Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 4, 2021, Pages. 2275 – 2290
Received 05 March 2021; Accepted 01 April 2021.

A Review on Investigation and Catagorization of Rheumatoid Arthritis and Osteoarthritis Using Image Processing Techniques.

[1]Revathy.B, [*1]Subramoniam.M, [2]Poornapushpakala.S, [3]Barani.S

[1]Research Scholar, Sathyabama Institute of Science & Technology, Chennai.
Mail:revathybashkar@gmail.com,

[*1,2,3] Faculty of EEE, Sathyabama Institute of Science & Technology, Chennai. Mail:
subramoniam.enc@sathyabama.ac.,

poornasuri1601@gmail.com, baraniselvaraj77@gmail.com

ABSTRACT

Arthritis is one of joint disorders that have affected many lives. Osteoarthritis and Rheumatoid arthritis are the most common types among the other arthritis. The earlier symptoms of arthritis are considered as pain, stiffness, inflammation, and at the later stage it could even cause severe immobility. Arthritis cannot be cured at any stage, but it could be controlled by proper diagnosis. The present approach for the evaluation of osteoarthritis and rheumatoid arthritis includes clinical diagnosis and medical imaging techniques. This review paper focused on the different medical imaging techniques for the assessment of arthritis. They are X-ray imaging, thermal imaging, ultrasound imaging, and Magnetic Resonance imaging for detection and classification of osteoarthritis and rheumatoid arthritis in a very illustrative and relative manner. Thus, an elaborated discussion on various image processing techniques such as segmentation, feature extraction, classification and machine learning techniques such as Artificial neural network, convolutional neural network is done and surveyed in a detailed manner.

Key Words: osteoarthritis, rheumatoid arthritis, investigation techniques medical imaging, image processing, machine learning etc,

1. Introduction

Arthritis is a type of the bone disease that affects joints in the body. It occurs mostly at hand joints, knee joints and finger joints. Arthritis [2] [4] [12] [13] cannot be cured but it could be controlled at any stage. The earlier symptoms are considered as pain, morning stiffness and swelling. If, the disease left untreated it could cause extreme immobility at the later stage. There are different types of arthritis affects the human lives. They are Osteoarthritis, Rheumatoid arthritis, Psoriatic arthritis, inflammatory arthritis, etc. among these OA and RA are considered most common types.

Osteoarthritis [4] [8] [10] [11] [16] [21] [23] [27] [30] can occur at bone ends, cartilages, femur and bone tissues. Loss of articulate cartilages are considered as the primary cause of osteoarthritis. Fig 1 shows the normal bone joint vs osteoarthritis affected bone joint.

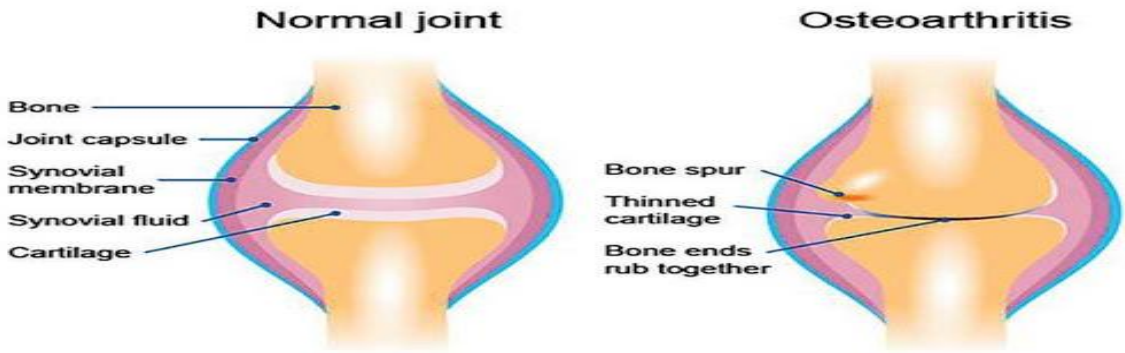

Figure 1. Normal joint vs Osteoarthritis (Courtesy. Ref no. 41)

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 4, 2021, Pages. 2275 – 2290
Received 05 March 2021; Accepted 01 April 2021.

The patients with OA may suffer from pain in the night, restricted motion, swelling and sound from the knee.

Rheumatoid arthritis [2] [3] [12] [13] [14] [15] [17] [19] [20] [22] is a chronic disease which affects joints on hands, feet, ankles and wrists. It also targets synovial joints. The overall life expectancy of a RA affected patient is reduced by four to ten years. Fig 2 shows the normal bone joint vs Rheumatoid arthritis affected bone joint.

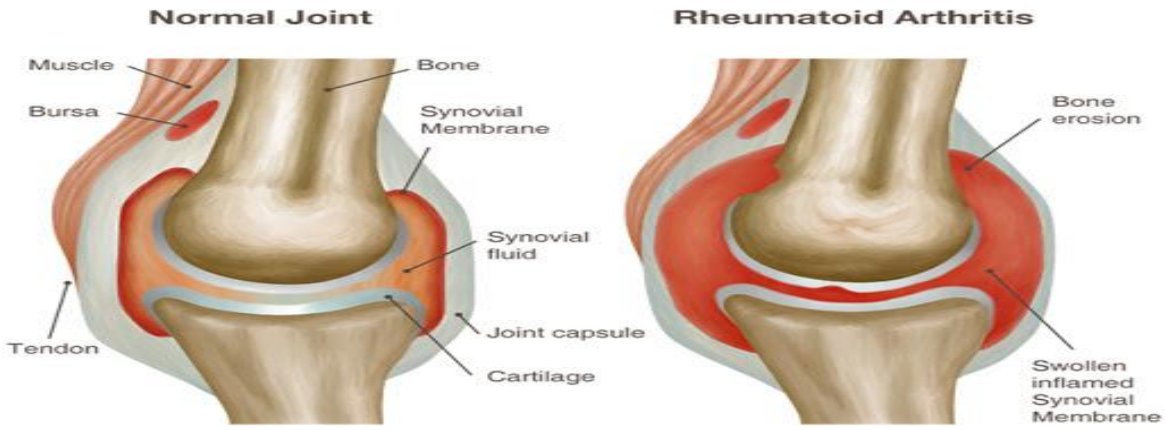

Figure 2. Normal joint vs Rheumatoid Arthritis (Courtesy. Ref no.42)

