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Deep Learning Based Knee Osteoarthritis Detection and Classification

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Abstract: *Knee osteoarthritis (OA) is a musculoskeletal disease that significantly affects patients' quality of life. Early and accurate diagnosis of knee osteoarthritis is important for timely intervention and development of appropriate treatment plans. In this study, we present a novel approach using artificial intelligence (AI)-based deep learning to solve the problem of knee joint localization, joint width (JSW) area, and grading of knee OA from digital radiographs. The main aim of this study is to investigate the effectiveness of the deep learning method in predicting knee OA severity based on the Kellgren Lawrence (KL) rating. To achieve this, we developed a custom tool that uses neural networks (CNN) to analyze digital radiographs of the knee joint. Our approach focuses on identifying the presence of knee OA and measuring its severity according to the KL score.*

Keywords: Knee Osteoarthritis, Musculoskeletal disease, Deep learning, Knee joint localization, Joint width, Kellgren Lawrence Grading system, Digital radiographs, CNN

I. INTRODUCTION

The Knee osteoarthritis (OA) is a common joint disease caused by the deterioration of knee cartilage. Its effects occur all over the world, affecting millions of people, causing suffering ranging from discomfort to severe disability, and changing people's lives. The importance of timely and accurate diagnosis cannot be underestimated because it is important to implement interventions that slow the disease and improve patient outcomes.Significant advances in medicine in recent years, combined with advances in artificial intelligence (AI), have helped revolutionize diagnosis. Deep learning, a group of artificial intelligence, has become a powerful tool for doctors, revealing good knowledge in many clinical areas. The ability to analyze electronic data, especially medical images, offers unprecedented hope for improving the diagnosis and classification of knee OA. By leveraging the power of deep learning algorithms, clinicians can unlock meaningful insights from complex image data of varying degrees of complexity and functionality. These algorithms are good at identifying dynamic changes in knee OA and help identify pathology quickly and accurately. In addition, they can combine various types of imaging, from traditional radiography to advanced MRI and CT scans, allowing for a comprehensive assessment of disease severity and growth.Integrating deep learning into functional diagnostics has the potential to reduce the content and diversity of traditional diagnostic methods. Deep learning algorithms offer a way to improve the consistency and reliability of knee OA diagnoses by providing objective, measurable data. Additionally, its prognostic abilities allow doctors to predict disease progression and adjust treatment strategies accordingly, bettering treatment outcomes and improving long-term pain outcomes.In addition to its diagnostic and usefulness, deep learning should also improve our understanding of knee OA pathophysiology. Deep learning algorithms explain the interactions between genetic, environmental and biomechanical factors in the initiation and progression of disease, paving the way for the development of targeted treatment programs

II. METHODOLOGY

The Methodology for the Knee Osteoarthritis detection and classification would involve the following steps:

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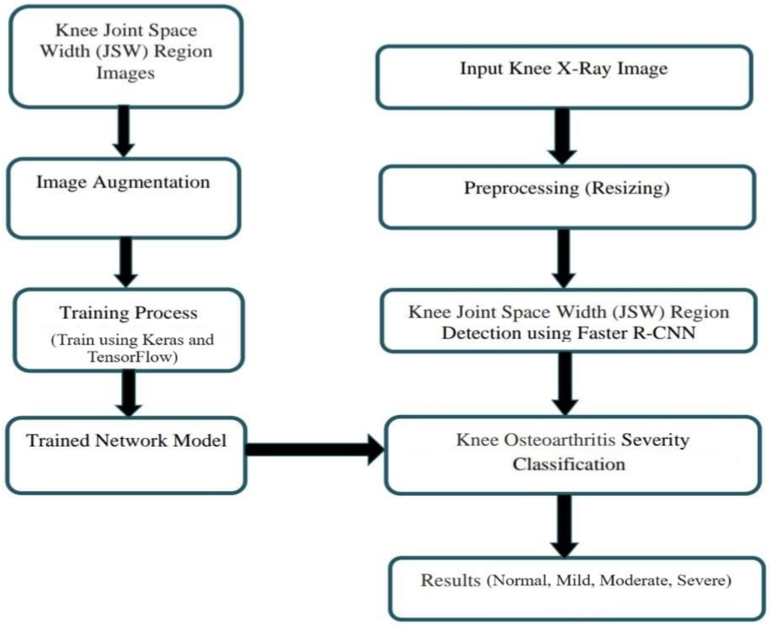

Fig. 1. Architecture diagram of Knee Osteoarthritis detection and classification.

