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A Comprehensive Review of Machine Learning's Role within KOA

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Abstract

INTRODUCTION: Knee Osteoarthritis (KOA) is a degenerative joint disease, that predominantly affects the knee joint and causes significant global disability. The traditional methods prevailing in this field for proper diagnosis are very subjective and time-consuming, which hinders early detection. This study explored the integration of artificial intelligence (AI) in orthopedics, specifically the field of machine learning (ML) applications in KOA.
OBJECTIVES: The objective is to assess the effectiveness of Machine learning in KOA, besides focusing on disease progression, joint detection, segmentation, and its classification. ML algorithms are also applied to analyze the MRI and X-ray images for their proper classification and forecasting. The survey spanning from 2018 to 2022 investigated the treatment-seeking behavior of individuals with OA symptoms.
METHODS: Utilizing deep learning (CNN, RNN) and various ML algorithms (SVM, GBM), this study examined KOA. Machine learning was used as a subset of AI, and it played a pivotal role in healthcare, particularly in the field of medical imaging. The analysis involved reviewing the studies from credible sources like Elsevier and Web of Science.
RESULTS: Current research in the field of medical imaging CAD revealed promising outcomes. Studies that utilized CNN demonstrated 80-90% accuracy on datasets like OAI and MOST, emphasizing its varied significance in vast clinical and imaging data archives.
CONCLUSION: This comprehensive analysis highlighted the evolving landscape of research in KOA. The role of machine learning in classification, segmentation, and diagnosis of severity is very much evident. The study also anticipates a future framework optimizing KOA detection and overall classification performance, with a strong emphasis on the potential for enhancement of knee osteoarthritis diagnostics.

Keywords: Artificial Intelligence, Knee osteoarthritis, Machine learning, Deep Learning, TKR, classification, segmentation, and object detection

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1. Introduction

KOA is a muscle condition where tissues deteriorate as a result of trauma, accidents, etc. It affects persons in their 40s to 70s[1]. Hips and elbows are two examples of the various types of joints. Knee and finger but in this study only talking about knee joints. The issue with joints is KOA [2]. Obesity is the primary cause of this illness [2]. The only effective treatment for the discomfort caused by this disease, a serious joint ailment, is total knee replacement surgery[3]. Knee osteoarthritis, which affects 3.8 million people worldwide[4], is a significant global contributor to disability. The majority of people on earth are afflicted by this illness[5]. According to a poll, it is a sickness that is primarily found in women and is widely distributed. Life gets uneasy as a result of KOA [5]. There is wear and tear, stiffness, and knee pain. Despite the illness's widespread frequency, there aren't many viable cures available right now[4]. The synovial fluid and all tissue types are affected by osteoarthritis (OA), which frequently starts in the articular cartilage that covers the surfaces of the bones in the knee joint [6]. Joints such as the knee, hip, spine, and feet are commonly affected. The main contributing factor to knee osteoarthritis is age[6]. Primary OA, which affects older adults for hereditary or ageing-related reasons, is one of two types of OA [7]. Either damaged articular cartilage, as in rheumatoid arthritis (RA), or an imbalanced distribution of force across the joint, as in post-traumatic osteoarthritis, can lead to secondary osteoarthritis. In addition to X-rays, other imaging modalities, such as magnetic resonance imaging, can be used to identify the onset of knee OA by looking for several soft tissue biomarkers associated with the condition, such as degeneration of the meniscus and cartilage, as well as deformation of the subchondral and trabecular bone [8]. A significant percentage of the population is impacted by the common and significant condition known as KOA. Its importance stems from the financial and medical costs it exacts on people as well as society, which is why medical research and healthcare interventions are heavily focused on it. In this thorough investigation, ML approaches were applied to a variety of disciplines, including robotics [9], medicine, biochemistry, bioinformatics, meteorology, agriculture, and economic sciences. It has been demonstrated by Kluzek, Mattei, and Jamshidi et al. that employing ML techniques to enhance KOA in 2019 is important [10]. Fig. [1] depicts a comparison of a knee with healthy and infected osteoarthritis. It is seen also in Fig [1. a] of the difference between a normal knee and a knee with KOA under this magnified image.

