

A Novel Approach for the Early Detection of Rheumatoid Arthritis on Hand and Wrist Using Convolutional Reinforcement Learning Techniques

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ABSTRACT

A reliable provocative issue which impacts the joints by harming the body's tissue is called as Rheumatoid arthritis . As needs be, the ID and ID of rheumatoid arthritis by hand, particularly during its unanticipated turn of events or pre-expressive stages, requires an extraordinary construction analysis. The standard end technique for Rheumatoid Arthritis (RA) recalls for the assessment of hands and feet radiographs. Notwithstanding, still for clinical experts it winds up being an unconventional endeavor considering the way that regularly the right completion of the disease relies on the exposure of unfathomably subtle changes in the typical eye. In this work, we built up a design using Convolutional Neural Networks (CNN) and Reinforcement Learning Technique for detecting RA from hand and wrist MRI. For this we took 564 cases(real information) which provided a precision of 100 %. Compared to the existing system, the system showed a high performance with very good results. This model is highly recommended to detect Rheumatoid arthritis automatically ,without human intervention.

Keywords: Machine learning, convolutional neural networks, deep learning, rheumatology, rheumatoid arthritis, artificial intelligence

Introduction

In around 1 % of the world population [55], Rheumatoid arthritis is an unobtrusively common disease, Rheumatoid arthritis is a persistent incendiary problem which will influence very your joints. In certain individuals, the skin, eyes, lungs, heart and veins can be affected. Rheumatoid arthritis is a autoimmune disease. Rheumatoid arthritis happens when your framework erroneously assaults your own body's tissues. Rheumatoid arthritis influences the liner of your joints, causing a difficult expanding which will in the long run end in bone disintegration and joint disfigurement. The aggravation identified with rheumatoid arthritis is the thing that can harm different pieces of the body additionally . While new kinds of prescriptions have improved treatment alternatives significantly, extreme rheumatoid arthritis can in any case cause actual handicaps.

Fundamentals that may develop your risk of rheumatoid arthritis include:

- Your sex- Ladies are almost certain than men to create rheumatoid arthritis.
- Age- Rheumatoid arthritis can happen at whatever stage in life, on the other hand it usually starts in middle age.
- Family ancestry- On the off chance that if your relative has rheumatoid arthritis, you perhaps will have a long-drawn-out risk of the sickness.
- Smoking- Cigarette smoking forms your threat of making rheumatoid arthritis, above all in case you have an inborn inclination for developing the ailment. Smoking moreover has all the reserves of being connected with more imperative ailment reality.
- Environmental Exposure- Rheumatoid arthritis hazard increments with word related openness to material residue. Also, word related residue openness is moreover connected to a danger of creating antibodies to rheumatoid arthritis, accordingly conceivably accelerating movement of the sickness.
- Obesity- People — especially women age 55 and more youthful — who are overweight

or hefty have all the earmarks of being at a fairly higher danger of creating rheumatoid arthritis.

Figure1 shows the MRI of a patient with the affliction.

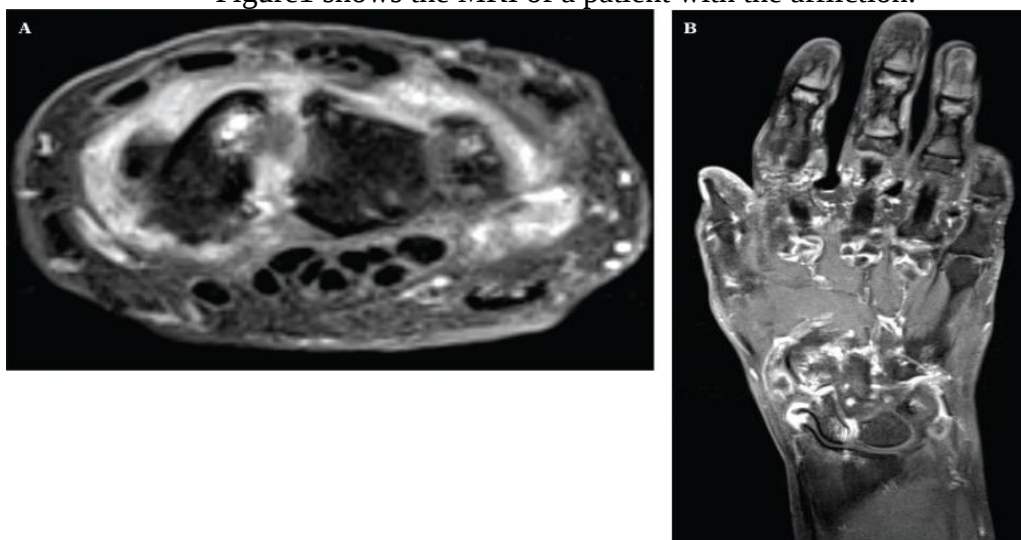


Figure 1 : A. axial plane; B. coronal plane: synovitis, disintegrations and incendiary growths in the radio-carpal, midcarpal, carpo-metacarpal and metacarpophalangeal joints

