ABSTRACT

Arthritis is a chronic inflammation of a joint with pain. It is one of the widely spreading diseases in worldwide. It affects people in all groups of ages but is comparatively high in females than in males. All the bone joint ends are covered with cartilage tissue in the human body that provides smoothness during the movement. Arthritis affects the cartilage tissue and tears the tissue which causes pain and swelling in the joints. It mainly occurs in the knee joint, finger joint, thumb, neck, etc. Initially, it starts with mild joint pain and becomes severe after a few days. The patient may experience pain and discomfort throughout their life. It also results in permanent damage to joints.

The most well-known type of Arthritis is Rheumatoid Arthritis (RA) and it occurs in the knee joint. Joint pain is the major symptom of Rheumatoid Arthritis later on it affects the whole joint with severe pain. A few existing methods like X-ray, MRI, CT scan, and infrared imaging are used to detect arthritis. Physicians may suggest non-surgical treatment for RA like weight reduction or doing exercises etc. Even though recommended treatments are available, the disease is not permanently curable if it is identified in later stages.

The existing diagnosis method often uses high radiation for arthritis detection at the same time it gives accurate results. The regular walking pattern is changed due to knee pain and it is reflected in the variations in the foot pressure distribution. To detect knee arthritis in its early stages the pressure distribution by the knee need to be monitored. To monitor the foot pressure some wearable sensor-based, floor sensor, and vision-based research

works are carried out. Using the insole with a pressure sensor and floor plantar pressure sensor the diagnosis of arthritis can be done easily. There are a few limitations that the insole or in-shoe system. It can be used by people with particular foot sizes. Also, the foot plantar pressure measurement needs a separate lab setup to experiment. To overcome these limitations it needs to develop a foot pressure pad that is suitable for all kinds of foot sizes. The piezoresistive sensor is suitable for pressure sensing applications. So the pressure pad for foot pressure distribution measurement is developed with the help of piezoresistive sensors.

There are few readily available sensors for pressure measurement but based on the application they cannot be customized. To design a foot pressure pad it is decided to design a sensor using piezoresistive material (velostat) with volume resistivity <50 ohm-cm and surface resistivity <31,000 ohms/sq.cm. Initially, the characterization of the material is done based on the resistance response concerning the applied pressure on it. Once the characterization is done it is arranged in a 16x16 matrix format to measure the pressure applied by a subject. The applied pressure changes the resistance of the piezoresistive material. The change in resistance response is converted as voltage response using a simple voltage divider circuit.

The raw data from each column of the 16x16 sensor matrix is acquired by the controller through the analog-to-digital converter. These acquired data are further converted as pressure map images for easy interpretation purposes. The heat map imaging technique is utilized to generate the pressure map images. The jet color map algorithm is utilized in the heat map imaging for respective foot pressure distribution. It scales the pressure values and assigns color for each set of values to generate it as heat map images. A Machine Learning algorithm is used for the classification of images. Before classification, the image is again subjected to pre-processing for feature

extraction. Here the Gray Level Co-occurrence Matrix (GLCM) method is used for the feature extraction process. After the feature extraction process, the dataset is subjected to classification with tenfold cross-validation using Machine Learning. For this proposed system, six algorithms are selected based on the performance of those algorithms in the field of medical diagnosis. Six algorithms were used for binary classification of pain and no pain data in our investigation; the K-nearest Neighbor algorithm, Logistic Regression, Support Vector Machine, Gaussian Naïve Bayes, Neural Network, and Fine Tree. The performance metrics namely accuracy, specificity, F1-score, Recall, Precision, and ROC curve is calculated from the confusion matrix obtained during the binary classification. Comparing the results of all 6 classificationalgorithms KNN algorithm yields an accuracy of 98.48% and KNN is identified as the optimum algorithm for pain and no pain classification.

Using binary classification, the patients with and without knee arthritis can be easily classified. The developed foot pressure pad classified the data with 98.48% accuracy and it is identified as the most suitable non-invasive method for the early detection of knee rheumatoid arthritis.