done by

R. NANDINI	20KH1A0589
N. KAVYA	20KH1A0567
Y. NAMITHA SREE	20KH1A05C1
P. HIMA PRIYA	20KH1A0584
T. THARUNA SREE	20KH1A05B1

In the Department of Computer Science and Engineering, Sri Venkateswara College of Engineering, Kadapa is affiliated to JNTUA-Anantapur in partial fulfillment of the requirements for the award of Bachelor of Technology in Computer Science and Engineering during 2020-2024.

This work has been carried out under my guidance and supervision.

The results embodied in this Project report have not been submitted in any University or Organization for the award of any degree or diploma.

INTERNAL GUIDE
Ms. P. MANVITHA VARSHA, M. Tech,MSW.,
Assistant Professor

HEAD OF THE DEPARTMENT
Mr. G. SREENIVASULU, M. Tech.,(Ph.D.)
Assistant Professor & HoD

INTERNAL EXAMINER

EXTERNAL EXAMINER

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Thanks for Your Valuable Guidance and kind support.

DECLARATION

We hereby declare that project report entitled **An Automated System for Predicting Knee Osteoarthritis from X-rays Images Using Neural Network Approach** is a genuine project work carried out by us, in B.Tech (Computer Science and Engineering) degree course of **JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY ANANTAPUR** and has not been submitted to any other courses or University for award of any degree by us.

Signature of the Student

1. R. Nandini
2. N. Kavya
3. Y. Namitha Sree
4. P. Hima Priya
5. T. Tharuna Sree

ABSTRACT

Arthritis is a term used to describe any disorder that affects the joints. Osteoarthritis, the most prevalent type of arthritis, affects almost 237 million people worldwide. Even though arthritis has no known cure, early detection and treatment can be very helpful along with assisting in alerting patients to the beginning of knee osteoarthritis. Additionally, this research informs them of the seriousness of their disease. Convolutional neural network was used as the algorithm, and Python was the programming language. Knee Osteoarthritis is one of the most common degenerative diseases affecting elderly people in the world, it can limit the mobility of a person affecting daily life activities and even causing early retirement predicts that this type of degenerative joint disease disorder will affect at least 130 million people across the world by 2050, of whom 40 million will be severely disabled by this condition. Moreover, when the disease is at the last stage the only treatment is a total knee replacement. So, it is recommended to identify Knee Osteoarthritis at first stages to avoid knee this medical procedure. Osteoarthritis (OA) is the result–and the observable status–of inflammatory processes in a joint leading to functional and anatomical impairments. The resulting status often shows irreversible damage to the joint cartilage and the surrounding bone structures.

LIST OF FIGURES

LIST OF PHOTOGRAPHS

TABLE OF CONTENTS

1. INTRODUCTION

1.1. ABOUT THE PROJECT

Arthritis is a term used to describe any disorder that affects the joints. Osteoarthritis, the most prevalent type of arthritis, affects almost 237 million people worldwide. Even though arthritis has no known cure, early detection and treatment can be very helpful along with assisting in alerting patients to the beginning of knee osteoarthritis. Additionally, this research informs them of the seriousness of their disease. Convolutional neural network was used as the algorithm, and Python was the programming language. Knee Osteoarthritis is one of the most common degenerative diseases affecting elderly people in the world, it can limit the mobility of a person affecting daily life activities and even causing early retirement predicts that this type of degenerative joint disease disorder will affect at least 130 million people across the world by 2050, of whom 40 million will be severely disabled by this condition. Moreover, when the disease is at the last stage the only treatment is a total knee replacement. So, it is recommended to identify Knee Osteoarthritis at first stages to avoid knee this medical procedure. Osteoarthritis (OA) is the result–and the observable status–of inflammatory processes in a joint leading to functional and anatomical impairments. The resulting status often shows irreversible damage to the joint cartilage and the surrounding bone structures. The knees are the most commonly affected joints in the human body and knee. Osteoarthritis (KOA) is more prevalent in females aged 60 years or more compared to males of the same age (13% vs 10%). Severity of KOA amongst females with more than 55 years of age is higher compared to their male counterparts and the severity of KOA is higher compared to other types of OA. Approximately one in every six patients consult with a general practitioner in their first year of an OA episode. The incidence of KOA has a positive association with age and weight and the prevalence is more common in younger age groups, particularly those who have obesity problems.

Swelling, joint pain, and stiffness are the prominent symptoms among others, such as restrictions in movement including walking, stair climbing, and bending. The symptoms worsen over time and elderly patients are affected more frequently than

patients in other age groups. The presence of OA in the knee reduces activity in daily life and eventual leads to disability , which can incur high costs related to loss in productivity. It is estimated that functional impairment of the knee and the hip are the eleventh highest disability factors contributing to considerable socio-economic burden with an estimated cost per patient per year of approximately 19,000 Euro. The estimated prevalence of disability due to arthritis is expected to reach 11.6 million individuals by 10 the year 2020, which is greater than the estimated risk of disability attributable to cardiovascular diseases or any other medical condition

Normal Knee Image

Osteoarthritis Knee Image

The main symptoms of OA are pain and difficulty in joint motion, reduced function and participation restriction, Joint stiffness in the morning or after prolonged rest. The present evaluation of OA is based on clinical examination, symptoms and simple radiographic assessment techniques (X-ray), MRI, CT etc. While several other methods have been proposed, Kellgren-Lawrence (KL) system is validated method of classifying individual joints into 5 grades. Table below shows the different grades of OA disease

Table 1: KL Grading System

KL Grades	OA Analysis
Grade 0	No Radiographic features of OA present
Grade 1	Doubtful OA(narrowing of joint space)
Grade 2	Mild OA(definite narrowing of joint space)
Grade 3	Moderate OA (multiple osteophytes, sclerosis)
Grade 4	Sever OA (large osteophytes, sever sclerosis, bone deformity)

The common X-ray findings of OA include destruction of joint cartilage; joint space is diminished between adjoining bones and bone spur formation [24]. MRI scans may be ordered when x- rays do not give clear reason for joint pain or when the x- ray suggests that other type of joint tissues can be damaged. In OA, after acquiring the Knee X-ray image, human experts need certain time to examine the knee X-ray image. The parameters used for the classification of OA are continues & complex. It may be possible that the experts may exceed time limit in investigating the knee x-ray image and may reach some other conclusion regarding the presence of OA. So to overcome these human errors Computer aided automation of knee x-ray image is required. Automation allows quick and efficient results with respect to the disease & has significantly less errors. Sometimes knee X-ray images may not be clear during early Osteoarthritis or due to some other distortions. If the knee X-ray findings are not clear doctor suggests the patients to go for MRI. As MRI is an expensive option, common man may not afford it. The current methods used for clinical diagnosis of Osteoarthritis are not accurate enough to efficiently measure the quality & evolution of Osteoarthritis. Thus more significant methods & algorithms are required which are multi-factorable to

access the parameters & progression of Osteoarthritis. Therefore the authors have tried to implement semi-automated method that helps in the diagnosis of the disease to some extent

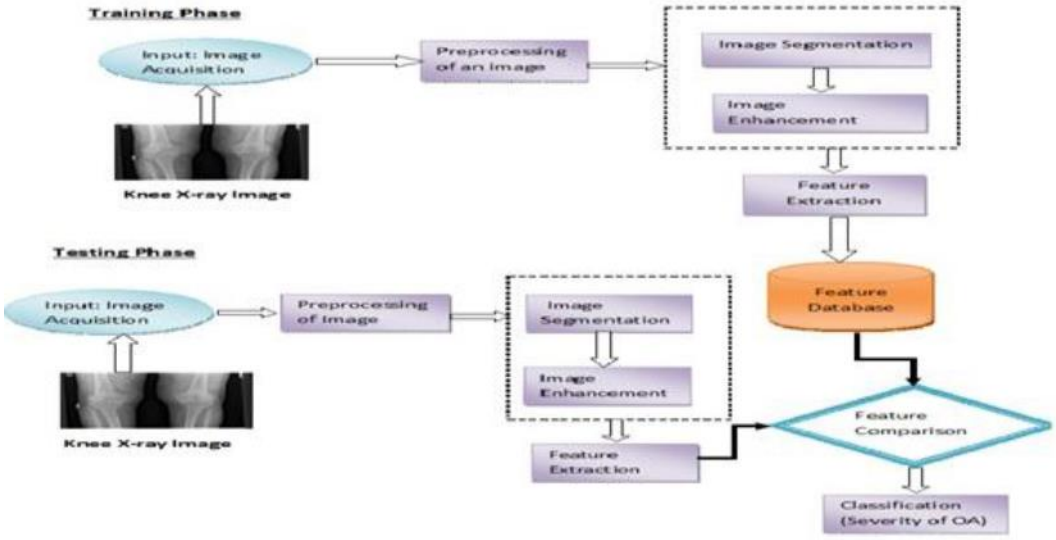


Fig.1.1: System Architecture

1.2 MODULES

The proposed methodology below figure 5 consists of five main steps, Preprocessing, Image segmentation, Image enhancement, Feature extraction and Classification of computed features. The steps are explained in the following subsections.

Image Acquisition

Image acquisition can be designated as the action of fetching an image from some source which is further processed to get new and better image [25].

Data Set: The authors have used the input data set of 200 knees X-ray images that were collected from various hospitals and diagnostic centre. The images collected were based on various specifications like age, gender, blood group, occupation etc.

Pre-processing

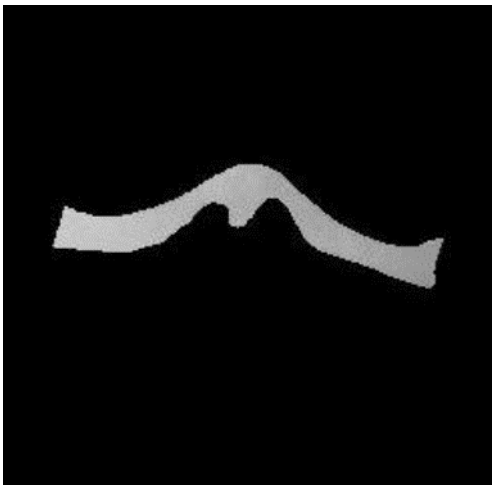
Pre-processing highlights some important features relevant to understand the image.

After collection of knee X-ray images, initially pre-processing techniques are used

which are application dependent. In the work pre-processing is carried out by cropping the image to 512x409 pixels and resized to 250x250 for the proper analysis.

Image Segmentation

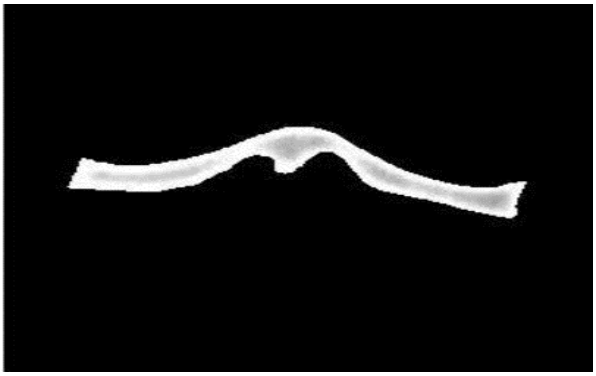
The segmentation is the process where the image is partitioned into its constituent parts or objects that can be identified individually [26]. In the work image segmentation is carried out using Active contour segmentation method. The boundaries of designated mask are used by Active contour as the initial state of the contour from where the evolution starts. The prominence and the suppressed regions of an image are segmented using active contour algorithm. The algorithm uses Chan-Vese and Edge methods to segment an image [28].The region between the femur and tibia is segmented and further processed for computation. The picture below shows the segmented region of Knee X-ray image.



Segmented Image

Image Enhancement

Enhancement techniques are used to improve the quality of the image to great extent. The technique can improve image quality in terms of shading, linear contrast adjustment, un-sharp masking, and median filtering and color. In the work segmented knee X-ray images are enhanced by contrast adjustment to get better extremity of an image. The picture below (figure 5) shows the enhanced segmented region of Knee X-ray image.



