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AyuAIra: Intelligent Ayurvedic Medicine System for Arthritis

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Abstract **- This research aims to develop an intelligent Ayurvedic medicine system for the early identification and successful treatment of arthritis. The proposed system consists of four major components: X-Ray Image Analysis, Blood Report Monitoring, Ayurvedic Treatment Recommendation, and Continuous Monitoring and Feedback. In the X-Ray Image Analysis component, the K-Nearest Neighbor (KNN) technique is utilized to analyze X-Ray images and classify them as indicative of arthritis and its severity. The Blood Report Monitoring component employs a Long Short-Term Memory (LSTM) algorithm to analyze time-series data from blood test results and predict the progression of arthritis. Based on Ayurvedic medical principles, the Ayurvedic Treatment Recommendation component generates specific treatment suggestions considering the patient's age, gender, symptoms, and overall health, utilizing a decision tree algorithm. For continuous monitoring, the XG Boost algorithm is employed in the Continuous Monitoring and Feedback component, allowing real-time monitoring of the patient's symptoms, treatment progress, and general health. This facilitates timely interventions and modifications by the treating clinician. The proposed system integrates advanced technology with traditional Ayurvedic medicine knowledge, providing a comprehensive solution for the early detection and successful management of arthritis.**

The development of this AyuAIra intelligent Ayurvedic medicine system has the potential to significantly improve arthritis care by providing accurate and personalized assessments, recommendations, and continuous monitoring using machine learning algorithms. Future studies will focus on further algorithm development, effective clinical validation, and integration of the system into healthcare settings to evaluate its real-world efficiency.

Keywords: arthritis, ayurveda, intelligent system, machine learning, personalized treatment.

I. INTRODUCTION

The ancient medicinal system Ayurveda uses herbal plants with medicinal values to cure many, whether it be a small cut or a chronic disease. There are several reasons for many people to opt for Ayurveda medicine over modern medicine. One is that Ayurveda medicine is made up of natural herbs, leaves, flowers, bark, and minerals, thus reducing the use of any harmful man-made chemicals from entering the body, another reason are due to the relatively lower price point of Ayurveda medicine in comparison to modern medicine. This is proved by the fact that 75% of the Sri Lankan population is said to depend on Ayurveda medicine because of its naturalness and the use of valuable plants [1].

Moving on, arthritis is another disease that is affecting the lifestyles and well-being of mainly older citizens [2]. The word ‘Arthritis’ comes from the Greek word referring to a disease in the joints, causing immense pain, inflammation, and damage to the bones in the affected area. Arthritis has a long history dating back to the ancient Egyptians, but it was not until Dr. John K. Spencer identified ‘osteoarthritis’ in 1886, the disease was given a proper identification [2].

In the current world, over 100 different types of arthritis have been identified with osteoarthritis being the most common form. Although arthritis and its type of it depend on several factors such as age, gender, weight, height, type of job, and more, arthritis can also be seen in patients that have other autoimmune diseases [2]. For the analysis of this report, two types of arthritis have been chosen: osteoarthritis, and rheumatoid arthritis. Osteoarthritic is the joint pains mainly experienced by females in their knees, rheumatoid arthritis is ‘an autoimmune systemic inflammatory disorder’ resulting in improper functioning of the immune system due to both genetics and environmental factors and psoriatic arthritis is the severe inflammation of the skin, and synovial tissue [2].

The current diagnosis and treatment process for an arthritis patient starts with the patient having to take an X-ray, several blood works done, and then the final diagnosis from

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the doctor. Who then will recommend a treatment plan which will then have to be followed by the patient. However, there is a gap in this modern medical system.

Several studies have shown that Ayurvedic medication may be beneficial for arthritis. A randomized controlled trial of 123 patients with rheumatoid arthritis, for example, discovered that Ayurvedic treatment resulted in significant improvements in joint tenderness, pain, and swelling when compared to placebo treatment. [3] Another research of 40 patients with osteoarthritis discovered that a combination of Ayurvedic treatments, including massage, yoga, and dietary changes, resulted in considerable pain and stiffness reductions. [4]

Through the model developed in this article, Ayurveda doctors can early detect the type of arthritis through the X-ray of the patient and create a comprehensive solution using both advanced technology and Ayurveda medicine for effective management of arthritis, while also reducing the trouble patients must face when trying to visit the doctor. This proposed system will make the entire process of diagnosing, treatment plans, and monitoring easier for Ayurveda doctors.