At present, there are three types of diagnosis has been carried out in the clinical investigation.They are a medical imaging, analysing blood samples and nerve-conduction techniques. Medical imaging [4] [6] [9] [13] [15] [17] [18] plays a vital role in the investigation of arthritis in a clinical diagnosis because of its availability, low cost and non-invasive nature. Most commonly used medical imaging techniques by the physicians are X-ray imaging [35] [38] [15] [21][23], Thermal imaging [13] [15] [24] [36] [37], Ultrasound imaging [8] [33] and Magnetic Resonance Imaging [18] [34] [39] [40]. Even though medical imaging comes under non-invasive type, they also fail to earlier diagnosis. The analysing blood samples and nerve-conduction techniques are invasive in nature so, it may cause more pain to the patients, still it does not help in accurate diagnosis. Although present evaluation of arthritis is based on medical imaging [23] [24] [30] [35], clinical diagnosis and symptoms., while some grading systems are also available to categorize the disorder as mild, moderate and severe. Kellgren-Lawrence grading [27] system is the most commonly used method by the physicians. The KL grading is listed in the table 1.

Table 1. KL Grading for Arthritis

KL GRADES	**ANALYSIS**
Grade 0	No feature present
Grade 1	Doubtful (joint space narrowing)
Grade 2	Mild (definite joint space narrowing)
Grade 3	Moderate (multiple osteophytes)
Grade 4	Severe(largeosteophytes, bone deformity)

The current methods used for clinical investigation of arthritis are not efficient [4] [8] [10] [11] [3] [12] [13] [17]. Thus, we need more accurate algorithms and methods. In the rest of the paper, Section 2 describes the methodology for processing acquired images. Section 3 describes the review work-related to various medical imaging that also includes different

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 4, 2021, Pages. 2275 – 2290
Received 05 March 2021; Accepted 01 April 2021.

image processing [22] [17] [18] [26] and machine learning techniques [12] [7] [8] [12] [26]. Section 4 describes the existing challenges and issues. Finally, section 5 and 6 dealt with conclusion and future scope in this field.

2. Methodology

Any image under processing is subjected to the following steps below. They are image acquisition, pre-processing, image enhancement, segmentation, feature extraction and classification. The flow chart of the common methodology used by the researchers is given in the Fig 3.

