A Review of an Early Detection and Quantification of Osteoarthritis Severity in Knee using Machine Learning Techniques

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Abstract. The major cause of frailty in older and overweight people is Osteoarthritis. It is a joint illness that generally influences the ligament that could be principally affects the cartilage. Cartilage is a smooth elastic tissue which makes the bones move easily, stabilizes the joint and prevents them from abrading one another. The protective cartilage in Osteoarthritis is ruptured and makes the bones rub one another, inflicting joint stiffness and excessive pain. The current system for the assessment of Osteoarthritis incorporates clinical examination and restorative imaging methods. In this project, by utilizing profound features and medical images we need to recognize and classify OA affected in knee. This can impact on the detection and classification of target area in images and cause of it the irrelevant features could be selected from the medical images. This project will moreover center on dealing the colossal quantity of image information by using high speed computing. This paper also discovers the Magnetic Resonance imaging (MRI) techniques for detection and classification of Osteoarthritis in descriptive and comparative manner. Hence a coordinating discourse of different location strategies, highlight extraction procedures and classification methods regarding Osteoarthritis is worn out in a logical way.

1. Introduction

Recent progresses in artificial intelligence have driven to completely computerized work-flows that often surpass human execution. State of the art neural networks can distinguish the objects within the images and divide them into hundreds of divisions more precisely and magnitudes quicker than humans. They interpret texts from multiple languages, drive cars independently through cities, and identify malware in computer frameworks. In majority of these cases, they are prepared on several thousand or indeed millions, of information sets. Neural systems have additionally discovered incredible achievement in the field of medical image examination where data sets are frequently a lot smaller. Although the same techniques can be applied, one is often confronted with a different set of challenges. Medical imaging is the way toward making visual portrayals of the inside structures covered up by skin and bones. For clinical finding and clinical mediation medical imaging method can reveal inside of the body. It is the part of biological imaging and joints the radiology which utilizes the imaging innovations of CT, X-ray, MRI,
ultrasound and so forth. Osteoarthritis is one in every of the foremost common type of joint disease that seen most in part of overweight, females and older individuals. Osteoarthritis (OA) is a joint illness that generally influences the ligament that could be principally affects the cartilage. Cartilage is a smooth elastic tissue which makes the bones move easily, stabilizes the joint and prevents them from abrading one another. The protective cartilage in Osteoarthritis is ruptured and makes the bones rub one another, inflicting joint stiffness and excessive pain. The foremost common cause of osteoarthritis of the knee is age. There are two sorts of OA, Primary OA seen in aged people due to hereditary reasons or aging. Auxiliary OA tends to appear prior in life due to some injury, diabetes, obesity, athletics or patients with rheumatoid pain. The Image of normal and affected Osteoarthritis knee is shown in Fig. 1

2. Literature Review

Azman Kiflie et.,al. [1] discusses about Early knee osteoarthritis detection and also accurate and consistent measurement required to identify early changes in the features of cartilage. The main features are identified using morphology, molecular composition, mechanical and electrical properties. Further, the proposed method is used to measure in a non-invasive, non-ionizing, and in-vivo modalities using MRI imaging technique. The risk factors of knee Osteoarthritis discussed in detail Sanjay S et.,al. [2] i.e, age, mass, disturbance to joint due to bending and kneeling actions. The authors obtained knee data from Osteoarthritis initiative [OAI] to assess the progression of the knee. Dual Echo Steady State MRI is used to analyse the images and then to select the region of comparison and then to conduct automated segmentation from the data. Active Appearance Model (AAM) is the technique and algorithm used. The obtained CDI score is applied to the machine learning algorithms (SVM, Random Forest, ANN) for accurate results.

Du Hyun Ro et., al. [3] implemented the SVM classification model to establish the deep learning model using radiographical maps. The Inceptio-ResNet-v2 is the deep learning network approach used for multi-classification. Authors calculated the sensitivity, precision and F1-score and the gait data & x-ray data were split and trained with feature extraction and deep learning feature extraction respectively and the SVM model is conditioned and trained using training set, and the resulting data for OA diagnosis is used. The ultimate findings of this paper are a profound learning approach focused on X-ray images, paradigm-based analysis of gear data and functional analysis. In a conclusion to this paper the identified improvement is accuracy of diagnosis in KOA. Mauridhi Hery Purnomo et., al. [4] uses Long Short-Term Memory (LSTM) For feature extraction to study the pre-processing via convolution neural Network (CNN). mainly paper concerns on cross validation process which is processed on training data, and also experiment was carried out with three-fold cross validation while 2/3 data considered as training data and 1/3 data as testing data. The Knee data Image is cropped into