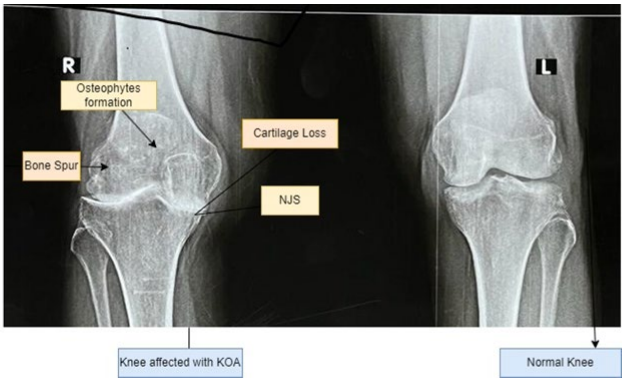

Fig 1: Normal Knee and OA Knee

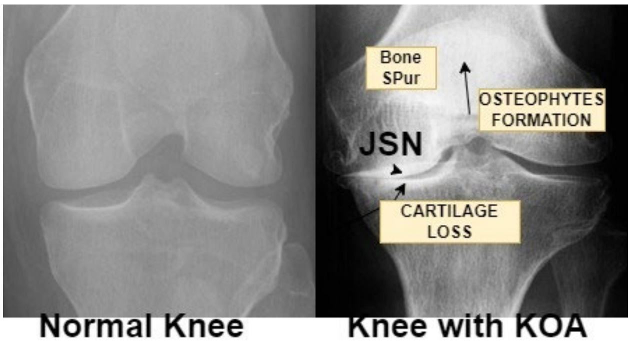

Fig 1. a: Normal Knee and OA Knee (Magnified image)

Joint pain and stiffness, reduced function and participation limitations, and stiffness in the morning or after rest are the main indications and symptoms of osteoarthritis (OA) [11]. We go over the various AI strategies employed in this systematic review below in Fig. [2].

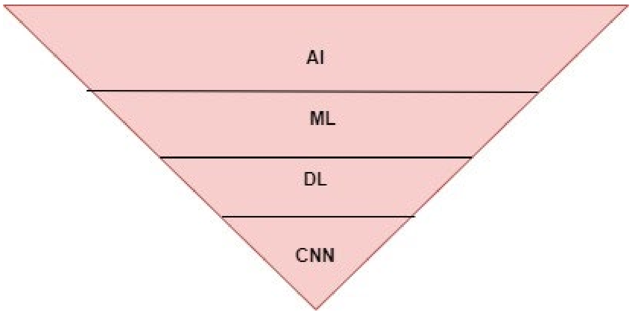

Fig 2: Umbrella Activities of AI

This Fig. [2] demonstrates how important a role artificial intelligence plays in medical imaging and healthcare. It is used to determine whether a person has KOA in the case of knee osteoarthritis. Further testing will be done to determine whether the person has osteoarthritis in their knees. In that situation, osteophytes develop and joints are found. Numerous research, including YOLO, SSD, and numerous other techniques [12], are employed for joint detection. Determine the person's class of lying based on KL grade after the joint detection [13]. A clinical examination, OA symptoms, and common radiographic diagnostic methods (X-ray, MRI, CT, etc.) are currently used to diagnose OA. The Kellgren-Lawrence (KL) system is a trustworthy means to categorize individual joints into five classes, even though other alternative methods have been put forth [14]. The Fig [3] below shows the various stages of OA disease.

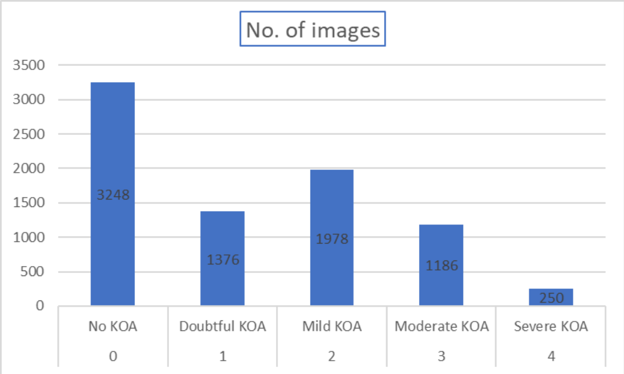

Fig 3: OAI Dataset

In this poll, we examine the value of AI for KOA. In general, AI aids in the early diagnosis of knee osteoarthritis. Early detection has several advantages, including the potential to save lives and money. The only remaining option is TKR (total knee replacement), also known as arthroplasty, however, it is too expensive for everyone to afford [15]. As a result, AI is crucial to KOA. The sections of the paper are as follows: The literature is reviewed in the second section; the third section shows the technology used in KOA and methodology; sections four and five discuss the discussion and conclusion; and section four shows the next course of action Describe the function that machine learning plays in KOA using the diagram that is provided below [16]. Here Fig. [4] shows various applications of machine learning used in knee Osteoarthritis.