Enhanced Segmented Image

Feature Extraction

Feature Extraction is one of the important modules of image processing. In this stage we compute features of segmented and enhanced image using Python which results in recognition accuracy with very simple classification module. Authors have computed various features from the obtained segmented region. The features computed are

The dataset which is collected from Kaggle is taken into consideration. The dataset contains knee X-ray data for both knee joint detection and knee KL grading. The Grade descriptions are

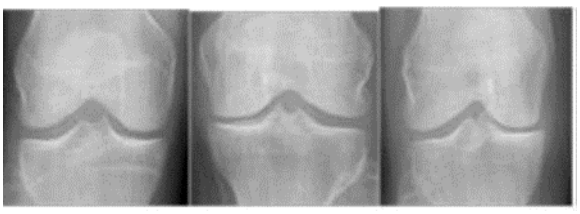
Grade 0: (Healthy): Healthy knee image.

Grade 1 (Doubtful): Doubtful joint narrowing with possible osteophytic lipping

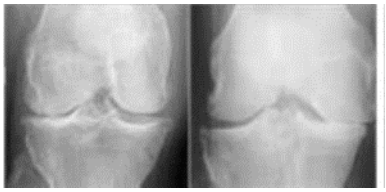
Grade 2 (Minimal): Definite presence of osteophytes and possible joint space narrowing.

Grade 3 (Moderate): Multiple osteophytes, definite joint space narrowing, with mild sclerosis.

Grade 4 (Severe): Large osteophytes, significant joint narrowing, and severe sclerosis



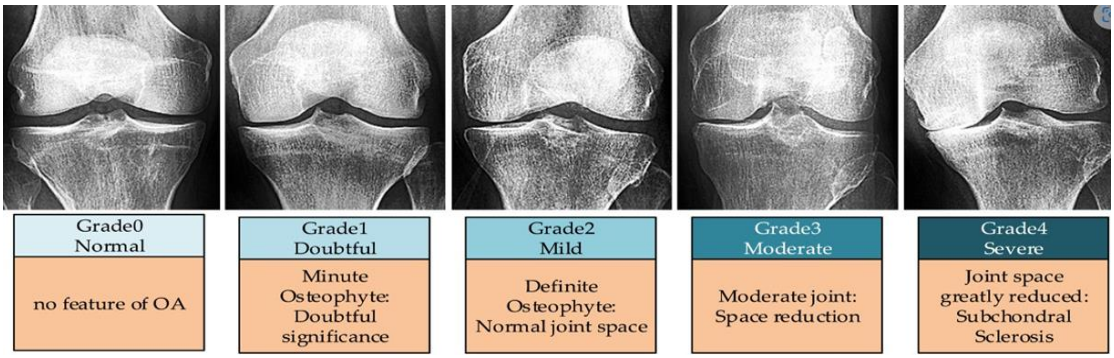
Healthy Knee, Doubtful and Minim



Moderate and Serve

Detection

The model is trained in such a way to classify the given input image into desired category. Here, the x-ray image is taken as input, the model analyses the input by extracting the features. The model classifies the given image accordingly and predict the grade of disease.



Grading System

2. LITERATURE SURVEY

A literature survey or literature review is the study of references and old algorithms that we have read for designing the proposed methods. It also helps in reporting summarization of all the old references papers, and their drawbacks. The detailed literature survey for the project helps in comparing and contrasting various methods, algorithms in various ways that have implemented in the research.

[1] Lior Shamir, Shari M.Ling,William W.Scott, Angelo Bos, Nikita Orlov, Tomasz Macura, D.Mark, Luigi Ferrucci, Ilya G.Goldberg "Knee X-ray Image Analysis Method for Automated Detection of Osteoarthritis", IEEE Transactions on Biomedical Engineering, ©2008.

We describe a method for automated detection of radiographic osteoarthritis (OA) in knee X-ray images. The detection is based on the Kellgren-Lawrence (KL) classification grades, which correspond to the different stages of OA severity. The classifier was built using manually classified X-rays, representing the first four KL grades (normal, doubtful, minimal, and moderate). Image analysis is performed by first identifying a set of image content descriptors and image transforms that are informative for the detection of OA in the X-rays and assigning weights to these image features using Fisher scores. Then, a simple weighted nearest neighbor rule is used in order to predict the KL grade to which a given test X-ray sample belongs. The dataset used in the experiment contained 350 X-ray images classified manually by their KL grades. Experimental results show that moderate OA (KL grade 3) and minimal OA (KL grade 2) can be differentiated from normal cases with accuracy of 91.5% and 80.4%, respectively. Doubtful OA (KL grade 1) was detected automatically with a much lower accuracy of 57%. The source code developed and used in this study is available for free download at www.openmicroscopy.org.

[2] Samir K.Bandyopadhyay "An Edge Detection Algorithm for Human Knee Osteoarthritis Images", Journal of Global Research in Computer Science, Volume 2, No. 4, ISSN-2229-371X, April 2011.

Digital image processing comprises varieties of applications, where some of these used in medical image processing include convolution, edge detection as well as contrast enhancement. Efficient edge detection depends on choosing the threshold; the

choice of threshold directly determines the results of edge detection.

Osteoarthritis (OA) results from a failure of cells within the joint to maintain the balance between synthesis and degradation of the extracellular matrix. OA is a major cause of pain and disability in the elderly yet there is at present no effective treatment for loss of joint function. This is partly because the condition is heterogeneous with obscure pathogenesis but also because there are no specific laboratory tests or screening procedures that provide a specific diagnosis of early OA. There is a clear need to be able to define onset of characteristic pathological changes when intervention would be timely and to monitor the natural history up to the stage of Radiological detected damage. In this paper, edge detection operator and its enhanced algorithm is used to detect edges for human knee osteoarthritis images in different critical situations. It is shown that the algorithm is very effective in case of noisy and blurs images.

[3] Dipali D.Deokar, Chandrashekar G.Patil "Effective feature Extraction Based Automatic knee Osteoarthritis Detection and Classification using Neural Network", International Journal of Engineering and Techniques, ISSN:2395-1303, Volume 3, Issue 3, PP: 134-139, May 2015

Osteoarthritis (OA) is the most common form of arthritis seen in aged or older populations. It is caused because of a degeneration of articular cartilage, which functions as shock absorption cushion in knee joint. OA also leads sliding of bones together, cause swelling, pain, eventually and loss of motion. Nowadays, magnetic resonance imaging (MRI) technique is widely used in the progression of osteoarthritis diagnosis due to the ability to display the contrast between bone and cartilage. Usually, analysis of MRI image is done manually by a physician which is very unpredictable, subjective and time consuming. Hence, there is need to develop automated system to reduce the processing time. In this paper, a new automatic knee OA detection system based on feature extraction and artificial neural network is developed. The different features viz GLCM texture, statistical, shape etc. is extracted by using different image processing algorithms. This detection system consists of 4 stages, which are pre-processing with ROI cropping, segmentation, feature extraction, and classification by neural network. This technique results 98.5% of classification accuracy at training stage and 92% at testing stage.

[4] M. Subramoniam and V. Rajini "Local Binary Pattern Approach to the Classification of Osteoarthritis in Knee X-ray Images", Asian Journal of Scientific Research, Volume 6, Issue 4, pp: 805-811, ISSN: 1992-1454, 2013.

Osteoarthritis is one of the popular causes of debility in elderly & overweight people. Osteoarthritis is a joint disease that invades the cartilage of bigger joints like knee, hip, feet and spine. Cartilage helps the easy glide of bones & obstructs them from rubbing each other. In Osteoarthritis cartilage is ruptured due to which bones start kneading each other with a severe pain. The scenario for the evaluation of Osteoarthritis includes clinical examination & various medical imaging techniques. In this work the authors have used Active contour segmentation technique to segment the portion/part of the knee X-ray image to diagnosis the disease. The numerous features like Haralick, Statistical, First four moments, Texture and Shape are computed and classified using Random Forest classifier. The proposed method gives the classification accuracy rate of 87.92% which are more competitive and promising with the existing algorithms.

[5] Prafull Sharma, Joshua Madhukar Singh " A Novel Approach towards X-ray Bone Image Segmentation using Discrete Step Algorithm", International Journal of Emerging Trends & Technology in Computer Science, Volume 2, Issue 5, PP:191-195, ISSN 2278-6856, 2013.

Arthritis is generally a joint disorder that causes inflammation or often painful feeling in joints, joint is an area of our body that have a common meeting point which makes it easier to move our body parts in several directions. It is said to be the systematic disease that can also affect other parts of our body if it happens once. Arthritis is a common disease that people miss work which results in a decreased quality of life There are some symptoms which may occur such as one can feel unusually fatigued, joint stiffness, joint pain, minor joint swelling etc. Although losing weight and exercise can be helpful and medicines for pain relief. With the passing of time, the realm of human knowledge is ever expanding. Further, with each passing day, we witness the explosion of information which is evident in life style, social events and breakthrough in science. Magnetic Resonance Images provides the early detection of the arthritis so that patient will get prepare for it and soon doctor will be able to find a way to cure it. Typically, Magnetic Resonance Images are complex and noisy.

This hints to the need of process which reduces difficulties in analysis and increases quality of output. However this paper will focus on all the aspects which are related to the arthritis and presents the more appropriate method required to detect arthritis in medical imaging. In this paper, we take images for analysis from the large dataset which may contain symptom of such disease. Such an algorithm is explained which can be a lot more useful than any other algorithms to detect arthritis.

3. SYSTEM ANALYSIS

3.1. EXISTING SYSTEM

The project began with the analysis of models and procedures that already exist to perform this activity. There were many ways to predict the disease using x-rays, MRI's that mainly used machine learning techniques and body mass index. However, precise and reproducible quantitative measurements from MRI scans are burdensome because of the knee's anatomy and morphology, as well as the complexity of MR imaging. It can take a reader up to six hours to manually segment through 3-dimensional (3D) knee MRI sequence. The exisiting method lacks sufficient accuracy and reliability to detect small cartilage changes due to the structure and morphology of the knee. Operators who use cartilage segmentation software often need extensive training which further contributes to the time and cost.

3.1.1 Limitations in Existing System

- existing system's is detecting knee problems manually by doctors
- Patients will be given an recommendation by considering xray report

3.2. PROPOSED SYSTEM

The proposed uses x-ray images to predict the knee osteoarthritis, besides it also provides the severity of the disease. Here KL Grading system is used to classify the image based on their features. The model is trained by providing images of five different stages. The model is trained in such a way that based the patterns and features in x-ray images it will predict the disease. Previously we don't used technique to know the severity instead we only have techniques to predict whether the disease is there or not.

3.2.1. Features of the Proposed System

- 24/7 is Monitored.
- Less Expenses In Implementation as Code can connected to all CC Camera

- Detects Multiple Faces at a time.
- Automatic Detection of Multiple Faces with or without masks.
- The proposed model has Validation accuracy of 96%. If anyone in the video stream is not wearing a protective mask a Red coloured rectangle is drawn around the face with a dialog entitled as NO MASK and a Green coloured rectangle is drawn around the face of a person wearing MASK.

ALGORITHM

Convolutional Neural Network (CNN)

CNN algorithm is a Deep Learning method that can take in an input image. With no loss of information its integrated convolutional layer reduces the high dimensionality of images. Each image is given a filter or kernel to create an output that is better and more detailed after each layer. By searching for patterns in the images the algorithm CNN are highly useful for identifying items, classes and photographs. The convolutional layer takes input from the pixels in the image and performs the convolution function. It produces a distorted map as a result. A ReLU function is used to apply the convolved map to produce a corrected feature map. This algorithm predicts the results more accurately which leads to a better result The experiment is carried out on various Knee X-ray of different age and blood groups of the rural and urban population. The experiment is conducted on 200 Knee X-ray samples. Different features were computed like Shape features, Statistical features, First-four moments, Haralick features and Texture analysis features. In the investigation 40% of training and 60% of testing was carried out for the analysis. The Random Forests algorithm was used to classify the image. The classification was demonstrated provided the given image is normal or affected by using below algorithm.