![Figure 1. Sample of Normal Knee and osteoarthritis knee](image-url)
400*100 pixels and then processed as a stacked augmented Image and then fed as input to CNN in the form of sequential data since LSTM need to be implemented in a sequential manner. Max pooling stride is followed by the three Convolution filters, then the complete CNN data is processed to LSTM with 1000 softmax channels. The proposed LSTM method works is describes using KL grade and shows that this technique works is accurate than deep learning. Jose G et., al. [5] considered the case analysis and carried out on the basis of public available data from participants in the Osteoarthritis initiative analysis. There were two kinds of radiological grades used in this case study, the first is a quantitative score and the second is a semi-quantitative score, with radiological results evaluated by two classes of radiologists. To determine the future pain associated variables, A univariate logistic regression test was performed. Results shows that the initial predictors of joint pain are early bone Osteophytes and the decline in the joint space is not related to subsequent joint pain. The findings of this research indicate that the sources of potential Osteoarthritis pain can be anticipated using clear radiographs. The current research illustrates the relationship between the univariate X-ray of regression and the developed clinical pain. Dimitrios Tsaopoulos et., al. [6] founds the deep neural networks for the classification of the difficult issues of the diagnosis of Osteoarthritis in the knee. The author incorporates deep neural networks for this classification problem as a modern effective machine learning technique, considering the vast number of health factors influencing Osteoarthritis. The capability of the proposed approach was shown by classifying various subgroups of patients treated from self-reported medical data and by creating a knee OA diagnostic category. A comparative study has been proposed to suggest best CNN and some of the standard machine learning methods, suggested for categorization was done and the results indicated the efficiency of deep learning in diagnosis of knee OA. Deep Neural Networks are effective technique to solve many machine learning concerns in medicine like prognosis, prediction and image classification.

Yaodong Du et., al. [7] concealed biomedical knowledge from the knee in the MR photos is analysed in this study for osteoarthritis (OA). There are four main machine learning approaches, which are used to forecast the progression of osteoarthritis and also to evaluate the transition in the Kellgren and Lawrence range, the Medial Compartment (JSM) Joint Space Narrowing (JSM) grades and the Lateral Compartment (JSL) Joint Space Narrowing (JSL). The 36-dimensional feature set was split into an 18-dimensional media feature set with an 18-dimensional side feature to be independently conducted through the tests on the four graded methods for inspecting the several impacts of medical and lateral informative areas. In order to minimise the region and enhance performance, the PCA analysis is beneficial. In this way, the techniques of machine learning for the analysis are used to forecast improvements in KL, JSM and JSL grades of hidden biomedical knowledge and the measurements offer a distinct view on the progress of knee osteoarthritis. The CDI data is computed from one of 36 informative positions on the 3D knee MR 3D tibiofemoral division and used as function selection tool for PCA analysis. Pooja P. et., al. [8] approaches using distance-based Active Form Models with a meaningful result is an effective tool for measuring the geometric parameters from the anterior-posterior knee radiography between the tibia and the femur. The other useful approach is the local binary pattern used in many pattern recognition systems, which is also useful in osteoarthritis. The main focus of this study is on feature extraction problems in osteoarthritis and in the key methodologies used by different researchers.

3. Problem Definition
Object identification is a general term for pc vision methods for finding and naming objects. Both static and moving images can be applied for object recognition procedures. Today in medical areas computer vision strategies are widely used, as they can offer important knowledge about various diseases to identify proficiently. In this extent we will understand an object detection and image classification problem, where the objective is to detect the area affected by OA in knee using MRI images. The process of finding out the particular objects in the image is called detection, in this case finding out the OA affected area from knee MRI images. Whereas the process of separating whether the yield image is OA affected or not is known as classification.

4. Existing Methods

The detection and classification of knee Osteoarthritis X-ray images using image processing technical and traditional computer vision techniques takes a lot of work. But in compared to deep learning techniques, the proposed approach was lacking the accuracy. There are generous methods [9, 10] in deep learning techniques i.e., two stage detection (CNN) which acts as feature extractor and various other techniques for image detection and classification. The current strategy for the detection and classification of Osteoarthritis from medical images includes medical expertise verification & medical imaging techniques. By using conventional computer vision techniques detection and classification of objects takes a lot of work. According to the survey researchers investigated that there are various methods for detection and classification of OA using X-ray.

5. Classification

The extraction of information from data sets is a method of classification. This is finished by dividing the information into classes depending on some features. The thought is to determine a model which can perform the categorization by making data objects trained, where the category or label is known. The model should then have the option to arrange unlabeled information with adequate exactness. There are a wide range of models that are utilized for classification, for example neural networks.

6. Machine Learning Methods

The concept of classical programming is that an engineer defines a set of rules, called an algorithm, as shown in Fig.2 which uses input data to calculate some form of output data.

![Figure 2. Classical programming pipeline](image)

A machine learning algorithm is an algorithm that can learn from data (shown in Fig.3) It can be used to calculate these rules automatically, so they do not have to be specified by hand. Three components are needed [11, 12] for such an approach:
- Input data the algorithm is supposed to transform
- The algorithm in output data is meant to predict
- A measurement to validate the performance of a prediction

It works by feeding input and output data into a pipeline, which will learn to transform one into the other. With the bit leeway that no express writing computer programs is expected to create guidelines,
comes the disservice that earlier information and yield information is required for the initial learning process. Machine learning may be applied as an effective method if it is not feasible or possible to define an algorithm by hand and sufficient data is available for training. How much “sufficient” is depends on factors like the type of task, the complexity of the data, the uniformity of the data, the type of machine learning algorithm and others. There are different subparts to machine learning like supervised and unsupervised learning. Supervised learning is used when it is clear what the output data looks like, whereas unsupervised learning can help to find unknown patterns in the data. Examples of supervised learning techniques include linear regression, gradient boosting and artificial neural networks (ANNs).