Various joints are covered with a covering called the synovium, which oils up the joint so it moves much more with no issue. Precisely, the synovium becomes inflamed, thickens, and produces an excess of joint fluid(synovitis) when you have rheumatoid arthritis. Swelling, damages cartilage, and softens the bone within the joint are caused by synovitis and the inflammatory chemicals released by the immune system . According to the American Society for Surgery of the Hand, deformity and instability is caused by the swollen tissue which stretch the surrounding ligaments(connective tissues that join two bones). The inflammation may also weaken and damage tendons(connective issues that join muscle to bone). The aggravation may moreover disable and harm ligaments. Tendons are connective tissues that join two bones; ligaments are connective issues that join muscle to bone.

Right when RA strikes the hand, it is by and large norm in the wrist and finger knuckles —the MCP (metacarpophalangeal) joint, or the tremendous knuckle where the fingers and thumb meet the hand, and the center knuckle or PIP (proximal interphalangeal) joint considerably more explicitly. Rheumatoid arthritis (RA) impacts joints on the various sides of the body, like two hands, the two wrists, or the two knees. This harmony assists with disengaging it from different sorts of arthritis. The confirmation of rheumatoid arthritis depends from a general point of view on the 1987 adjusted models of the American College of Rheumatology (earlier, the American Rheumatism Association) [72], including clinical, biologic, and radiologic divulgences. The joints of the hands are among the first to be influenced in rheumatoid arthritis, and they are astoundingly persuading in the appraisal of patients with suspected early rheumatoid arthritis [73]. X-shaft has been demonstrated to be more delicate than radiography at seeing bone disintegrations in the hands and wrists of patients with rheumatoid arthritis [74, 75]. In like manner, MRI can give depiction of edema, hyperemia, and joint radiation, identically as perspective on synovial pannus with the usage of IV gadolinium implantation [74–78].Advances in AI, especially CNN and Reinforcement Learning have opened extra open entrances in the field of drug, making structures for seeing dermatological debasements [59], lung pathologies [60], breaks and bone damage [61], among others, to tie the space for give and take in clinical finding and attracting an early revelation of illnesses.

Associated Works

The finish of Periarticular Osteoporosis (one of the consequences of RA) was tried in the evaluation coordinated by Murakami et al. [63]. Thickness characteristics of hand X-transmits utilizing histogram assessment, co-occurrence frameworks, Fourier changes and extraction of line parts were chosen by the structure.

A changed assurance plan of RA from hand radiographs, utilizing a couple of electronic picture taking care of figuring for feature extraction and a neural association for its strategy was proposed by Chokkalingam and Komathy [64]. Twenty three pictures were used for setting up the model in any case no underwriting tests were performed, along these lines its precision is dull.

Considering the area of bone deterioration, Murakami et al. [65] executed a system for diagnosing RA by using 129 radiograph pictures. In this evaluation, a division assessment and a CNN were used to remove the region of the phalanges and for perceiving the presence of the pathology. 30 cases with RA was taken for the work. The rates of true positive and false positives obtained were 80.5 % and 0.84 % respectively, the fake positive number of the division calculation was 3.3 per case.

The existing systems present restricted results, with high slip up rates and low hypothesis to detect RA. Made on Convolutional Neural Network, works on retrained model with less number of images, detects simply finger joint deteriorations and it fail to recognize intercarpal joints. Sensitivity for deteriorations was unmistakably low. Their unflinching quality should improve to be used as an end mechanical gathering in the clinical environment, which has no protection from botches in light of the regular meaning of this assignment.

Methodology

For the improvement of this work, we used Convolutional Reinforcement Learning Technique to perceive Rheumatoid Arthritis from hand and wrist MRI, considering Feature Extraction, Deep learning and Reinforcement learning methodology to distinguish RA (Rheumatoid Arthritis) to diminish human dependence and takes most choices naturally.