Data Collection: Use medical images such as x-rays to capture images for the Knee Osteoarthritis Machine Learning Project. Collecting different data representing different stages and symptoms of osteoarthritis from Kaggle and using machine learning model training. Standardize image resolution and format for consistency.

Data Preprocessing: Pre-processing in a knee osteoarthritis machine learning project includes things like normalizing pixel values, normalizing image resolution, noise reduction, segmenting/testing the knee region, data quality and integration of relevant metadata. Together, these steps improve the quality of the data and prepare it for model training and quality assessment.

Image training process: The training process for diagnosing knee osteoarthritis using Keras and TensorFlow involves several important steps. After pre-processing, the dataset is divided into training, validation and test sets for model evaluation. Deep learning models are then developed using Keras' sequential or functional API, which is often combined with convolutional neural networks (CNN) for image analysis. The model is compiled using quality loss, optimizers, and evaluation methods such as binary cross-entropy loss and Adam optimizer. The model is then trained using the training data and training metrics such as loss and accuracy are monitored to evaluate convergence and performance. Mechanisms such as early dismissal and school scheduling can be used to prevent overwork. After training, the model is evaluated on existing data to evaluate its effectiveness in diagnosing knee osteoarthritis. Finally, the model can be transferred to real-world use, perhaps embedded in software applications or sent to cloud services to be mirrored. Experimentation with hyperparameters, data augmentation techniques, and modeling techniques are required to reach consensus throughout the process.

Knee Joint Space Width (JSW) area detection: Detect knee width using area-based convolutional neural networks (RCNN) with model training to identify and determine the location of the knee in treatment. RCNNs are particularly useful for object detection tasks because they combine local networks with neural networks.

Knee Osteoarthritis Classification:

Grade 0 (None): No X-ray changes are seen in osteoarthritis

Grade 1(doubtful): Narrow joint space and possible knee osteophytes.

Grade 2 (minimal): Significant osteophytes and possible joint narrowing.

Grade3 (Moderate): There are numerous osteophytes and some sclerosis marking the joint space and possible deformation of the bone ends.

Grade 4 (severe): Large osteophytes, major narrowing of the joints, sclerosis and significant deformation of bone ends.

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Performance Evaluation: The performance of the Knee Osteoarthritis Detection and Classification project will be evaluated through metrics such as accuracy, precision, and recall, which demonstrate that the system is able to identify and describe the stage of osteoarthritis based on knee x-rays. Additionally, evaluating computational performance, including the processing time of an image, is important to evaluate the feasibility of transfer to the clinical field.

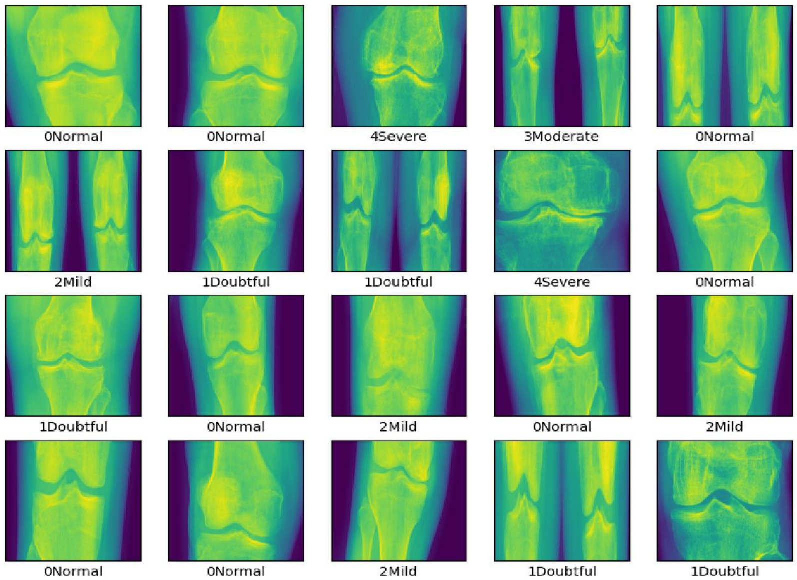

Fig.2.Sample Test Images for Knee Osteoarthritis detection.