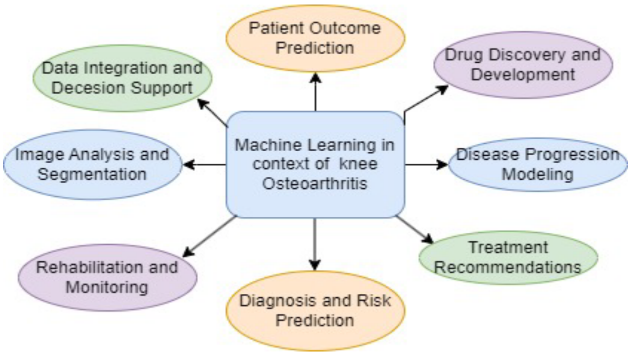

Fig 4: Ways of Machine Learning in the context of KOA

Healthcare practitioners should carefully assess and integrate machine learning utilized in clinical practice, as depicted in the diagram, to ensure accurate and secure results [17]. Our knowledge of knee osteoarthritis will be improved, and patient care will be improved thanks to machine learning.

2. Literature Review

To achieve this, go over several research and review publications. In that work, we looked into how AI can treat osteoarthritis of the knee. This study uncovered the application of image processing and how CNN is utilized for classification and how object detection is applied, how segments are created. These studies found that early identification of OA can be predicted. Image analysis, diagnosis, treatment optimization, and patient monitoring are just a few of the subjects that have received the most attention in earlier studies on using AI to treat KOA. However, there are substantial research holes that still need to be closed. Schiratti et al. [10] predicted additional cartilage degradation as measured by joint space narrowing at 12 months based on MR images and clinical variables including body mass index (BMI) using a DL technique with 9280 knee MR images from 3268 individuals in the osteoarthritis initiative (OAI) database. The classification model's area under the curve (AUC) was 65%, but trained radiologists performing a comparable job received an AUC score of 58.7%, indicating that the classification problem was challenging as mentioned by C.Kokkotis et.al. in [18]. Wang et al. [16] presented a convolutional neural network (CNN)-based automatic technique for OA diagnosis using the OAI database. The proposed model's accuracy was 69.18%. Kondal et al. [17] presented a system for rating knee radiographs using CNN and the KL scale. Here is a list of some of the research gaps [6]: Even though AI systems require a large amount of high-quality data for training and validation, there may not be enough well-annotated datasets specifically for knee OA. Data synthesis from many modes: Patient-reported outcomes, imaging data (X-ray, MRI, etc.), biomarkers, and clinical records are some of the data modalities relevant to knee OA as by D.Dur. et. al. in [19]. Understanding and interpreting AI models: Deep learning models, in particular, are frequently referred to be "black boxes" due to their complex structures and sophisticated decision-making processes. Since knee OA is a progressive disorder, disease progression, and longitudinal study are crucial for prognosis and therapeutic planning. Prior research has been predominately cross-sectional. Acceptance and translation in medicine: Though exciting developments in AI for knee OA have been made, the clinical use of these models is still in its early stages. The practical utility, scalability, and therapeutic applicability of AI models in knee OA are not fully understood by S. A. El-Ghany. Et. al. in [20]. Using Table [1] below, analyze these diverse studies depending on the segmentation of knee OA:

Table 1: KOA Studies Based on ML Algorithms

Sl. No.	Paper Reference	Dataset & Year	Algorithm	Remarks
1	[7] S.Majmudar ,P.Cao	OAI dataset and 2019	CNN, 3D double-echo steady-state	81.03 % accuracy We can improve the accuracy. We can use the augmentation technique for binary classification.
2	[8] Ajay K Pandeyb , Mohana sankar Sivaprakasam	COCO and 2019	Mask RCNN, ResNet-50	87% Accuracy This technique is quick and can segment the femoral cartilage at different knee flexion angles (0 and 30 degrees)
3	[1] Nasser Y, * at all	OAI dataset and 2020	Discriminative Regularized Auto-Encoder (DRAE)	Exactness 85.53%This study demonstrates that classical auto-encoders can still be enhanced to better extract discriminative patterns associated with OA.
4	[10] Adam Noworolski, * at all	OAI and 2018	Dense net architecture U-net model	This ensemble of DenseNets yielded testing sensitivity rates of 83.7, 70.2, 68.9, and 86.0% for no OA, mild, moderate, and severe OA, respectively. Those specificity rates were 86.1, 83.8, 97.1, and 99.1%, respectively.
5	[9] S. Majumdar V. Pedoia	OAI and 2019	3D-CNN, Deep Learning	It improved performance, increasing overall accuracy to 86.7%. (i) develop models to recognize cartilage lesions (CLs) and gauge their severity; (ii) recognize the existence of bone marrow edema lesions (BMELs)

In the below Table [2], the literature review of the classification is shown.