Input: Knee X-ray image.

Output: Normal or Affected Knee X-ray image.

Step-1: Pre-processing i.e. removal noise, images resize, etc and Convert it into gray-scale.

Step-2: Normalize gray scale image to size 250x250 for further analysis

Step-3: Segmentation is carried out using Active contour algorithm.

Step-4: The segmented image is enhanced using Contrast adjustment technique for further interpretation.

Step-5: The different features computed are Shape features, Statistical features, First-four moments, Texture analysis features.

Step-6: Lastly 40% training and 60% testing is carried out on the obtained list of features using ML classifier.

Step-7 End of the algorithm.

4. SOFTWARE AND HARDWARE REQUIREMENTS

4.1 Software Specifications:

- **Operating System** : Windows 7/8/10
- **Coding Language** : Python
- **Server** : Wamp
- **Libraries Used** : Numpy, Flask, Keras
- **Database** : MYSQL

4.2 Hardware Specifications:

- **Processor** : I3/Intel Processor
- **Hard Disk** : 250 GB
- **RAM** : 4 GB

5. SYSTEM DESIGN

5.1. SYSTEM ARCHITECTURE

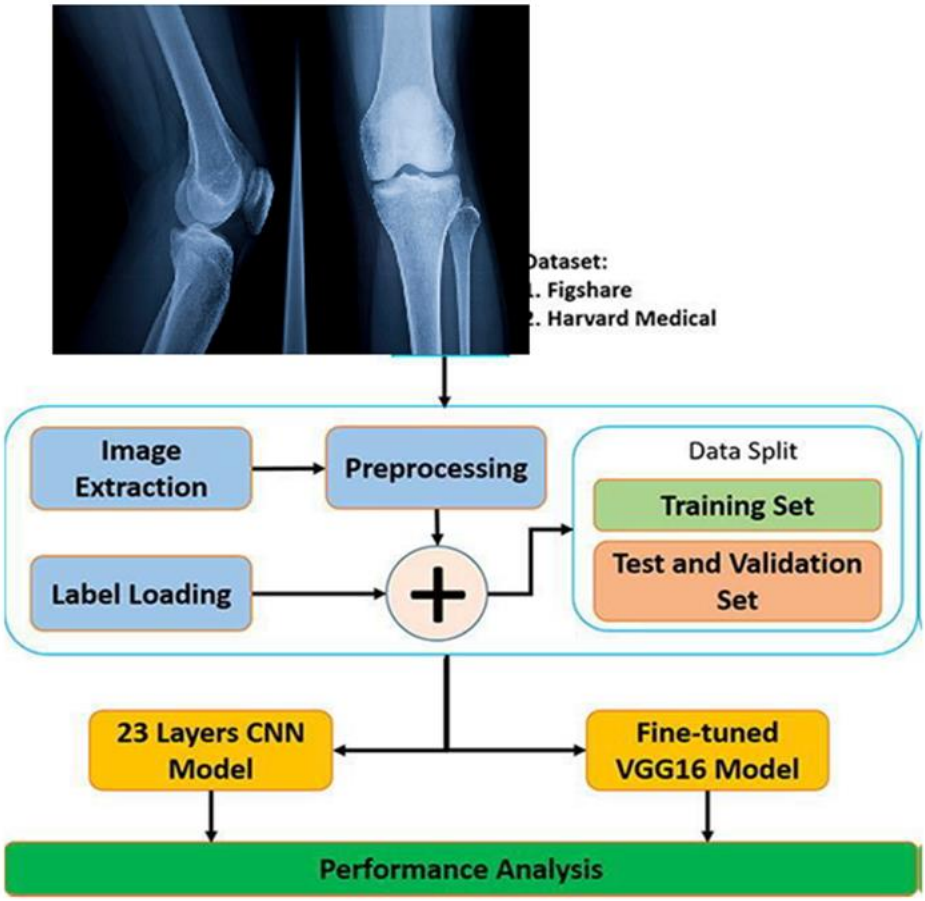


Fig 5.1: System Architecture

5.2. DATA FLOW DIAGRAM

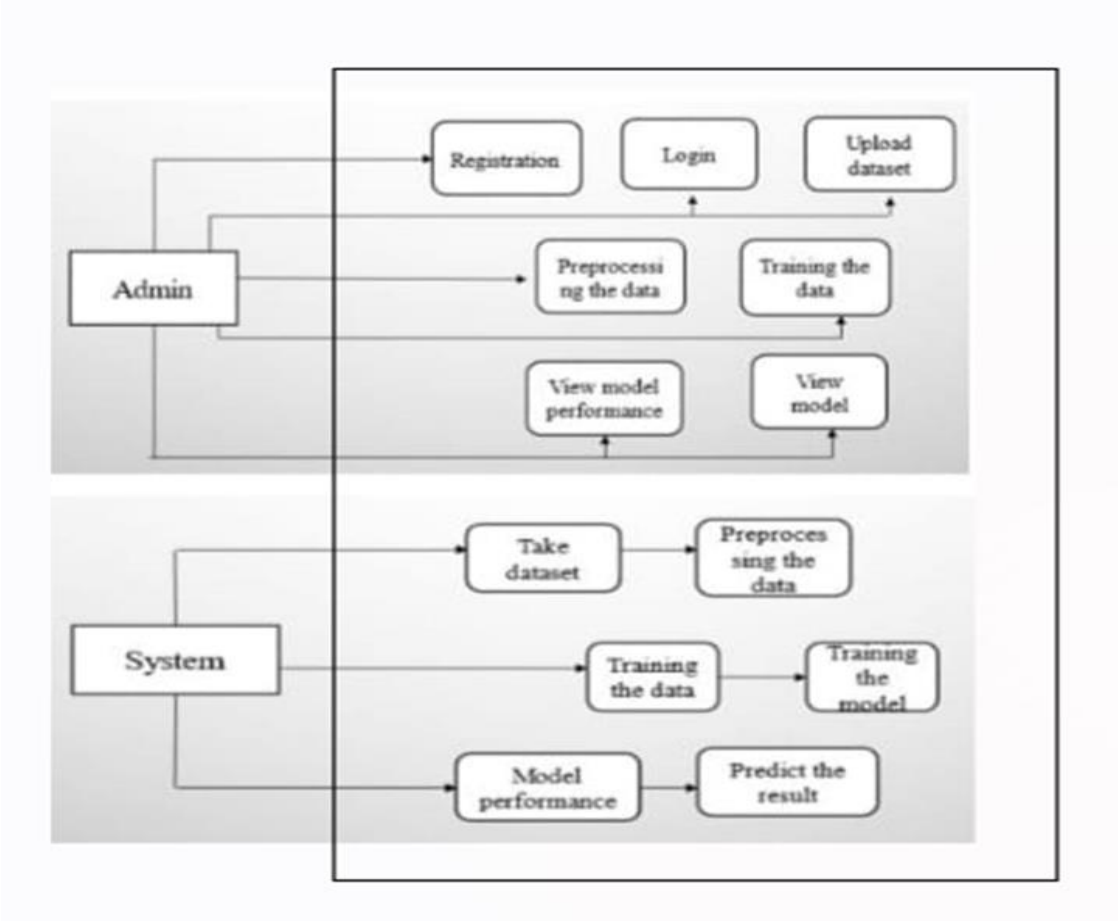


Fig.5.2: Data Flow Diagram

Dataflow Diagram works as follows:

1. It can be used to represent a system in terms of input data to the system, various processing carried out on this data, and the output data is generated by this system.
2. The data flow diagram (DFD) is one of the most important modeling tools. It is used to model the system components. These components are the system process, the data used by the process, an external entity that interacts with the system and the information flows in the The DFD is also called as bubble chart. It is a simple graphical formalism that system.
3. DFD shows how the information moves through the system and how it is modified by a series of transformations. It is a graphical technique that depicts

information flow and the transformations that are applied as data moves from input to output.

4. DFD is also known as bubble chart. A DFD may be used to represent a system at any level of abstraction. DFD may be partitioned into levels that represent increasing information flow and functional detail. DFD

5.3. UML DIAGRAMS

UML stands for Unified Modeling Language. UML is a standardized general-purpose modeling language in the field of object-oriented software engineering. The standard is managed, and was created by, the Object Management Group.

The goal is for UML to become a common language for creating models of object oriented computer software. In its current form UML is comprised of two major components: a Meta-model and a notation. In the future, some form of method or process may also be added to or associated with, UML.

The Unified Modeling Language is a standard language for specifying, Visualization, Constructing and documenting the artifacts of software system, as well as for business modeling and other non-software systems.

The UML represents a collection of best engineering practices that have proven successful in the modeling of large and complex systems. The UML is a very important part of developing objects oriented software and the software development process. The UML uses mostly graphical notations to express the design of software projects.

GOALS:

The Primary goals in the design of the UML are as follows:

- Provide users a ready-to-use, expressive visual modeling Language so that they can develop and exchange meaningful models.

5.3.1. Use Case Diagram

A use case diagram is a type of behavioural diagram created from a Use-case analysis.

The purpose of use case is to present overview of the functionality provided by the system in terms of actors, their goals and any dependencies between those use cases. In the below diagram the use cases are depicted with actors and their relationships.

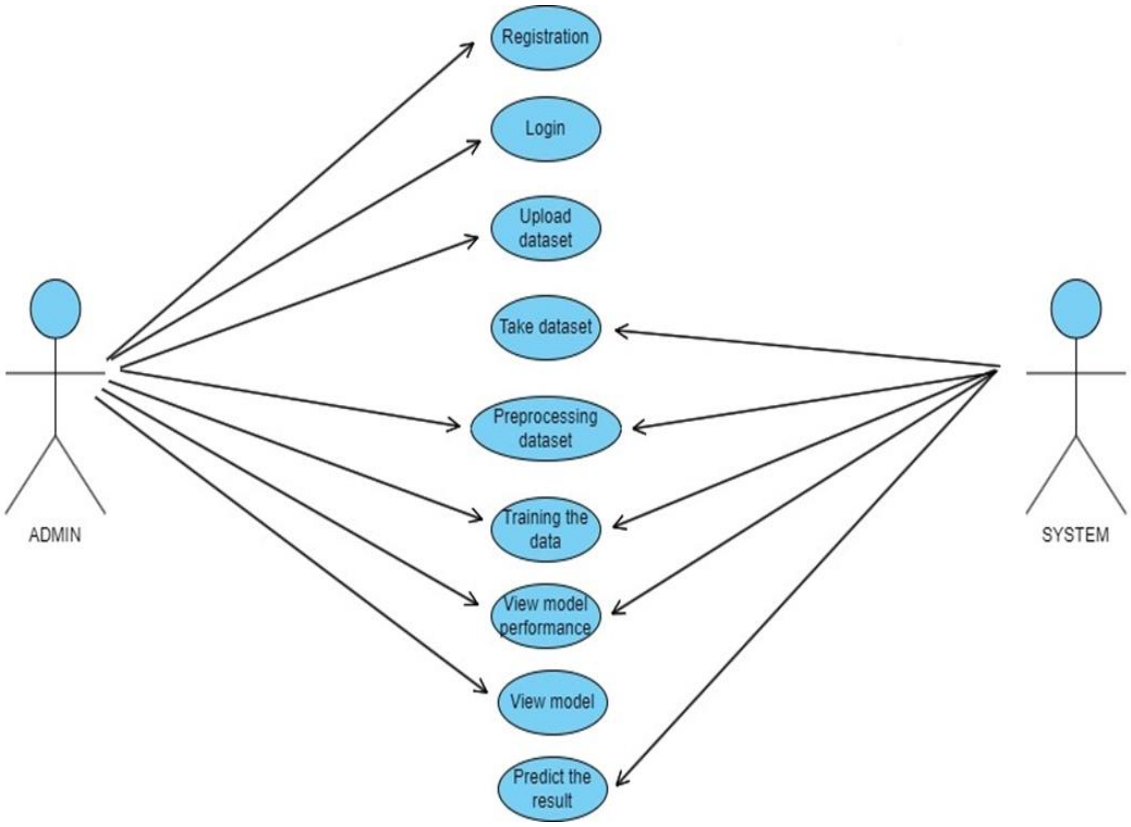


Fig.5.3: Use Case Diagram for System & Admin

5.3.2. Class Diagram

A class diagram in the UML is a type of static structure diagram that describes the structure of a system by showing the system's classes, their attributes, and the relationships between the classes. Private visibility hides information from anything outside the class partition. Public visibility allows all other classes to view the marked information. Protected visibility allows child classes to access information they inherited from a parent class.