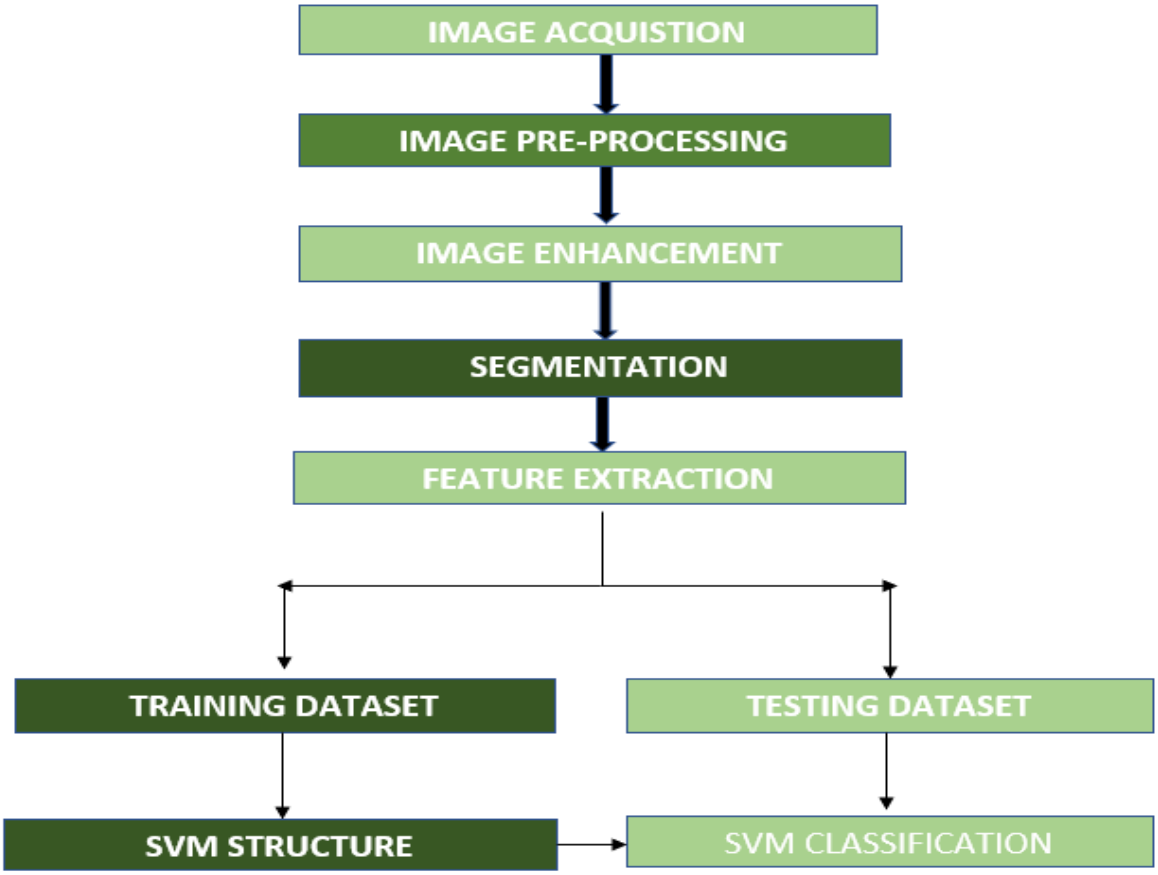

Figure 3. Process Flow

2.1 ImageAcquisition

Image acquisition is the first and foremost step in every image processing application. It is defined as the action of retrieving an image from some source. Some of the common devices used for collection of images were digital camera, high resolution camera, CCD, Thermo vision camera [36] [24], FLIRT-650sc camera and smart phone camera [27]. Most of the researchers have used images from public databases such as MEDUSA [33], OAI [23] and MOST [23].

2.2 Pre -Processing

Pre-processing [8] [9] [16] [21] [27] [36] is a kind of image improvement that enhances some image features or eliminates undesired distortions for further processing. The major image processing techniques used in the study are conversion of RGB into grey, resizing of images and filtering [5] [7] [10]. Noises in the processed images can be removed using various filters

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 4, 2021, Pages. 2275 – 2290
Received 05 March 2021; Accepted 01 April 2021.

such as mean filter, median filter [36], Gabor filter [5] and Weiner filter [16]. The quality of the images can be enhanced using various enhancement techniques such as contrast enhancement [9], gamma correction [36] and CLAHE enhancement [33].

2.3 Image Segmentation

Image segmentation [11] [16] [18] [21] [27] [36] [37] is that the method of partitioning a digital image into multiple segments. The results of image segmentation could be a set of segments that conjointly cowl the whole image, or a group of contours extracted from the image. every of the pixels during a region is comparable with reference to some characteristic or computed property, like colour, intensity, or texture**.** The investigation of osteo arthritis and rheumatoid arthritis is implemented using various segmentation techniques. As per the study some of the major segmentation techniques used are:

- Pixel based segmentation [1] [6]
- K-means clustering [13] [37]
- Fuzzy c-means algorithm [5] [11] [13]
- Active contour segmentation [12] [28]
- Thresholding [14] [24] [39]
- Otsu's segmentation [7] [8] [21] [37]
- Crude segmentation[35]
- Consensus segmentation [37]
- Seeded region growing method [37] [21]
- Fast greedy snake algorithm [35]

2.4 Edge Based Segmentation

Edge detection [5] [7][10] [21] [31] allows us to store structural information of the objects present in an image in a very small storage area. The various edge detection methods used in the study are sobel [7] [10] [21] edge detection, canny [10] edge detection, Laplace [10] [21] edge detection, Robert's detection [10], prewitt [7] [10] edge detection and zero crossing [10].

2.5 Feature Extraction

Feature extraction [40] [5] [13] [14] [15] [22] [27] is the most vital part in every image processing application. In this stage we compute features of the segmented images which results in recognition accuracy with simple classification modules. The Authors have generated various features from the segmented region. The features computed are morphological features,Haralick features [4], shape based features [11] such as area, perimeter, circularity, roundness, solidity, textural features [31] such as grey tone difference, run-length matrix, GLCM features [5] [15] and statistical features [24] [14] [13] [9] such as mean, deviation, kurtosis, skewness, energy, correlation, contrast etc., They have also used various methods to extract features such as Euclidean distance [9], histograms[33] [5] , inverse transform [16], independent component analysis[8] and particle swarm optimization [20], Local Binary Pattern [40] and Histogram Oriented Gradients [40].

2.6 Classification

In this stage, the extracted features from the input images are given as input to the classifiers [9] [19] [22] [29] [28] [17] [19] [25] [38] [40]. Based on the comparison of parameters with the database the classifiers generate the output. The researchers have used both image

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 4, 2021, Pages. 2275 – 2290
Received 05 March 2021; Accepted 01 April 2021.

processing [31] [32] [14] and machine learning-based classifiers [29] [17] [18] [23] to classify the outputs. As per the study, some of the major classification techniques used are:

- Support Vector Machine [9] [22] [28] [29] [31] [32] [38] [40]
- Multi-class SVM [28]
- Artificial Neural Network [29]
- Convolutional Neural Network [17] [18] [23] [12] [8]
- Back Propagation Learning Algorithm [2]
- K-Nearest Neighbour [7] [40]
- Random Forest Classifier [4] [8] [19] [26] [40]
- Naïve Bayes Classifier [8] [29]
- ADTree Classifier [14]
- Adaboost Classifier [19] [25] [29] [26]
- Bagging Classifier [19]

As per the study, most of the researchers have concluded that Support Vector Machine classifier [40] [31] [29] [19] [22] [31] [38], Random Forest Classifier [4] [8] [26] [19] and Adaboost classifier [29] [25] were obtained highest accuracy than the other classification methods.

3. Systemizationof Rheumatoid Arthritisand Osteoarthritis

As per the study, researchers have explored different methods on the detection and analysis of rheumatoid arthritis [43] [12] [13] and osteoarthritis [8] [16] [21]. Medical imaging [9] [13] [15] plays a vital role to diagnose and treat the diseases. Various imaging technologies have been used by the researchers are X-ray radiography [35] [38], Magnetic Resonance Imaging (MRI) [40] [39], Ultrasound Imaging [28] [33], Medical Photography and Thermal Imaging [13] [15]. Computer aided diagnosis like Artificial Intelligence (AI), Pattern Recognition, Feature Extraction techniques [13] [14] [15], Machine learning techniques [22] [17], Segmentation techniques [16] [18] etc., which are commonly used in the processing of medical images. To identify the appropriate progression and severity of the disease medical imaging is implemented in terms of X-ray imaging, Thermal imaging, ultrasound imaging and Magnetic resonance imaging.