Table 2: Classification of literature review of KOA

Sl.no.	Paper Reference	Dataset & Year	Algorithm	Conclusion
1	[10] Ming Zhang 2,3, * and Juan Shan	OAI and 2021	3D –CNN	83% Accuracy In this study achieve better performance by using 3D –CNN in comparison of 2D-CNN.
2.	[11] Ramadhan J. Mstafa	OAI & 2022	CNN, SVM,Transfer learning PCA	90.8% Precision in both binary and multiclass categorization. This study aims to reduce the progression of the disease and improve quality of life by classifying it at an earlier stage.
3	[12] V. Lakshminarayanan*	OAI & MOST dataset and 2022	CNN, ANN, RBF,MLP	61.7 Average multiclass accuracy. Data processing using optimized

				times.
4	[13] Agam Das Goswami, *	OAI and 20	DCNN, ResNet v2, Inception	91.03% Accuracy In this study image sharpening method used to optimize the performance.
5	[2] Xiaoshuang Shia, Kyle Allena, Lin Yang	OAI and 2019	CNN, VGG-19, DenseNet	69.7 Classification accuracy Firstly, detect the joint ten and identify the class of KOA.

Numerous articles with numerous shortcomings, such as a laborious and time-consuming manual method and subpar performance, were examined for this systematic review. Thus, this work employed machine learning to detect knee osteoarthritis; additional research on this topic is covered in the methodological section that follows.
Now, based on this extensive literature review done on the use of AI for the treatment of knee osteoarthritis (KOA), it is evident that much important progress had been made in the leveraging of image processing. Previous studies have focussed mainly on the early detection of KOA, image analysis, diagnosis, treatment optimization, and patient monitoring. However, despite having notable research gaps such as the need for data synthesis from various modalities, complex challenges in the interpretation of AI models, and the nascent stage of clinical and practical acceptance of AI models in Knee Osteoarthritis (KOA) treatment, this study proposed a comprehensive methodology that combined advanced data synthesis with interpretable AI models besides having a longitudinal approach. The methodology also aimed at the access of practical utility, scalability, and therapeutical applicability of AI models in KOA.

3. Material and Methodology

Artificial intelligence has played a major impact in KOA. In this investigation, we scrutinized a total of 40 papers, encompassing a diverse range of studies. Some of these papers focused on clinical research, while others delved into object detection, classification, and segmentation. Subsequently, we conducted an extensive review of literature from various reputable sources, including Web of Science, Scopus journals, conference proceedings, and academic publications[14]. Our search primarily revolved around the keyword "Knee Osteoarthritis" in the context of object detection using artificial intelligence, as well as the classification, detection of severity, and segmentation of this condition. Detailed information about these papers is provided in the literature section. Different techniques are used to categorize and find the KOA. There are four classes of KOA depending on the KL grade, as we have already discussed. We used a flow diagram as part of our technique [15]. Phases of training and testing were assigned to data collection, preprocessing, and evaluation (70:20:10). Thirty percent of the remaining amount is used for teaching, ten percent for validation, and tests. Provide an image, develop a methodology, test the model, and it will then forecast osteoarthritis [16]. The general process for categorizing the KOA kind of imaging is displayed in Fig. 2. In this methodology, the first stage is data collection, followed by preprocessing, or removing useless photos. Obtain details on any imaging tests performed on the knee joint, such as X-rays, MRIs, or CT scans. After that, do feature engineering and feature selection, which involve performing dimensionality reductions to optimize and improve efficiency. Additional data splitting (80:20) is then performed for training and testing reasons. Then employ machine learning models like SVM, RF, DT, regression, and many others on customer needs[17]. A model's performance, hypertuning, etc., are then accessed, and overfitting is avoided, by model training and validation. Following these actions, we carry out model evaluation. During this phase, we compute the performance matrix and generate the AUC, ROC, and f1 scores. Finally, to improve accuracy, perform system interpretation, visualization, and continuous monitoring[18]. A detailed methodology is shown in Fig. [5]

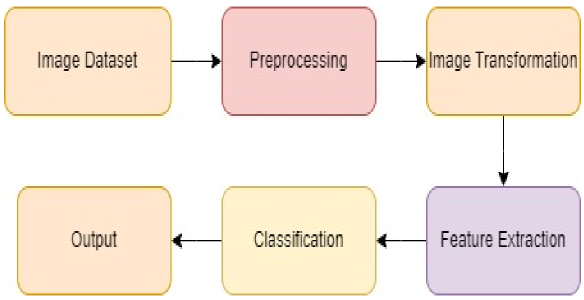

Fig 5: General Data Flow Techniques for KOA Detection

The previous study saw various algorithms like CNN, RNN RCNN, and SVM, and many more algorithms. Here we used how AI is used in KOA as we know that machine learning is the subpart of AI[19].

