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Knee Osteoarthritis Detection and Severity Prediction Using Convolutional Neural Network

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Abstract: The worst kind of arthritis is knee osteoarthritis (KOA). If left untreated, it can require a knee substitute. Right away KOA diagnosis is therefore essential for the best possible care. The manual detection of KOA is a laborious and susceptible to mistakes process. Computational methods are required for timely and accurate detection. The failure of the connective tissue in the knee joint, which results in bone fragments rubbing against other bones, leads to osteoarthritis of the knee. The wear and tear hurt, stiffens, and inflames the knees. Even though osteoarthritis of the knee cannot be cured, there are several treatments that can help to reduce symptoms and decrease the condition's development. A radiologist grades the anomalies on knee X-ray pictures according to their severity using Kellgren-Lawrence's five-point ordinal scale (0–4). The datasets must be trained first using the CNN approach, which is used in this study. Various convolutional layers emerge on the CNN algorithm during training, and the precision increases with each layer. Once uploaded, the X-ray image is shrunk, its color is turned to grey, and several Convolutional layers are applied to it with the help of the CNN algorithm.
Keywords: KOA, CNN, X-ray.

I. INTRODUCTION

Knee osteoarthritis (KOA), the most common musculoskeletal condition affecting senior individuals worldwide, is characterized by changes to bone and cartilage. Although arthritis right now has no known cure, the advantages of early identification cannot be emphasized. The Knee Osteoarthritis Detection app aids users in both the initial and late detection of osteoarthritis in their knees. Knee osteoarthritis is diagnosed through clinical and X-ray tests, and the only effective treatment for the disease's advanced stages is a full knee substitute. To prevent the necessity for this surgical procedure and to halt the deterioration of bone and cartilage, promptly recognizing of knee osteoarthritis is advised. A selection of biological imaging techniques, including X-ray, magnetic resonance imaging, ultrasound, and others, are used to evaluate KOA [1]. Doctors in radiology have used Kellgren's and Lawrence's criteria to medically establish the diagnosis of osteoarthritis (OA).

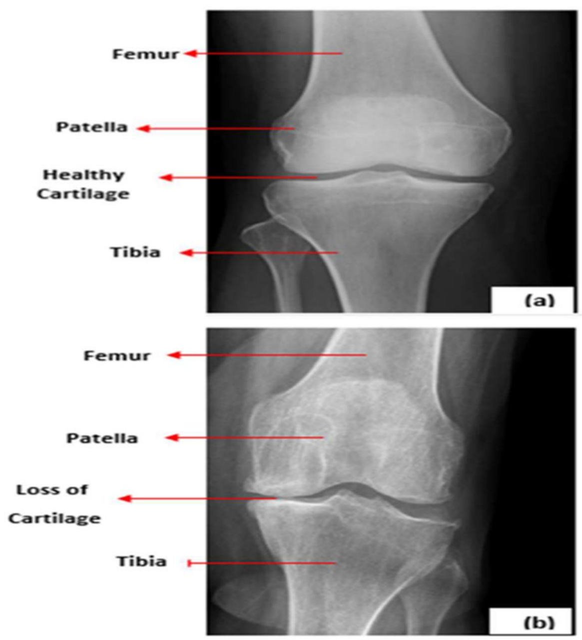

Fig. 1. a: Healthy Image. b: KOA Image [19].

A normal radiograph has a Class 0. Class 1 Osteoarthritis are possible, whereas Class 2 Osteoarthritis are certain. In Class 3, keep an eye out for Osteoarthritis and a narrower joint space. Class 4: Osteoarthritis a type of joint space restriction and deformity. According to the clinical diagnosis of osteoarthritis, most studies have used Class 2 (the presence of Osteoarthritis) Others require verification of joint shrinkage (Class 3) as an indication for illness identification.

It is significant to highlight that most artificial intelligence professionals aim to use this data to speed up the detection of early osteoporosis due to advancements in medical imaging and electronic record accessibility, such as the Osteoarthritis Initiative (OAI) [2] [3]. KOA categorization and identification based on medical and imaging data may improve task efficiency. Most investigations continue to be hampered by the challenges of processing this data utilizing various computer systems when using magnetic resonance imaging pictures [4]. This sparked additional research and development in medical imaging methods, giving rise to a diverse spectrum of methodologies.

