CLASSIFICATION OF DEEP LEARNING ALGORITHM FOR RHEUMATOID ARTHRITIS PREDICTOR

Aarthi S S
Department of Electronics and Communication Engineering Bannari Amman Institute of Technology, Sathyamangalam, Erode, TamilNadu, India
aarthi.ec19@bitsathy.ac.in

Divyasreetha M
Department of Electronics and Communication Engineering Bannari Amman Institute of Technology, Sathyamangalam, Erode, TamilNadu, India
divyasreetha.ec19@bitsathy.ac.in

Dharshini K S
Department of Electronics and Communication Engineering Bannari Amman Institute of Technology, Sathyamangalam, Erode, TamilNadu, India
dharshini.ec19@bitsathy.ac.in

Selvakumar M
Assistant Professor
Department of Information Technology
Bannari Amman Institute of Technology
Sathyamangalam, Erode, Tamil Nadu, India
selvakumarm@bitsathy.ac.in

***Abstract*—Rheumatoid Arthritis shortly called as RA is a complex systemic autoimmune disorder that affects the internal body tissues and frequently leads to irrepairable structural damage by causing chronic inflammation, mainly in synovial joints. Early detection of rheumatoid Arthritis is very important so that the problems can be avoided in the future. Outbreaks of rheumatoid Arthritis have increased in white people by 3% - 7% almost every year. Medical assessments, laboratory investigations, and patient self-evaluation are used to determine the disease's activity. Disease progression and responses to treatment also vary substantially, even though there are many alternative treatment options available for different stages of disease. Radiographs of the hands and feet are used to determine the disease's prognosis over the long term which is the input image for our model, also evaluating the X-ray images by trained medical staff requires a lot of time to assist the patient's condition and stages which is a tedious task. In the same way, a timely diagnosis of the illness is crucial for the patient's treatment for a chronic autoimmune illness which is expensive to treat and has a poor survival rate. Machine learning researchers have worked hard to create quick and precise automatic approaches for diagnosing RA. Deep learning (DL) has given rise to a booming body of academic study as well as industrial applications in the field of medicine. If used properly, deep learning might be very relevant to rheumatology. The ability of deep learning to learn the structure of the underlying data is the key to this effectiveness. Radiographs of the hands and feet are physically examined and graded to determine the extent of joint destruction in Rheumatoid Arthritis (RA).In order to identify and detect rheumatoid arthritis by hand, particularly during its early development or pre-diagnostic stages, an efficient system analysis is required. The goal is to create an intelligent system that can recognize rheumatoid arthritis by utilizing convolutional neural networks (CNN) in deep learning. Our dataset contains images of four different classes of rheumatoid Arthritis such as Synovitis, Pannus, Fibrous Ankylosis, Bony Ankylosis. To remove noise from images, we have applied augmentation (adjustment) techniques such as brightness, zoom, rear, flip, etc. Using augmentation techniques, we are making the dataset clearer and generating new dataset from existing dataset. Based on different values of epochs and other**

parameters, we are measuring accuracy and loss values of convolutional neural network models and the performance of the algorithm is evaluated by accuracy score, loss and mean accuracy. During preprocessing, we have passed resizing, rescaling, shuffling, dropout, zoom/brightness adjustment, rotation, background correction, horizontal flipping, etc. parameters so that we can convert our image data into augmented image data which will help our CNN model to learn for low-resolution images. The main aim is to analyze the success rate of the proposed models and compare the outcome with other strategies.

***Keywords*—Rheumatoid Arthritis, Joint destruction, Convolutional Neural Network, Deep learning, Augmentation**

I.INTRODUCTION

The term "arthritis" is used to describe a number of inflammatory conditions that can affect the muscles, bones, joints, and other regions of the body, the disease attacks healthy tissue instead of bacteria and viruses. It comes in a variety of forms, including gouty arthritis, juvenile arthritis, psoriatic arthritis, osteoarthritis, and rheumatoid arthritis, which can cause stiffness, discomfort, redness, and swelling in the joints. If neglected, the condition may continue to affect larger joints and is characterised by damaging joint alterations that begin in the tiny joints of the extremities. It might be difficult to identify rheumatoid arthritis because there are no defined diagnostic standards or gold-standard tests.