3.1 Convolutional Neural Networks (CNNs)

CNNs have proven themselves to be indispensable in the field of medical image analysis tasks, particularly in the efficient interpretation of radiographic and MRI images crucial for diagnosing KOA[13]. The architecture of CNN is highly adept at capturing the hierarchical features in images, enabling them to automatically learn and discern intricate patterns that are indicative of knee joint conditions[15]. This article explored the use of CNNs for feature extraction and classification in KOA-related medical imaging datasets[8]. As part of the convolution operation, which is a pivotal part of the algorithm, can be expressed as in Eq. [1] below:

$$(I * K)(i,j) = \sum_{m} I(m,n).K(i-m, j-n)$$

Equation 1: Equation of the convolution layer in CNN

Where S(i,j) denotes the value at position (i,j) in the output feature map, I represents the input image and K is the convolution kernel.

3.2 Recurrent Neural Networks (RNNs)

Here, Recurrent neural networks (RNNs) emerge as a pivotal tool for the capture of various temporal dependencies and other sequential patterns inherent in KOA data. RNNs are very particularly adept at modeling the dynamic nature of physiological and biomechanical variables associated with knee health over time[20]. The utilization of RNNs allows for the integration of time-series information, such as patient-record outcomes and continuous monitoring of different biomechanical parameters related to patients, into the predictive models as input for early detection, prognosis, and personalized treatment. The Long Short-Term Memory (LSTM) and Gated Recurrent Unit (GRU) architectures, two prominent variants of RNNs, are specifically highlighted for this work for their ability to mitigate the vanishing gradient problem and preserve the various long-range dependencies[21]. The equations governing LSTM and GRU cells are fundamental to their inner calculations, where i_t, f_t, o_t, and c_t, denote the input, forget, output, and cell state vectors respectively from Eq. [2], [3], [4], [5], [6] and [7]:

$$i_t = \sigma(W_{ii}x_t + b_{ii} + W_{hi}h_{t-1} + b_{hi}) \quad [2]$$

$$f_t = \sigma(W_{if}x_t + b_{if} + W_{hf}h_{t-1} + b_{hf}) \quad [3]$$

$$o_t = \sigma(W_{io}x_t + b_{io} + W_{ho}h_{t-1} + b_{ho}) \quad [4]$$

$$g_t = tanh(W_{ig}x_t + b_{ig} + W_{hg}h_{t-1} + b_{hg}) \quad [5]$$

$$c_t = f_t \odot c_{t-1} + i_t \odot g_t \quad [6]$$

$$h_t = o_t \odot tanh(c_t) \quad [7]$$

This underscores how RNNs, through their LSTM and GRU state-of-the-art architectures, played a pivotal role in the uncovering of intricate temporal patterns and aiding predictive modeling in the KOA studies[22].

3.3 Support Vector Machines (SVM)

The Support Vector Machine (SVM) plays a very crucial role in the realm of Knee Osteoarthritis (KOA) within the broader context of machine learning applications[23]. SVM, as it is known, is a very powerful supervised learning algorithm, and is adept at classification and regression problems, making it particularly relevant for the prediction and diagnosis of KOA based on various clinical and imaging data. Now, here in this context, SVM's utility can be well exemplified through its ability the discern patterns and relationships within complex datasets, and enable the accurate classification of KOA severity levels or predicting disease progression. The SVM formulation involves identification and finding a hyperplane that can maximally separate the different classes in the feature space[17]. The decision function for classification is defined in the Eq. [8] below:

$$f(x) = sign(wx + b)$$

Equation 8: Decision function for classification

Where w represents the weight vector, x denotes the input features, and b is the bias term. This optimization objective includes the minimization of $||w||$ to maximize the margin between different classes, thereby enhancing the generalization performance of the model[24].