Imagedataset

The pictures utilized in this examination came from Dr Kirubanadan, Radiologist, Noble scan centre, Vaniyambadi, Tamil Nadu, associated with Apollo Hospitals and Central labs, Thrissur Kerala with the assistance of Dr. Hari Krishnan G, Rheumatologist, Kottayam Medical College, Kerala. They comprise of 564 gray scale MRI of both hands and wrist of the patients between the age 30 to 60, utilized by clinical expert in their analysis of RA. The properties of dataset is displayed in Table 1.

Table 1. Image database characteristics.

Total cases	564
RA-affected	282
RA-not affected	282
Resolution of Image	1378 x 654 pixels
Format- Image	DICOM
Bit depth	32 bits

Ethics

It is not possible to expect to relate the patient's name to the MRI. They are anonymous. Keeping all rules of confidentiality, they were just utilized to build the model.

Software Tools

For the ease, speed and control during the arrangement of complex networks, we used Python, Tensorflow and Keras. OpenCV, sklearn, imutils, matplotlib, and Numpy modules were used to manage and quantify the photos.

Algorithm

KCP Algorithm

- Required import statements for packages: This characterizes all the significant packages for picture pre handling, preparing system, data wrangling and directory storage.
- Dataset of 282 Images of RA influenced and another 282 pictures of Normal pictures are stacked in the 'yes' and 'no' indexes separately.
- Using the ImageDataGenerator capacity of cv2 (opencv) for making more pictures utilizing picture augmentation, the outcome is increased in addition to the ordinary images. (6200 pictures after augmentation). These augmented images are utilized to identify the contours of the images for cropping of the image, aka edges of the image. This uses erode and dilate. When the shapes are done, the example picture and the cropped picture is shown.
- These pictures are given as 3 dimensional, and the influenced and ordinary pictures are plotted for review of the augmented pictures.
- Data is part utilizing train test split into 3 phases – train, approve and test. 70% for preparing, 15 % for validation and another 15% for testing. The state of the pictures, for all x_train, x_val and x_test seen and showed.
- The model is planned with (input layer + zeropadding layer + convolutional layer + maxpooling layers + softmax layer + straighten layer). This is a binary classifier with 1 as Affected and 0 as Normal.
- The synopsis of the model, is brought with the state of the dev network made. The tensorboard is instated.
- The models is prepared for 30 epochs, the callbacks are utilized for each age which stores the validation accuracy and the age for each model made.
- The trained network details are utilized with history which stores all the loss, accuracy and f1 score subtleties of all train, validation and test clumps. The loss and accuracy plots are plotted
- The best model is picked from the maximum validation accuracy from the ages, and the measurements are assessed with the hyper parameters.
- Finally the after effects of the accuracy, exactness and f1 score are determined for test and validation datasets in the confusion matrix.
- Use Deep Reinforcement learning to anticipate and just as train the framework.

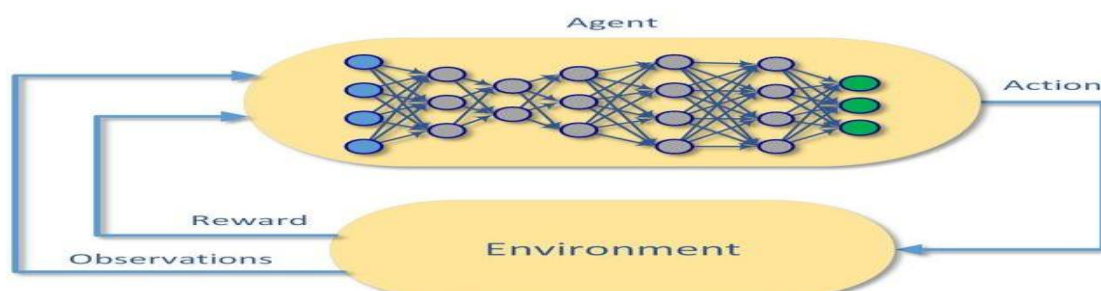


Figure 2: Deep Reinforcement learning architecture[79]

Data Augmentation For Rheumatoid Arthritis Detection

The dataset contains 2 organizers: yes and no which contains 564 Hand MRI Images. The folder 'yes' contains 282 Hand MRI Images that are RA influenced and the organizer 'no' contains 282 Hand MRI Images that are Normal. As this is a little dataset, We have utilized information augmentation utilizing ImageDataGenerator to make more pictures on the fly. It is very difficult to train a model with limited data. To overcome this, we did augmentation of the images by transforming the MRI with a random combination of rotation, width shift, height shift, shear, brightness, horizontal flip, vertical flip and fill mode. Since the training examples got incremented, it helped us to improve the classification results of the architecture. The progressions applied, granted the networks to become familiar with these changes in various points and sizes without having influence on the visual highlights in little locales of the primary pictures. After augmentation, we have 6200 images. Each image has a shape of (240, 240, 3)=(image_width, image_height, number_of_channels)