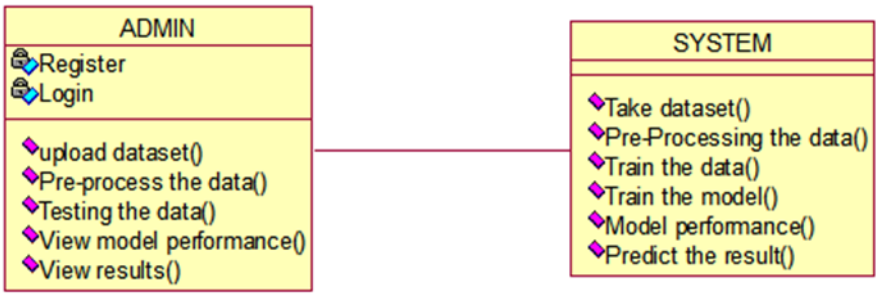


Fig.5.4: Class Diagram

5.3.3. Sequence Diagram

The sequence diagram describes the flow of messages being passed from object to object. Unlike the class diagram, the sequence diagram represents dynamic message passing between instances of classes rather than just a static structure of classes. In some ways, a sequence diagram is like a stack trace of object messages.

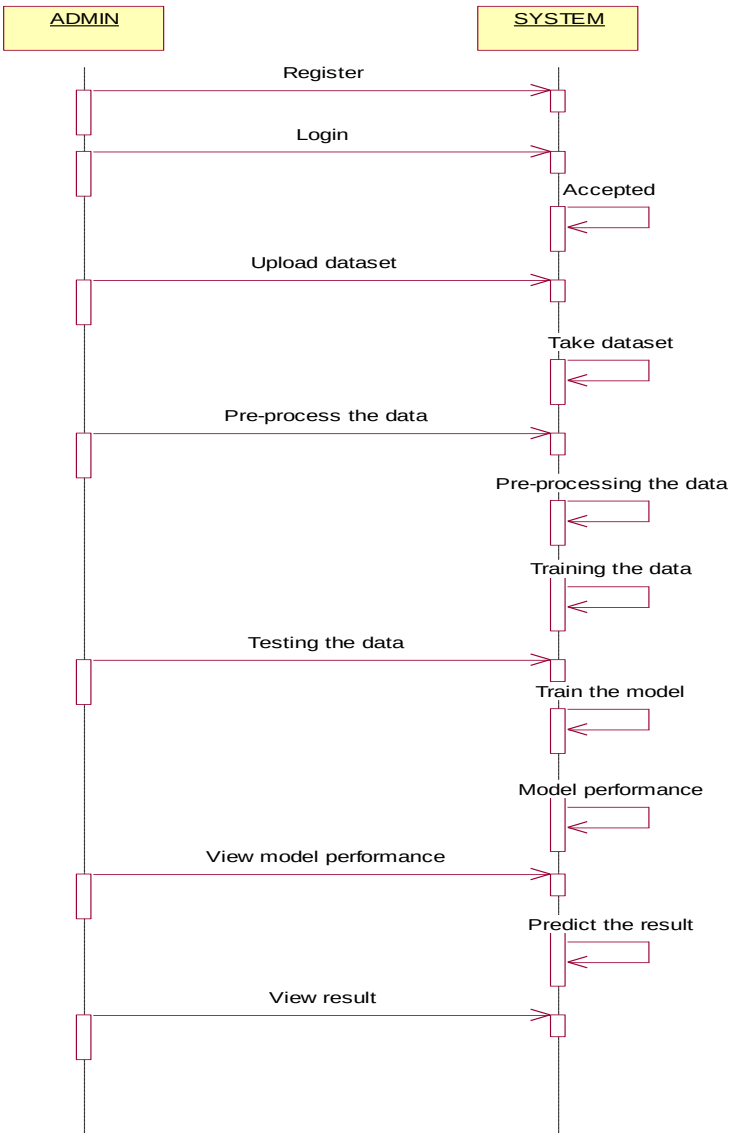


Fig.5.5: Sequence Diagram for Overall Project

5.3.4. Activity Diagram

Activity Diagram in some ways is like a flowchart with states. With the activity diagram you can follow flow of activities in your system in the order that they take place. An activity diagram illustrates the dynamic nature of a system by modelling the flow of control from activity to activity. Because an activity diagram is a special kind of state chart diagram, it uses some of the same modelling conventions.

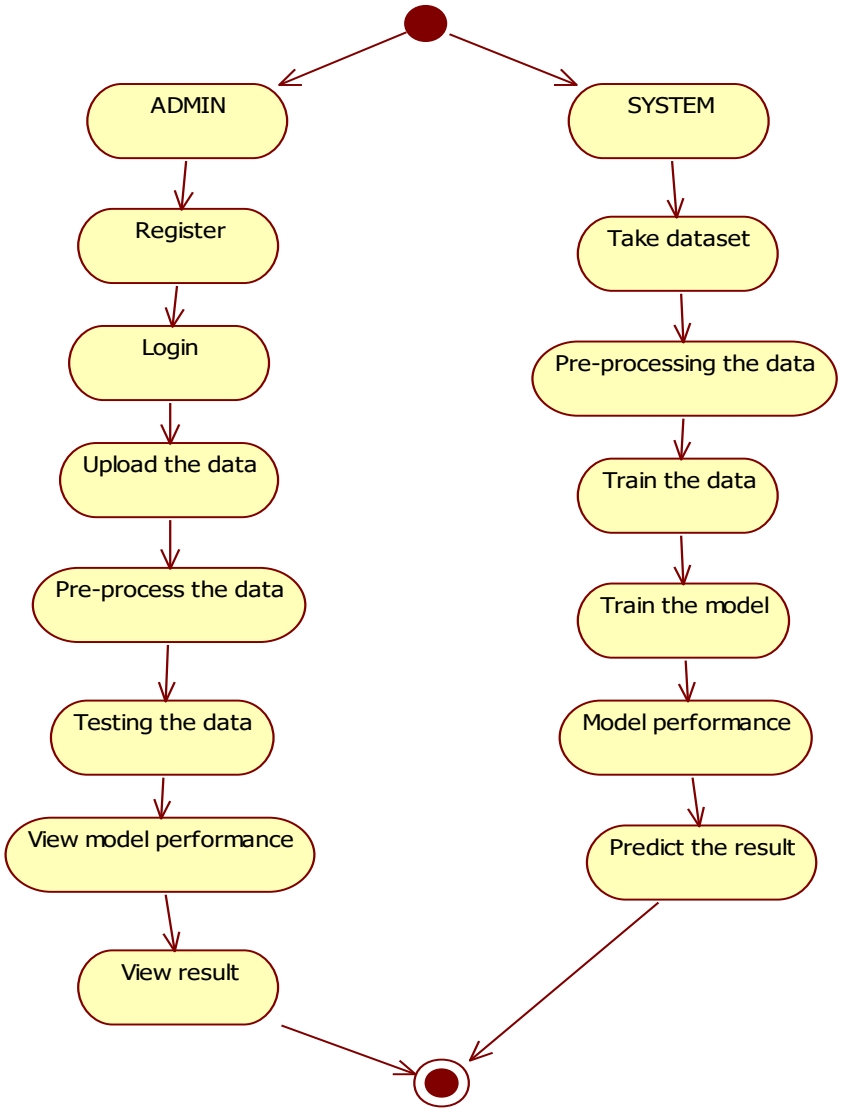


Fig.5.6: Activity Diagram

6. MODULE IMPLEMENTATION

6.1. Python

Below are some facts about Python. Python is currently the most widely used multi-purpose, high-level programming language. Python allows programming in Object-Oriented and Procedural paradigms. Python programs generally are smaller than other programming languages like Java. Programmers have to type relatively less and indentation requirement of the language, makes them readable all the time. Python language is being used by almost all tech-giant companies like – Google, Amazon, Facebook, Instagram, Dropbox, Uber… etc. The biggest strength of Python is huge collection of standard library which can be used for the following –

- Machine Learning
- GUI Applications (like Kivy, Tkinter, PyQt etc.)
- Web frameworks like Django (used by YouTube, Instagram, Dropbox)
- Image processing (like Opencv, Pillow)
- Web scraping (like Scrapy, BeautifulSoup, Selenium)
- Test frameworks
- Multimedia

Advantages of Python :

Let’s see how Python dominates over other languages.

1. Extensive Libraries

Python downloads with an extensive library and it contain code for various purposes like regular expressions, documentation-generation, unit-testing, web browsers, threading, databases, CGI, email, image manipulation, and more. So, we don’t have to write the complete code for that manuall

2. Extensible

As we have seen earlier, Python can be extended to other languages. You can write some of your code in languages like C++ or C. This comes in handy, especially in projects.

3. Embeddable

Complimentary to extensibility, Python is embeddable as well. You can put your Python code in your source code of a different language, like C++. This lets us add scripting capabilities to our code in the other language.

4. Improved Productivity

The language's simplicity and extensive libraries render programmers more productive than languages like Java and C++ do. Also, the fact that you need to write less and get more things done.

5. IOT Opportunities

Since Python forms the basis of new platforms like Raspberry Pi, it finds the future bright for the Internet Of Things. This is a way to connect the language with the real world.

6. Simple and Easy

When working with Java, you may have to create a class to print 'Hello World'. But in Python, just a print statement will do. It is also quite easy to learn, understand, and code. This is why when people pick up Python, they have a hard time adjusting to other more verbose languages like Java.

7. Readable

Because it is not such a verbose language, reading Python is much like reading English. This is the reason why it is so easy to learn, understand, and code. It also does not need curly braces to define blocks, and indentation is mandatory. This further aids the readability of the code.

8. Object-Oriented

This language supports both the procedural and object-oriented programming paradigms. While functions help us with code reusability, classes and objects let us model the real world. A class allows the encapsulation of data and functions into one.

9. Free and Open-Source

Like we said earlier, Python is freely available. But not only can you download Python for free, but you can also download its source code, make changes to it, and even distribute it. It downloads with an extensive collection of libraries to help you with your tasks.

10. Portable

When you code your project in a language like C++, you may need to make some changes to it if you want to run it on another platform. But it isn't the same with Python. Here, you need to code only once, and you can run it anywhere. This is called Write Once Run Anywhere (WORA). However, you need to be careful enough not to include any system-dependent features.

11. Interpreted

Lastly, we will say that it is an interpreted language. Since statements are executed one by one, debugging is easier than in compiled languages.

Any doubts till now in the advantages of Python? Mention in the comment section.