3.1 Diagnosis using Various Imaging Technologies

3.1.1 X-ray Imaging

X-ray imaging [15] [21] [24] gives us a 2-Dimensional view of our bone joints. They show various signs of arthritis like bone narrowing, bone spurs, bone erosions, bone fractures, synovial fluid change and joint space narrowing. Fig 4 shows the X-ray images of normal and abnormal conditions of bone joint space.X-ray imaging is the first imaging technology used to detect osteo arthritis, rheumatoid arthritis and inflammation arthritis.

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 4, 2021, Pages. 2275 – 2290
Received 05 March 2021; Accepted 01 April 2021.

Figure4. X-ray image of the bone joint (Courtesy. Ref no. 43)

3.1.2 Ultrasound Imaging

Ultrasounds [28] [33] can be useful at showing inflammations in tissues, tendons and joints. Mostly Ultrasounds has been used to detect Rheumatoid arthritis.

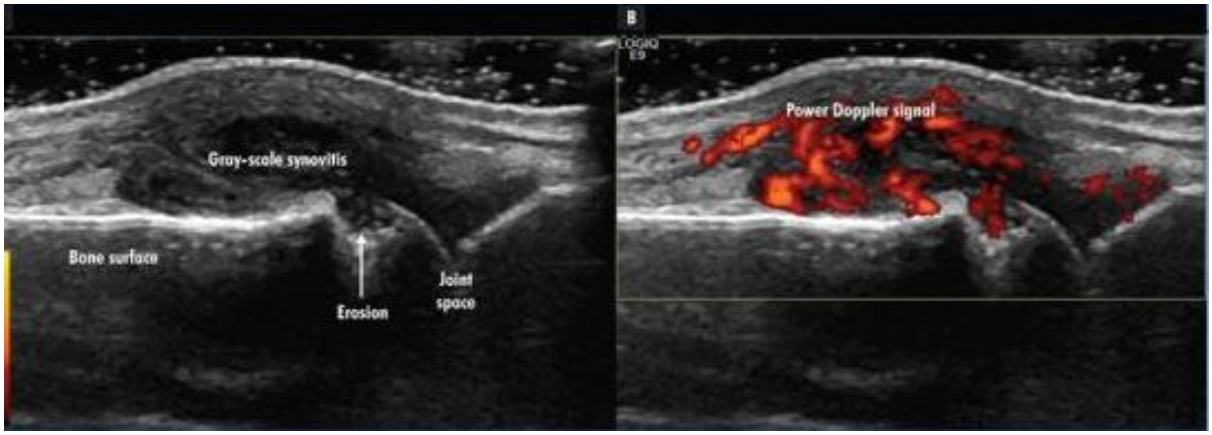

Figure5. Ultrasound image of the bone (Courtesy. Ref no. 44)

Ultrasound Imaging uses a high frequency sound waves to create an image which helps for spotting crystal deposits in joints and joint erosion from gout. Fig 5 shows the ultrasound image of eroded bone joint.

3.1.3 Magnetic Resonance Imaging

Magnetic Resonance Imaging [18] [34] [39] [40]gives us a 3-Dimensional view of our bones. MRI can be useful at showing mild to severe infections at bone joints, tears in meniscus, fluid build-up etc., MRIs are way expensive in cost compared to the other available imaging technologies. Fig 6 shows the sample MR Image of the bone.

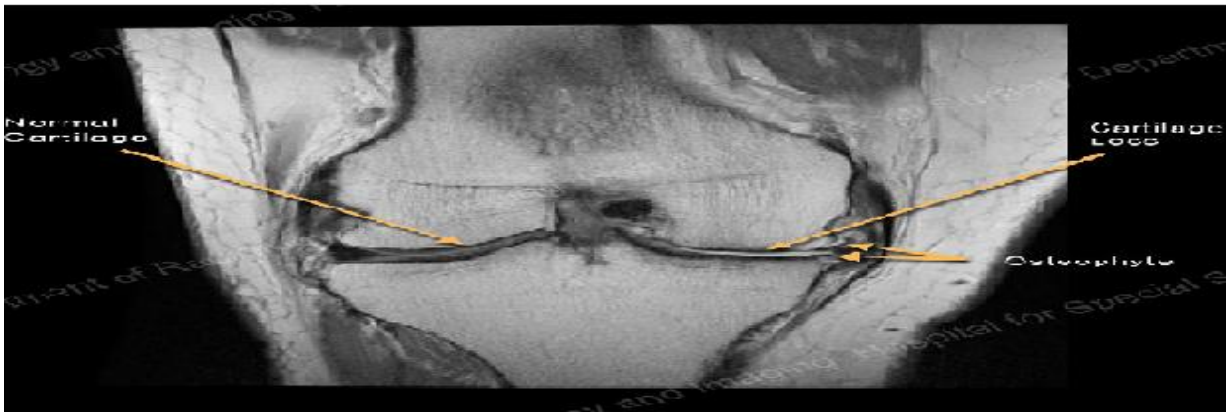

Figure6. MR Image of the bone (Courtesy. Ref no. 45)

3.1.4 Thermal Imaging

Thermal imaging [13] [15] [24] [36] is one of the emerging technologies in detection of arthritis.

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 4, 2021, Pages. 2275 – 2290
Received 05 March 2021; Accepted 01 April 2021.