Preprocessing & Segmentation

The dataset contains 2 organizers: yes and no which contains 564 Hand MRI Images. The folder 'yes' contains 282 Hand MRI Images that are RA influenced and the organizer no contains 282 Hand MRI Images that are Normal. After augmentation we have a sum of 6200 Images for the identification.

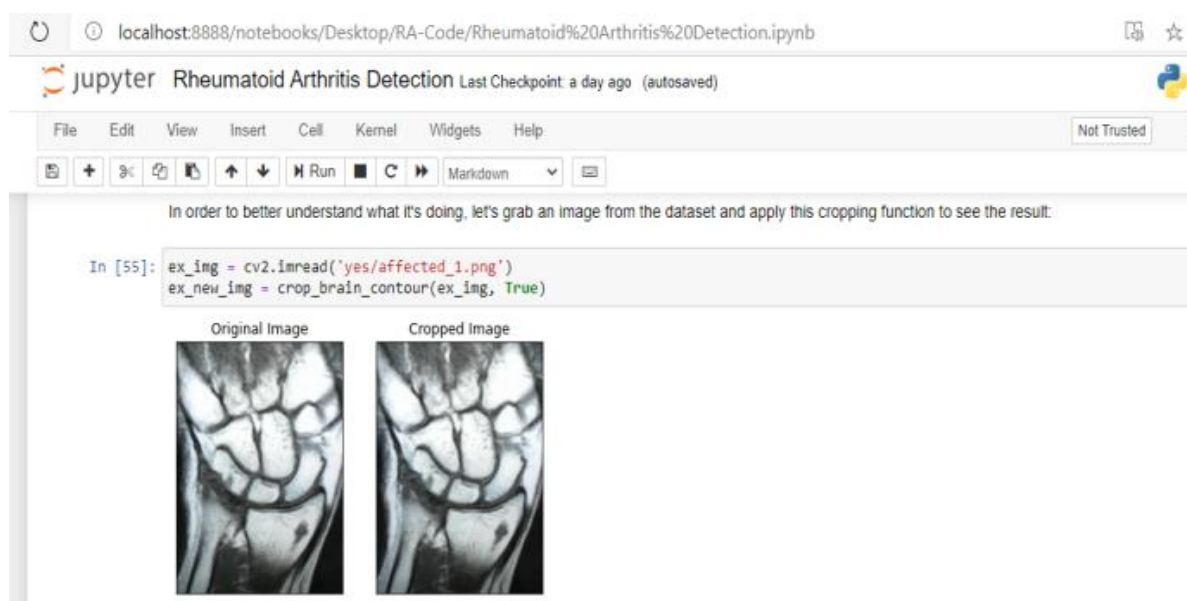


Figure 3: Original Image and Cropped Image

Load Data

- The following function takes two arguments, the first is a rundown of directory paths for the folders 'yes' and 'no' that contain the picture information and the subsequent argument is the picture size, and for each picture in the two directories and does the accompanying:
- Read the picture.
- Crop the piece of the picture addressing just the hand and wrist. Resize the picture (in light of the fact that the pictures in the dataset come in various sizes (which means width, height and # of channels). Along these lines, we need the entirety of our pictures to be (240, 240, 3) to take care of it as a contribution to the neural organization.
- Apply standardization since we need pixel esteems to be scaled to the reach 0-1.
- Append the picture to X and its mark to y.
- After that, Shuffle X and y, on the grounds that the information is requested (which means the exhibits contains the initial segment having a place with one class and the subsequent part having a place with the other class, and we don't need that).
- At long last, Return X and y.