To identify RA from other autoimmune illnesses and to stratify patients according to their clinical characteristics, several classification techniques have been proposed. Early diagnosis and treatment of RA can help reduce the severity and progression of the disease. A deep learning technique, more especially a Convolutional Neural Network (CNN) model, can be used to predict the beginning and progression of RA. The analysis of medical pictures, such as X-rays and MRIs, to identify RA is a promising application for CNNs, which are powerful machine learning models that are frequently employed in computer vision and image recognition applications. A deep learning algorithm using a Convolutional Neural Network (CNN) model has been proposed as a tool for predicting RA. The CNN model uses medical imaging and clinical data as input, and trains on a large dataset to recognize patterns and features associated with RA. The model can then make predictions about whether a patient has RA or not. This approach shows promising results in terms of accuracy and can potentially aid healthcare professionals in making more informed and timely diagnoses of RA. However, further research and validation is necessary to establish the reliability and robustness of this approach.

Algorithms for machine learning are capable of automatically picking up useful data representations. They can process a wide range of data inputs, including genetic data, language, such as electronic health records, patient cohorts, and medical photographs. Furthermore, it can provide results by recognising disease patterns and traits, drawing on the knowledge found in clinical data. Additionally, it can aid in the improvement of treatment plans. Therefore, ML has greatly filled the gap left by automated learning based on clinical experience. Additionally, a branch of machine learning called deep learning (DL) makes use of huge data, multi-layered neural networks, and computationally complex algorithms. Both ML and DL have been employed in the field of medicine throughout the previous ten years.

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STAGES OF RA AND ITS SYMPTOMS: Synovitis, pannus, fibrous ankylosis, and bony ankylosis are the four stages of rheumatoid arthritis.

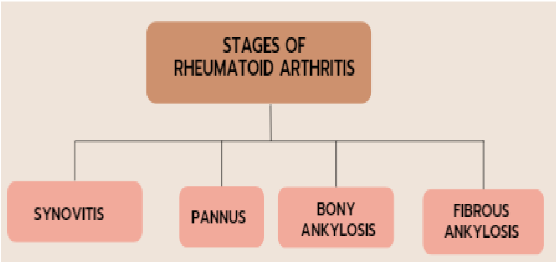

Fig.1.Four Stages Of RA

Stage I: Synovitis

You might experience modest symptoms including joint soreness and stiffness during stage I. The hands, fingers, ankles, and knees are the most often affected areas. The synovial membrane has swollen and inflammatory changes because the immune system has started attacking the joint tissue.

Stage II: Pannus

The cartilage has thinned in rheumatoid arthritis stage II as a result of the ongoing inflammation. Normally, cartilage helps the bones feel a little softer and facilitates smoother joint action. Without all that padding, stiffness and joint pain may get worse. Additionally, this facilitates joint deterioration. The bones at the joint may start to deteriorate without cartilage to protect them.

Stage III: Fibrous Ankylosis

The condition known as ankylosis occurs when bones begin to fuse together at a joint, resulting in an unusual lack of mobility. In stage III, a connective fibrous tissue begins to merge with the injured joint area. Your range of motion will be drastically reduced as a result, which can make already challenging jobs even harder. Your joints might start to seem twisted and bent at this time.

Stage IV: Bony Ankylosis

Stage IV, as the name suggests, is when true bone tissue, rather than just connective fibrous tissue, fuses the bones together. At this point, the capacity to move is lost along with the physical pain. Since the joint is essentially gone, the area cannot be bent or flexed. When rheumatoid arthritis reaches stage IV, a person may find it difficult to engage in their usual activities.

II. RELATED WORKS

The studies used to determine rheumatoid arthritis have been briefly discussed in this section. **Tajbakhsh et al**. have examined the performance of four different applications of transfer learning for classification, detection, and segmentation in the medical fields of radiology, cardiology, and gastroenterology. They found that fine-tuned CNNs were more resilient to the number of training sets than CNNs taught from scratch, and that a pre-trained CNN with appropriate fine-tuning outperformed or performed as well as a CNN trained from scratch.

In a 20*20 pixel picture patch, **Shamir et al**. suggested a template matching method for locating the knee joint centre. Their method involved downscaling the x-ray image to 10% of its original size before exposing it to histogram equalisation to make the intensity normal. The Euclidean distance was then calculated for each input image by scanning it via a sliding window of 20*20 pixels. The centre of the knee joint was determined to be the window with the shortest Euclidean distance. Although the method was simple to use, huge data made the detection accuracy poor and the method slow.

Retina Net was recently trained to recognise the left and right hip joints in a radiograph. Additionally, the 640x640-pixel input image of the hip that is being shown was cropped, contrast stretched, and resized to 224x224 pixels. In order to create a multitask neural network, a pretrained Dense Net 161 was used as a shared convolutional feature extractor with multitask loss function. To achieve final evaluation, each completely linked layer was trained for each radiographic characteristic of OA. According to the findings, Retina Net correctly placed bounding boxes for every joint image, and the model's accuracy was 80.8%.

