Knee Osteoarthritis Prediction Using Deep Learning

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Abstract:-

A significant fraction of the population is affected by the common degenerative joint condition known as knee osteoarthritis (OA), which can cause pain, stiffness, and functional difficulties. The ability to detect knee OA early and accurately can lead to proactive measures and individualized treatment plans. CNNs and the VGG model are two examples of Models of deep learning that recently displayed notable performance in a range of image recognition applications. The goal of this research paper is to use CNN and the VGG architecture to create a knee osteoarthritis model for prediction. The suggested method involves a sizable dataset of knee radiography images to train a CNN model, specifically the VGG model.

Knee osteoarthritis (OA) is a progressive joint disorder characterized by the degeneration of articular cartilage, changes in subchondral bone, formation of osteophytes, and varying degrees of inflammation in the synovial lining of the knee. It is the most common form of arthritis and a major cause of chronic disability in older adults worldwide. As the knee joint bears a significant portion of body weight, it is particularly susceptible to wear-and-tear-induced damage, especially in individuals with certain risk factors such as obesity, previous joint injuries, sedentary lifestyles, or occupations requiring repetitive joint loading.

Osteoarthritis is one of the most common form of arthritis that affects middle-aged and elderly people, and osteoarthritis (OA) usually affects knees and small finger joints, as well as thumb. The conventional prevalent practice to diagnose such as osteoarthritis diseases relies on human interpretation of medical images. This manual diagnosis approach is prone to the medical skills of individuals, time consuming, and error-prone task. However, the Artificial Intelligence (AI) has emerged in the recent years as a new diagnosis approach with the potential to overcome these limitations, and it shown outstanding success in processing and analysis of medical images. This paper presents a convolutional neural network based model and a mobile application that can help healthcare specialists and nonprofessional individuals in diagnosing knee OA from 2D (X-ray) images. The proposed model was trained and was tested using images from three different sources: an online reputed medical source, local diagnostic centers, and from local hospitals. The user-friendly mobile application was designed to take an X-Ray image as an input to this model and then displays the level of severity of the knee OA. The obtained results were very satisfactory the model yields up to 92% accuracy to predict the presence of osteoarthritis or not. The model also achieved about 86% accuracy to predict the Knee OA severity level (five grades) based on the KL system.

1. Introduction

Knee osteoarthritis, a common degenerative joint condition, is a major issue for millions of people, mainly those aged 50 to 60. It is a fatal disease that produces pain, stiffness, and functional restrictions. Early and precise diagnosis of knee osteoarthritis can lead to proactive medicine and personalized treatment plans, potentially improving patient outcomes and lowering healthcare costs.

Deep and machine learning technologies are now playing vital roles in a variety of industries, including agriculture, business, automobiles, and, most notably, medicine. In our work, we constructed and compared two deep learning models: Convolutional Neural Networks (CNNs) and Visual Geometry Groups (VGG16), with the Convolutional Neural Network model outperforming the others in picture recognition tasks such as medical image analysis. CNNs can extract complicated characteristics and patterns from images, making them useful for medical image analysis and abnormality detection. VGG16 is the most prominent and extensively used model in computer vision among CNN architectures.

2. Methodology

2.1 Anaconda Navigator: is open source for working with ML and DL technologies because of its enormous applications like Jupyter Notebook, Jupyter Lab, DataSpell, Spyder, PyCharm, R Studio, Oracle, etc. It has a vast collection of pre-built packages and libraries usually used in analysis of data and computing scientifically.

2.2 Jupyter Notebook: is an application of Anaconda Navigator that provides enormous packages and modules. Web-based computing environment that interactively allows programmers to build and share various files and documents. It also combines live code, visualization, narrative text, and multimedia resources. It is used in various fields like data science, research, and education for data exploration, prototyping, and collaborative work.

2.3 NumPy: It is a numerical package implemented using Python programs basically for scientific computing and processing multi-dimensional and single-dimensional array elements. We can also say that it is array-oriented computing. NumPy is designed for beginners and professionals who contribute to improving advanced technologies.

2.4 TensorFlow: TensorFlow is a powerful open-source machine learning framework, and it is one of the modules in Anaconda Navigator. It provides a comprehensive ecosystem for constructing and deploy the machine learning methods.

2.5 Matplotlib: Matplotlib is an integrated design package in Python useful in preparing interactive static, and animated visualizations. It provides various tools and functions for creating plots, bar graphs, histograms, and more. Using Matplotlib, we can customize according to the user's needs to visualize the data and control various aspects of their visualizations.

3. Implementation

3.1 Dataset: The dataset used in our study is from Kaggle, which consists X-ray images of knee.

3.2 Data Pre-Processing: The dataset has been pre-processed by applying scaling, sheering, zooming, horizontal flip to extract relevant features from the images.

