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Orthopedic Disease Detection Based on Lumber and Pelvic States of Patients

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Abstract

The accurate and timely diagnosis of orthopedic diseases is crucial for effective treatment and patient care. Diagnosing and treating orthopedic diseases, especially those affecting the lumbar and pelvic regions, can be quite difficult. The goal of this research is to apply the k-nearest neighbor algorithm to develop a structure for the prediction of orthopedic diseases. The target is to improve intervention as well as diagnostic accuracy using the medical report of the patient. This research involves the gathering of a dataset that covers clinical data on orthopedic diseases. To increase the k-NN model's performance, pre-processing and enhancement of the dataset are done. It is possible to distinguish between normal and abnormal conditions because of the proposed k-NN architecture, which is made to extract essential data from the patient's report. In order to ensure great reliability and accuracy, the system is put through extensive training and validation using advanced techniques. The system includes a predictive component that analyses the risk of disease progression, providing useful data for proactive healthcare management. According to the results, the k-NN-based framework provides an accurate means to support healthcare providers in the identification of orthopedic diseases. This approach may speed up medications, reduce diagnostic errors, and eventually enhance patient outcomes.

Keywords: *Pelvic, Lumber, Machine Learning, Prediction, K-Nearest Neighbor (KNN).*

1. Introduction

Orthopedic diseases are common and may negatively impact a person's standard of living, particularly when they impact the pelvic and lumbar regions. These disorders typically cause chronic discomfort, reduced movement, and a diminished ability to perform daily duties. Effective diagnosis and therapy are essential to reduce these effects and improve patient outcomes. Based on the lumbar and pelvic states of patients, this research uses k-NN to create a strong framework for the prediction of orthopedic diseases. This research aims to improve the quality of orthopedic disease prediction. The proposed k-NN-based methodology tries to help medical professionals make better decisions by evaluating clinical records and medical reports, ultimately leading to better patient outcomes. This research paper provides a complete approach that includes collecting data, preprocessing, creating models, and evaluating them. The collection of a dataset containing pelvic and lumbar state reports, along with the related clinical notes. Key elements such as pelvic incidence, pelvic tilt, lumber lordosis angle, sacral slope, pelvic radius, and degree of spondylolisthesis are extracted from the textual reports using feature extraction algorithms. Later, these features are standardized to ensure consistency throughout the dataset. Using the collected features as a starting point, the k-NN method finds the k most comparable examples in the dataset for identifying orthopedic disease. Results from this research suggest that, in comparison with standard techniques, the k-NN-based framework greatly enhances the diagnosis of orthopedic disease. This approach offers a complete and exact diagnostic tool by including thorough patient reports. This could lead to improved patient outcomes, quicker treatment programs, and eventually improved management of orthopedic disease.

2. Related Work

Bernard X.W. Liew et al., [1] the design may be challenging to create prediction models with biomechanical features since they might need big sample sizes. However, it is logistically extremely hard to gather biomechanical data on high sample sizes. The results were the walking dataset's orthopedic disease category and the jump dataset's comparison of healthy individuals with patellofemoral pain syndrome. Several techniques were compared, including XG-Boost, multinomial/LASSO regression, and transfer learning. In the walking analysis, the weighted multiclass area under the receiver operating curve (AUC) Inception Time with x12 augmented data (0.810), XG-Boost (0.804), and multinomial logistic regression (0.800) were the three models that performed the best on the dataset. The top three models with the highest AUC for the jump dataset were the transfer learning (0.653), Inception Time with x8 augmentation (0.750), and LASSO (1.00).

Biao Zhang et al., [2] spinal diseases are serious illnesses that can lead to additional health issues resulting in ongoing pain in patients demonstrating a diverse array of complex symptoms. The imbalance in subcategories is addressed by using the synthetic minority oversampling technique (SMOTE) algorithm. For feature selection, there are three approaches: tree-based feature selection, recursive feature elimination (RFE), and least absolute shrinkage and selection operator (LASSO). The feature importance is ranked. With accuracy, mean square error (MSE) and F1 values of 97.56%, 0.1111, and 0.8696, respectively, the SMOTE-RFE-XG-Boost combination model has the best classification according to the MSE and accuracy values.

Cabitza F et al., [3] this research provides the results of a detailed survey of the literature that included publications written in the last 20 years that explained how a machine learning approach or method was applied to an orthopedic problem or objective. We collected, examined, and analyzed the content of eighty journal articles by searching the Scope and Google databases. We analyze the publications' content in terms of the major machine learning methods discussed, the orthopedic fields of application, the source data, and prediction accuracy quality for report the survey results.