The Knee X-ray dataset on Kaggle contains a collection of high-resolution X-ray images capturing various knee conditions, including fractures, arthritis, and abnormalities. Each sample typically includes metadata such as patient information, image resolution, and diagnosis labels. Researchers and medical professionals often use this dataset for developing and evaluating machine learning algorithms for knee-related diagnostic tasks

III. RESULTS

In Knee Osteoarthritis Detection Using RCNN, learning loss and accuracy graphs provide a graphical representation of the training model showing loss and accuracy over time. Additionally, the confusion matrix provides insight into the model's performance in different groups, helping to evaluate its ability to accurately differentiate between healthy knees and osteoarthritic knees with 95%. The integrated predictive front-end interface facilitates user interaction, allowing doctors and patients to easily access knee images and measurement of osteoarthritis risk, thereby increasing the accessibility and validity of diagnosis.

Approach	Accuracy	Limitations
SOM	53.34%	A black-box approach with poor classification accuracy particularly for KL grade 2
CaffeNet	59.6%	Poor classification and ROI detection of accuracy with limited explainability
CNN and GBM	75%	Based on only X-ray modularity and limited explainability
R-CNN	95%	Computationally intensive training and inference training process due to its multi-stage architecture.

Table 1. Approaches with accuracy based on radiographs.

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Fig.3. Graphical representation of training loss and accuracy of datasets.

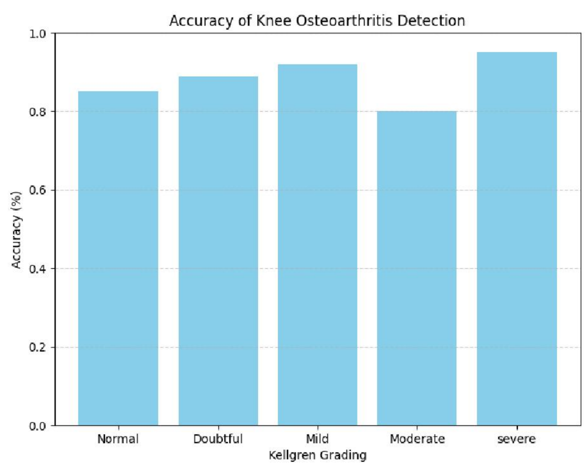

Fig.4. Graphical representation of accuracy of knee osteoarthritis detection.

Analyzing the confusion matrix and associated performance metrics allows researchers and clinicians to assess the model's strengths and weaknesses in distinguishing between different severity levels of knee OA. This information can inform further refinement and optimization of the deep learning model to improve its diagnostic accuracy and predictive capabilities across the spectrum of knee OA severity. Thus, enhancingits predictive capabilities. By examining the confusion matrix, researchers and clinicians can gain valuable insights into how the deep learning model is performing across various severity levels of knee osteoarthritis (OA), identifying areas where it excels and where it may need improvement. Understanding the model's strengths and weaknesses in distinguishing between different severity levels of knee OA is crucial for enhancing its clinical utility and ensuring accurate diagnoses for patients. The insights gleaned from analyzing performance metrics can guide targeted refinements to the deep learning model, addressing specific challenges in accurately predicting different stages of knee OA progression. With this nuanced understanding, clinicians can tailor interventions and treatment plans more effectively, ensuring that patients receive timely and appropriate care based on the severity of their condition. Additionally, ongoing refinement and optimization of the deep learning model based on performance, improvement and reliability.

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Fig. 4. Confusion Matrix classification based on Kellgren Lawrence grading system.