II. LITERATURE REVIEW

Ayurveda originated in India several thousand years ago and still to date this ancient medicinal system is used to treat everything from small cuts and wounds to cure chronic illnesses. The use of all parts of Ayurvedic plants; including leaves, flowers, bark, roots, and other minerals, guarantees the naturalness of the medicinal system and ensures a no to low level of side effects [1][5].

Research conducted by the University of Ruhuna to identify the level of Ayurveda knowledge people has concluded that most people are not aware of Ayurveda treatments proved by the fact that only 27.2% of the 235 respondents chose to undergo Ayurveda treatments, while 91.1% of respondents liked to have easy access to Ayurveda treatments [5].

On the other hand, according to a 2009 report from the World Health Organization (WHO), approximately 80% of the world's population depends on Ayurveda, giving the reasons forthe high costs and side effects of modern medicine [1]. The authors, further state that in the past few millennia, 75% of the Sri Lankan population relies on Ayurveda as a result of its natural use of valuable herbal plants and oils.Arthritis, in Greek, is translated as the "disease of the joints". Sometimes confused with 'Arthralgia' which is pain from a localized joint as opposed to Arthritis which is acute or chronic joint inflammation with both pain and damage to bone structure [2].

Several studies have been conducted to develop intelligent Ayurvedic medicine systems for arthritis. Researchers created an intelligent Ayurvedic medicine system employing machine learning algorithms to aid in the diagnosis and treatment of arthritis in a paper published in the Journal of Ayurveda and Integrative Medicine. Based on clinical symptoms and laboratory tests, the approach was proven to be very accurate in diagnosing arthritis. This approach, however, only used modern diagnostic methods and did not take into consideration traditional Ayurvedic diagnostic techniques [6].

In another investigation, researchers created an intelligent Ayurvedic medicine system for the treatment of rheumatoid arthritis using fuzzy logic and decision tree algorithms. The technique was proven to be quite successful in lowering rheumatoid arthritis-related pain, inflammation, and stiffness. The system, however, failed to incorporate Ayurvedic medical principles into consideration and was not created directly for Ayurvedic treatments [7].

For the treatment of osteoarthritis, an intelligent Ayurvedic medicine system was created, according to a study published in the International Journal of Computer Applications in Technology. The effectiveness of traditional Ayurvedic treatments for osteoarthritis was predicted by the system using fuzzy logic and neural network methods. The method was shown to be quite reliable in predicting how well Ayurvedic treatments for osteoarthritis will work. The algorithm, however, only used data from earlier trials and failed to adjust for unique patient characteristics [8].

Through this research, AyuAIra is an intelligent Ayurvedic medical system that monitors the effective results in the diagnosis and treatment of several forms of arthritis. The system recommends personalized medical treatments based on the person's constitution and disease type using machine learning algorithms and Ayurvedic principles. According to studies, AyuAIra is very effective at identifying and treating osteoarthritis, and rheumatoid arthritis. Additional investigation is required to assess AyuAIra's usefulness in treating different kinds of arthritis and to enhance the precision and efficacy of the system.

III. METHODOLOGY

The application is consisting of four major components, as shown in the system diagram in Fig. 1. They are as follows: X-Ray image analysis, which uses image processing to identify patterns in X-Ray images and classify them as indicative of arthritis and their severity; blood test results analysis, which uses deep learning to predict the progression of arthritis; personalized Ayurvedic treatment recommendation generation based on Ayurvedic principles; and continuous monitoring, which provides real-time feedback

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to the doctor. Initially, the application will capture X-Ray images of arthritis as well as the results of the blood report, analyzing the patient's current condition.

Separately implemented algorithms are used to recommend the most appropriate personalized Ayurvedic treatment to the patient based on those inputs. However, based on the X-Ray image pattern and blood report results, this system is allowed to identify the selected types of arthritis-Rheumatoid arthritis and Osteoarthritis. The application's four components are discussed further below.

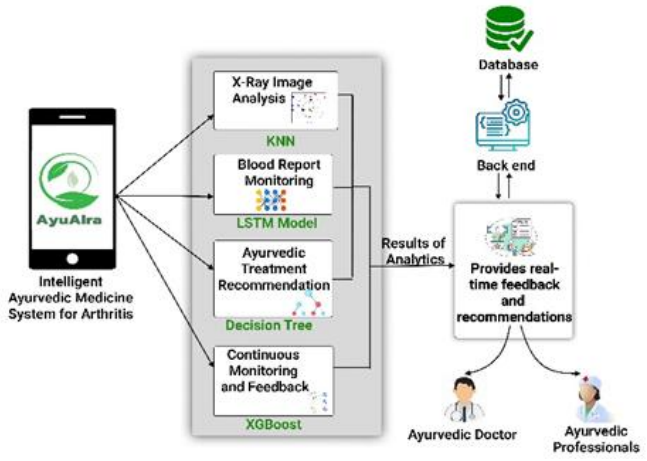

Figure 1: Overall System Diagram

A) X-Ray Image Analysis

X-ray imaging is critical in identifying pain in the joints, especially in cases of arthritis. However, the traditional method of neurological specialists manually examining X-rays and relying on their experience in the Ayurvedic approach is time-consuming and error-prone. To address these constraints, there has been a substantial increase in the pursuit of automated approaches that use technology and machine learning algorithms to detect joint inflammation and quantify its severity using X-ray images.