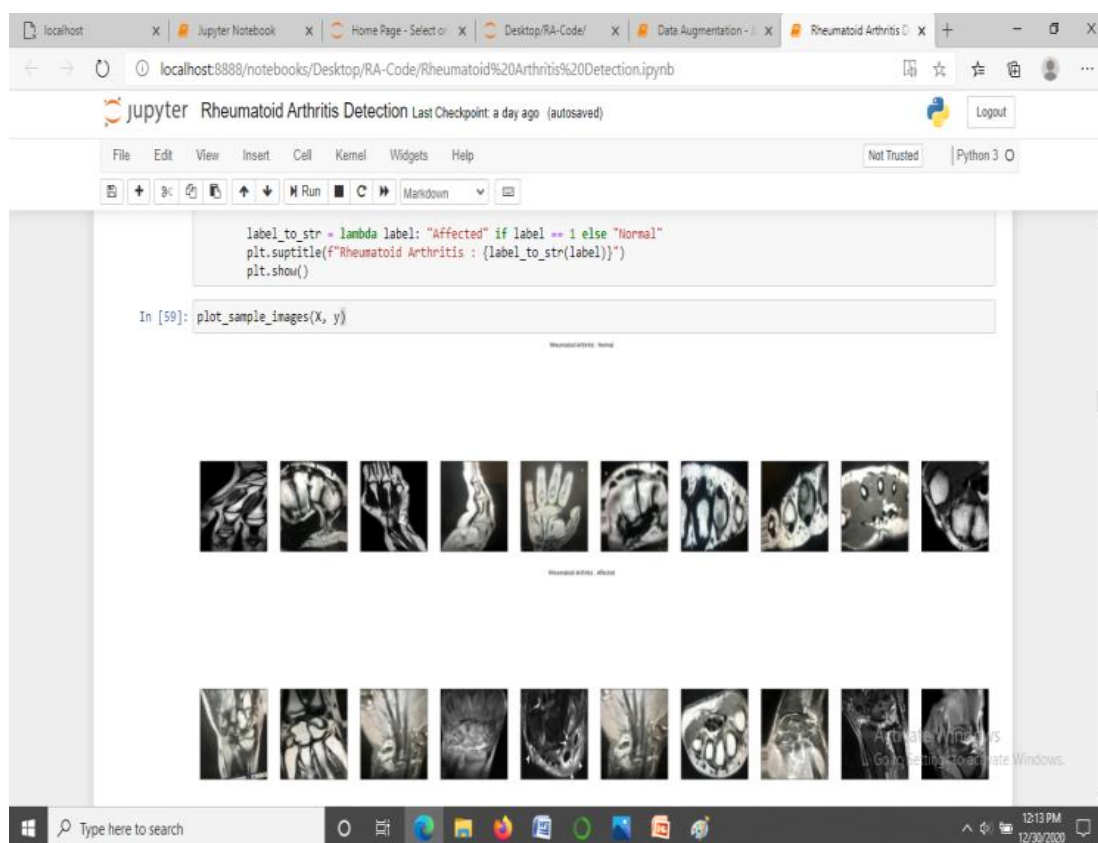


Figure 4 :Plot Sample Images For RA

Data Set Division

We used the following way to split:

- 70% of the data for training.
- 15% of the data for validation.
- 15% of the data for testing.

Results and Discussions

Build The Model

- There are 9 layers in the model

Table 2 : Number of parameters

Total Parameters	11137
Trainable parameters	11073
Non trainable parameteres	64

```
model.summary()
```

Model: "Rheumatoid_Arthritis_Detection_Model"

Layer (type)	Output Shape	Param #
input_4 (InputLayer)	[(None, 240, 240, 3)]	0
zero_padding2d_3 (ZeroPaddin	(None, 244, 244, 3)	0
conv0 (Conv2D)	(None, 238, 238, 32)	4736
bn0 (BatchNormalization)	(None, 238, 238, 32)	128
activation_3 (Activation)	(None, 238, 238, 32)	0
max_pool0 (MaxPooling2D)	(None, 59, 59, 32)	0
max_pool1 (MaxPooling2D)	(None, 14, 14, 32)	0
flatten_3 (Flatten)	(None, 6272)	0
fc (Dense)	(None, 1)	6273
Total params: 11,137		
Trainable params: 11,073		
Non-trainable params: 64		