3.4 Gradient Boosting Machines

In this field of Knee Osteoarthritis (KOA), Gradient Boosting Machines (GBMs) play a very important pivotal role in leveraging the true potential of machine learning for predictive modeling and feature importance analysis. GBMs, as it is known as a very powerful ensemble learning technique, have demonstrated remarkable performance in the handling of complex and non-linear relationships within the KOA datasets. This algorithm iteratively built a long series of weak learners, which is typically known as decision trees, and combined its predictions to create a highly robust accurate, and efficient model. Mathematically, the final prediction of the GBM can be expressed mathematically as in Eq. [9].

$$F(x) = \sum_{i=1}^{N} \beta_i h_i(x)$$

Equation 9: Final Prediction Function for Gradient Boosting Machines

Here in Eq. [9], F(x) is the overall prediction, β_i are the weights assigned to each weak learner h_i (x). This boosting process mainly focused on the minimization of residual errors from the preceding models, which effectively refined the model's predictive capabilities. This iterative nature of Gradient Boosting Machines allowed the algorithm to capture very intricate patterns in KOA data, which finally aided in early diagnosis, prognosis, and treatment planning. Moreover, this interpretability of its feature importance scores derived from Gradient Boosting Machines enhanced the understanding of the key factors that contributed to KOA progression, which ultimately facilitated more targeted interventions and personalized healthcare strategies.

3.5 K-Means Clustering

In this full comprehensive review of the role and leveraging the potential of machine learning within Knee Osteoarthritis (KOA), K-Means Clustering played a pivotal role in uncovering varying meaningful patterns and subgroups within the heterogeneous datasets related to KOA. K-Means Clustering is employed as an unsupervised learning technique to partition data into various distinct clusters based on similarities in the feature space, which allows it for the identification of subpopulations of patients with similar types of knee osteoarthritis characteristics. This algorithm minimizes the sum of squared distances within clusters and can be defined mathematically as in Eq. [10].

$$argmin_c \sum_{i=1}^{k} \sum_{j=1}^{n} ||x_j - \mu_i||^2$$

Equation 10: Function of K-Means Clustering minimizing sum of squared

Here, C represents the clusters, k is the number of clusters, n is the number of data points, x_j is a data point, and μ_i is the centroid of cluster i. By the application of this K-Means Clustering to KOA data, this research could gain insights into distinct phenotypes or stages of the disease, and in turn, facilitate personalized treatment strategies and advance the understanding of the heterogeneity within the KOA patient population.

Evaluation Metrics are chosen for the classification, detection of severity, and segmentation of this condition[24]. Detailed information about these papers is provided in the literature section. The classification accuracy calculated is shown below in Eq. [9].

Classification Accuracy=TP+TN / TN+TP+FN+FP (11)

Confusion Matrix: This type of matrix is used to display the results of a classification model[25]; the rows denote the number of examples with a given predicted label and the columns denote the number of occurrences with a given correct label. The precision calculation is shown below in Eq. [10].

Precision = TP/ TP+FP (12)

Recall: It calculates the percentage of predicted positive events that occur by the Eq. [11] below.

Recall = TP/ TP+FN (13)

F1 score: The harmonic mean of recall and precision is shown here in Eq. [12]. A balance supplies precision and recall.

F1 Score=2*Precision*Recall / Precision + Recall (14)

ROC curve: FPR and TPR are plotted along the X and Y axes of the ROC curve, which is a tool for assessing the accuracy of the classification[26].

In adherence to this methodology described above, the exploration of various diverse sources led to the identification of four KOA classes based on the Kellgren-Lawrence (KL) grade[27]. This proposed methodology unfolded through a well-designed systematic process, starting from data collection and preprocessing to weeding out irrelevant images. The results will now delve into the outcomes of the meticulous methodology while shedding light on the efficacy of the developed model, insights gained, and its implications for the field of KOA detection using artificial intelligence and machine learning[28].

4. Analysis and Discussions

Various works in this review study are based on classification, object identification, and segmentation. In this article, we'll talk about how AI is excellent for spotting osteoarthritis early on[29]. AI holds great promise for KAO in the areas of disease development and diagnosis, picture identification and analysis, treatment planning and decision support, patient monitoring and remote therapy, data integration, and knowledge discovery[30]. Even though AI offers potential in the treatment of KOA, its integration into clinical practice should be done cautiously and in collaboration with regulatory bodies, medical experts, and AI experts[31]. Verification, accessibility, and ethical concerns should be carefully taken into account to ensure the safe and effective application of AI in the management of knee osteoarthritis. i) It helps in immediately recognizing knee osteoarthritis symptoms. ii) This technique even tells you how serious your arthritis is. iii) Easy to operate[15]. In this research, we conducted a survey involving approximately 4,500 participants as in Fig. [6]. Out of these, around 3,500 individuals were diagnosed with knee osteoarthritis, while the remaining participants were free from this condition [32].