In this study, we propose developing a K-Nearest Neighbors (KNN) method to recognize patterns in X-ray images and classify them as indicative of arthritis and its severity. We obtained a dataset of X-ray images from the Gampaha Wickramarachchi University of Indigenous Medicine to train and assess the KNN model. This dataset was extensively assigned and contains X-ray images from patients suffering from mild to severe arthritis. To ensure an accurate evaluation, we divided the dataset into training and testing sets in a 70:30 ratio.

We performed preprocessing measures on the images from X-rays before training the KNN model to increase their quality and classification accuracy. In the beginning, each image was downsized to a fixed dimension of 150x150 pixels to ensure consistency across all images. This step was required to reduce image size fluctuations that might affect the model's performance. The images were then normalized, which involved changing the pixel intensities to a consistent scale. This normalization technique attempted to increase the model's stability during training and ensure that the KNN algorithm could learn successfully from the data.

The severity of arthritis is divided into three unique categories in the final result of our methodology: healthy, moderate, and severe. These classifications are linked to the patterns observed in the images from X-rays and serve as markers of the severity of the arthritic condition. We hope to construct a robust system capable of reliably categorizing X-ray images depending on the presence and severity of arthritis by applying the KNN algorithm and training it on our carefully curated dataset.

In conclusion, by implementing X-ray images, our methodology presents a potential strategy for automating the detection and severity assessment of joint inflammation. We want to overcome the constraints of physical inspection by neurologists by using the KNN algorithm and a curated dataset to produce a more efficient and accurate diagnostic tool for arthritis.

B) Blood Report Monitoring

Blood tests are mainly used to monitor the progression of arthritis and evaluate treatment effectiveness. analyzing blood tests for arthritis face complex challenges due to the many factors that can influence the interpretation of values ESR, CRP, anti-CCP antibodies, and RF, including patient-specific and external factors, including age, sex, medication use, laboratory variation, and need to consider multiple values together with clinical history and presentation. Their analysis can be complex and time-consuming. This study aims to investigate the use of deep learning algorithms to analyze time-series data of blood test results and track the progression of arthritis and the effectiveness of ayurvedic treatments.

Research and blood test results from arthritis patients will be tracked over time using a longitudinal strategy. Patients with arthritis who are under therapy will be chosen for the research, which will be carried out at an Ayurvedic medical clinic. Patients with arthritis who are getting treatment will be chosen for the research. Patients will receive consideration if they have had at least two blood tests performed at the medical center, with the first test being performed at the time of diagnosis or before receiving treatment.

Data from outpatient sections and clinic sections testing performed at Gampaha Wickramarachchi University over

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three months in 2022–2023 were used in this investigation according to ethical considerations and the privacy policy of data. Each patient's blood reports were gathered and were extracted ESR, CRP, anti-CCP antibodies, and RF values. The patient's age, sex, blood report findings, and medical history for predictive tests run on the same collection were all included in the data set. Point-of-care test outcomes and testing from none state laboratories were not included; only results from testing completed within the main hospital laboratories were. If a collection lacked at least two predictor tests, it was eliminated. Pre-processing was performed on the data to eliminate any missing values or outliers. The blood test results were converted into a time series format, with each result serving as a data point in the series.

Recurrent neural networks (RNN) and long short-term memory (LSTM) networks were taken into consideration in the ML model development for time-series analysis of blood test results and arthritis progression prediction. The model was developed and trained using deep learning libraries such as Tensor Flow, with the model architecture optimized to achieve the best performance on the validation dataset. Finally, the LSTM model was selected, as it is better suited for analyzing time-series data and making predictions about evaluation treatment effectiveness based on historical data compared to KNN. The developed LSTM model was evaluated on a testing dataset using metrics such as accuracy, precision, recall, and F1-score. The evaluation results were compared with state-of-the-art models to validate the performance of the developed model.