Since convolutional neural networks have shown results that are comparable to those of manual procedures used by true professionals, they are widely used in deep learning. Through a succession of model architectural changes, deep learning approaches, like CNN, mechanically acquire photographic data in order to identify complicated properties. The figure illustrates the CNN branch of AI. Deep learning methods like CNN are part of the machine learning branch of artificial intelligence (AI). CNNs are reliable, simple to train, and low in complexity as the network picks up new skills during the tuning process. There are many different factors. The overall architecture of CNN consists of an input layer, hidden layers linked to various image filtration systems, feed-forward network layers where the image filtration are displayed upon the input picture, and a result layer where the feature will be recovered.

II. RELATED WORKS

In a variety of computer vision and machine learning problems, the Convolutional Neural Network (CNN) has proven to perform exceptionally well. On this subject, several solid publications as well as a few top-notch open-source CNN software packages have been published. A deep learning paper about KOA was published in 2021 by Jean Baptiste Schiratti and Remy Dubious, the goal of the study was to help or support radiologists in their tough task of determining the stage of knee osteoarthritis. This is because radiologists are prone to human errors that can have disastrous effects, especially when it comes to matters of health. For the same reasons, numerous academics from throughout the globe have published articles on KOA [5]. In 2022, about three papers were submitted, all with the goal. We present the most recent findings on automatic KL assessment in this work. Our method calculates the KL grade based solely on the Osteoarthritis Initiative (OAI) dataset.

Develop fully autonomous neural network algorithms for determining the severity of Osteoarthritis in the knee is the aim of this effort. The methods for using neural networks and photo enhancement to increase the early diagnosis of osteoarthritis of the knee have been improved [6]. This is due to the fact that the investigation's most difficult components are the inadequate x-ray images and the prompt identification of knee osteoarthritis.

CNN was used by P. Chen et al. [7] to monitor the development of knee Osteoarthritis. CNN models including Residual neural network, Visual Geometry Group, Densely Connected Convolutional Networks were used to classify the images of the identified knee joints after detecting them with the YOLO9000 network. The OAI dataset's baseline x-ray images are next evaluated. The study found that the tuned Visual Geometry Group-19 model has the best predictive accuracy rating of 68.7% when compared to Residual neural network or Densely Connected Convolutional Networks versions.

The use of a deep learning system to identify knee osteoarthritis was suggested by A. Swiecicki [8]. On the MOST dataset, the application had an accuracy of 71.90 %. The region of interest in images from X-rays was found using the Region Proposal Network method. Then, to anticipate entity limitations, the Region Proposal Network and Visual Geometry Group16 convolutional networks were used. A novel strategy that integrates preprocessing, CNN as the extraction of features method, and Long Short-Term Memory as an algorithm for categorizing features in the same context was put out by R. T. Wahyuningrum et al [9]. The research was done using the OAI the data set, and the results showed a mean accuracy of 75.2%. Additionally, the Visual Geometry Group16 model was the best at identifying distinctive features from pictures of knee Osteoarthritis.

R. K. Jain et al. developed the Osteo High-Resolution Network, it is a deep learning system that instantly evaluates the severity of osteoarthritis of the knee [10]. The properties of knee X-ray images were also recorded using the High-Resolution Network. On the OAI data set, the algorithm had an accuracy rate of 71%.

The following parts comprise this paper: Part two includes materials and methods for collecting datasets, pre-processing them, and developing and training deep learning models. Part Three discusses and explains the outcomes of the experimental setting, followed by Part four conclusion.

III. MATERIALS AND METHODS

Data collecting, pre-processing, which includes actions like shrinking the knee images, and noise reduction are the three steps of the proposed system, which is shown in Fig. 3. Following the extraction and classification of features, a convolutional neural network is used.

A. Image Acquisition

The Osteoarthritis Initiative (OAI) was the only publicly available dataset used in this investigation [16]. For every class, examples and standards are shown in Figure 2. There are 1650 photos of knee OA in the sample. According to the Kellgren-Lawrence (KL) categorization, which is based on the descriptions of medical experts, the dataset is classified into five classes.

Fig. 2. Different levels of Knee osteoarthritis [11]

B. Pre-processing

The initial process after loading an x-ray image is preprocessing, which is important for visual evaluation and interpretation in numerous programmes. Therefore, how effectively image enhancement removes irregular illuminations and enriches minimal-contrast images determines the accomplishment or decline of automated analytical procedures in these applications [6]. As a result, a lot of research has been done to improve the quality of x-ray images.