3.3Model Training: In this study, we have used two architectures for training the model and extract features from x-ray images of knee.

3.4 Cnn Model: The model trained using a straightforward CNN architecture. Shape (150, 150, 3) input photos are used to train the model, which has two convolutional layers. The First step make use of convolutional layer with 32 filters or a kernel size of three and a half (3.3). The model accepts input photos with the shape (150, 150, 3). A max pooling layer is then added using the MaxPool2D function, with a pool size of (2,2). It is used to extract relevant features and reduce the spatial dimensions of feature map while retaining all the important features used for classification. The second convolutional layer uses Con2D function with 128 filter size(3,3) followed by relu activation function.

The second max pooling layer is used to perform down sampling on the output of the previous convolutional layer. The output image is then passed through a flattening layer to flatten the output image matrix and convert it to 1D vector. This array is passed (150, 150, 3) on to fully connected layer which uses a dense function with 256 units and relu activation function.

The output layer uses dense function with 1 unit and sigmoid activation function.it uses binary classification to where the output is represented by probability of the input belonging to the class. Fig. 3 shows the working model.

The features from images are extracted by applying series of filters and performing convolutional operation where each filter is used to extract different patterns and relevant features from the x-ray image. The Relu function used to add non-linearity to the feature map. The final output layer uses a sigmoid function to provide probability estimate for the binary classification task.

The VGG16 model helps to classify the image with its pretrained module and can compute 130 million parameters so the features extracted by the model is very precise and classification is done accurately.

5. Result

In this work a CNN was trained to perform a binary classification task. Experimental results of CNN architecture model showed that the model achieved a certain level of accuracy and loss on both the dataset for training and validation. The accuracy obtained using CNN model is 0.6919 and the validation accuracy obtained is 0.74. The training accuracy and validation accuracy plotted over the epochs, showing how the model's performance improved over time. Similarly, the training and validation loss plotted to visualize the convergence of the model during training.

The next model, VGG16, was trained to perform a binary classification task. The model extracts the feature based on the filters, which are followed by the convolutional layers, and predicts knee osteoarthritis.

The experimental results of the VGG16 architecture used in training the model shows the model accomplished a high level of accuracy on both the training and validation datasets. This model achieves 0.95 accuracy, and the validation accuracy achieved is 0.92. The training accuracy and validation accuracy were plotted over the epochs, showing how the model's performance improved over time. Similarly, the training loss and validation loss were plotted to visualize the convergence of the model during training.

7. Conclusion

DL models such as CNN and VGG are used to analyze medical imaging data like X-rays or MRI scans. In this study, a knee x-ray dataset is used to recognize fine patterns and abnormalities that designate knee osteoarthritis. By manipulating the capacity of learning image recognition, CNN models have demonstrated the power of external human observers in diagnosing knee osteoarthritis. These models high specificity and sensitivity make them major technical tools for assisting doctors in making accurate and fast diagnoses.It is critical for effective treatment and prevention, detecting minor changes in joint structure like joint space narrowing, osteophyte production, or bone remodelling. Doctors can engage in tailored therapies to likely reduce disease progression and enhance patient outcomes if these changes are detected early. CNN models offer an objective for evaluating knee osteoarthritis. It can provide consistent evaluations while minimizing the influence of individual perceptions. This standardization aids clinical decision-making and allows for effective tracking of illness progression over time. Knee osteoarthritis datasets can be useful for radiologists and orthopaedic specialists to identify regions of interest, evaluate disease severity, and provide further opinion. In the healthcare environment, this integration saves time, reduces human error, and increases overall efficiency. Therefore, there are several constraints and obstacles that must be handled.Training a CNN model requires large, diversified datasets, which might be difficult to get. And the VGG model provides better diagnostic accuracy, early diagnosis, and results. To solve the current situation and enable the safe and reliable use of this model's additional research work, which is required in real-world healthcare settings.In future datasets of medical images need to be collected for accurate images from various sources and should work on a various other algorithms to improve the performance level and accuracy to resolve unbalanced training samples that might impact the performance of deep learning techniques. The advanced learning algorithms to be adopted for appropriate performance and results. In future, robust clinical validation studies to be conducted to calculate the efficiency of these models in a variety of patient healthcare settings.

Individual Contribution of Students

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2130127	Ratan Kumar	Research the contents and prepare the abstract.
2130137	Sivakumar Reddymala	Research the contents and prepare the ppt
2130139	Siyaram Kumar	Research the contents and prepare the ppt
2130164	Gaurav Nayan	Research the contents and prepare the abstract.

Roll Number	Name	Signature
2130127	Ratan Kumar	
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