6.1. Artificial Neural Networks:
AI is a field in software engineering expecting to imitate the process of human learning. Human brain structure is the inspiration of machine learning techniques like ANN or just neural networks. The ANN is a system worked of various interconnected neurons, the neurons are basic handling units that change their inner state or initiation, in view of the current information and produces a yield that relies upon both the information and current enactment.

6.2. Convolution Neural Networks:
CNNs have wide applications in image and video acknowledgement, recommender systems and normal language handling. Convolutions are frequently used in image processing [13], which is also why they were introduced to visual tasks in deep learning domain. They allow learning local patterns in the data instead of treating the input features in a global manner like dense layers do. Convolutional neural networks (CNNs) are a specific type of ANN that uses an operation called convolution in at least one of their layers. The first CNN was introduced by Yann LeCunn in 1990 at which time its popularity was limited. A convolution is a mathematical operation on two functions of real-valued argument. In imaging terminology, the first function refers the input, and the second function describes the kernel. The output of this operation is called a feature map. CNN models stand for one of the oldest deep neural networks hierarchy that have hidden layers among the general layers to help the weights of the system learn more about the features found in the input image. Another type of layer that is frequently used in CNN architectures perform a pooling operation. By doing so, the spatial resolution is reduced, and only the most relevant features are kept. This is important to maintain a manageable network size.

6.3. Detection of object Classes:
In the forms of treatment today machine vision technologies are commonly used for Detection of medical objects would be a process of discovering surgical materials within an object. Medical image analysis features [14] perform an increasing role in facilitating pediatricians in diagnostics, object-guided outcomes, and therapeutic. Adequate, sustainable, and rapid evaluation of convex body segments such as the organ is a vulnerable state mostly to examine the clinical images. Technologies
allow need for the identification and diagnosis of various diseases (in certain context Osteoarthritis) A few of the biggest obstacles seems to be the analysis of its precise destination of the particular location. A lot of contemporary detection algorithms has been used in the health care profession to overcome these problems. Today’s generation various technologies have been outlined with a focus on the identification and diagnosis of several other diseases. The conventional object analysis techniques could also be applicable to a wide range therapeutic imaging strategy, including such Cardiac Computed Tomography, Ultrasound, X-Ray Fluoroscopy and Magnetic Resonance Imaging(MRI).

6.4. Framework of Categorization: 

The key thing to understand while image classification in this project is that the model, we are building is trained on two classes of normal knee MRI and OA affected knee MRI. The way we are going to achieve this classification [15] by training an artificial neural network on image datasets and make the neural network learn to predict which class the input image belongs to, next time it sees an image the model will be able to predict if the input contains having a normal knee MRI or a OA affected knee MRI. A simple workflow of classification model is shown in Fig.4 shows the prediction of input MRI image after training the neural network on the image datasets of OA affected knee MRI and normal knee MRI.

6.5. Data Pre-processing:

The parameters in a Neural Network commonly range from tens of thousands to hundreds of millions. This complexity allows the model to learn on its own what features of an image are relevant for any given task. It works in conjunction with the fact that high volumes of data are available for the training. Because of the small data set that was available for this study, several types of preprocessing were applied to the images. For the most part, these techniques remove irrelevant information and reduce variance between multiple samples. Other preparation methods experimented.

6.6. Labelling the image datasets:

The MRI datasets are labeled based on two different classes. One class contains the normal knee MRI images, and the other class contains the OA affected knee MRI images.

6.7. CNN based modern neural network model:
A simple deep learning-based classification model is shown in Fig.5

![Figure 5. A classification model](image)

Convolution neural network of neural networks Categories for the identification of pictures, labeling of pictures, detection of objects, identification of features, etc. are some of the fields where CNNs are commonly used. For this initiative, the classification model is also focused on CNN for the classification of images. In this project, based on our created features from medical MRI images, later we were able to classify the normal knee MRI images and the disease affected knee MRI images. We were often able to spot the precise address of the affected region in MRI images of the knee.

7. Conclusions

Various changes, experiments and tests have also been rendered for such coming years due to missing data and inadequate time. The analysis require a large amount dataset to achieve better accuracy results. Furthermore, tests with actual data are typically time intensive, taking several days to complete a single test. Future work for this project concerns with solving this object detection and localization problem with considering some more possibilities of OA cases like edema and osteophytes. The future scope of this project would be Using a broad data collection of OA knee MRIs and function on two other perspectives. This would help this project in classifying and detecting the location of disease even in minor OA cases and with better accuracy. Other future scopes would also include the experiments to be done on 3-D images, which may help to detect the presence disease region from whole knee. Another future scope for this project would be to work on the medical images of other body joints also. After achieving so much of work on this project, the model then would be sufficient enough to predict the cases of OA as well as would also be able to detect the origin of OA development in the knee of the patient as well as in certain body joints.

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