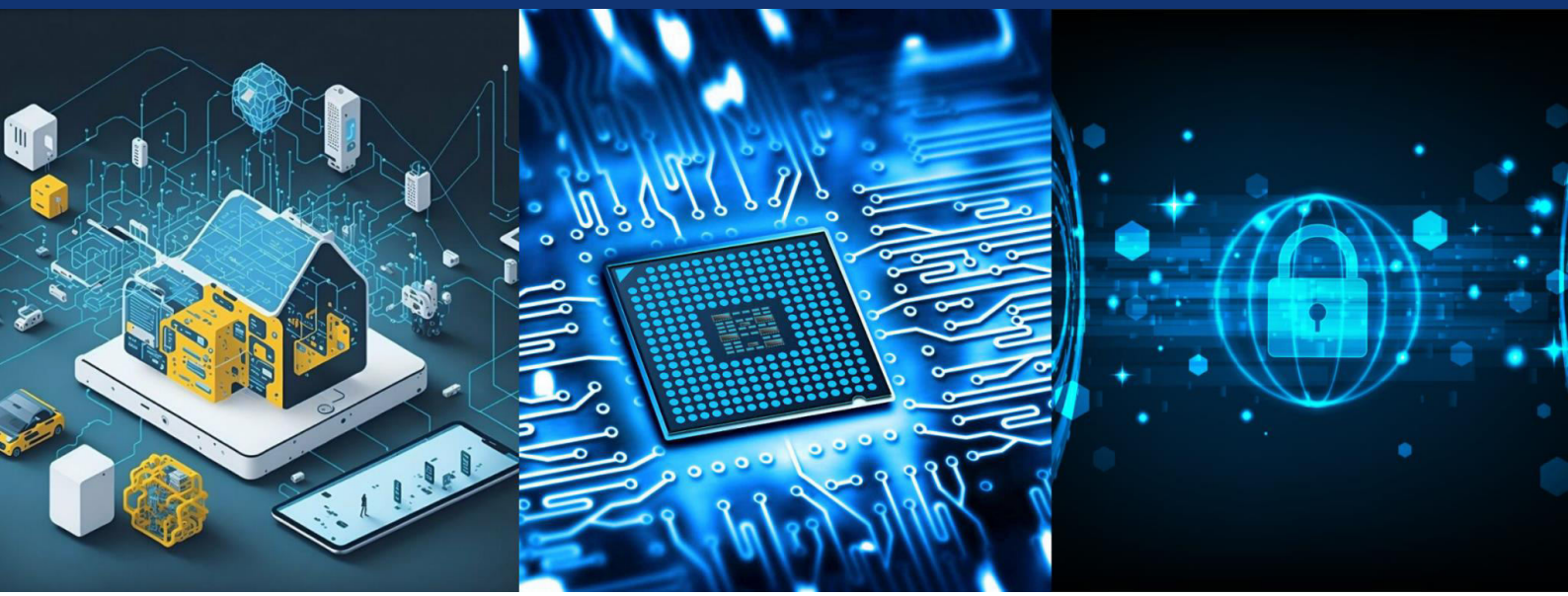
IJIRCCE

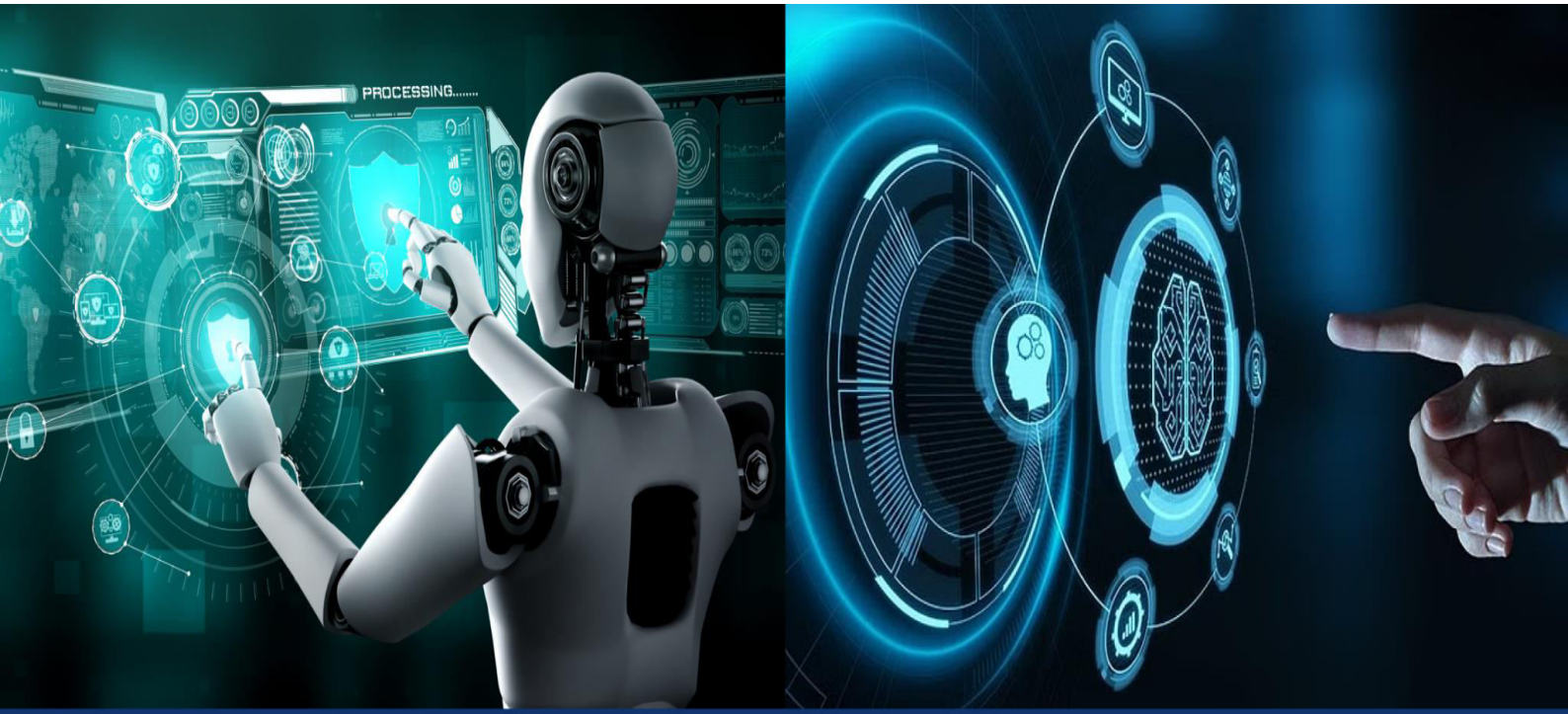
ISSN(O): 2320-9801

ISSN(P): 2320-9798



International Journal of Innovative Research in Computer and Communication Engineering

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)



Impact Factor: 8.771

Volume 13, Issue 4, April 2025

© 2025 IJIRCCE | Volume 13, Issue 4, April 2025| DOI: 10.15680/IJIRCCE.2025.1304119

www.ijircce.com | e-ISSN: 2320-9801, p-ISSN: 2320-9798| Impact Factor: 8.771| ESTD Year: 2013|

International Journal of Innovative Research in Computer and Communication Engineering (IJIRCCE)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

Knee Osteoarthritis and using a Customized Center net with Densenet201

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ABSTRACT: The Wa Knee osteoarthritis (KOA) is a prevalent joint disorder diagnosed using imaging modalities like MRI, CT scans, and X- rays, with X-rays being the most cost-effective. Early detection is crucial for effective management. This study presents an automated deep learning approach to detect and classify KOA severity based on the Kellgren-Lawrence (KL) grading system using single posteroanterior standing knee X-ray images. Utilizing the Osteoarthritis Initiative dataset, we employed transfer learning to fine-tune DenseNet-201, enhancing model performance. Additionally, knowledge distillation was applied to reduce computational complexity while maintaining accuracy. Our model achieved over 95% accuracy on both testing and cross-validation datasets, outperforming existing methods. This approach offers a reliable tool for early KOA diagnosis and grading, potentially aiding clinical decision-making

KEYWORDS: Knee osteoarthritis, Kellgren-Lawrence grading, deep learning, DenseNet-201, knowledge distillationn.