Figure 5 :Number of layers in the Serialization Model

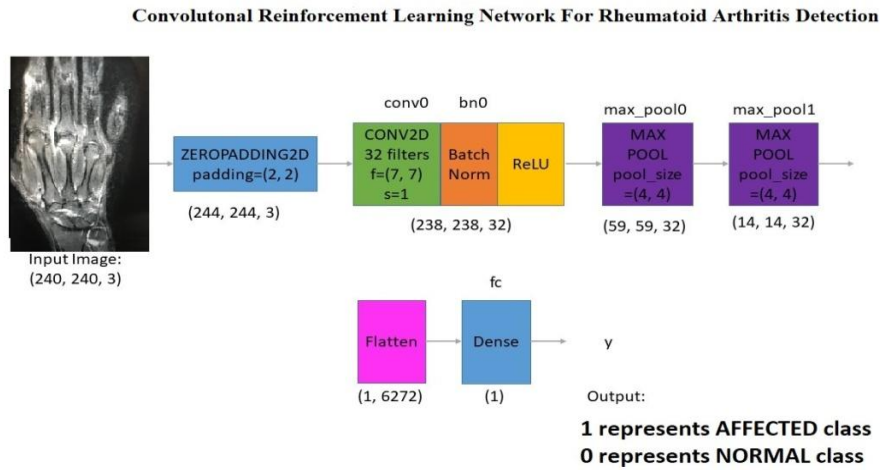


Figure 6 :Convolutional Reinforcement Learning Network Architecture for RA Detection
Train The Model

For the determination of the optimization algorithm Adam was thought of, contrasting their outcomes after 30 epochs of preparing. Adam was picked for having the quickest combination result.We used Serializing Model which is the best model for industry organization as it decrease measure and improve performance.Figure 6 shows the plot of loss and accuracy.

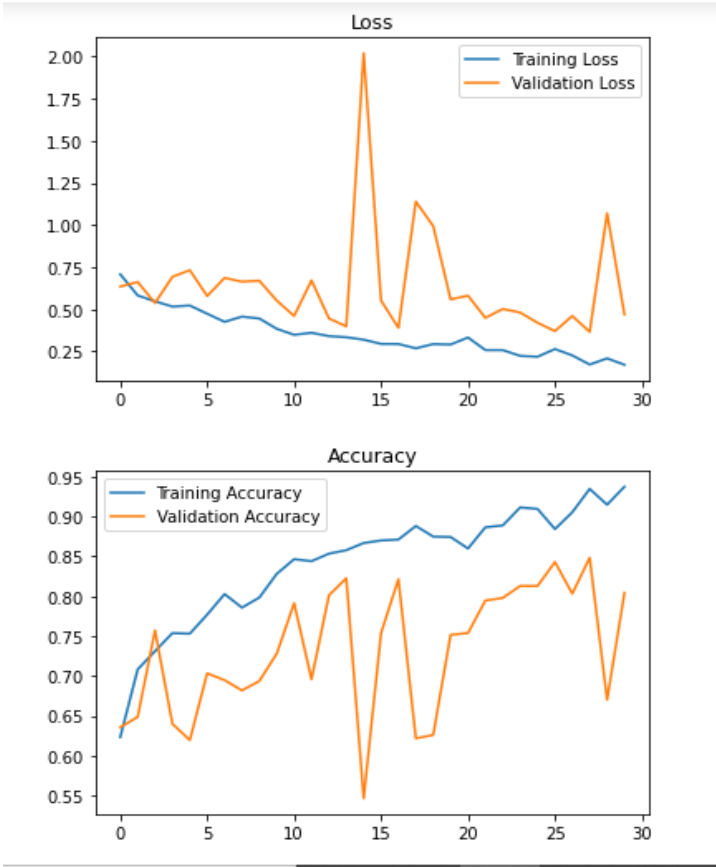


Figure 6 :Plot Loss & Accuracy

Load The Best Model

After training we evaluated the best model on the testing data by using pretrained model.

Table 3 : Accuracy of the best model on testing data

Test Loss	0.5157854557037354
Test Accuracy	0.7935484051704407

Result

Table 4 displays best validation results and test accuracy.

Table 4 : F1 Score For The Best Model On The Testing Data & Validation Set

	Training Data	Validation Data	Testing Data
No : of Examples	4340	930	930
No : of positive examples	2184	441	474
Percentage of positive examples	50.32%	47.42%	50.97%
No: of negative examples	2156	489	456
Percentage of negative examples	49.68%	52.58%	49.03%

Performance Table:

	Validation set	Test set
Accuracy	80%	79%
F1 score	0.76	0.76

Table 5 : Result Interpretation

Conclusion

In this examination we arranged and evaluated the certified enlightening assortment with Convolutional Reinforcement Learning Techniques. The RA detection is successful with a validation accuracy of 80% and a training accuracy of 99-100% . The test sets have been created and found that the model identifies the images with the expected accuracy and serves the purpose. We propose this system that recognizes RA from hand and wrist MRI without broad preprocessing or excellent features, simply using rough pixel regards and achieving favored exactnesses over near models of the front line. The major results show the ability of this structure.

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