IJIRCCE

e-ISSN: 2320-9801 | p-ISSN: 2320-9798

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN COMPUTER & COMMUNICATION ENGINEERING

Volume 12, Issue 5, May 2024

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

Impact Factor: 8.379

International Journal of Innovative Research in Computer and Communication Engineering

| e-ISSN: 2320-9801, p-ISSN: 2320-9798| www.ijircce.com | |Impact Factor: 8.379 | Monthly Peer Reviewed & Referred Journal |

|| Volume 12, Issue 5, May 2024 ||

| DOI: 10.15680/IJIRCCE.2024.1205020 |

Patellofemoral Arthritis Prediction Using Machine Learning

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ABSTRACT: Patellofemoral arthritis is a degenerative joint disorder that affects both the patella (the kneecap) and femur (the thigh bone). There have been hopeful developments in the diagnosis and management of a number of medical conditions, including arthritis. Patellofemoral arthritis is a prevalent disorder that can cause pain and impairment in patients. One of the diagnostic techniques for detecting patellofemoral arthritis is X-ray imaging. Machine learning techniques have shown great promise for analyzing medical images and assisting in the diagnosis and treatment of various ailments. Machine learning algorithms may be trained to analyze X-ray pictures and identify the existence of patellofemoral arthritis based on particular radiological markers. Machine learning has the potential to enhance diagnostic precision, individualized treatment regimens, and ultimately enhance patient outcomes in the processing of X-ray images for patellofemoral arthritis. To properly evaluate the effectiveness and generalization of machine learning algorithms in this situation.

KEYWORDS: Machine Learning, X-ray Images, Arthritis, Healthcare, Image Processing

I. INTRODUCTION

Patellofemoral Arthritis is a highly prevalent condition that will gradually cause disability, which troubled older adults a lot. It is a complicated disease to cure and hard to detect at the beginning of the disease. The prevalence rate of arthritis is very high, which occurs in 10% men and 13% in women aged 60 years or older .Patellofemoral Arthritis is a degenerative disease of the knee joint the most common form of arthritis causing pain, mobility limitation, affecting independence and quality of life in millions of people There is no known cure for arthritis, but there are several medical, biological and environmental risk factors, both modifiable and non-modifiable, that are known to be involved in the development and progression of the disease.

The aforementioned data characterizing arthritis are high-dimensional, heterogeneous and the limited number of simple logistic regression models are not capable of handling large numbers of risk factors and most importantly, any interactions between environmental and other medical and biological factors. Furthermore, they cannot identify the tendency of a healthy subject to show signs of the disease and its progression based on patient outcomes. Despite that, the power and importance of correct study design should not be underestimated. In the well-designed study even "simple" analysis can give trustful results. These significant shortfalls in arthritis risk prediction models require a completely different modelling and computational approach to the problem.

Machine Learning (ML) is the study of how computer algorithms can "learn" complex relationships or patterns from empirical data and hence, produce models linking an even large number of covariates to some target variable of interest. As mentioned before, the ability to analyse complex cases with a huge volume of data and the maximum possible results it renders ML a valuable tool against Patellofemoral arthritis. It is worth noting that ML has been applied in areas such as robotics, medicine, biochemistry, bioinformatics, meteorology, agriculture and the economic science.

A. *Problem Statement:*

The problem statement is to develop a predictive model for Patellofemoral Arthritis based on X- ray images using a Convolutional Neural Network (CNN) algorithm. The model should take X-ray images of the knee joint as input and predict the likelihood of arthritis development. The dataset used for this problem statement includes a large number of X-ray images of the knee joint. The CNN algorithm should be trained on this dataset to identify patterns and features associated with knee OA in the X-ray images.

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B. *Objective:*

- Investigate the state-of-the-art related to prediction of Knee Osteoarthritis based on clinical and imaging data.
- Implement and evaluate machine learning models based on clinical data.
- Implement and evaluate deep learning models based on imaging data.
- Merge the two methods and evaluate the performance.

II. RELATED WORK

[1] Li et al. (2018) developed a machine learning model that combines clinical data, radiographic features, and genetic markers to predict the progression of knee OA. Their model achieved high accuracy in identifying patients at risk of disease progression.

[2] Chaudhari et al. (2020) used machine learning algorithms to analyze gait data and predict knee osteoarthritis. Their study demonstrated the potential of ML techniques in identifying early gait abnormalities associated with the development of OA.

[3] Kalli et al. (2019) employed deep learning algorithms for the segmentation and classification of knee joint structures in MRI images. Their model achieved high accuracy in identifying different anatomical regions and pathological changes associated with knee osteoarthritis.

[4] Zhang et al. (2021) developed a deep learning-based model for the automatic quantification of knee osteoarthritis severity from X-ray images. Their study showed promising results in accurately grading the disease severity, which can aid in clinical decision-making.
[5] Predictive Modeling: a. Tang et al. (2018) used machine learning techniques to predict the progression of knee osteoarthritis using longitudinal clinical data. Their study demonstrated the potential of ML models in estimating disease progression and identifying potential interventions to slow or halt disease development.