I.INTRODUCTION

Knee osteoarthritis (KOA) is a chronic disorder characterized by joint pain, swelling, and movement difficulties. The term "osteoarthritis" originates from Greek, meaning "inflammation of the joints and bones." KOA progresses through three stages:

1. **Early Stage**: Minimal damage with inconspicuous symptoms.
2. **Moderate Stage**: Noticeable damage due to further cartilage wear and joint space narrowing.
3. **Severe Stage**: Bone-on-bone contact within the knee joint.

Early detection of KOA is crucial for maintaining mobility and quality of life. Imaging modalities such as MRI, CT scans, and X- rays are utilized for diagnosis, with X-rays being the most cost- effective. The Kellgren-Lawrence (KL) grading system categorizes KOA into four grades, ranging from 1 to 4.

The primary objective is to enhance KOA detection efficiency by employing a flexible deep learning model that extracts optimal features. The enhanced architecture of CenterNet contributes to the model's effectiveness.

II. LITERATURE SURVEY

Knee osteoarthritis (KOA) diagnosis has been approached using various imaging techniques, including X-rays and MRI, analyzed through classification-based, segmentation-based, and feature extraction-based methods. Recent studies have introduced early detection systems for osteoarthritis (OA) that move beyond traditional grading systems, focusing on molecular, mechanical, electrical, and morphological traits. Non-invasive imaging modalities, particularly MRI, have been utilized to assess disease progression. For instance, a study employed dual-echo steady-state MRI for image processing, region-of-interest detection, and segmentation, applying machine learning techniques such as Support Vector Machines, Random Forests, and Artificial Neural Networks to determine the most effective method.

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Segmentation-based methodologies have been extensively explored, with studies segmenting articular cartilage and other knee joint components. However, some lacked statistical comparisons of proposed methods. Feature selection based on fuzzy logic, combined with machine learning, achieved an average accuracy of 78.14% using 31 selected features. A robust feature selection procedure was also proposed to identify KOA risk factors, addressing critical challenges.

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III. PROBLEM STATEMENT

The project aims to address the problem of detecting and classifying Knee Osteoarthritis (KOA) using knee images obtained from X-ray scans.The existing methods for knee disease detection using image processing techniques have limitations in terms of accuracy and precision.The objective is to develop an improved deep learning model that can automatically extract features from knee images and accurately detect KOA.The proposed model utilizes an improved CenterNet architecture with a pixel-wise voting scheme and DenseNet201 as the base network for feature extraction.The model aims to provide precise detection of KOA in knee images and determine the severity level according to the KL grading system.

IV. METHODOLOGY

The methodology Knee osteoarthritis (KOA) consists of the following key steps:

3.1 Importing Necessary Packages

Load essential Python libraries such as TensorFlow, Keras, OpenCV, NumPy, and Pandas for deep learning, image processing, and data handling.

3.2 Exploring the Dataset

Knee Osteoarthritis Dataset (Roboflow) , Additional knee X-ray datasets (if applicable).

3.3 Image Processing: ImageDataGenerator: Used for data augmentation. Re-scaling: Normalization of pixel values. Shear Transformation: Applying geometric transformations to images. Zooming: Augmenting dataset with zoomed-in images. Horizontal Flip: Flipping images to increase dataset diversity. Reshaping: Standardizing image dimensions

3.3 Building the Model: The Pixel-Wise Voting Scheme: Improves detection precision. Deep Convolutional Layers: Extract detailed feature representations. Bounding Box Prediction: Identifies regions of interest (ROI) in X-ray images

3.4 Training the Model: Model is trained using

- **Loss Function**: Custom loss function optimizing detection accuracy
- **Optimization Algorithm**: Adam optimizer for faster convergence
- **Batch Size & Epochs**: Hyperparameter tuning for optimal training.

V. OBJECTIVES

The objective of the project is to develop an improved deep learning model for the detection and classification of Knee Osteoarthritis (KOA) using knee images obtained from X-ray scans. The proposed model is based on a customized Center Net architecture with a pixel-wise voting scheme and utilizes DenseNet201 as the base network for feature extraction. The model aims to automatically extract the most representative features from knee samples and provide accurate bounding box predictions based on a weighted pixel-wise voting scheme. Additionally, the project incorporates knowledge distillation to simplify the model without increasing computational cost and transfer knowledge from a complex network to a simpler network. The performance of the proposed technique is evaluated using various experiments, and it is estimated that the model outperforms existing techniques with high accuracy over testing and cross- validation datasets