While there are initiatives for computer-aided RA diagnosis and some DNN models for medical picture classification, there has been little to no research into the input augmentation component that leads to effective accuracy. Our model assumes Since the original photos' resolution, pixel sizes, and scale differed, two model architectures were initially taken into consideration. The original photographs were altered during image augmentation in order to crop, zoom in, scale up, add noise, flip horizontally, and modify contrast so that the resulting images might match the distribution of the original dataset's images. Additionally, a model was used to replace the training set photos with multiple altered variants (such as duplicating an image and changing the contrast to turn a right knee with high contrast into a left knee with low contrast).

EXISTING WORK:

There have been a number of studies that have explored the use of convolutional neural networks (CNNs) for rheumatoid arthritis (RA) using machine learning. Some examples include using CNNs for imaging-based classification of RA, predicting disease progression and treatment response, and identifying potential biomarkers for RA.

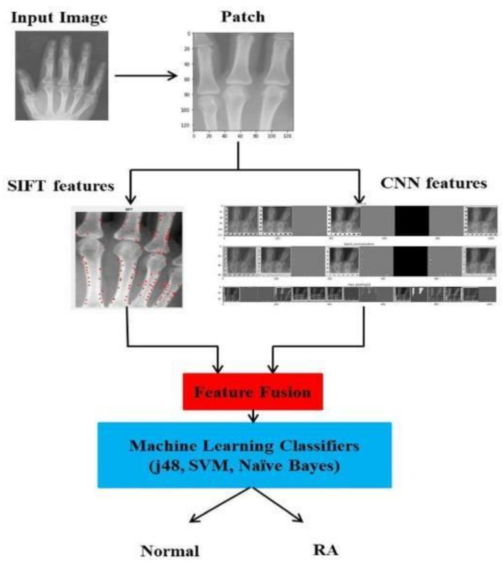

Fig.2.Existing Work Of Machine Learning Model

One study used a deep learning approach to classify hand radiographs as normal or abnormal (RA) with high accuracy. Another study used a 3D CNN to analyze magnetic resonance imaging (MRI) data to predict disease activity in RA patients.

Another study used a machine learning approach to predict the progression of joint damage in RA patients based on hand radiographs. This approach incorporated both traditional machine learning algorithms and deep learning techniques to analyze the radiographic images.

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Epoch	Neuron	K-fold split	Mean Accuracy (%)	Standard deviation (%)
25	128	10	85	24.09
50	128	10	77.5	21.10
75	200	10	65.83	21.87
100	200	10	78.33	25.60

Table 1.K-Fold Cross validation Observation

Overall, these works suggest that machine learning and CNNs can be effective tools for the diagnosis, prognosis, and treatment of RA. However, more research is needed to validate these findings and to further explore the potential of machine learning for RA.

III. SYSTEM MODEL

The study aimed to automate the discovery of rheumatoid arthritis in patients. Our suggested strategy uses CNN to describe rheumatoid arthritis and examining its performance .

The system model comprises of dataset, splitting of data, performing augmentation in order to generate large number of data, finally building a CNN model and performing classification and predicting the specific stage of the RA among four stages with improved accuracy compared to others and analysing the level of zone of patient condition in the form of web page as “Safe” and “Risk” and further leads to early medication and treatment to the patient in order to save patient’s life from danger.

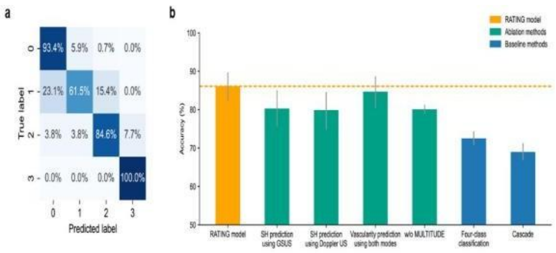

Fig.3.Accuracy And Performance Comparison Of Existing Machine Learning Models

THE PROPOSED METHODOLOGY

In this section, a discussion is made in the classification and prediction of several stages of rheumatoid Arthritis at an almost early development stage using Convolution Neural Networks in order to improve its accuracy with attention, which are leveraged in the proposed approach.

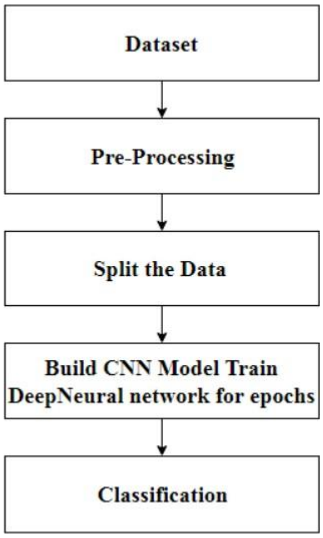

Fig.4.Flow Diagram of the Proposed System

In the dataset, we can take multiple images and take one as input image. In pre-processing, image is used to encode the label and resize the image. In split the data, image is set as 80% Training Data and 20% Testing Data. Then build CNN model train deep neural network for epochs, batch size, etc.., Then by performing multi-classification with the help of four classes and predicting the result which in turn leads to early diagnosis to the patients by the doctors.