The proposed model for blood report monitoring has demonstrated the ability to predict the progression of arthritis based on input values of ESR, CRP, Anti CCP, and RF from a patient's blood report. The model has shown the capability to provide accurate predictions of the severity of the disease, indicating mild, moderate, or severe progression, or no progression. The model has significant potential to assist healthcare professionals in developing personalized treatment plans for patients with arthritis by providing a reliable and accurate tool for monitoring disease progression. Future research may focus on the clinical application of this model to improve patient outcomes and inform treatment decisions.

C) Ayurvedic Treatment Recommendation

The Ayurvedic Treatment Recommendation System is a research component to provide specific treatment recommendations for arthritis patients based on the principles of Ayurvedic medicine, considering the patient's age, sex, symptoms, and overall health. To identify thebest algorithm for the Ayurvedic treatment recommendation system, several machine-learning models will be evaluated in this research. Several of the algorithms up for evaluation are the decision tree, random forest, logistic regression, support vector machine, and neural network. The performance metrics obtained through experimentation will be used to determine which algorithm is most appropriate for the Ayurvedic treatment recommendation system. Precision, recall, accuracy, and F1 score will all be used to evaluate the algorithms' effectiveness. As a result of the evaluation, the decision tree method was determined to be the best choice for this system.

Decision tree: The decision tree method is a popular machine learning algorithm that can be used in classification and regression tasks. Recursively splitting the data down into smaller and smaller subsets that depend on the most important characteristics is how it works. As a result, a tree-like structure is produced, with each node indicating a feature or characteristic and each branch indicating a decision rule.

The decision tree algorithm can be used to generate specific recommendations for Ayurvedic treatments based on the characteristics of the patient, including age, sex, symptoms, and overall health. Accordingly, the phase of collecting data and preprocessing is crucial for the research approach for the Ayurvedic Treatment Recommendation System. The Ayurvedic General Hospital in Rajagiriya and the Gampaha Wickramarachchi Ayurveda Institute in Sri Lanka provided data on Ayurvedic treatments for arthritis during this phase. Several sources, including medical records, patient histories, and expert advice, will be utilized to collect this data. To identify patterns and relationships between various variables and the recommended treatments for them, the algorithm can be trained on a dataset of previous patient data. Based on a new patient's particular characteristics, the trained decision tree model can then be used to predict the most effective Ayurvedic treatment.

Null values and duplicate values were identified through the data processing process and removed. The data collection was then scaled for best performance using Scikit Learn StandardScaler. After eliminating missing values, encoding categories, and normalizing numerical variables, the dataset still needs to go through pre-processing. The data was then split into two sections for training and testing preparations. The model's performance can be evaluated using the testing data, and several performance metrics are generated to determine the model's accuracy, precision, and recall.

Ayurvedic treatment recommendations using a decision tree algorithm are highly crucial for providing patients with arthritis individualized treatment recommendations. This method can improve the efficacy of treatments while reducing the risk of side effects by making specific recommendations for treatment based on specific patient characteristics and

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requirements. Overall, the Ayurvedic treatment recommendation system is a significant step in providing patients with individualized effective medical treatments.

D) Continuous Monitoring and Feedback

The continuous monitoring and feedback component of the Intelligent Ayurvedic Medicine System for Arthritis aims to develop a predictive model that considers the patient's symptoms, treatment progress, and overall health and provides real-time feedback to the treating doctor. This component is crucial for the proper treatment of arthritis since it allows for the early detection of changes in the patient's health, which may help with the avoidance of disease progression and the improvement of treatment plans. We provide an innovative approach in this methodology that use a combination of deep learning algorithms to integrate data from numerous sources, including physiological signals and self-reported data. Several machine learning models were experimented with to make this monitoring, including Artificial Neural Network (ANN), Decision Tree, Random Forest, XG boost, and Long Short-Term Memory (LSTM). Based on the results of these algorithms, the XG Boost model was chosen as the most appropriate model for further implementations.

Extreme Gradient Boosting or XG Boost is a popular machine learning algorithm that is utilized for both regression and classification tasks. It is a performance- and speed-focused implementation of gradient boosting. The XG boost algorithm may be used to predict the patient's symptoms, treatment progress, and overall health based on numerous inputs such as physiological signals, self-reported data, and treatment information in the case of continuous monitoring and feedback.

Data collection, data pre-processing and splitting, model development and training, model deployment and prediction, and plotting the results were all performed to implement this XG boost algorithm.

To use the XG boost algorithm, we must first train it using a dataset of patient data. Gampaha Wickramarachchi Ayurveda Institute and Rajagiriya Ayurvedic Hospital in Sri Lanka provided data. This dataset should contain data on the patient's symptoms, treatment progress, medications, and overall health over time. The dataset should also include details about the inputs utilized to make these predictions, such as physiological signals and self-reported data.