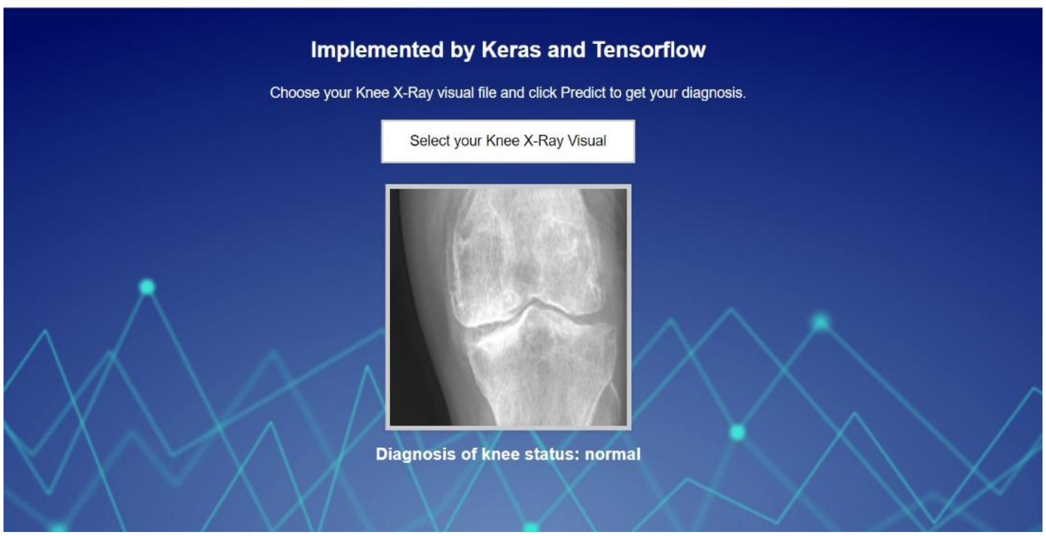

Fig.5.The integrated predictive front-end interface for knee osteoarthritis detection and classification

IV. CONCLUSION

In Knee Osteoarthritis Detection Using RCNN, learning loss and accuracy graphs provide a graphical representation of the training model showing loss and accuracy over time. Additionally, the confusion matrix provides insight into the model's performance in different groups, helping to evaluate its ability to accurately differentiate between healthy knees and osteoarthritic knees. The integrated predictive front-end interface facilitates user interaction, allowing doctors and patients to easily access knee images and measurement of osteoarthritis risk, thereby increasing the accessibility and validity of diagnosis. In conclusion, utilizing deep learning for knee osteoarthritis detection and prediction shows promising potential in advancing early diagnosis and proactive management strategies. By leveraging sophisticated algorithms and large datasets, deep learning models can effectively analyze complex patterns in medical imaging and patient data, aiding in accurate diagnosis and prognosis. However, further validation studies and clinical trials are essential to ensure the reliability and generalizability of these models in real-world healthcare settings. With continued research and development, deep learning holds the promise of revolutionizing knee osteoarthritis care.

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REFERENCES

[1] Y. X. Teoh, K. W. Lai, J. Usman, S. L. Goh, H. Mohafez, K. Hasikin, P. Qian, Y. Jiang, Y. Zhang, and S. Dhanalakshmi, ‘‘Discovering knee osteoarthritis imaging features for diagnosis and prognosis: Review of manual imaging grading and machine learning approaches,’’ J. Healthcare Eng., vol. 2022, pp. 1–19, Feb. 2022.

[2] Y. Badshah, M. Shabbir, H. Hayat, Z. Fatima, A. Burki, S. Khan, and S. U. Rehman, ‘‘Genetic markers of osteoarthritis: Early diagnosis in susceptible Pakistani population,’’ J. Orthopaedic Surgery Res., vol. 16, no. 1, pp. 1–8, Dec. 2021.

[3] D. Saini, T. Chand, D. K. Chouhan, and M. Prakash, ‘‘A comparative analysis of automatic classification and grading methods for knee osteoarthritis focussing on X-ray images,’’ Biocybernetics Biomed. Eng., vol. 41, no. 2, pp. 419–444, Apr. 2021.

[4] C. L. Chowdhary and D. P. Acharjya, ‘‘Segmentation and feature extrac-tion in medical imaging: A systematic review,’’ Procedia Comput. Sci.,vol. 167, pp. 26–36, Jan. 2020.