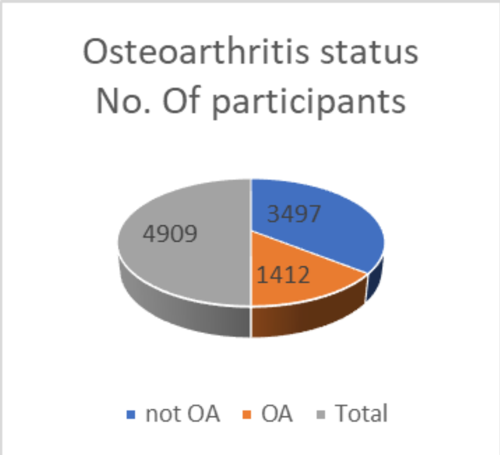

Fig 6: Status of OA Patients

A survey from the years 2018 to 2022 was used in this study. This study has shown that this issue is getting worse every year[33]. According to the graph below in Fig. [7], women are mostly experiencing this problem's growth.

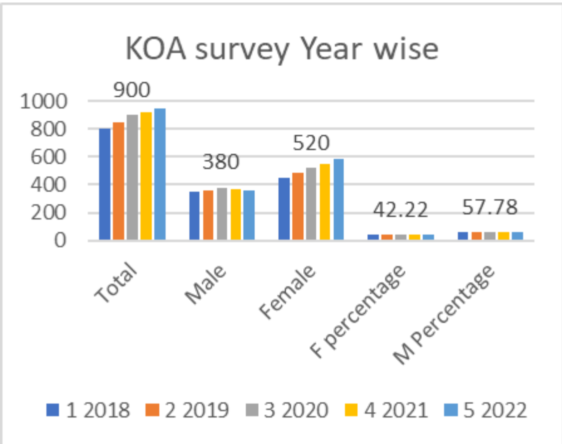

Fig 7: Survey of KOA

The study was conducted at five different locations in India, each of which included a range of urban and rural areas. These areas were categorized into big cities, small cities, towns, and villages to ensure diversity in the study's sample. In total, the research included 5,000 subjects as participants[34] . The research tools utilized in this study included a structured questionnaire for collecting data and plain radiograms (skiagrams) to confirm the presence of osteoarthritis (OA) in the participants[35]. This approach allowed for a comprehensive examination of OA across various settings and demographics within India as shown in Table [3] and with a graphical representation of place-wise distribution[36] in Fig [8].

Table 3: Place-wise distribution of study sample

OA Status	No/Prev alence	Larg e City	Small City	To wn	Village
place 1	Numbers	73	40	57	47
	Prevalen ce (%)	20.4	20.5	23.5	23.2
place 2	Numbers	90	88	60	29
	Prevalen ce (%)	23.1	37.6	30.3	15.8
place 3	Numbers	107	50	54	114
	Prevalen ce (%)	31.8	28.7	37.8	33.6
place 4	Numbers	115	63	69	108
	Prevalen ce (%)	37.8	28.8	48.3	32.3
place 5	Numbers	84	32	18	114
	Prevalen ce (%)	29.3	29.1	17	27.9
Sum	Numbers	464	249	251	436
	Prevalen ce (%)	33.1	17.8	17.9	31.1

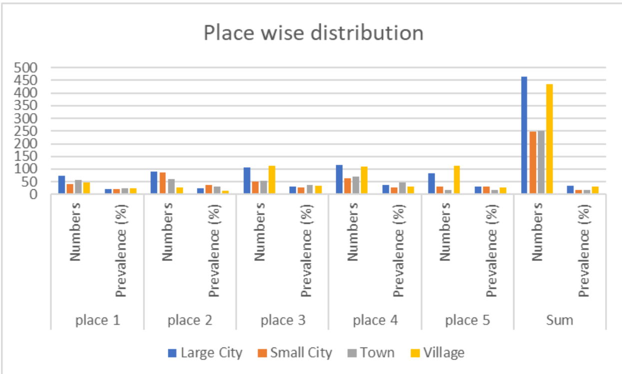

Fig 8: Site-Wise Distribution Graph

The findings and outcomes from this extensive study highlight the pivotal role of AI in the early detection and management of patients differently of Knee Osteoarthritis (KOA). Through the survey which encompassed 4500 participants, this research elucidated the escalating prevalence of KOA, with around 3500 individuals diagnosed. Now, utilizing this data between 2018 and 2022, caused the emergence of a very concerning trend, which indicated the worsening scenario year by year, predominating and affecting women as illustrated in Fig