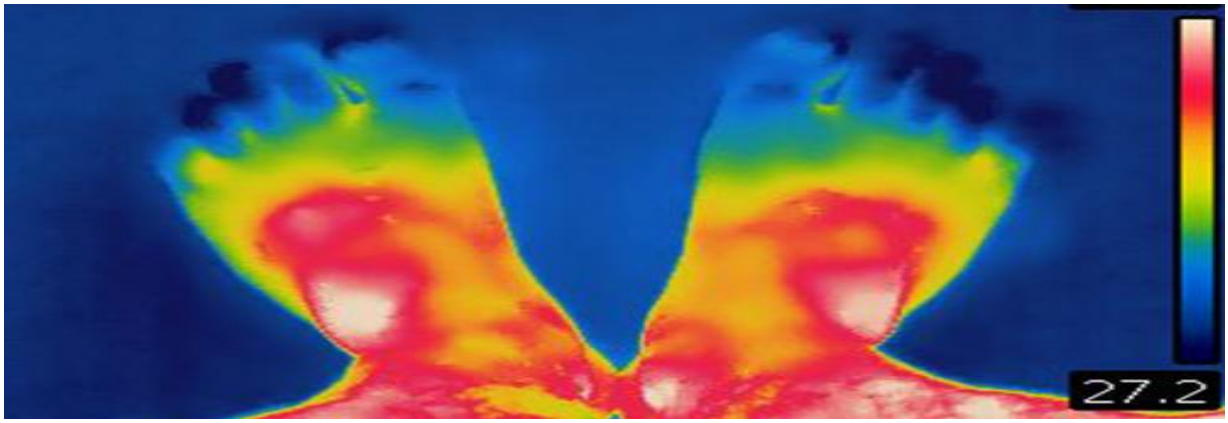

Figure7. Thermal image of the inflamed bone (Courtesy. Ref no. 46)

As per the study, researchers have found that the temperature values are higher at palm and finger regions of arthritis affected patients. The temperature difference might be the result of disease activity [3]. Fig 7 shows the thermal image of the inflamed bone.

Many experiments and algorithms have been used and developed by the researchers to detect and classify the type of arthritis such as osteoarthritis, rheumatoid arthritis using various imaging technologies are.,

2015: Bhagayashri L. wagai et al [1], have used pixel-based segmentation method to diagnose the osteoarthritis disease. The cartilage of knee joint was segmented using pixel-based segmentation method. Cartilage area was calculated from the segmented images and depending on its estimated value, the image is classified into normal one and the affected one. In this work they have used totally 32 images in which 16 are normal one's and 16 are affected with osteoarthritis. For normal case, it has classified all the images correctly. For affected case, it has misclassified one image among 16 images. They have achieved 100 % accuracy in normal case and 96.87% accuracy in abnormal case.

2016: Abdulkadarheman et al [2], have developed new intelligent system for the identification of Rheumatoid arthritis. They have used both image processing and machine learning techniques. The whole system was divided into two stages. The first stage is the image pre-processing stage in which the images are pre-processed and the second stage is the classification stage. They have used back propagation learning algorithm which involved training of the network on 400 knee x-ray images of both normal and affected with rheumatoid arthritis. They have achieved good identification rate of 95.5 %.

2016: Gopi Krishnan et al [3], have used thermal image segmentation to diagnose the presence of Rheumatoid arthritis. Thermal imaging technique is based on infrared thermo grams, that shows a temperature variation in disease affected regions. They have used fuzzy c means image segmentation method to segment the thermal images. From the segmented images they have extracted statistical features like standard deviation, mean, kurtosis and skewness. They have used totally 10 images in which 5 images are from normal case and the remaining 5 are from affected with rheumatoid arthritis. They have concluded that comparing to the normal one's, the abnormal images have higher values on their features due to high temperature variation.

2016: Shivanand S. Gornale et al [4], have used semi automated system to detect osteoarthritis in x-ray images. They have used three major image processing techniques in their system. They are pre-processing, segmentation and classification. They were collected 200 knee x-ray images from the diagnostic centres. The active contour segmentation method

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 4, 2021, Pages. 2275 – 2290
Received 05 March 2021; Accepted 01 April 2021.

was applied on the pre-processed images. From the segmented images they have extracted features like haralick, statistical, texture, shape, first four segments. The extracted features were classified using random classifier. Out of 200 images 40% were used for training, 60% were used for testing. They have concluded that among 200 images the success rate was up to 87.92%.

2017: Tanudeepkaur et al [5], have used various image processing techniques to detect bone fraction on x-ray images. The major techniques used in this work are Fuzzy c means, multilevel wavelet transform, thresholding, Gabor filter, histogram smoothing and Hough transform. The collected images were pre-processed, segmented using thresholding and Fuzzy c means method. From the segmented images, edges were detected using Gabor filter. Hough transform was used to find the longest line in the bones then multi-level wavelet transform was applied on the extracted GLCM features. They have concluded with accuracy 89.6%, precision 93%, sensitivity 93.5 %. The only drawback of their system was fracture found only on horizontal images.

2017: M. subramonium et al [6], have used a novel method to diagnose the arthritis at the earliest. They have used radiographic images collected from the arthritis affected patients. From those radiographic images they have identified change in pixel formation due to abnormality caused by the arthritis. The authors have concluded that the proposed algorithm is applicable for all types of bone joints.

2019: Shivanand S. Gornale et al [7], have used major segmentation techniques in image processing to detect arthritis. They are sobel edge detection, prewitt segmentation, texture-based segmentation and Otsu's segmentation. Statistical features are extracted from the segmented image. K-nearest neighbour was used to classify the affected and normal one's. They have concluded that 91.16% accuracy for Sobel method, 96.80% accuracy for Otsu's method, 94.92% accuracy for texture method and 97.55% accuracy for Prewitt method was obtained. Out of the 4 methods, it was observed that Otsu's method and Prewitt method have outperformed compared to other methods.