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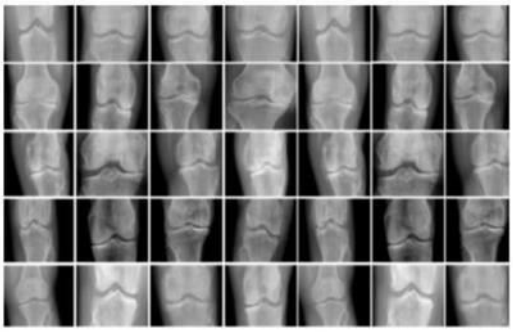
VI. DATARESOURCES

We employed two datasets for several investigations, which included testing, training, and cross-validation. The first dataset is typically used to determine KOA intensity classification and identification based on the Kellgren Lawrence scheme. It includes two thousand knee X-ray digital pictures with a resolution of 8 bits. Two medical specialists annotated the knee photos for appraisal, dividing them up using the KL approach. Furthermore, The photos are in PNG format and are in greyscale. The dataset is partitioned into two parts: 25% is used for test and 75% for training and validation. To be moreprecise, more than sixteen hundred photos have been trained by the model and examined more than four hundred knee photographs. The joint evaluation of the dataset distribution by both experts took into account, which included five hundred photos belong to healthy class. Four hundred images belong to Grade 1, two hundred fromGrade 2, two hundred from Grade 3, and two hundred from Grade 4. Figure 1 depicts the class-wise distribution of knee pictures used to assess and train the suggested method.

Furthermore, cross-validation is performed using the Osteoarthritis Initiative dataset. It includes knee joint X-rays and 3T M scans to be classified according to the Kellgren Lawrence approach. Data was collected from many individuals, ages forty to eighty, who were both male and female. Furthermore, the dataset did not include patients who had knee replacement surgery. Some of the individuals' knees were in good condition, while other images fell into groups 2, 3, and In addition, our suggested model was assessed using a few images from each of the following classes: Healthy, Grade 1 to 4.



VII. PROPOSED METHODOLOGY

This research paper presents a robust framework for KOA recognition. This method can be adapted to knee images that have different degrees of KOA and can be used with new photos that have never been seen before. The main process of the superimposed medical image is to extract the hyperdimensional features which can aid in the diagnosis and description of the disease. The samples were placed in the center and indicated area which were marked with rectangular boxes. Our improved CenterNet was developed by using as a base network DenseNet201 for feature creation. In DenseNet, the end points are highly interconnected, which makes it possible to capture the small among the knee joints, therefore it was a better choice than ResNet. ResNet employs shortcut connections as well as information derived from inserts of the special procedure, namely, the second and third stages. However, by means of a dense block along with pentagon architecture, DenseNet201 division can reveal a straightforward pattern of the capturing in papillae. Further, it utilizes conversions that are the most efficient and still are the most creative beyond ResNet.Prior to the knee joint feature extraction step, the localization outcomes are enhanced by providing the voting function with an input rectangular box predicate from our customized CenterNet. Every pixel in the estimated bounding box is voted for by the function to determine the best rectangular box so that the best bounding box is the one which has the largest score - this is then returned. Additionally, knowledge distillation is applied to the compressed model and knowledge of the larger model is transferred to the small model without enhancing processing power. Thus, the means of an automatic process can be used to detect the presence of KOA in the first dataset. Diverse knee joint specimens which were gathered from doctors among other things are utilized to create a more efficient CenterNet neural networkregion of interest has been incorporated in order to enhance the