6.2. HISTORY OF PYTHON

What do the alphabet and the programming language Python have in common? Right, both start with ABC. If we are talking about ABC in the Python context, it's clear that the programming language ABC is meant. ABC is a general-purpose programming language and programming environment, which had been developed in the Netherlands, Amsterdam, at the CWI (Centrum Wiskunde &Informatica). The greatest achievement of ABC was to influence the design of Python. Python was conceptualized in the late 1980s. Guido van Rossum worked that time in a project at the CWI, called Amoeba, a distributed operating system. I worked as an implementer on a language

called Wiskunde en Informatica (CWI). I don't know how well people know ABC's influence on Python. I try to mention ABC's influence because I'm indebted to everything I learned during that project and to the people who worked on it."Later on in the same Interview, Guido van Rossum continued: "I remembered all my experience and some of my frustration with ABC. I decided to try to design a simple scripting language that possessed some of ABC's better properties, but without its problems. So I started typing. I created a simple virtual machine, a simple parser, and a simple runtime. I made my own version of the various ABC parts that I liked. I created a basic syntax, used indentation for statement grouping instead of curly braces or begin-end blocks, and developed a small number of powerful data types.

What is Machine Learning :

Before we take a look at the details of various machine learning methods, let's start by looking at what machine learning is, and what it isn't. Machine learning is often categorized as a subfield of artificial intelligence, but I find that categorization can often be misleading at first brush. The study of machine learning certainly arose from research in this context, but in the data science application of machine learning methods, it's more helpful to think of machine learning as a means of building models of data. Fundamentally, machine learning involves building mathematical models to help understand data. "Learning" enters the fray when we give these models tuneable parameters that can be adapted to observed data; in this way the program can be considered to be "learning" from the data. Once these models have been fit to previously seen data, they can be used to predict and understand aspects of newly observed data. I'll leave to the reader the more philosophical digression regarding the extent to which this type of mathematical, model-based "learning" is similar to the "learning" exhibited by the human brain. .

Categories Of Machine Learning :

At the most fundamental level, machine learning can be categorized into two main types: supervised learning and unsupervised learning. Supervised learning

involves somehow modelling the relationship between measured features of data and some label associated with the data; once this model is determined, it can be used to apply labels to new, unknown data. This is further subdivided into classification tasks and regression tasks: in classification, the labels are discrete categories, while in regression, the labels are continuous quantities. We will see examples of both types of supervised learning in the following section. Unsupervised learning involves modelling the features of a dataset without reference to any label, and is often described as "letting the dataset speak for itself." These models include tasks such as clustering and dimensionality reduction. Clustering algorithms identify distinct groups of data, while dimensionality reduction algorithms search for more succinct representations of the data. We will see examples of both types of unsupervised learning in the following section.

Need for Machine Learning

Human beings, at this moment, are the most intelligent and advanced species on earth because they can think, evaluate and solve complex problems. On the other side, AI is still in its initial stage and haven't surpassed human intelligence in many aspects. Then the question is that what is the need to make machine learn? The most suitable reason for doing this is, "to make decisions, based on data, with efficiency and scale". Lately, organizations are investing heavily in newer technologies like Artificial Intelligence, Machine Learning and Deep Learning to get the key information from data to perform several real-world tasks and solve problems. We can call it data-driven decisions taken by machines, particularly to automate the process. These data-driven decisions can be used, instead of using programing logic, in the problems that SVM & NAIVE BAYES be programmed inherently. The fact is that we can't do without human intelligence, but other aspect is that we all need to solve real-world problems with efficiency at a huge scale. That is why the need for machine learning arises.

Challenges in Machines Learning :

While Machine Learning is rapidly evolving, making significant strides with cyber security and autonomous cars, this segment of AI as whole still has a long way

to go. The reason behind is that ML has not been able to overcome number of challenges. The challenges that ML is facing currently are −

Quality of data − Having good-quality data for ML algorithms is one of the biggest challenges. Use of low-quality data leads to the problems related to data pre processing and feature extraction.

Time-Consuming task − Another challenge faced by ML models is the consumption of time especially for data acquisition, feature extraction and retrieval.

Lack of specialist persons − As ML technology is still in its infancy stage, availability of expert resources is a tough job.

No clear objective for formulating business problems − Having no clear objective and well-defined goal for business problems is another key challenge for ML because this technology is not that mature yet.

Issue of over fitting & under fitting − If the model is over fitting or under fitting, it SVM & NAIVE BAYES be represented well for the problem.

Curse of dimensionality − Another challenge ML model faces is too many features of data points. This can be a real hindrance.

Difficulty in deployment − Complexity of the ML model makes it quite difficult to be deployed in real life.

Applications of Machines Learning :

Machine Learning is the most rapidly growing technology and according to researchers we are in the golden year of AI and ML. It is used to solve many real-world complex problems which SVM & NAIVE BAYES be solved with traditional approach. Following are some real-world applications of ML −

- Emotion analysis
- Sentiment analysis

- Stock market analysis and forecasting
- Speech synthesis
- Speech recognition
- Customer segmentation
- Object recognition
- Fraud detection
- Fraud prevention
- Recommendation of products to customer in online shopping

6.3. Learning Machine Learning

Arthur Samuel coined the term "Machine Learning" in 1959 and defined it as a "Field of study that gives computers the capability to learn without being explicitly programmed".

And that was the beginning of Machine Learning! In modern times, Machine Learning is one of the most popular (if not the most!) career choices. According to Indeed, Machine Learning Engineer is The Best Job of 2019 with a 344% growth and an average base salary of $146,085 per year.

But there is still a lot of doubt about what exactly is Machine Learning and how to start learning it? So this article deals with the Basics of Machine Learning and also the path you can follow to eventually become a full-fledged Machine Learning Engineer. Now let's get started!!!

How to start learning ML?

This is a rough roadmap you can follow on your way to becoming an insanely talented Machine Learning Engineer. Of course, you can always modify the steps according to your needs to reach your desired end-goal!

In case you are a genius, you could start ML directly but normally, there are some prerequisites that you need to know which include Linear Algebra, Multivariate Calculus, Statistics, and Python. And if you don't know these, never fear! You don't need a Ph.D. degree in these topics to get started but you do need a basic understanding.

(a) Learn Linear Algebra and Multivariate Calculus

Both Linear Algebra and Multivariate Calculus are important in Machine Learning. However, the extent to which you need them depends on your role as a data scientist. If you are more focused on application heavy machine learning, then you will not be that heavily focused on maths as there are many common libraries available. But if you want to focus on R&D in Machine Learning, then mastery of Linear Algebra and Multivariate Calculus is very important as you will have to implement many ML algorithms from scratch.

7. SOURCE CODE

BASE

```
#http://buffml.com/

from flask import Flask, render_template, request

from keras.models import load_model

import keras.utils as image

import random

import numpy as np

import cv2

app = Flask(__name__)

dic = {0 : 'Normal', 1 : 'Doubtful', 2 : 'Mild', 3 : 'Moderate', 4 : 'Severe'}

#Image Size

img_size=256

model = load_model('model.h5')

model.make_predict_function()

def predict_label(img_path):

    img=cv2.imread(img_path)

    gray = cv2.cvtColor(img, cv2.COLOR_BGR2GRAY)

    resized=cv2.resize(gray,(img_size,img_size))

    i = image.img_to_array(resized)/255.0

    i = i.reshape(1,img_size,img_size,1)

    p = np.argmax(model.predict(i), axis=-1)

    return dic[p[0]]
```

```
# routes

@app.route("/", methods=['GET', 'POST'])

def main():

    return render_template("index.html")

@app.route("/about")

def about_page():

    return "Please subscribe  Artificial Intelligence Hub..!!!"

@app.route("/predict", methods = ['GET', 'POST'])

def upload():

    if request.method == 'POST':

        img = request.files['file']

        img_path = "uploads/" + img.filename

        img.save(img_path)

        p = predict_label(img_path)

        acc = random.randint(88, 95)

        print("Accuracy: ")

        print(acc)

        return str(p).lower()

        print(acc)

        return str(p).lower()
```

```
if __name__ =='__main__':
    #app.debug = True
    app.run(debug = True)
if __name__ =='__main__':
    #app.debug = True
    app.run(debug = True)
plt.savefig(args["plot"])
```

Index.html

```
<html>
    <head>
        <meta name="viewport" content="width-device-width, initial-scale=1.0">
        <link href="https://fonts.googleapis.com/css?family=Play&display=swap"
rel="stylesheet">
        <title>Digital Knee X-ray Images Classification</title>
        <meta name="theme-color" content="#ffffff">
    </head>
<body>

    <div class="very_main">
        <header>
            <div class="top_frame">
                <h1>Diagnosis for the Prediction of Knee Osteoarthritis Using Deep
Learning</h1>
```

```
        </div>
    </header>
    {% extends "base.html" %} {% block content %}
    <p class="description">
        Choose your Knee X-Ray visual file and click Predict to get your diagnosis.
    </p>
    <div>
        <form id="upload-file" method="post" enctype="multipart/form-data">
            <label for="imageUpload" class="upload-label">
                Select your Knee X-Ray Visual
            </label>
            <input type="file" name="file" id="imageUpload" accept=".png, .jpg,
.jpeg">
        </form>
        <div class="image-section" style="display:none;">
            <div class="img-preview">
                <div id="imagePreview">
                </div>
            </div>
            <div>
                <button type="button" class="upload-label" id="btn-
predict">Predict!</button>
            </div>
        </div>
```

```
        <div class="loader" style="display:none;"></div>
        <h3 id="result">
            <span> </span>
        </h3>
      </div>
   </div>
   {% endblock %}
</body>
</html>
<html lang="en">
<head>
   <meta charset="UTF-8">
   <script
src="https://cdn.bootcss.com/popper.js/1.12.9/umd/popper.min.js"></script>
   <script src="https://cdn.bootcss.com/jquery/3.3.1/jquery.min.js"></script>
   <script src="https://cdn.bootcss.com/bootstrap/4.0.0/js/bootstrap.min.js"></script>
   <link href="{{ url_for('static', filename='css/main.css') }}" rel="stylesheet">
</head>
<body>
   <div class="container">
      <div id="content" style="margin-top:2em">{% block content %}{% endblock
%}</div>
   </div>
</body>
```

```
{
 "cells": [
  {
   "cell_type": "code",
   "execution_count": 1,
   "metadata": {
    "colab": {
     "base_uri": "https://localhost:8080/"
    },
    "executionInfo": {
     "elapsed": 24172,
     "status": "ok",
     "timestamp": 1624603153123,
     "user": {
      "displayName": "NOUMAN AHMAD",
      "photoUrl": "https://lh3.googleusercontent.com/a-/AOh14GhcQ3BpK0-
GAMrjLlr__tOqeFHLlT11IEFK0ztPsVY=s64",
      "userId": "11031044337039581497"
     },
     "user_tz": -300
    },
    "id": "Ui9cLjMdn17_",
    "outputId": "eb40dc63-c988-4957-bd42-585c64e8880d"
   },
```

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  "outputs": [
   {
    "name": "stdout",
    "output_type": "stream",
    "text": [
     "Mounted at /content/drive\n"
    ]
   }
  ],
  "source": [
   "from google.colab import drive\n",
   "drive.mount('/content/drive')"
  ]
 },
 {
  "cell_type": "code",
  "execution_count": 50,
  "metadata": {
   "colab": {
    "base_uri": "https://localhost:8080/"
   },
   "executionInfo": {
    "elapsed": 570,
    "status": "ok",
```

"timestamp": 1624607243550,

"user": {

"displayName": "NOUMAN AHMAD",

"photoUrl": "https://lh3.googleusercontent.com/a-/AOh14GhcQ3BpK0-GAMrjLlr__tOqeFHLlT11IEFK0ztPsVY=s64",

"userId": "11031044337039581497"

},

"user_tz": -300

},

"id": "wL61Pc3_S06E",

"outputId": "008e1132-3c8d-47b6-b1c3-bd3bdf4780f4"

},

"outputs": [

{

"name": "stdout",

"output_type": "stream",

"text": [

"/content/drive/MyDrive/Knee-project\n"

]

}

],

"source": [

"cd /content/drive/MyDrive/Knee-project"

]