C. Resizing the x-ray pictures

There are preprocessing processes that seem to be application-specific after the gathering of knee X-ray images. As the disease impacts with age, the distance between the knee ligaments widens [12]. The image is compressed and resized to 224x224 pixels as part of preprocessing in this study to enable better analysis.

D. CNN Architecture

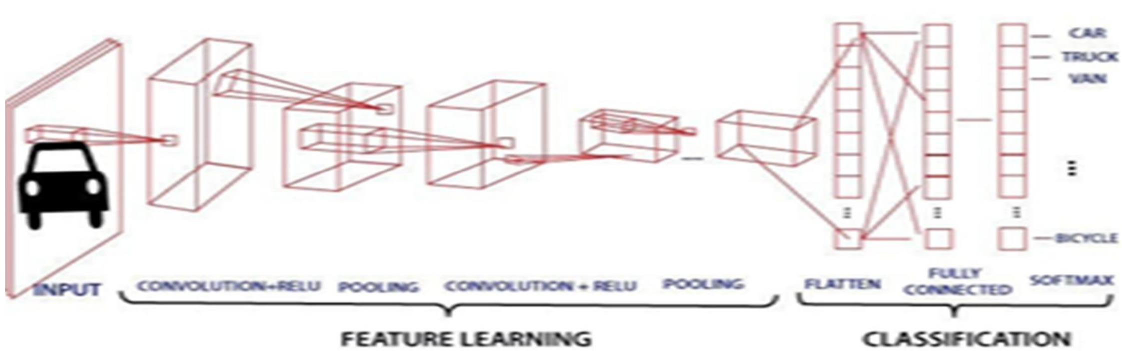

Fig. 3. Proposed system Architecture [14].

The mutually reinforcing responses of the distinct neurons for distinct specific areas of the original visual result in a more accurate visual representation of the input image. Patterns that are hidden from them can be found by hand-crafted features [15]. After using the CNN architecture which is primarily useful for identifying patterns in images to identify objects and classify them, we use the RELU activation function which primarily converts to zero if any input is negative, next we use a pooling layer to reduce the dimensionality, then flatten to turn the 2D-matrix into a linear vector, and finally a fully connected layer to produce the output.

IV. RESULTS AND DISCUSSION

The Knee Osteoarthritis Severity Dataset was the only publicly available dataset used in this investigation [16]. The knee is depicted in 1650 X-ray Pictures in the batch.

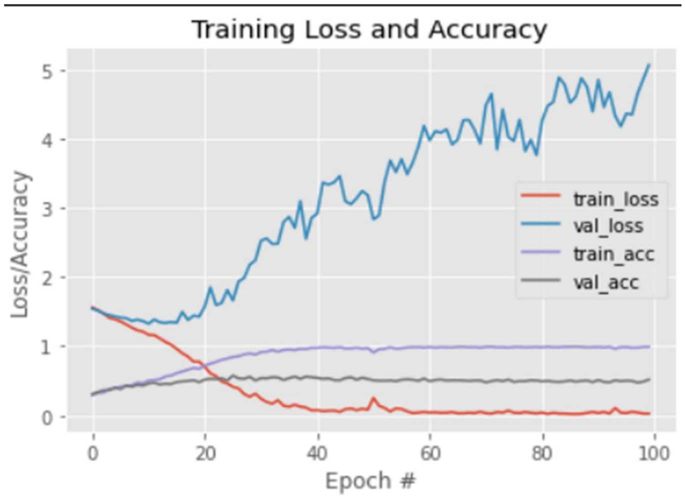

Fig.4. Training Loss and Accuracy

The model guards against another model misclassifying class 1 as class 0. Our Model can classify all the 5 classes with the accuracy of 70, but other Models classify 2 classes and 3 classes with the accuracy of 70.6 and 80

Table I: Comparison Between Existing Models And Proposed Model

Studies	Approaches	Data set	Classes	Accuracy%
[19]	YOLOv3	OAI	3	70.60
[18]	2D CNN	OAI	2	80
Our proposed	2D CNN	OAI	5	70

A. Limitation

The present study's limits can be seen, for instance, in the model accuracy, which is not very high. Using alternative architectural designs Future work will review this task and attempt to address it.