In our proposed system , we are using convolutional neural network. Our dataset contains images four different classes of rheumatoid Arthritis such as Synovitis, Pannus, Fibrous Ankylosis, Bony Ankylosis.

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- To remove noise from images, we have applied augmentation (adjustment) technique such as brightness, zoom, rear, flip, etc. Using augmentation technique, we are making dataset clearer and generating new dataset from existing dataset.
- Based on different values of epochs and other parameters, we are measuring accuracy and loss values of convolutional neural network model and the performance of the algorithm is evaluated by accuracy score, loss and mean accuracy.
- During pre-processing, we have passed resizing, Rescaling, Shuffling, Dropout, Zoom/Brightness adjustment, Rotation, Background correction, horizontal flipping, etc parameters so that we can convert our image data into augmented image data which will help our CNN model to learn for low-resolution images to analyze the success rate of the proposed models and compare the outcome with other strategies.

A. Dataset

The dataset is taken from the **IRAIC** (International Rheumatoid Arthritis Image Collaboration) Archive. All images have been converted to low resolution (64x64x3) RGB. Dataset was partitioned into training (80%) and validation (20%) datasets.

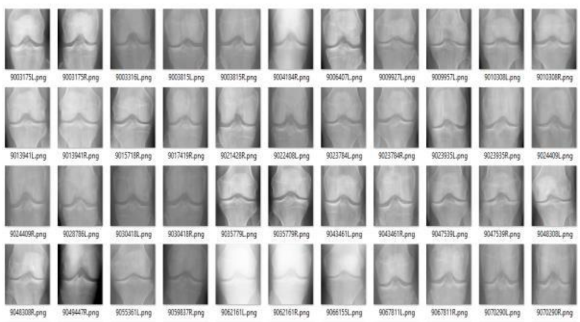

Fig.5.Dataset

Dataset	Class	Number of Images
Train 80%	Synovitis and pannus	1928
	Fibrous and Bony Ankylosis	3813
Test 20%	Synovitis and pannus	498
	Fibrous and Bony Ankylosis	935

Fig.6.Splitting Of Four Stages Of RA into 4 classes of datasets

B. Pre-processing

To make them suitable for usage with the CNN model, the medical images are pre-processed. In order to make sure that the photographs are of a uniform size and format, this may involve cropping, resizing, and standardizing them. To enhance the performance of the model, the pre-processing step may also comprise eliminating any unneeded data or background noise from the photos.

Fig.7.Preprocessing

After pre-processing,

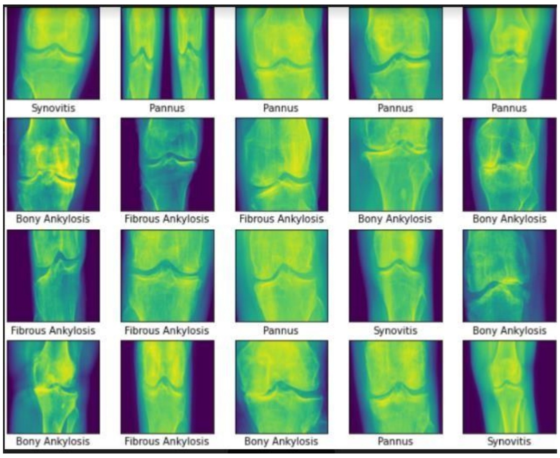

Fig.8.After Pre-processing

DATA AUGMENTATION:

Data augmentation is a deep learning strategy used to expand the training data set's size and diversity, which can enhance the model's accuracy and robustness. Data augmentation can involve modifying the medical images in a variety of ways, such as rotating, flipping, scaling, and adding noise, in the context of a CNN model for predicting rheumatoid arthritis. This reduces over fitting and enhances the model's classification performance by enabling it view the same image from various angles. The model can be strengthened against minute alterations in the photos and improved for use in real-world scenarios by training on augmented data. In general, data augmentation can significantly help a CNN model performance better.

The pre-processed images can be enhanced using a variety of transformations, such as rotating, flipping, scaling, and adding noise, to improve the size and diversity of the training data set. This can avoid over fitting and increase the model's accuracy and robustness. It is mainly performed for dataset generation. Since large number of data is required in order to get the accuracy and enhanced performance.