```
 },
 {
  "cell_type": "markdown",
  "metadata": {
   "id": "Kl1j2aXXv_Co"
  },
  "source": [
   "# Dataset Link:\n",
   "https://data.mendeley.com/datasets/t9ndx37v5h/1"
  ]
 },
 {
  "cell_type": "markdown",
  "metadata": {},
  "source": [
   "## for more project and Data sceince materials folow our blog link below:"
  ]
 },
 {
  "cell_type": "markdown",
  "metadata": {},
  "source": [
   "# http://buffml.com/"
  ]
```

```
 },
 {
  "cell_type": "markdown",
  "metadata": {},
  "source": [
   "# Youtube channel:"
  ]
 },
 {
  "cell_type": "markdown",
  "metadata": {},
  "source": [
   "# https://www.youtube.com/c/artificialintelligencehub"
  ]
 },
 {
  "cell_type": "code",
  "execution_count": 51,
  "metadata": {
   "executionInfo": {
    "elapsed": 5,
    "status": "ok",
    "timestamp": 1624607243551,
    "user": {
```

"displayName": "NOUMAN AHMAD",
"photoUrl": "https://lh3.googleusercontent.com/a-/AOh14GhcQ3BpK0-GAMrjLlr__tOqeFHLlT11IEFK0ztPsVY=s64",
"userId": "11031044337039581497"
},
"user_tz": -300
},
"id": "FcJvFmOTznEi"
},
"outputs": [],
"source": [
"%tensorflow_version 1.x"
]
},
{
"cell_type": "code",
"execution_count": 52,
"metadata": {
"colab": {
"base_uri": "https://localhost:8080/"
},
"executionInfo": {
"elapsed": 2,
"status": "ok",

"timestamp": 1624607245155,

"user": {

"displayName": "NOUMAN AHMAD",

"photoUrl": "https://lh3.googleusercontent.com/a-/AOh14GhcQ3BpK0-GAMrjLlr__tOqeFHLlT11IEFK0ztPsVY=s64",

"userId": "11031044337039581497"

},

"user_tz": -300

},

"id": "NTL9JAB_zn0k",

"outputId": "56bd5df1-eb81-49e5-b23c-a11ee6bd185a"

},

"outputs": [

{

"name": "stdout",

"output_type": "stream",

"text": [

"1.15.2\n"

]

}

],

"source": [

"import tensorflow\n",

"print(tensorflow.__version__)"

```
   ]
  },
  {
   "cell_type": "markdown",
   "elapsed": 407,
     "status": "ok",
     "timestamp": 1624607292189,
     "user": {
      "displayName": "NOUMAN AHMAD",
      "photoUrl": "https://lh3.googleusercontent.com/a-/AOh14GhcQ3BpK0-
GAMrjLlr__tOqeFHLlT11IEFK0ztPsVY=s64",
      "userId": "11031044337039581497"
     },
     "user_tz": -300
    },
    "id": "XgsZogOtUPm2"
   },
   "outputs": [],
   "source": [
    "from keras.models import Sequential\n",
    "from keras.layers import Dense,Activation,Flatten,Dropout\n",
    "from keras.layers import Conv2D,MaxPooling2D\n",
    "from keras.callbacks import ModelCheckpoint\n",
    "\n",
```

```
    "model=Sequential()\n",
    "\n",
    "model.add(Conv2D(128,(3,3),input_shape=data.shape[1:]))\n",
    "model.add(Activation('relu'))\n",
    "model.add(MaxPooling2D(pool_size=(2,2)))\n",
    "#The first CNN layer followed by Relu and MaxPooling layers\n",
    "\n",
    "model.add(Conv2D(64,(3,3)))\n",
    "model.add(Activation('relu'))\n",
    "model.add(MaxPooling2D(pool_size=(2,2)))\n",
    "#The second convolution layer followed by Relu and MaxPooling layers\n",
    "\n",
    "model.add(Conv2D(32,(3,3)))\n",
    "model.add(Activation('relu'))\n",
    "model.add(MaxPooling2D(pool_size=(2,2)))\n",
    "#The thrid convolution layer followed by Relu and MaxPooling layers\n",
    "\n",
    "model.add(Flatten())\n",
    "#Flatten layer to stack the output convolutions from 3rd convolution layer\n",
    "model.add(Dropout(0.2))\n",


<footer>
    <script src="{{ url_for('static', filename='js/main.js') }}"
type="text/javascript"></script>
```