2019: AbdelbassetBrahim et al [8], have presented a fully developed computer aided system for early osteoarthritis diagnosis. They have performed both medical imaging and machine learning algorithms. The collected images are pre-processed using circular Fourier Filter. From the pre-processed images, the features are extracted using independent component analysis approach. For the classification task, they have used naive Bayes and random forest classifiers. This proposed approach was applied on 1024 knee x-ray images, which are collected from public database. They have concluded that, accuracy 82.78%, sensitivity 87.15% and specificity 80.65% was obtained.

2019: Karpagavallikuppusamy et al [9], have developed an algorithm to detect the osteoarthritis on knee x-ray images. They have performed various image processing methods such as pre-processing, Image enhancement and feature extraction using Euclidean distance. The extracted features were classified using Support Vector Machine classifier. They have concluded that 65% of osteoarthritis images were differentiated from normal OA.

2020: Maheukh Saleem et al [10], have presented a computer vision-based approach to diagnose the osteoarthritis. They have used different image processing techniques on the knee radiographic images. They have performed six edge detection algorithms such as sobel, prewitt, Laplacian, Roberts, zero crossing and canny's for evaluating the proposed method. Out of which, canny's edge detection have achieved best detection accuracy. They have concluded that the proposed algorithm gives efficient good results.

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 4, 2021, Pages. 2275 – 2290
Received 05 March 2021; Accepted 01 April 2021.

2016: Chun Soo Ahn et al [11], have proposed fully automated level set based segmentation to diagnose three types of knee cartilage. They have constructed new template data from database consists of osteoarthritis affected patients. Fuzzy c-means clustering technique were used for an automatic initialization of contours. The proposed algorithm resulted in 87.1% of femoral cartilage, 84.8% of patellar cartilage, 81.7% for tibial cartilage.

2019: RJ Hemalatha et al [12], have proposed an automated system to diagnose Rheumatoid arthritis using deep learning approach. The proposed method was based on spatial analysis using intensity-based approach to segment skin border, bone region, bone line and distance. An active contour technique was used to determine the synovial region. Convolution neural network were used to diagnose the particular grade of synovitis. Finally, validation and evaluation were performed using five-fold cross-validation kernels.

2017: Snehalathaumapathy et al [13], have developed a computer aided diagnostic tool for the evaluation of Rheumatoid arthritis. They have acquired thermal images from both normal subjects and RA affected subjects. K-means algorithm and fuzzy c-means algorithm were the two segmentation methods used to segment the captured thermal images. Selected features were extracted from the segmented images. They have concluded that k-means algorithm provided better segmentation results compared to the fuzzy c-means algorithm.

2017: Chokkalingam Subramaniam et al [14], have proposed threshold segmentation method with slider control for diagnosing Rheumatoid arthritis from lymphocyte images. The pre-processed lymphocytes images were segmented using threshold segmentation method. They have extracted area, perimeter, circularity, roundness and solidity from segmented lymphocytes. The ADTree classification method were used to classify features and based on this, decision rules were generated.

2017: U Snekalatha et al [15], have used computer aided diagnosis for the detection of RA using x-rays and thermal imaging. The x-ray images were segmented using fast greedy snake algorithm and features were extracted using grey level co-occurrence matrix. The thermal images were segmented using RGB based segmentation and features were extracted using statistical analysis. The authors have concluded that thermal imaging provided better results than the radiographic images.

2017: Ravindra S. Hegadi et al [16], have proposed an automatic segmentation algorithm to detect the synovial cavity using image processing techniques. The osteoarthritis affected knee images were enhanced using wiener filter and the images were binarized by applying thresholding. The synovial cavity was extracted by applying inverse transform. They have obtained better segmentation results compared with the manual segmentation.

2018: Kernaloreten et al [17], have proposed an automated diagnostic method to detect rheumatoid arthritis using convolutional neural network. The CNN network was trained using 135 hand radiographs, out of which 61 were normal and 74 were affected with RA and tested it on 45 radiographs, out of which 20 were normal and 25 were abnormal. They have obtained 73.33% of accuracy, 68% of sensitivity, 78% of specificity and 75% of precision.

2018: Fang Liu et al [18], have developed a deep learning approach to detect cartilage lesions within the knee joints of MR images. The proposed system consists of two 2D deep CNN's. The Rapid segmentation of cartilage and bone was performed by first CNN. The Classification within the segmented cartilage tissues was performed by second CNN. The proposed system was implemented in a hybrid computing environment involving python and MATLAB. They have achieved better diagnostic accuracy for detecting cartilage lesions.

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 4, 2021, Pages. 2275 – 2290
Received 05 March 2021; Accepted 01 April 2021.

2019: Ho Sharon et al [19], have used machine learning algorithms for the classification of Rheumatoid arthritis. In their work, four different classifiers were used to distinguish between normal subjects and affected with RA. They were bagging, Adaboost, random forest and SVM classifier. The authors have concluded that out of four classifiers, SVM and bagging classifiers provided better classification results than the other two classifiers.

2019: S. Shanmugam et al [20], have presented a hybrid optimization strategy called REACT to diagnose Rheumatoid arthritis. The REACT was based on the combination of Iterative Dichotomizer, Particle swarm optimization and classification. The features were extracted and selected using Iterative dichotomizer and Particle swarm optimization. For classification, they have used weighted tree approach to classify between RA and non-RA.