C. Data Splitting

Next, training, validation, and test sets of the pre-processed and enhanced photos are created. The CNN model is trained using the training set, validated using the validation set, then tested against the test set to determine how well the model performed. Dataset was split into training (80%) and validation (20%) datasets.

D. Building CNN Model

1. Initially, there is a convolutional layer (Conv2D). It is comparable to a group of learning filters. Each of the 32 filters in the first two layers of conv2D translates a portion of the picture (determined by kernel size) using a kernel filter. The entire image is subjected to the kernel filter matrix. Filters can be thought of as image editing.

2. **CNN** is able to identify important features in these altered photos, including maps, everywhere.

3. The pooling layer is CNN's second-most crucial layer (MaxPool2D). This layer simply serves as a filter to reduce the sample. It examines two adjacent pixels and selects an extremely high value. This is used to cut down on computing costs and, to a certain extent, over fitting. We must decide on the pooling size (i.e., how much of the pool gets compacted each time) when the pool size is large and sample reduction is crucial.

4. CNN may incorporate regional features and learn many of the global picture features by combining convolutional layers and pooling.

5. Modifier 'relax' (activation function (0, x). The network is given nonlinearity using the Rectifier function.

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6. The final feature maps are transformed into a single 1D vector using the flatten layer.

7. This flattening process is necessary in order to transmit the fully connected layers from some convolutional / max-pooling layers to the classification neural network. includes all locally accessible features from earlier convolutional layers.

8. Finally, one fully-connected (Dense) layer is just artificial neural networks (ANN) classifier.

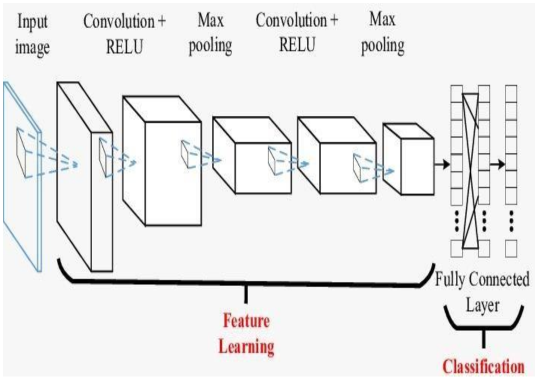

Fig.9.Layers Of CNN Model

The remainder of this paper is organised as follows: First section contains the related works followed by proposed methodology, last and final section contains conclusions and observations.

E. Classification, Prediction, Web Development

The CNN model is lastly trained using an optimization approach, such as stochastic gradient descent, using the training set. The parameters of the model are modified in response to the mistakes made on the training set, enabling the model to develop an understanding of the patterns and characteristics connected to rheumatoid arthritis. Multi-classification is performed and further classify the data into 4 classes. After the model has been trained, its performance and accuracy on the test set. At last, a single prediction is made in the web page whether the person in which stages of rheumatoid arthritis and then we will analyse the graph for various accuracy and loss metrics.

ARCHITECTURE:

The medical pictures are typically processed via a variety of steps before being used for training and evaluation in a CNN model for predicting rheumatoid arthritis.

- Augmentation – Dataset generation / contrast enhancement
- Convolution layer/Pooling layer – Features Extraction
- CNN Neural Network – Classification

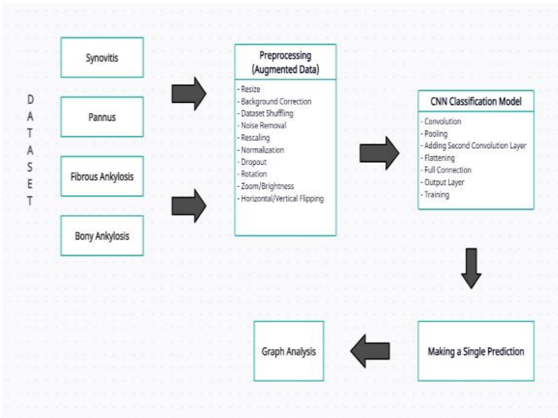

Fig.10.Architecture

IV. EXPERIMENTAL RESULTS

PERFORMANCE EVALUATION

OBSERVATIONS OF CNN MODEL:

Epoch	Neurons	Accuracy	Loss	Val-loss	Val/Accuracy
25	128	86.35	29.68	35.79	82.27
50	128	89.55	21.44	31.98	84.85
75	200	91.65	18.85	35.69	85.15
100	200	95.62	11.92	34.79	85.61