```
</footer>

</html>
```

8. SYSTEM TESTING

8.1. SOFTWARE TESTING TECHNIQUES

Software testing is a critical element of software quality assurance and represents the ultimate review of specification, designing and coding.

8.1.1. Unit Testing

In software testing, Unit testing mainly focuses on verification effort on the smallest unit of program or software design that is also called a module. In unit testing the procedural or functional design provides a detailed description as a guide, focal the control paths are tested to uncover errors occurred in the designed software within the boundaries of the module. The unit testing of software is normally white box or open testing oriented and the series of steps can be conducted in corresponding or parallel for multiple modules or functions.

8.1.2. Integration Testing

Integration testing is another Testing for systematic technique and product module integrating which constructs the program structure and makes the data flow between the modules, while conducting Integration Testing it requires to uncover errors associated with various interfaces. The main objective is to take unit tested methods and activities to build a program structure that have been dictated by design.

8.1.3. Validation Testing

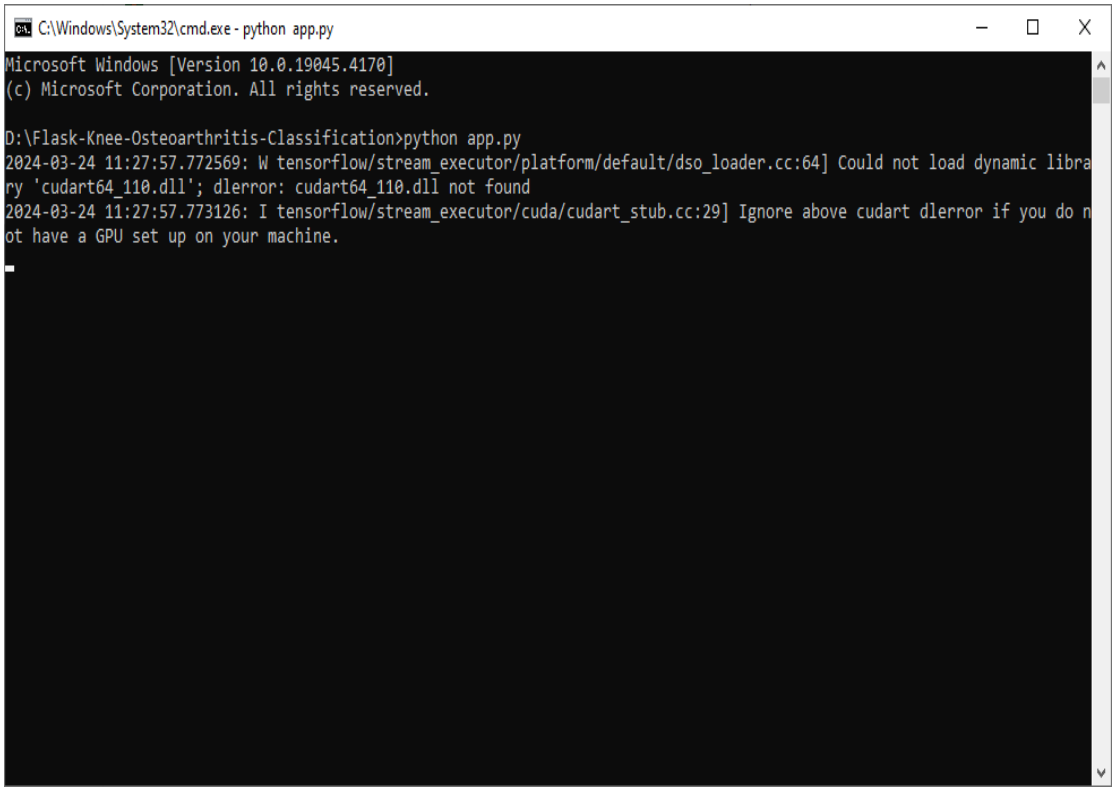
The Validation Testing is integration testing for software which is completely assembled as a package. The Validation testing is the next stage in Testing Activities, which can be defined as successful testing process for the software functions in the SVM & NAIVE BAYES reasonably expected by the customer. The validation Testing is mainly performed at the end approach of the user needs in testing the information input to the product and information contained in those sections are to validated through various testing approaches.

8.2. TEST CASES

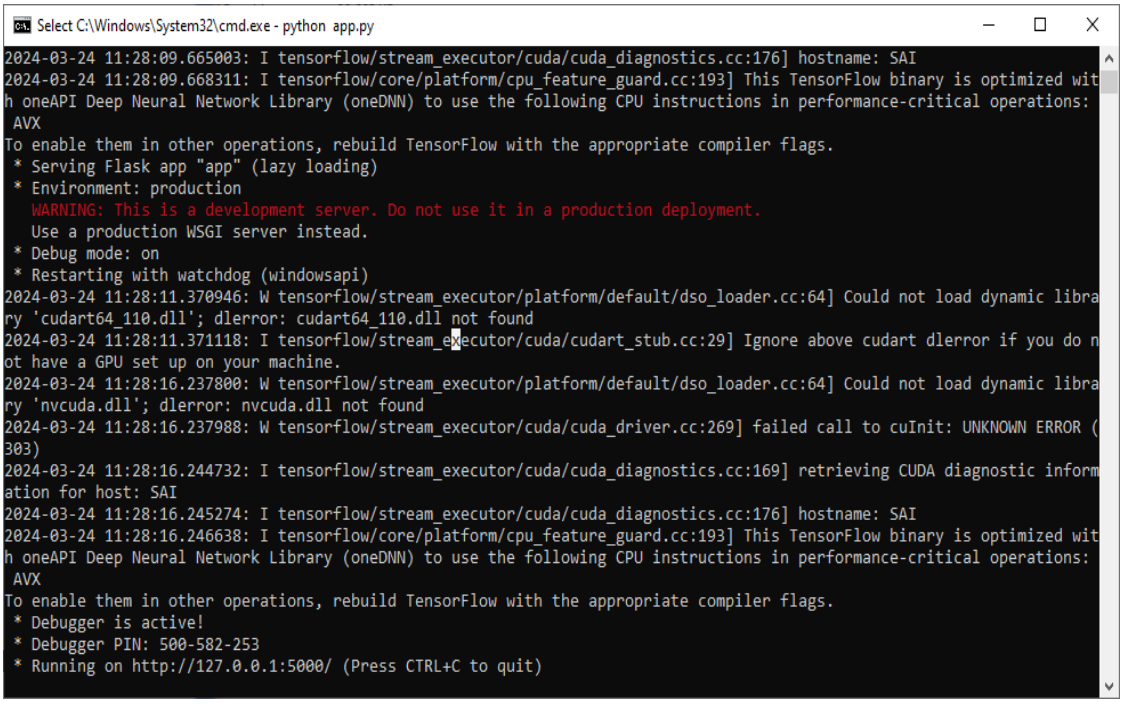
S. No.	TEST CASES	INPUT	EXPECTED RESULT	ACTUAL RESULT	STATUS
1	User Registration	Enter all fields	User gets registered	Registration is successful	Pass
2	User Registration	if user miss any field	User not registered	Registration is un successful	Fail
3	Admin Login	Give the user name and password	Admin home page should be opened	Admin home Page has been opened	Pass
4	Upload Knee Dataset	Test whether the Knee Dataset is uploaded or not into the system	If Knee Dataset is not uploaded	We cannot do further operations	Knee Dataset uploaded we will do further operations
5	Preprocess Dataset	Verify the Dataset is Per – processed or not	Without loading the dataset	We cannot Per-processing Dataset	We Can Pre-process Dataset successfully
6	Run CNN algorithm	Verify the CNN algorithm will run or not	Without training model	We cannot run CNN algorithm	We can run CNN algorithm

Table 8.2: Test Case Results

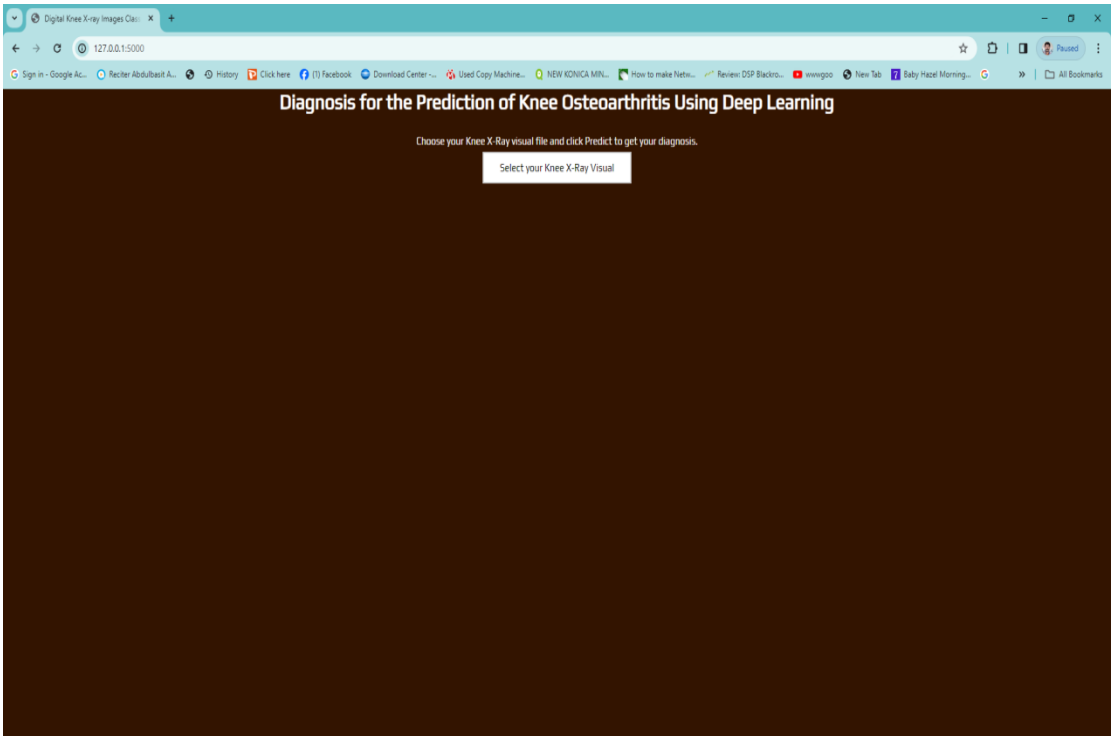
9. OUTPUT SCREENSHOTS



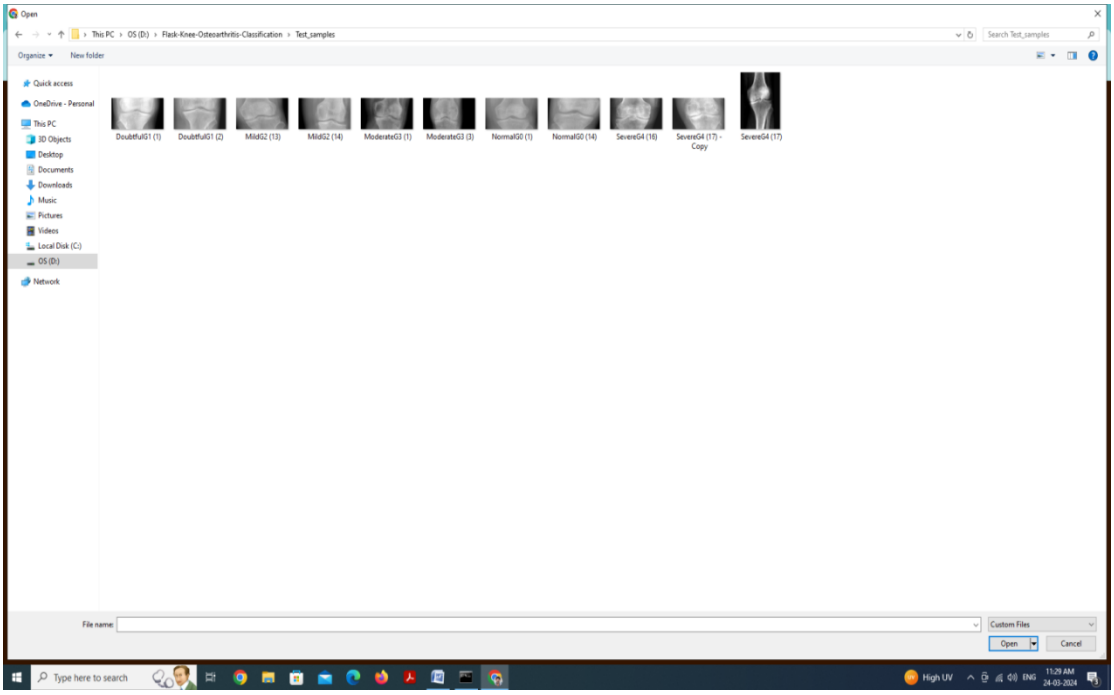
Screen 1: Start App Server



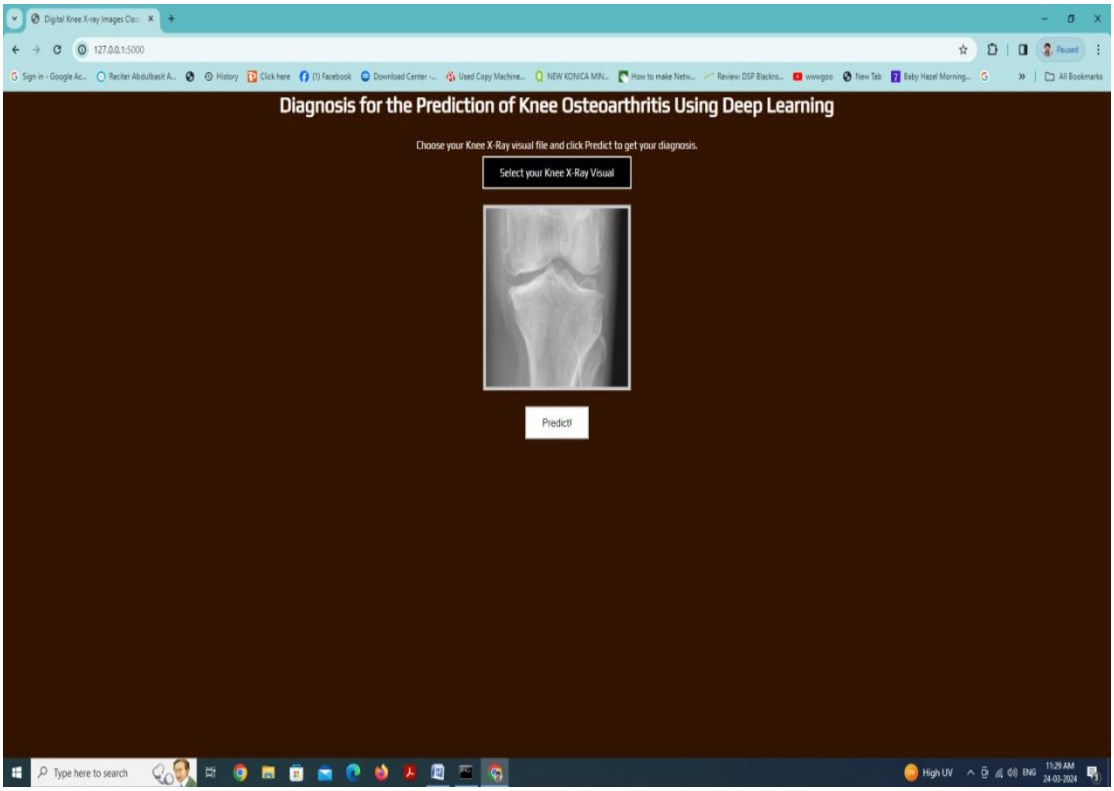
Screen 2: App Server Started with running Link



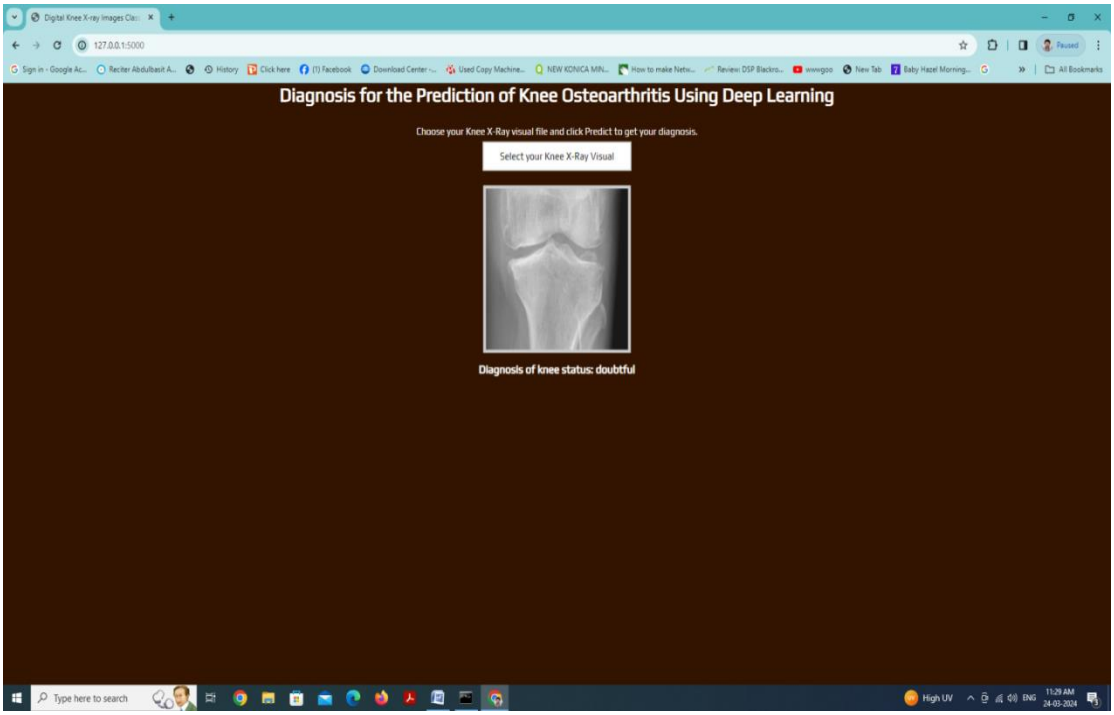
Screen 3:Home Page of Project



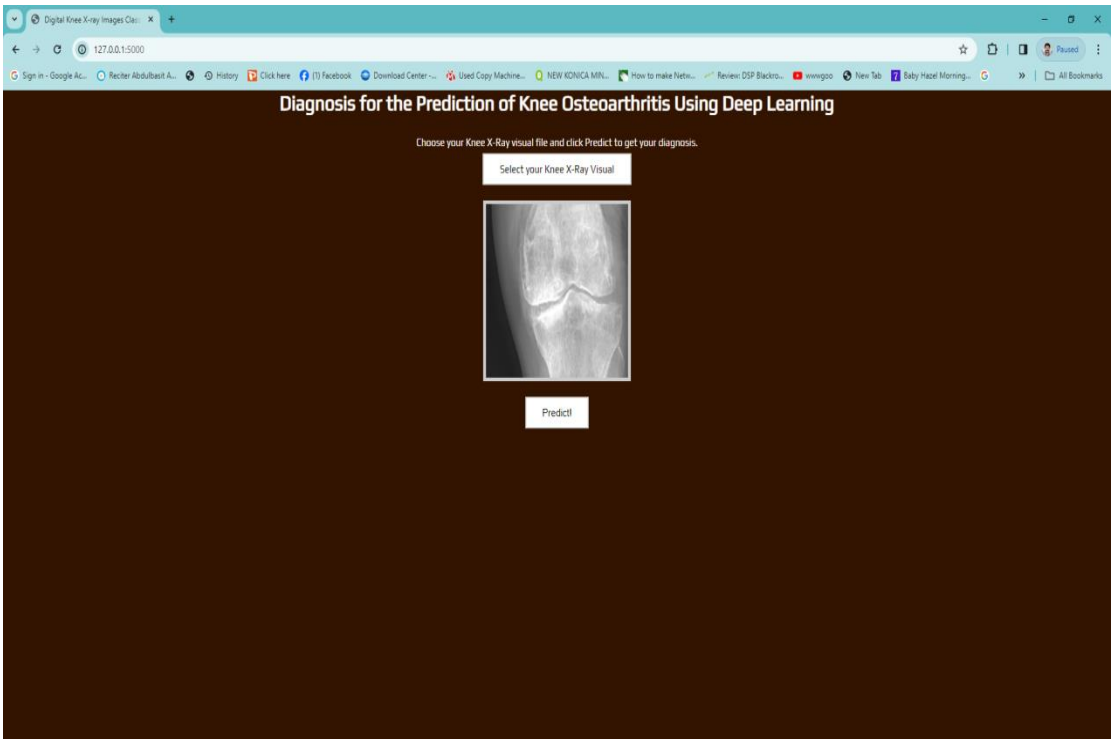
Screen 4: Selecting a File



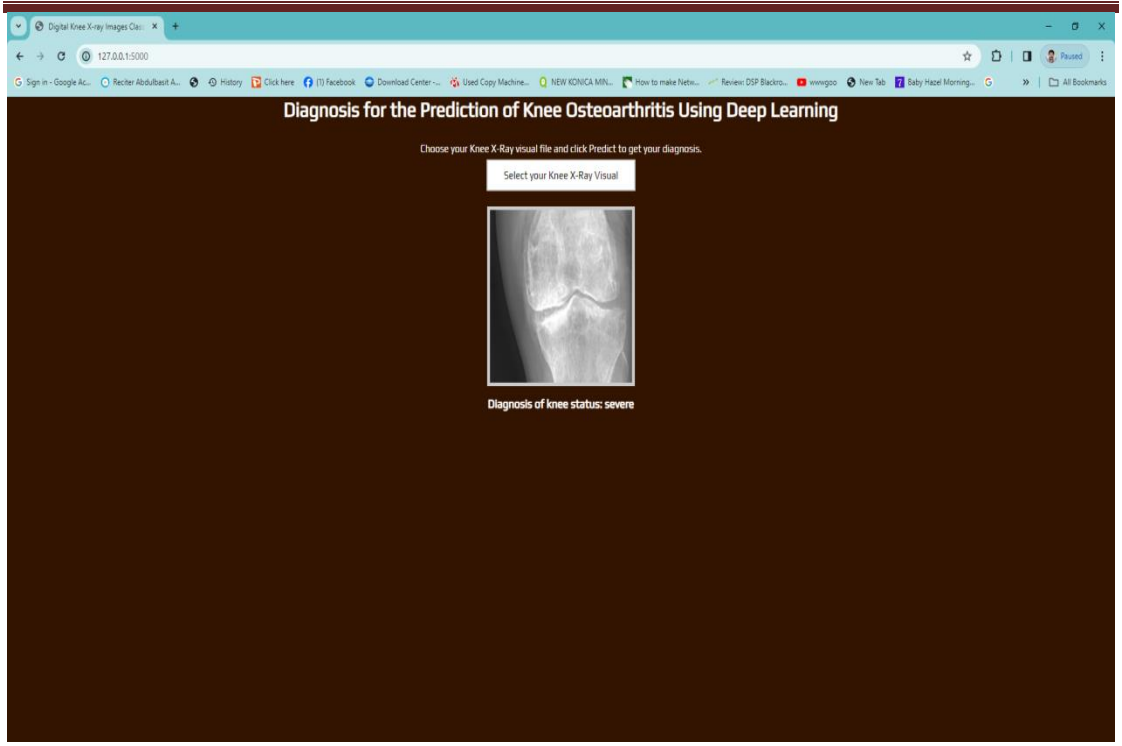
Screen 5: View of Xray



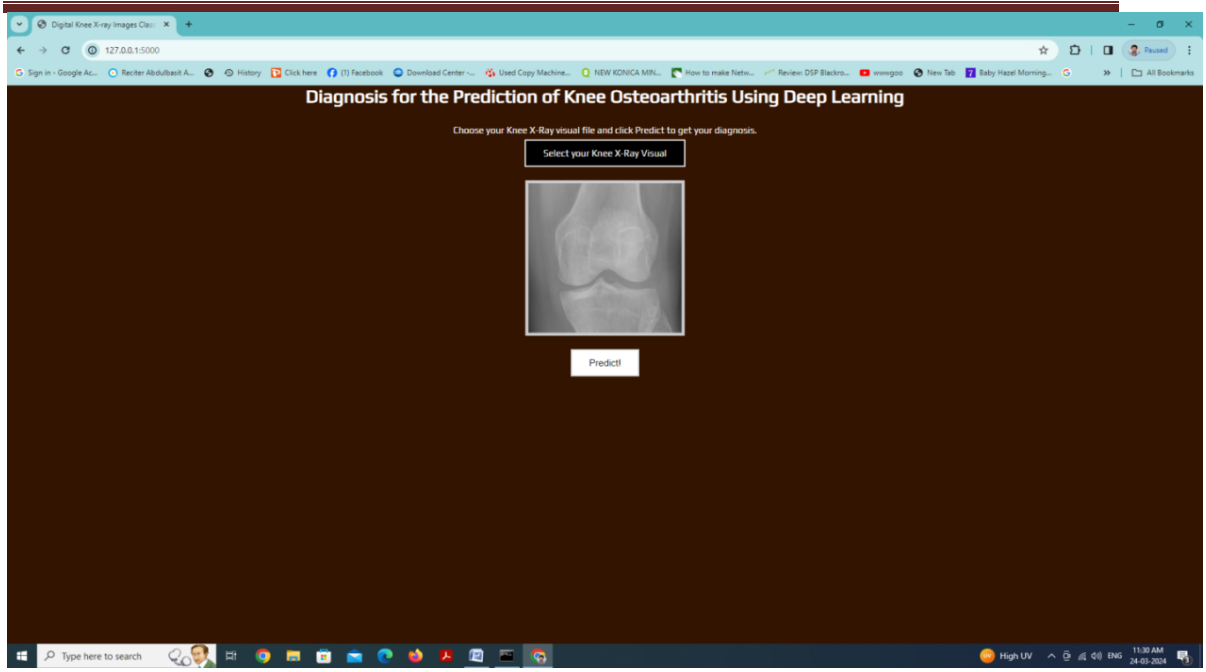
Screen 6: Prediction of Xray



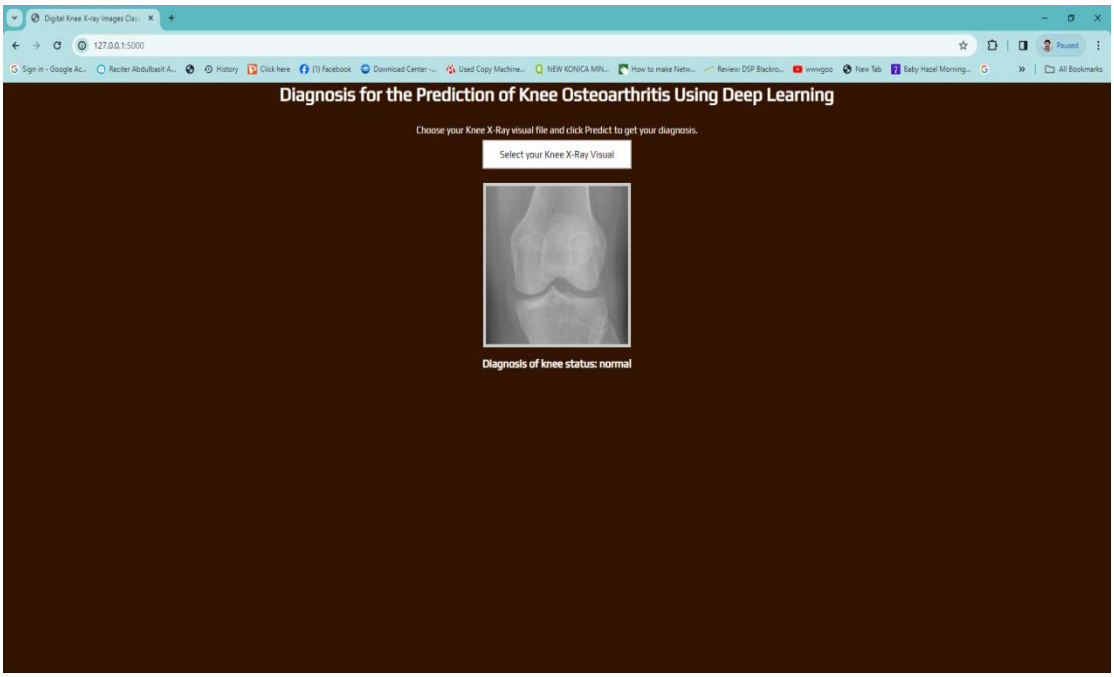