[7]. The approach of multi-location, which spanned urban and rural areas across India, ensured a very diverse representation of 5000 subjects in this wide comprehensive study. Next, employing the structured questionaries and radiograms, enabled and helped get a nuanced understanding of Osteoarthritis (OA) presence across various complex demographics and settings, as depicted in Table [3] and more clearly spatially represented in Fig. [8]. This underscored the real potential of AI in prompt symptom recognition and severity assessment, offering a widely accessible and user-friendly approach to aid and help in the early identification of KOA. However, while AI presents immense promise in KOA management, its integration and addition into clinical practice necessitates a very cautious and collaborative effort involving the regulatory bodies, with medical experts and AI specialists for the addressing of verification, accessibility, and ethical considerations, while ensuring its safe and effective application.
The compelling findings from this extensive survey have illuminated the very critical role played by artificial intelligence (AI) in its early detection and effective management of Knee Osteoarthritis (KOA). The involvement of 4500 participants in the survey has already drawn attention to the escalating prevalence of KOA, with approximately 3500 individuals diagnosed within the timeframe of 2018 to 2022. This concerning trend of the worsening scenario year by year, which particularly affected women, was vividly illustrated in Fig. [7]. This also emphasized the urgent need for the adoption of various advanced technologies, such as AI, to address the various growing healthcare challenges posed by KOA.
A detailed table with a concise and organized overview of the key aspects of the results is discussed in Table [4].

Table 4: Summary of the analysis and results

Aspect	**Description**
Survey Participants	The study involved a sizable sample of 4500 participants.
Koa Diagnoses	Approximately 3500 individuals within the surveyed population were diagnosed with KOA.
Study Period	The research spanned from 2018 to 2022.
Trend Analysis	This study revealed a concerning trend of the KOA scenario worsening each year, particularly in the case of women. (Fig. [7]).
Geographical Diversity	The research covered five locations in India, including big cities, small cities, towns, and villages, ensuring a representative sample and comprehensive understanding across urban and rural.
Total Subjects	The study encompassed a total of 5000 subjects, ultimately contributing to the robustness of the research.
Research tools	Two key tools were utilized – a structured questionnaire and plain radiograms (skiagrams).
Spatial Distribution	Geographical representation was visually depicted in Fig. [8], offering deep insights into how KOA is well distributed across different regions.
AI Emphasis	This study emphasized the potential of artificial intelligence in the prompt recognition of symptoms and assessing the severity of KOA.
Accessibility	AI-based tools were very important for its accessibility and user-friendly nature.
Collaborative Partnerships	Regular collaboration and connection between regulatory bodies, medical experts, and AI specialists were identified as a major step for successful AI integration into KOA management.

5. Conclusion

The development of artificial intelligence as a potentially practical technique for computer-aided KOA diagnosis is examined in this paper. Osteoarthritis is often diagnosed visually by looking at medical imaging because it might be difficult to see even the tiniest progression of early-onset osteoarthritis during a physical examination. Here is when KOA's use of AI truly shines. In conclusion, the development of therapeutic decision assistance for osteoarthritis offers considerable promise for AI techniques like machine learning and deep learning. 3D automated clinical apps might be employed in clinical practice in the future to take advantage of new opportunities. According to the study, new cases of osteoarthritis have steadily risen in both sexes over the past five years. In the first three years (2018–2020), there was a fairly even distribution of cases between the sexes, with slightly more females than males. These programmers compete effectively with clinical professionals in the early detection of OA and can be utilised to develop biomarkers. Therefore, in order to prevent knee osteoarthritis from progressing to its final stage, we conducted a survey based on multiple machine learning algorithms. Research on the number of people with osteoarthritis (OA) symptoms who actively seek medical assistance is crucial in order to understand the treatment-seeking behaviour and pain tolerance associated with OA. Knowing whether and when individuals with OA symptoms seek medical attention can be highly helpful in enhancing patient education, healthcare delivery, and pain management techniques. In the future, we'll use deep learning to suggest a method based on this research. It is anticipated that machine learning will advance accuracy, early detection, and personalised treatment in the context of knee osteoarthritis in the future. It will also address important issues pertaining to data quality, privacy, and clinical integration.

The integration of artificial intelligence, particularly the field of machine learning and deep learning, in the diagnosis and management of knee osteoarthritis (KOA) represented a very important leap forward in the field of healthcare. The visual diagnosis of KOA, often reliant on the medical imaging due to the subtle progression of its early-stage osteoarthritis, benefitting immensely from the applications based on AI. The study also underscores the real potential of AI in providing computer-aided assistance for KOA diagnosis, which offers immediate recognition of symptoms, assessing the severity of arthritis, and providing an easy-to-operate solution. The use of well-structured questionnaires and radiograms here across the diverse settings in India, which involved 5000 participants, ensured a comprehensive examination of KOA and its prevalence across different demographics. The rising trend in new cases, particularly as for women, as highlighted in the study's findings from 2018 to 2022, underscores the significant need for innovative and well-designed new approaches.

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