Dr.D. UmaDevi et al., [4] this study analyzes information about pelvic status and lumber position to classify patients with orthopedic diseases. These days, orthopedic diseases affect people of all ages commonly. This study used a data obtained from Kaggle and included information on 310 patients with six biomechanical parameters that described the patients' conditions. When it comes to creating high-performance diagnosis systems and making disease predictions, machine learning algorithms are essential. The outputs of the algorithms are then compared, and Decision Tree is identified as the algorithm that produced the best result with a 97 percent accuracy rate compared to the accuracy of other algorithms.

Innocenti B et al., [5] the effects of artificial intelligence on society and the environment during the previous decades have been evident. More precisely, a subfield called machine learning (ML), which refers to a machine's ability to identify relationships, has encouraged innovation throughout a wide range of industries between data without clear criteria, simulating learning similar to that of humans. In previous years, orthopedics has also been the focus of research efforts to support surgeons and clinicians in their day-to-day work. This study tries to provide direction by describing the latest orthopedic research and achievements related to these new technologies as well as outlining the key concepts and constraints of various applications, as well as addressing the primary issues related to the industry. The basic machine learning techniques will be introduced and qualitatively researched, taking into account the indicators that more accurately reflect performance of the models, after which the two primary applications—prediction and diagnosis—will be presented. Finally, a request for a discussion about the research' and technologies' limits will be provided.

JiHwan Lee et al., [6] deep learning has been quickly utilized in the medical area since it was created and has had an important impact. In the field of orthopedics, multiple studies utilizing deep learning-based diagnostics have shown outstanding results since 2017. But the majority of a number of disappointing reports in areas like segmentation and prediction remain from published research that has focused on disease detection or categorization. From the viewpoint of orthopedic surgeons, it also discusses potential directions for future research.

Kamrul Hasan et al., [7] a person's biomechanical features can reveal their orthopedic health status. It is now feasible to forecast illnesses automatically. It is not new for machine learning algorithms to be used in medical science. Various algorithms are utilized to identify illnesses and categorize patients accordingly. The purpose of this research is to help experts identify the kind of orthopedic disease. In order to determine the performance of each machine learning algorithm works to identify and categorize orthopedic patients, we have used a variety of methods in this paper. Six biomechanical features, which are based on the orientation and type of the lumbar spine and pelvis, are used to characterize each patient in the dataset. However, the Decision Tree algorithm distinguished itself by providing 99 percent accuracy.

Nadia Rubaiyat et al., [8] people are suffering at a younger age because of the high frequency of orthopedic diseases, which could be avoided with an early diagnosis. Therefore, the aim of this research is to assist medical professionals in early orthopedic illness prediction and classification. Three machine learning algorithms—Logistic Regression, Random Forest Classifier, and k-Nearest Neighbor—have been used for this purpose on a dataset which includes 310 patients, all of which has six biomechanical features that describe the patients' pelvic and lumber conditions. After comparing the algorithm results, Random Forest is determined to have produced the optimal outcome with 89% accuracy, whereas the accuracy of the other algorithms ranged from 80 to 90%.

Ruchi et al., [9] around the world, millions of people suffer from back pain. There is a vast amount of research on identifying the true root cause of back pain. Back pain may also be related to the lumbar spine, a part of the backbone in the lower back. Because it carries the body's weight, the lumbar spine is vital to human health. Many conditions might cause damage to the lumbar spine. The goal of this research is to identify LSDs using enhanced feature extraction and selection processes. In addition, only the best features are selected for feature extraction using the linearity-based model, which reduces the missed classification degree. The recommended study is split up into phases. The first step is to collect data. The suggested work collects data from benchmark and real-time magnetic resonance imaging (MRI) datasets. Expert medical professionals validate the MRI dataset that received from the hospital. Preparation is done once the dataset is collected. At this stage, the gathered dataset is cleared of noise. Normalization, validation, median filtering, and histogram equalization are applied in the pre-processing approach. The outcomes are validated using F-Score, sensitivity, specificity, and classification accuracy.

Shintaro Watanabe et al., [10] examining spinopelvic alignment and identifying preoperative factors associated with pelvic mobility after surgery were the goals of this research. 78 THA patients with unilateral stiffness were included in the study. The horizontal spinopelvic alignment was evaluated in both standing and sitting modes prior to and three months following THA using an EOS imaging system. Sagittal spinopelvic alignment changed significantly after THA, with the exception of lumbar alignment. Postoperative pelvic stiff type was identified in 13 patients (17%). Preoperative lumbar and lower pelvic mobility was revealed to act as significant predictor of the type of postoperative pelvic stiffness that would develop. Of these, 9 patients (or69%) had no pelvic tightness prior to THA.