Screen 7: Selection of Xray



Screen 8: Prediction of Xray



Screen9: View of Xray



Screen 10: Prediction of Xray

10. FUTURE ENHANCEMENT

- Despite the advantages offered by the technique suggested in this paper, it has some challenges that may restrict its potential in the detection of knee osteoarthritis. For example, transfer learning can result in complex models that are difficult to interpret and understand, which can reduce the ability to validate and explain the results of the automated system. Pretrained models may not be fully adaptable to the specific requirements of the target task and may require fine-tuning or additional modifications to improve their performance. Furthermore, pretrained models may contain biases and inaccuracies introduced during the training process, which can impact the performance of the automated system. Our future work will attempt to resolve these challenges and use advanced techniques such as ensemble learning and reinforcement learning

11. CONCLUSION

Knee osteoarthritis (OA) is a major cause of disability in adults. The progression of OA is generally unstoppable, and there is currently no cure for it. At present, the diagnosis of OA relies on X-ray images. However, this is a manual process that may produce inaccurate results if not implemented properly. To solve this challenge, an automated approach for the prediction of OA from X-ray images is suggested in this paper. Three models, sequential CNN, VGG-16, and ResNeT-50, are suggested for predicting OA from X-ray images. All three models achieved good accuracy, greater than 90%, but the most accurate model for the prediction of OA was VGG-16, which achieved a testing accuracy of 92.17%. From our analysis, we found that under expert supervision and a large amount of high-quality data, this automated system can perform better and generate predictions while taking the least possible time. The methodology suggested in this paper is easy to operate and is cost-effective to implement in real-world scenarios. Furthermore, the findings of our study have implications beyond the scope of knee osteoarthritis detection, as they demonstrate the potential of transfer learning models to effectively handle various medical imaging tasks. The success of our approach in detecting knee osteoarthritis from X-ray images highlights the versatility of transfer learning, which could be applied to other medical imaging modalities, such as MRI or CT scans, to detect and diagnose a wide range of diseases and conditions. In clinical practice, the proposed model could serve as an essential tool for assisting healthcare professionals in making more accurate and timely diagnoses. This can, in turn, lead to improved patient care and management, as early detection and intervention are often crucial in minimizing the impact of many medical conditions. Additionally, the use of such models can help reduce the workload of radiologists and clinicians, enabling them to focus on more complex cases or spend more time with patients. By exploring the potential of transfer learning models in various medical imaging tasks, researchers and healthcare professionals can pave the way for more advanced and reliable diagnostic tools that can revolutionize the field of medical imaging and ultimately improve patient outcomes.

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