[6] Hunter et al. (2020) developed a machine learning model that integrated clinical, genetic, and imaging data to predict knee osteoarthritis outcomes following arthroscopic surgery. Their model showed promising accuracy in predicting patient-reported outcomes and surgical success rates.

[7] Treatment Optimization: a. Lee et al. (2019) utilized reinforcement learning algorithms to optimize treatment decisions for knee osteoarthritis. Their study demonstrated that machine learning approaches can assist in personalized treatment selection, leading to improved patient outcomes.

[8] Zhu et al. (2021) proposed a machine learning-based framework for predicting response to hyaluronic acid injections in knee osteoarthritis patients. Their model successfully identified patients who would benefit the most from the treatment, thereby optimizing therapy selection

[9] Duan, H., Wang, L., Wang, X., & Lu, X. (2019). Machine Learning Methods for Predicting Knee Osteoarthritis Progression: A Survey. Frontiers in Bioengineering and Biotechnology, 7, 247. doi: 10.3389/fbioe.2019.00247

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III. METHODOLOGY

A. *System Architecture:*

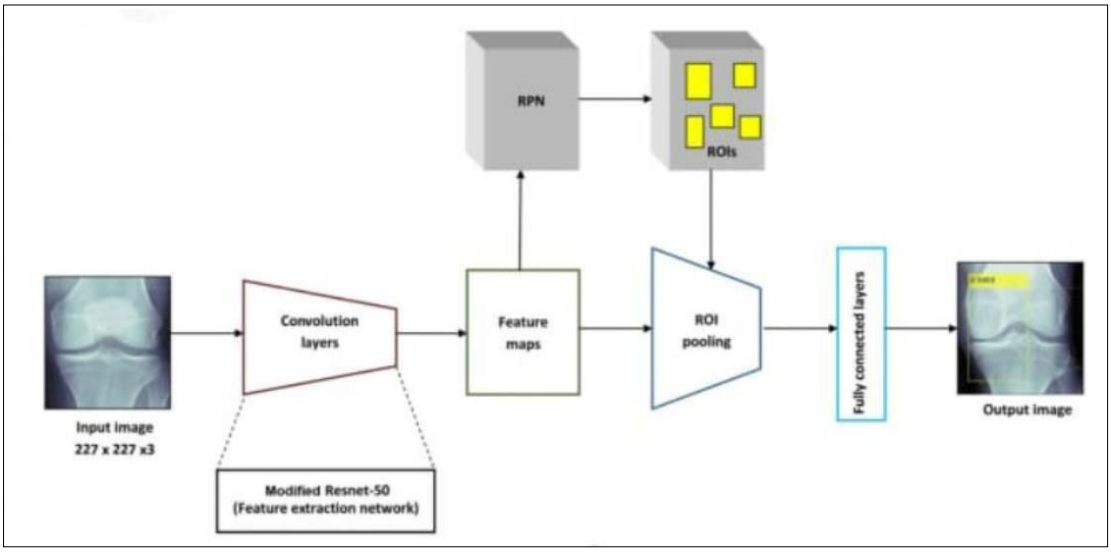

Fig 1: System Architecture

B. *Working:*

The framework of the proposed approach. First, the given dataset was pre-processed and split into training and test sets. Then, unlike other existing research that develops a classification model for a

specific n classes category, we developed a classification model for each n classes category to determine the overall performance of the proposed models; that is, two classes, three classes, four classes, and finally five classes-based models. Primarily, the developed models fall into two frameworks: DHL-I and DHL-II.

The architecture of a large-scale service will have a high level of complexity. It can have several micro services deployed running in conjunction with each other in a distributed environment. The comprehensive architecture of a service that involves several different components is called the system architecture The system architecture design shows us the relationship between the different components being used. They are usually created for gaining a deep understanding of how the different components work with each other to achieve the goals that were set to be achieved by the project.

IV. CONCLUSION AND FUTURE WORK

Analysis of X-ray images is done manually by the physician that is time consuming, subjective & unpredictable. The complexities associated with the X-ray images make it difficult to analyse them in an effective way. A knee X-ray image is very much prone to unwanted distortions that cause problem in analyzing the bone structures. To overcome these problems authors have used semi- automated technique that provides a quick and efficient method to analyse the abnormalities & problems associated with the bone structures. In the work authors have used Active contour algorithm to segment a knee x-ray image that undergoes various feature extraction techniques. The extracted features demonstrated the accuracy rate of 87.92% using Random Forest classifier. In future the technology or process need to be developed that is associated to Osteoarthritis pain and clinical symptoms, such as whether the symptoms are related to joint tissue, neuropathic pain, muscular pain etc. This may help in acquiring good classification rate.

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INTERNATIONAL STANDARD SERIAL NUMBER INDIA

INNO SPACE SJIF Scientific Journal Impact Factor

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