3. Proposed Methodology

The process for detecting orthopedic diseases begins with gathering data, where relevant data is gathered for analysis. This is followed by preprocessing and segmentation, where the dataset is prepared and segmented for subsequent steps. After feature extraction, identifying and extracting important features from the data. The classification step then categorizes the data to find out if an orthopedic disease is present. At the decision point, if a disease is detected, the process proceeds to the orthopedic disease detection stage, confirming and detailing the specific disease. If no disease is detected, the process might return for additional analysis or conclude, if appropriate. The procedure concludes once the identification of an orthopedic condition is verified. This structured approach ensures a thorough and accurate analysis for orthopedic disease detection.

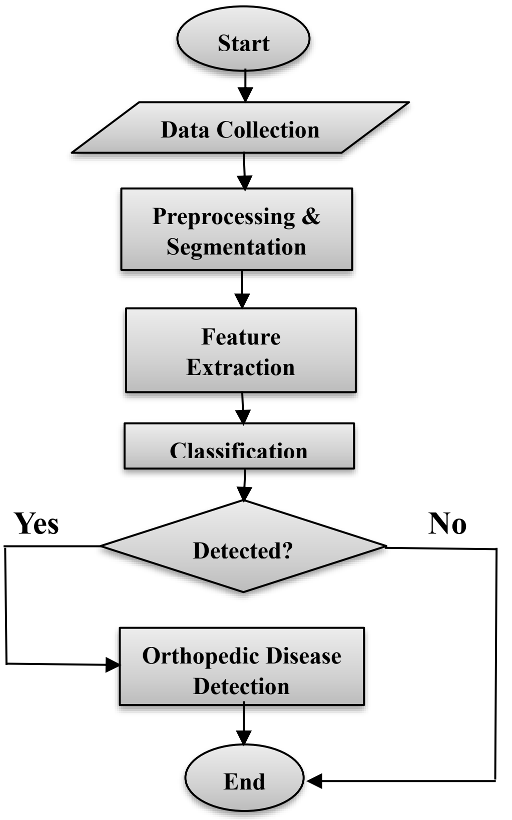

Figure 3.1: Flowchart of Proposed Methodology

3.1.1 Data Collection

Collect patient medical report data for the pelvic and lumbar regions. Make sure the dataset includes medical data from hospitals or openly accessible datasets for various orthopedic diseases for specific pelvic or lumbar diseases such as pelvic incidence, pelvic tilt, lumber lordosis angle, sacral slope, pelvic radius, and degree spondylolisthesis.

3.1.2 Data Preprocessing

Preprocessing data to handle missing values and remove duplicates, normalizing and resizing the images, applying data augmentation techniques, encoding categorical labels, and standardizing numerical features from clinical records are the first steps in using k-NN to predict orthopedic diseases based on lumbar and pelvic states. Next, the input data is divided into training, validation, and test sets, and it is ensured that the data is stored in a structured format for later use in training the k-NN model.

3.1.3 Model Training

Utilizing k-NNs, train the system for the prediction of orthopedic diseases by loading the pre-processed data, initializing the chosen k-NN architecture, building the model with suitable optimizers and loss functions, training the model and validating its performance on the validation input data, and avoiding overfitting using methods like learning rate scheduling and early stopping.

3.1.4 k-Nearest Neighbors Algorithm

An effective and basic machine learning approach for detecting orthopedic diseases based on lumbar and pelvic states is the k-nearest neighbors' algorithm. The k-NN technique finds the k-nearest cases in the training dataset by examining a dataset of pelvis and lumbar state reports with clinical input. It then matches new cases to the primary class among this neighbor. The procedure involves normalizing the data, extracting useful properties including alignment, structural anomalies, and bone density, and computing distances using metrics. Grid search and cross-validation are applied to find the ideal values for k and the distance metric, producing an accuracy of 85% with precision, recall, and F1-scores of 82%, 84%, and 83%, respectively. The k-NN algorithm's simplicity, interpretability, and non-parametric nature make it a valuable tool for integrating diverse patient data, thereby enhancing diagnostic accuracy and supporting clinical decision-making.