Fig.11.Observations of CNN Model

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Epochs- 25, Neurons- 128

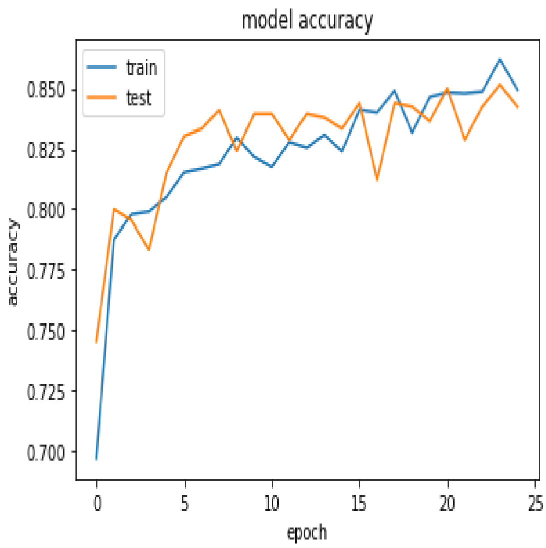

Fig.12.Train and Test accuracy of the image dataset

- In the figure 12 shows accuracy and figure 13 shows loss of observation #1 in table 2. The first observation of figure 11 for 25 epochs and 128 neurons gives 0.8474 accuracy and 0.3209 loss.
- In the figure 12, the train accuracy of first epoch is 0.6387 and for endmost epoch 0.8474. Epoch #24 gives the best/highest train accuracy 0.8717, is attained in #24 epoch. From the figure, the train accuracy is increasing during all #25 epochs. The Val accuracy is slightly distinct from the train accuracy during all #25 epochs. Epoch #24 gives the highest Val accuracy is 0.8515. The endmost epoch gives Val accuracy 0.8424.

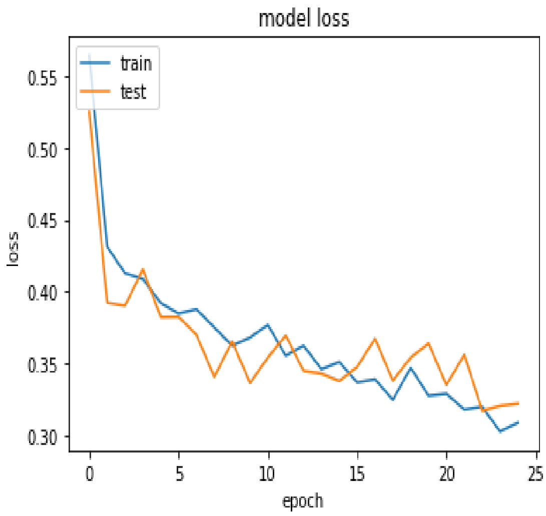

Fig.13.Train and Test loss of the image dataset

- In the figure 13, the train loss of first epoch is 0.6248 and for the endmost epoch 0.3209. The minimum train loss 0.2933, is attained in epoch #24. From the figure, the train loss plot is decreasing during all #25 epochs. The val_loss is slightly distinct from the train loss during all #25 epochs. The endmost epoch gives val_loss is 0.3222.

Epochs- 50, Neurons- 128

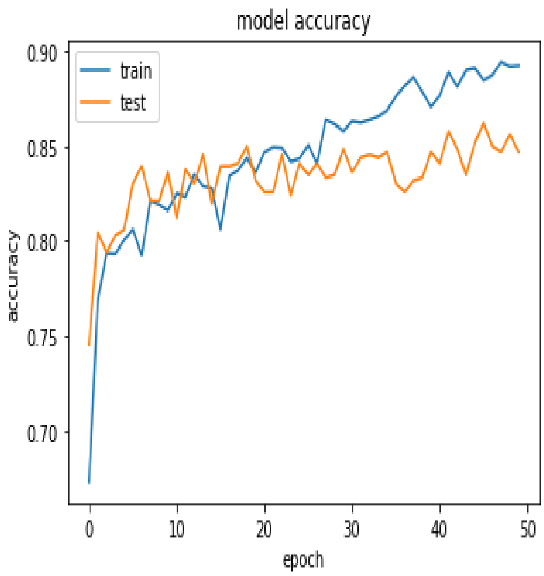

Fig.14.Train and Test accuracy of the image dataset

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- In the figure 14 shows accuracy and figure 15 shows loss of observation #1 in figure 11. The first observation of figure 11 for 50 epochs and 128 neurons gives 0.8933 accuracy and 0.2205 loss.
- In the figure 14, the train accuracy of first epoch is 0.6114 and for endmost epoch 0.8933. Epoch #47 gives the best/highest train accuracy 0.8976, is attained in #47 epoch. From the figure, the train accuracy is increasing during all #50 epochs. The Val accuracy is slightly distinct from the train accuracy during all #50 epochs. Epoch #46 gives the highest Val accuracy is 0.8621. The endmost epoch gives Val accuracy 0.8470.