V. CONCLUSION

It has been proposed to use KL grades and x-ray images to determine the severity of knee OA using an effective 2D CNN. Our suggested models produced incredibly pleasant results that were extremely precise.

Our model, which made use of the OAI dataset, has a 65% accuracy rate for the multi-class categorization of KL grades using 5 class. This effort demonstrates the attraction of deep learning applied to osteoarthritis and has the potential to highly help radiology professionals in the challenging process of identifying sufferers with an extremely hazardous for disorder advancement.

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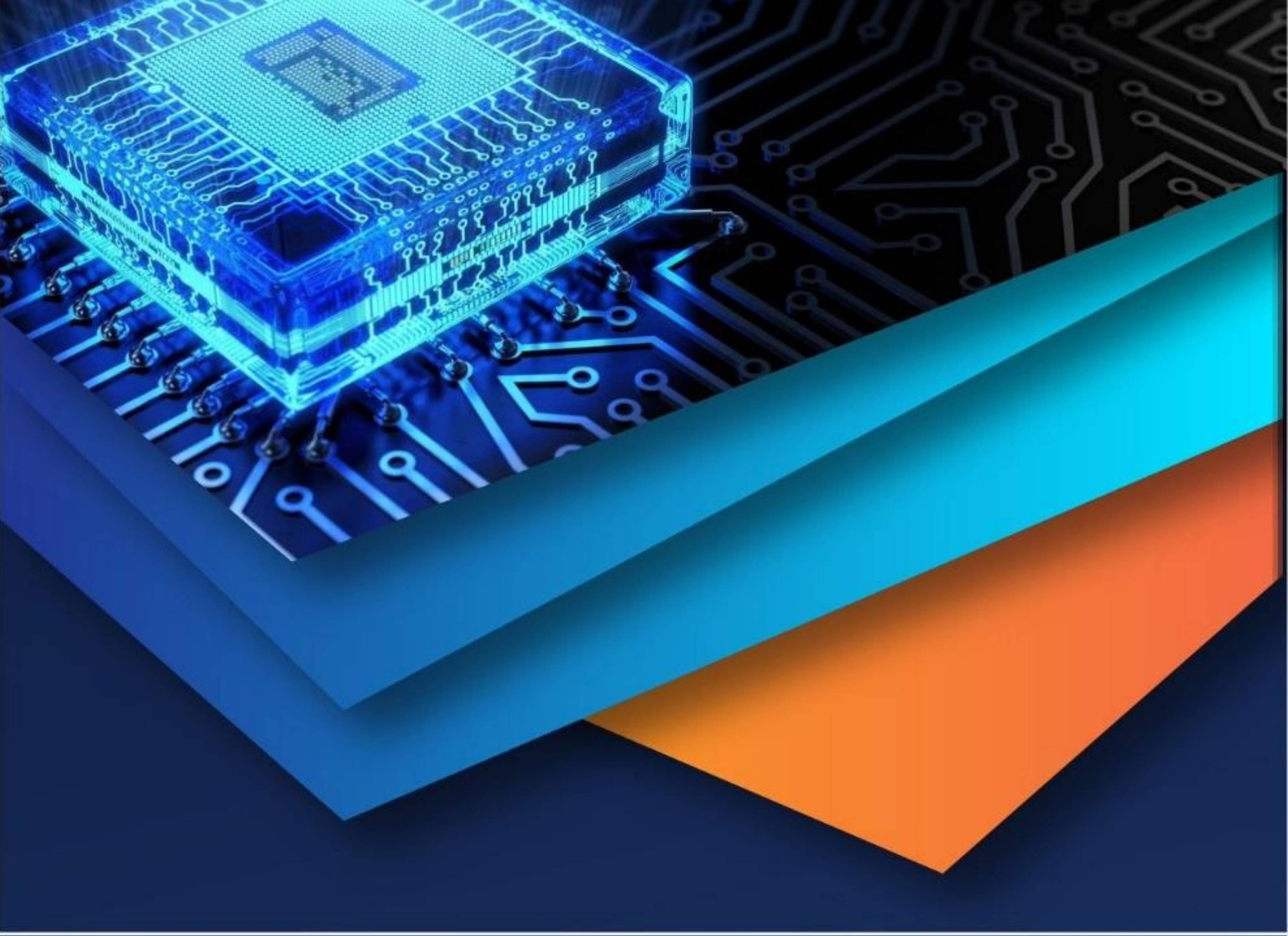

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