Null values and duplicate values were detected and eliminated throughout the data preparation process. Next Scikit Learns was used to preprocess the data, select a model, and evaluate it. Then the data was split into two sections for training and testing preparations.

Following the collection and preprocessing of data, the next stage is to create a prediction model using machine learning methods. We will create a prediction model that considers the patient's symptoms, treatment progress, and general health, and will send real-time feedback to the doctor. To create the prediction model, we will use deep learning methods such as CNNs and RNNs.

After the machine learning model has been developed and evaluated, it may be deployed to provide real-time feedback to the treating doctor. The model should be integrated into the intelligent Ayurveda medicine system, allowing the doctor to monitor the patient's symptoms, treatment progress, and overall health. The system can be programmed to warn the doctor when the patient's condition changes, indicating the need for a change in treatment.

The system's real-time feedback may also be utilized to improve the model's performance. As new data is available, the model may be retrained and updated to represent the most recent information. This iterative model improvement and real-time feedback procedure might result in a more accurate and effective continuous monitoring and feedback system.

IV. RESULTS AND DISCUSSION

The AyuAIra system was developed to offer an intelligent Ayurvedic medicine system for the early detection and successful treatment of arthritis. The system is divided into four key components, each of which uses machine learning algorithms to deliver precise and tailored assessments, recommendations, and continuous monitoring. The X-Ray Image Analysis component detects patterns in X-Ray images and classifies them as indicative of arthritis and its severity using the K-Nearest Neighbor approach. The Blood Report Monitoring component uses a Long Short-Term Memory (LSTM) algorithm to analyze time-series data from blood test results and predict the progress of arthritis. The Ayurvedic Treatment Recommendation component generates treatment recommendations based on Ayurvedic medical principles, taking into account the patient's age, gender, symptoms, and overall health. Finally, the Continuous Monitoring and Feedback component applies the XG Boost algorithm to continually monitor the patient's symptoms, treatment progress, and overall health, allowing for immediate actions and improvements.

Discussion: By providing specific assessments, recommendations, and continuous monitoring, the AyuAIra system has the potential to greatly enhance arthritis treatment. To provide a comprehensive solution for the early detection and successful management of arthritis, the system combines advanced technology with ancient Ayurvedic medicine

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knowledge. The X-Ray Image Analysis component is critical in determining the existence and severity of arthritis in patients, allowing doctors to make accurate treatment decisions. The Blood Report Monitoring component enables disease progression prediction and early management, ultimately leading to better patient outcomes. The Ayurvedic Treatment Recommendation component offers customized treatment alternatives, which are a characteristic of the practice of Ayurveda and an important part of successful management. Finally, the Continuous Monitoring and Feedback component is critical in recognizing changes in the patient's condition and modifying treatment plans as needed.

To assess the AyuAIra system's real-world efficiency and efficacy, more development and validation are required. While the system shows significant potential in the early detection and treatment of arthritis, its implementation in healthcare settings requires extensive clinical validation to assure its accuracy in providing correct assessments and recommendations.

Further algorithm optimization is required to increase the system's overall performance and accuracy. Finally, the AyuAIra system's success will be determined by its ability to provide efficient and effective care for arthritis patients, eventually increasing their quality of life.

V. CONCLUSION

In conclusion, the goal of this research study was to create an intelligent Ayurvedic medicine system to address the early identification and effective management of arthritis, a widespread and significant condition that affects millions of people worldwide. The suggested approach can give personalized and specific diagnosis, prediction, and treatment recommendations via using machine learning algorithms and merging traditional Ayurvedic medicine experience with advanced technology. Furthermore, the continuous monitoring and feedback capability of the system guarantees that patients receive real-time support and advice, improving their quality of life and medication adherence.

This study's fundamental impact cannot be emphasized. It has the potential to greatly enhance the lives of patients all around the world by improving the diagnosis and management of arthritis. The AyuAIra application, which is now available in English, can be expanded to include Sinhala, so increasing its accessibility and reach.

Furthermore, while the system was initially created to treat rheumatoid arthritis and osteoarthritis, it can be altered and changed to treat other types of arthritis. In the future, work is going to focus on improving and testing various prediction algorithms to improve accuracy to unlock new possibilities for advancement.

In conclusion, the intelligent Ayurvedic medicine approach demonstrated in this study shows enormous promise for the treatment of arthritis. It provides a way for significant improvements in early detection, personalized treatment, and overall patient well-being through the integration of traditional knowledge with modern technologies.

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