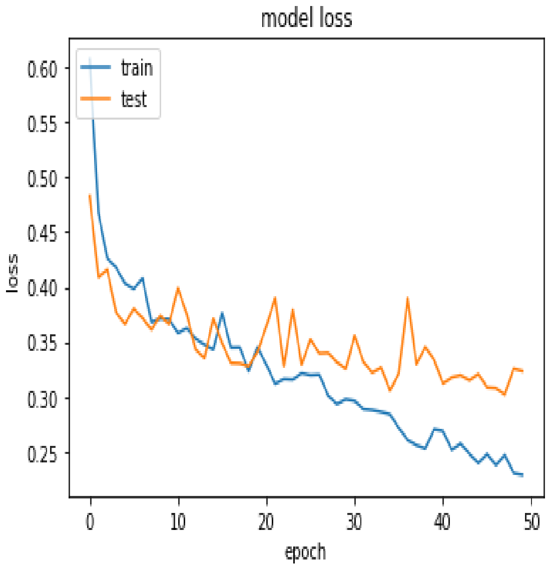

Fig.15.Train and Test loss of the image dataset

- In the figure 15, The train loss of first epoch is 0.6793 and for the endmost epoch 0.2205. The minimum train loss 0.2197, is attained in epoch #46. From the figure, the train loss plot is decreasing during all #50 epochs. The val_loss is slightly distinct from the train loss during all #50 epochs.
- The endmost epoch gives val_loss is 0.324.

Epochs- 75, Neurons- 200

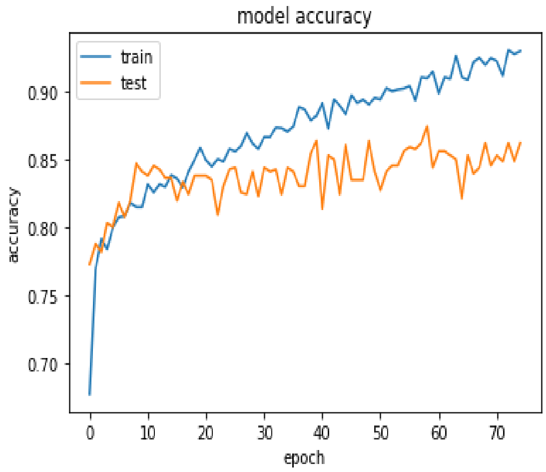

Fig.16.Train and Test accuracy of the image dataset

- The figure 16 shows accuracy and figure 17 shows loss of observation #1 in figure 11. The first observation of figure 11 for 75 epochs and 200 neurons gives 0.9362 accuracy and 0.1557 loss.
- In the figure 17, the train accuracy of first epoch is 0.6029 and for endmost epoch 0.9562. Epoch #75 gives the best/highest train accuracy 0.9362, is attained in #75 epoch. From the figure, the train accuracy is increasing during all #75 epochs. The Val accuracy is slightly distinct from the train accuracy during all #75 epochs. Epoch #59 gives the highest Val accuracy is 0.8742. The endmost epoch gives Val accuracy 0.8621.

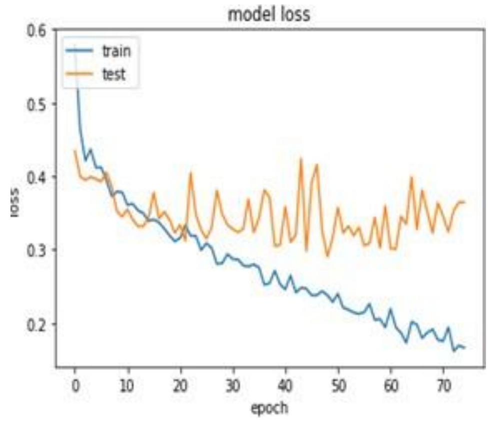

Fig.17.Train and Test loss of the image dataset

In figure 17, the train loss of first epoch is 0.6593 and for the endmost epoch 0.1557. The minimum train loss 0.1557, is attained in epoch #75. From the plot, the train loss plot is decreasing during all #75 epochs. The val_loss is slightly distinct from the train loss during all #75 epochs. The endmost epoch gives val_loss is 0.3646.