2018: YongpingLi et al [21], have constructed a knee osteoarthritis diagnostic system using x-ray images. They have used four indicators to detect osteoarthritis. They were articular sclerosis, intra-articular loose bodies, asymmetric joint space and rugged articular surface. The pre-processed x-ray images were segmented using Otsu segmentation method and region growing method. The edges were extracted using sobel, canny and Laplace operators. They have concluded that the system had the highest recognition rate for determination of intra-articular loose bodies and the lowest recognition rate for determination of rugged articular surface.

2018: Kentomorita et al [22], have proposed an automatic joint detection method to diagnose Rheumatoid arthritis using machine learning techniques. The proposed method was composed of 3 steps. They were image patch extraction, modified total sharp score estimation and finger joint detection using SVM classifier. The results showed that 91.8% of finger joint detection accuracy was obtained.

2018: AlekseiTiulpin et al [23], have developed a deep learning-based approach to diagnose knee osteoarthritis from plain radiographs. The data were acquired from two public data sets. They were MOST and OAI. MOST dataset was used for training. OAI dataset was used for testing. The acquired images were pre-processed and classified using deep Siamese CNN architecture. They have concluded that the proposed method helps in better diagnosis of disease.

2018: Agnieszka Wasilewska et al [24], have used image processing techniques to identify Rheumatoid arthritis using thermal images. They have identified heat patterns from ROIs to identify the presence of RA. The thermal images were generated by a thermal scanning camera. The temperature measurement was performed at post-cooling temperature and post-recovery temperature. Thresholding method were used to isolate the foot from the pre-processed thermal images. The features were computed using statistical analysis. Results revealed that statistically significant differences between inflamed and healthy area was found.

2019: YafeiOu et al [25], have developed computer aided diagnosis of Rheumatoid arthritis using image processing techniques. Phase only correlation (POC) was used to detect the progression of Joint space narrowing between images. The acquired images were pre-processed and segmented using Otsu's segmentation method. Adaboost classifier were used for classification task. They have concluded that, the proposed method was effective for patients who are in early stages.

2016: RafalCupek et al [26], have used major image processing and machine learning methods for the assessment of joint synovitis activity. The major computed features were co-occurrence matrix, gray-tone difference and run-length matrix. Random forest classifier was

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 4, 2021, Pages. 2275 – 2290
Received 05 March 2021; Accepted 01 April 2021.

used for classification task. The authors were successful in calculating the joint synovitis activity for classifying RA.

2017: FartashVasefi et al [27], have developed a mobile medical application to diagnose the hand arthritis. The presented system consists of a smartphone camera, patient input, internet connectivity and cloud-based image processing techniques to analyse physiological characters of hands in OA affected patients. The major image processing techniques used in their work were pre-processing, segmentation, hough transform, feature extraction. They have concluded that the methods used have the ability to accurately visualize the hand OA.

2018: R.J.Hemalathaet al [28], have used contour based segmentation methods to detect synovial region in arthritis affected ultrasound images. The major contour-based segmentation methods used in their work were Caselles, Bernard, Chan-vese, Chumming Li, Lankton. Among the 5 segmentation methods the best suited were identified using statistical analysis. Multi class SVM were used for classification. The authors have concluded that Lankton method was the best for synovial region segmentation from ultrasound images.

2018: J.Shanmugan et al [29], have proposed Machine Learning based Ensemble Analytic Approach(MLEAA) to defect Rheumatoid arthritis. The proposed method consists of 2 major phases such as learning phase and prediction phase. Map reduce framework in Hadoop were used for data processing in Learning phase. Adaboost, SVM, ANN and Naïve Bayes algorithms were used in the prediction phase. The best classification rate of 85% was achieved using Adaboost classifier.

2018: Urban PAVLOCIC et al [30], have proposed a combination of hyperspectral imaging and 3D profilometer to diagnose Rheumatoid arthritis. The proposed imaging system was used to identify the changes in blood flow, concentration of tissue chromophores and tissue oxygenation, which might indicate the presence of RA.

2017: SanjeevakumarKubakkaddi et al [31], have used SVM classifier for the early detection of knee osteoarthritis. The computed textural features such as contrast, correlation, energy, homogeneity and statistical features such as mean, median, variance was fed as training features to the SVM classifier. The results showed that they have achieved 95.45% of accuracy.

2019: S. A. Bhisikar et al [32], have developed an assessment of Rheumatoid arthritis using image processing techniques. In their proposed work RA was classified into 3 stages such as non-RA, RA, severe RA. SVM classifier was used to classify the type of RA. They have obtained 95% of accuracy for non-RA, 70% of accuracy of RA and 100% of accuracy for severe RA.

2018: Hemalatha. R et al [33], have developed histogram-based synovitis scoring system to diagnose Rheumatoid arthritis. They have collected 276 ultrasound images from MEDUSA database. The acquired images were pre-processed, filtered and enhanced using CLAHE technique. The ROI was analysed using histogram technique. The respected features were also extracted from the histogram. Based on the histogram the images were graded into no disease, less severity, moderate and more severity. They have achieved 93% of sensitivity, 94% of specificity and 93.5% of accuracy.

2018: Mallika Arjuna Swamy M. S. et al [34], have used various image processing techniques to detect menisci tears in knee joint. Seeded region growing segmentation algorithm was developed to detect an visualize menisci tears from MRI. Finally, the segmentation accuracy was evaluated using Dice Similarity Coefficient (DSE). The authors

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 4, 2021, Pages. 2275 – 2290
Received 05 March 2021; Accepted 01 April 2021.

have concluded that the developed method was helpful in treatment and surgery planning of knee joint affected patients.