[5] S. Kubakaddi, K. M. Ravikumar, and D. G. Harini, ‘‘Measurement of cartilage thickness for early detection of knee osteoarthritis,’’ in Proc. Point-of-Care Healthcare Technol. (PHT), pp. 208–211, Jan. 2020.

[6] S. Ranjeeth, T. P. Latchoumi, and P. V. Paul, ‘‘A survey on predictive models of learning analytics,’’ Procedia Comput. Sci., vol. 167, pp. 37–46, Jan. 2020.

[7] A. Tiulpin, S. Klein, S. M. A. Bierma-Zeinstra, J. Thevenot, E. Rahtu, J. V. Meurs, E. H. G. Oei, and S. Saarakkala, ‘‘Multimodal machine learning-based knee osteoarthritis progression prediction from plain radio- graphs and clinical data,’’ Sci. Rep., vol. 9, no. 1, pp. 1–11, Dec. 2019.

[8] B. Norman, V. Pedoia, A. Noworolski, T. M. Link, and S. Majumdar,‘‘Applying densely connected convolutional neural networks for staging osteoarthritis severity from plain radiographs,’’ J. Digit. Imag., vol. 32, no. 3, pp. 471–477, Feb 2019.

[9] H. Lee, S. Yune, M. Mansouri, M. Kim, S. H. Tajmir, C. E. Guerrier, S. A. Ebert, S. R. Pomerantz, J. M. Romero, S. Kamalian, R. G. Gonzalez, M. H. Lev, and S. Do, ‘‘An explainable deep-learning algorithm for the detection of acute intracranial haemorrhage from small datasets,’’ Nature Biomed. Eng., vol. 3, no. 3, p. 173, Jan 2019.

[10] A. Tiulpin, J. Thevenot, E. Rahtu, P. Lehenkari, and S. Saarakkala,‘‘Automatic knee oseoarthritis diagnosis from plain radiographs: A deep learning-based approach,’’ Sci. Rep., vol. 8, no. 1, p. 1727, Dec. 2018.

[11] R. Riad, R. Jennane, A. Brahim, T. Janvier, H. Toumi, and E. Lespessailles, ‘‘Texture analysis using complex wavelet decomposition for knee osteoarthritis detection: Data from the osteoarthritis initiative,’’Comput. Electr. Eng., vol. 68, pp. 181–191, May 2018.

[12] A. Chattopadhay, A. Sarkar, P. Howlader, and V. N. Balasubramanian,‘‘Grad-CAM++: Generalized gradient-based visual explanations for con-volutional networks,’’ in Proc. Appl. Comput. Vis. (WACV), pp. 839–847, Mar. 2018.

[13] N. Hafezi-Nejad, S. Demehri, A. Guermazi, and J. A. Carrino,‘‘Osteoarthritis year in review 2017: Updates on imaging advancements,’’Osteoarthritis Cartilage, vol. 26, no. 3, pp. 341–349, Mar. 2018.

[14] B. Foster, A. A. Joshi, M. Borgese, Y. Abdelhafez, R. D. Boutin, and A. J. Chaudhari, ‘‘WRIST: A WRist image segmentation toolkit for carpal bone delineation from MRI,’’ Computerized Med. Imag. Graph., vol. 63, pp. 31–40, Jan. 2018.

[15] S. S. Gornale, P. U. Patravali, and R. R. Manza, ‘‘Detection of osteoarthritis using knee X-ray image analyses: A machine vision based approach,’’ Int. J. Comput. Appl., vol. 145, no. 1, pp. 20–26, Jan 2018.

[16] A. Khatami, A. Khosravi, T. Nguyen, C. P. Lim, and S. Nahavandi, ‘‘Medical image analysis using wavelet transform and deep belief networks,’’Expert Syst. Appl., vol. 86, pp. 190–198, Nov. 2017.

[17] Y. Du, J. Shan, and M. Zhang, ‘‘Knee osteoarthritis prediction on MR images using cartilage damage index and machine learning methods,’’ in Proc. IEEE Int. Conf. Bioinf. Biomed. (BIBM), pp. 671–677, Nov. 2017.