Epochs- 100, Neurons- 200

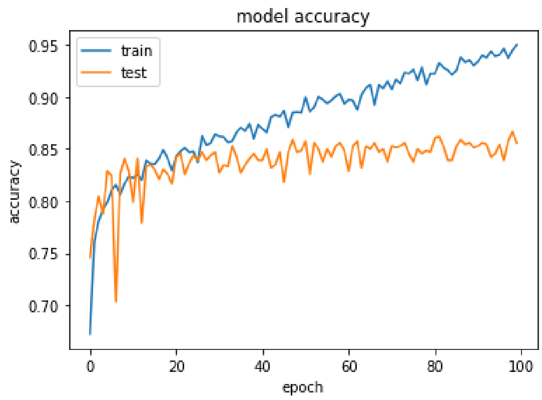

Fig.18.Train and Test accuracy of the image dataset

- In figure 18 shows accuracy and figure 19 shows loss of observation #1 in figure 11. The first observation of figure 11 for 100 epochs and 200 neurons gives 0.9562 accuracy and 0.1192 loss.
- In the figure 18, the train accuracy of first epoch is 0.6065 and for endmost epoch 0.9562. Epoch #100 gives the best/highest train accuracy 0.9562, is attained in #100 epoch. From the figure, the train accuracy is increasing during all #100 epochs. The Val accuracy is slightly distinct from the train accuracy during all #100 epochs. Epoch #99 gives the highest Val accuracy is 0.8667. The endmost epoch gives Val accuracy 0.8561.

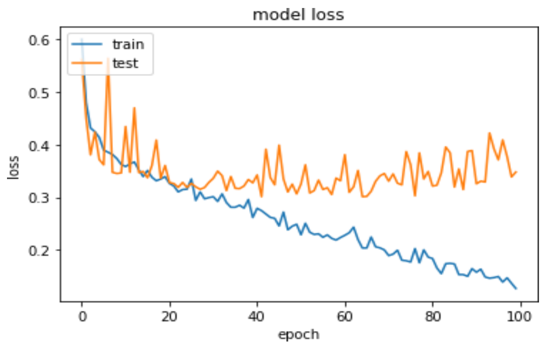

Fig.19.Train and Test loss of the image dataset

In figure 19, the train loss of first epoch is 0.7055 and for the endmost epoch 0.1192. The minimum train loss 0.1192, is attained in epoch #100. From the figure, the train loss plot is decreasing during all #100 epochs. The val_loss is slightly distinct from the train loss during all #100 epochs. The endmost epoch gives val_loss is 0.3479.

Fig.20.Web Development

FUTURE SCOPE

Though expected accuracy is achieved , in future we further plan to add VGG-16 model in order to bring improved accuracy and better results which will help doctors to take prediction of Rheumatoid Arthritis. Doctor will take scan image of rheumatoid arthritis from patient and will give it to the model and then the model will predict the result. It will help to take action at early stage of rheumatoid arthritis. Once the stage of Rheumatoid Arthritis get increased, it will be difficult to save life of patient. Early detection of rheumatoid Arthritis is very important so that the problems can be avoided in the future.

V. CONCLUSION

Rheumatoid arthritis (RA) can reduce quality of life and has numerous negative social and physical effects. It may result in suffering, impairment, and untimely death.

The main advantages of our deep learning approach compared to human scorers are using image augmentation for the dataset enhancement which increases the quality of images and helps during training to our model while learning and further increasing the performance too. Deep Learning is taken into consideration as one of the high-quality strategies in dataset evaluation and synthetic intelligence, regardless of dropping a touch in explainability. The identical may be completed with the aid of making use of photo enhancement strategies and studying the overall performance of different AI strategies. Compared to conventional styles, the results showed that the proposed network armature was appealing and performed exceptionally well in classification and prediction. Various processing operations were also carried out to enhance the model’s effectiveness.

IMPACTS OF RHEUMATOID ARTHRITIS:

Premature heart disease: RA patients are also more susceptible to other chronic conditions, such as diabetes and heart disease. To prevent people with RA from developing heart disease, RA treatment also emphasises reducing heart disease risk factors. For instance, doctors might advise RA patients to stop smoking and to eat healthier.

Obesity: People with RA who are obese are more prone to develop risk factors for heart disease like high blood pressure and high cholesterol. The chance of developing chronic illnesses like diabetes and heart disease is also increased by obesity. Finally, obese RA patients benefit less from their medical treatment than do RA patients who are not obese.

Employment: Working while suffering from RA may be difficult. Adults with RA are less likely to be employed than adults without the illness. When their RA progresses, many people find they are no longer able to perform as much as they once could. RA patients with physically demanding jobs are more likely to lose their jobs. Less work loss affects those who have employment with lower physical demands or jobs where they can set the pace and activities of their workday.

VI. REFERENCES

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