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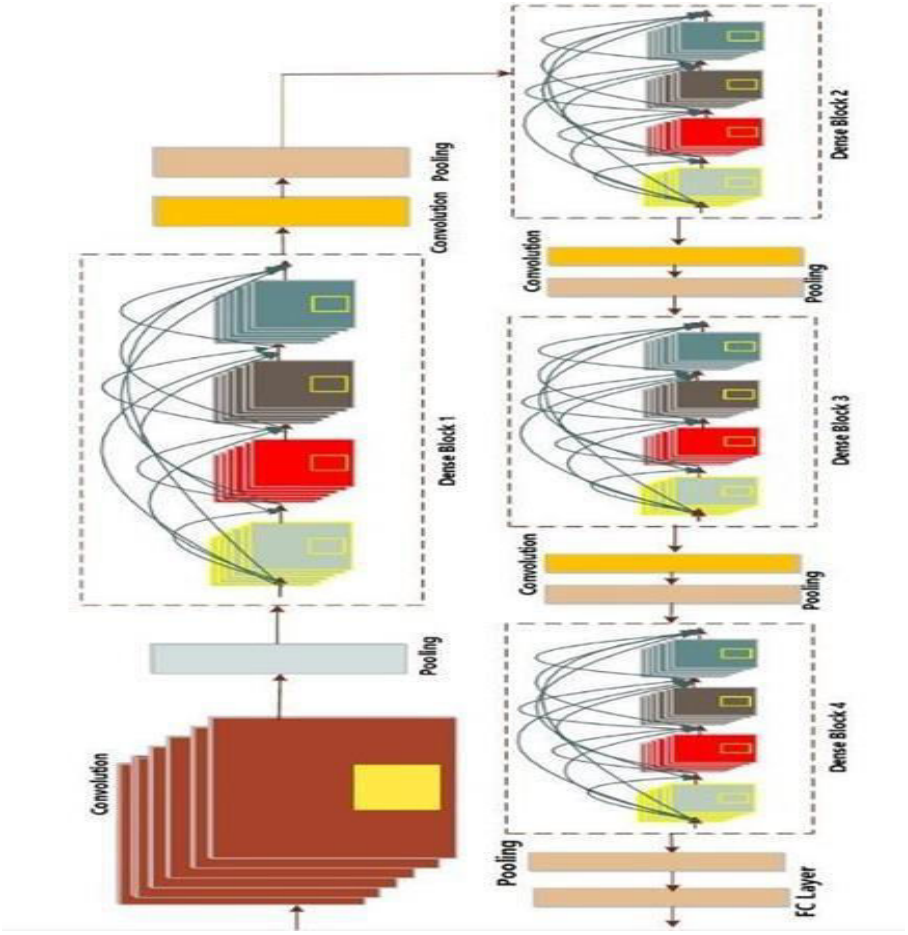
prediction abilities as well as the detection accuracy of the proposed system. Therefore, health organizations are able to implement the proposed method for KOA intensity detection. For example, consider a case where a radiologist takes X-rays of a patient who has mild pain in the knee. The patient can then be told that he has not developed KOA by radiologists using the proposed method. In the long run, this will save time and effort for both the patients and healthcare providers.The model being adaptable allows it to use other imaging modalities like MRI and CT along with X-rays. MRI may help in the early diagnosis by concentrating on soft tissue structures like cartilage and ligaments, while CT can offer detailed information about bone morphology and joint space narrowing.The proposed model shows some good results; however, when put into consideration of justification, clinical usage still faces issues. Image quality variation, patient differencing, and large datasets diversity requirements will surely undermine proper performance. The integration of knowledge distillation does further improve model efficiency and training time, further exploration could refine this improvement.



VIII. CONCLUSION

For identifying Knee Osteoarthritis (KOA) and also evaluating the intensity levels with Kellgren Lawrence grading, in this work, a strong deep learning architecture is proposed. The proposed technique is based on a modernized architecture of CenterNet that utilizes a base technology, namely DenseNet201. Due to the strong connections between all layers, it extracts the best features from the designated focal point. The distillation of knowledge that simplifies the model with less cost of computation, as well as to move information from a complex network to a straightforward one. We used two datasets. 1) Cross-validation was done on the other dataset after testing and training on the former one. The model achieved cross validation accuracy of 98.97% on the second dataset and an accuracy of 99.14% for total localization of knee joints and classification of KOA. Our study's most significant application is the KL grading system for the early and precise localisation of knee joints and the identification of KOA, thereby reducing the amount of time and money needed for additional testing techniques. As a result, healthcare organisations can easily implement the suggested method for KOA early identification. Our proposed process accepts raw X- ray pictures and handles all changes inside. Our proposed approach is intended for use by orthopaedic surgeons and radiologists in the early detection and severity of KOA utilising X-rays. By detecting KOA disease early on, the system helps to prevent it from progressing to the severe state. The proposed model proposes detection of the focal point using the voting mechanism, followed by the extraction of the best significant features due to the dense connections as present in DenseNet201. Feature extraction from the

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