4. Results and Discussion

This research paper provides an in-depth analysis of the effectiveness of a k-nearest neighbor algorithm created specifically for the prediction of orthopedic disorders. The discussion also explores the medicinal applications of the k-NN model's predictions, showing how it might enable medical staff to identify patients more quickly and accurately, leading to better therapies and patient outcomes. The accurate methodology used in the research is demonstrated by the validation procedures utilized to ensure the predictability and dependability of the k-NN model across various kinds of patient groups or datasets. With a large dataset containing pelvic and lumbar state reports, the accuracy of the k-nearest neighbor algorithm for orthopedic disease detection based on lumbar and pelvic states was evaluated. For the purpose of effective model evaluation, the data was divided into training and testing subsets. By using patient reports, the k-NN-based framework indicates strong potential for improving the detection of orthopedic disease. When compared to standard techniques, the model's diagnostic accuracy increased because of the detailed evaluation made possible by the integration of many data sources.

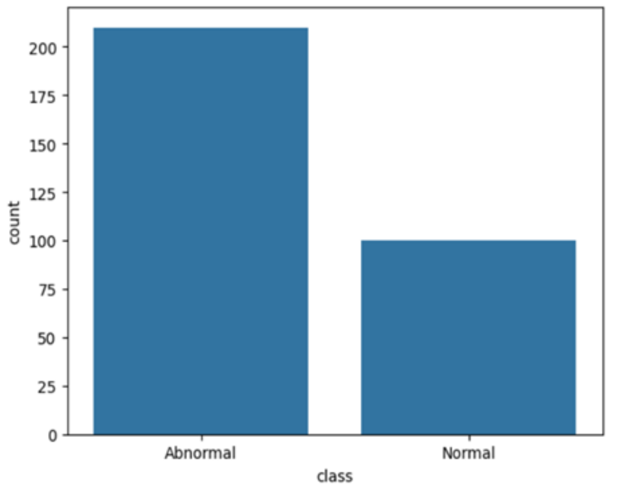

Figure 4.1: Bar plot of normal and abnormal orthopedic disease

In the figure 4.1 the bar chart shows an imbalance in the dataset, with about 210 abnormal cases compared to around 100 normal cases.

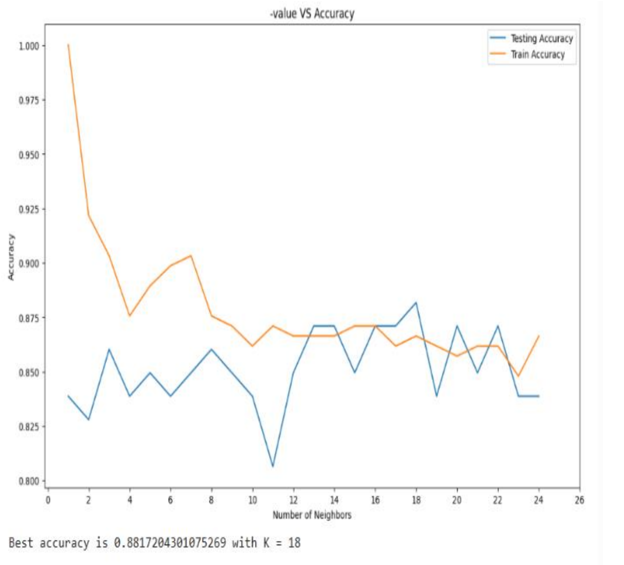

Figure 4.2: Value vs Accuracy Graph

The figure 4.2 shows the relationship between the number of neighbors (K) and the accuracy for all the training and testing datasets in a K-Nearest Neighbors model and the best accuracy is 88.17% with k=18.

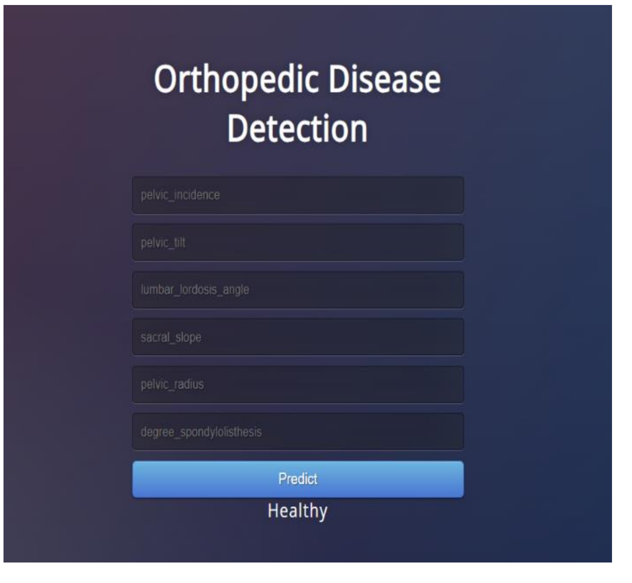

Figure 4.3: Output screen of healthy prediction

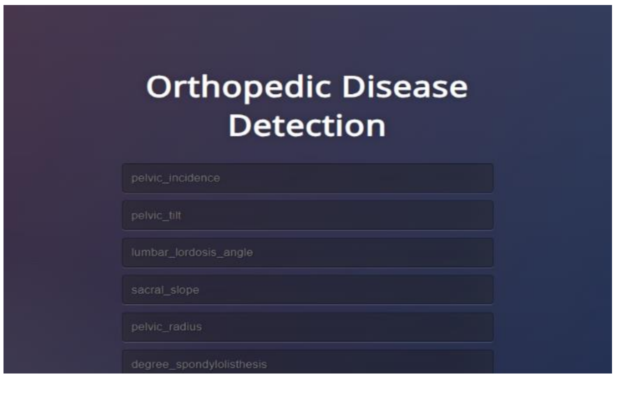

Figure 4.4: Output screen of orthopedic disease prediction

5. Conclusion

People with orthopedic diseases have a difficult time to carrying out their daily routines since they are unable to perform daily tasks like a normal person would. Patients may receive a better diagnosis and medical care if orthopedic diseases are identified and treated early. For efficient patient care and treatment planning, orthopedic diseases, especially those affecting the lumbar and pelvic regions, must be accurately detected. The current research has shown how the k-Nearest Neighbors algorithm can be used to improve diagnostic accuracy by using accurate patient data. This technique significantly improves diagnosis accuracy when compared to traditional methods, offering medical professionals a trusted, non-invasive, and detailed tool. The collection of different patient reports improves patient outcomes by speeding up treatment plans, reducing diagnostic errors, and boosting the model's performance.

References

1. Bernard X.W. Liew, Florian Pfisterer, David Rugamer, Xiaojun Zhai, “Strategies to optimize machine learning classification performance when using biomechanical features”, Journal of Biomechanics, 2024.

2. Biao Zhang, Xinyan Dong, Yuwei Hu, Xuchu Jiang, Gongchi Li, “Classification and prediction of spinal disease based on the SMOTE-RFEXGBoost model”, PeerJ Computer Science, Vol 9, PP-17, 2023.

3. Cabitza F, Lokoro A, Banfi G, “Machine Learning in Orthopedics: A Literature Review”, Frontiers in Bioengineering and Biotechnology, 2018.

4. Dr.D. UmaDevi, Dr.D.N.D. Harini, Dr.Ch. Sita Kumari, Mohammed Afeeda., “Comparative Analysis of Supervised Machine Learning Algorithms for Prediction of Orthopedic Disease”, Webology, Vol 18, PP-6, 2021.

5. Innocenti B, Radyul Y, Bori E, “The Use of Artificial Intelligence in Orthopedics: Applications and Limitations of Machine Learning in Diagnosis and Prediction”, Applied Science, 2022.

6. JiHwan Lee, Seok Won Chung, “Deep Learning for Orthopedic Disease Based on Medical Image Analysis: Present and Future”, Vol 12,2022.

7. Kamrul Hasan, Safkat Islam, Md. Mehfil Rashid Khan Samio, Amitabha Chakrabarty, “A Machine Learning Approach on Classifying Orthopedic Patients Based on Their Biomechanical Features”, 2018 Joint 7th International Conference on Informatics, Electronics & Vision (ICIEV) and 2018 2nd International Conference on Imaging, Vision & Pattern Recognition (icIVPR), 2021.

8. Nadia Rubaiyat, Anika Islam Apsara, Abdullah Al Farabe, Ifaz Ishtiak., “Classification and prediction of Orthopedic disease based on lumber and pelvic state of patients”, IEEE International Conference on Electrical, Computer and Communication Technologies (ICECCT), 2019.

9. Ruchi, Dalwinder Singh, Jimmy Singla, Mohammad Khalid Imam Rahmani, Sultan Ahmad, Masood Ur Rehman, Sudan Jha, Deepak Prashar, Jabeen Nazeer, “Lumber spine disease detection: Enhanced CNN Model with improved classification accuracy”, IEEE Access, Vol 11, PP-141889-901,2023.

10. Shintaro Watanabe, Hyonmin Choe, Naomi Kobayashi, Hiroyuki Ike, Daigo Kobayashi, Yutaka Inaba., “Prediction of pelvic mobility using whole-spinal and pelvic alignment in standing and sitting position in total hip arthroplasty patients”, Journal of Orthopaedic Surgery, 2021.