2017: Seiichi Murakami et al [35], have used deep convolutional neural networks to detect bone erosions in RA using hand radiographs. The phalanges region from hand radiographs were segmented using crude segmentation and extracted using MSGVF algorithm (Multi Scale Gradient Vector Flow snake's method). Deep convolutional neural network classifier was used to identify the presence or absence of bone erosion. The proposed method has achieved 80.5% of true positive rate and 84% of false positive rate.

2019: Jolanta Pauk et al [36], have proposed an assessment of Rheumatoid arthritis using infrared thermography sensor. The images were captured using thermo vision camera. The captured images were analysed and the temperature values were extracted using the MATLAB software. The proposed method employed various image processing techniques such as pre-processing, median filtering, gamma correction, histogram thresholding and statistical feature extraction. Finally, group of patients with high disease activity and moderate disease activity were identified.

2019: Kakali Das et al [37], have generated consensus segmentation techniques to detect arthritis from Knee thermograms. The thermograms were captured using FLIRT-650sc camera. The proposed method was compared with the baseline methods such as k-means, Fuzzy c-means, Region Growing and Otsu's thresholding. The authors have concluded that the proposed ensemble consensus segmentation techniques have obtained better results than the baseline methods.

2015: Dattatray Ishwar Navale et al [38], have used block-based texture analysis approach for knee osteoarthritis identification. They have collected 20 x-ray images from normal objects and 20 x-ray images from abnormal objects. The collected input images are divided into 9 blocks of similar size. In which the blocks contained useful information regarding the knee osteoarthritis part only considered for further processing. They have applied texture analysis algorithm to the selected blocks and extracted 6 statistical features. Those extracted features are trained and classified using Support Vector Machine. They have obtained 86.67% accuracy for normal subjects and 80% accuracy for abnormal subjects.

2019: Angi wang et al [39], have proposed semi-automated segmentation technique to detect Juvenile Idiopathic Arthritis (JIA). They have used MR images acquired from the public database. The proposed algorithm was based on multi-level thresholding. They have detected inflamed regions in and around major joints in the ankle using multi-level thresholding. They have concluded that JIA detection was possible using the proposed method.

2019: Ahmet Say Gili et al [40], have proposed an assessment of meniscus tears using MR images. Histogram oriented gradient and local binary pattern were the two feature extraction methods used to extract features from MR images. The selected features were classified using four different classifiers. They were Random forest, SVM, K nearest neighbour and Extreme Learning Machine. The authors have concluded that SVM classifier have achieved highest accuracy of 90.13% than the other classifiers.

4. Challenges and Issues

Different image processing techniques [7] [8] [12] are developed for the detection and classification of osteo arthritis [4] [8] and rheumatoid arthritis [15] [17]. The selection of suitable technique for specific task is most important. Therefore, we may need to develop efficient algorithm to obtain better results. A lot of studies have been carried out by the

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 4, 2021, Pages. 2275 – 2290
Received 05 March 2021; Accepted 01 April 2021.

researchers in the field of arthritis detection, but still, it remains challenging to diagnose the presence of disease at the earlier stage. Early detection is the most important step because, if the disease has not predicted at the right stage it eventually leads to immobility. As per the study, only limited methodologies are available for the early diagnosis. There are three existing methods has been following in clinical diagnosis for arthritis detection. They are imaging studies [9] [13] [18] [21], analysing blood samples and nerve conduction techniques. The imaging studies are non-invasive type, even though they are non-invasive it does not help in earlier diagnosis. The other two methods are invasive type which may cause more pain to the patients. However, all the above-mentioned methods are not useful for early detection of arthritis. Along with these issues, some of the other issues reported by the researchers are anatomical structures such as tibia, cartilage, patella, bone spur, bone marrow [28] [30] [34] [35] [8] etc., are very difficult to analyse, noise effects in images and multi-dimensional images etc.,

5. Conclusion

Analysis of imaging studies is done by the physician manually, which is considered as time consuming and unpredictable. Distortions occurred while imaging may cause problems in analysing the bone structures. Therefore, the difficulties associated with the medical imaging makes it is difficult to observe them in a hastily manner. Even though some progress has shown in developed algorithms, still a several issues need to be addressed. To overcome these issues, we may need to develop fully automated method or diagnostic tool to detect arthritis at the earlier stage.

6. Future Scope

- In the future, there is a need to develop fully automated method to diagnose arthritis. Researchers should focus on better visualization, Quantification and reduced manual interactions.
- A non-invasive type diagnostic tool in a hybrid environment implementedwith the advanced programming languages like python, oracle must be developed.
- The existing image processing and machine learning algorithms must be improved in order to extract more useful information.
- The researchers should focus on developing a device with the combination of hardware and software packages embedded in a single kit.

Hence, a truthful research has been made on various machine learning and images processing techniques for the detection and classification of osteoarthritis and rheumatoid arthritis.

Acknowledgement

This work was supported by Department of Science and Technology, Government of India. The Authors are also thankful to Christian Medical College, Vellore, India for the support extended.

References

[1] BhagyashriL.Wagaj et al. (2015).Osteoarthritis disease detection with the help of image processing technique. International Journal of Computer Applications. 0975 – 8887.

[2] Abdulkader Helwan et al. (2016).Ikrai: intelligent knee rheumatoid arthritis identification, I.J. Intelligent Systems and Applications, 1, 18-24.

[3] Gobikrishnan M et al. (2016).Diagnosis of rheumatoid arthritis in knee using fuzzy c means segmentation technique, International Conference on Communication and Signal Processing.

[4] Shivanand S. Gornale et al. (2016).Detection of osteoarthritis using knee x-ray image analyses: a machine vision-based approach, International Journal of Computer Applications, Vol. 145.

[5] Subramonium. M et al. (2017).A novel method for early diagnosis of arthritis from radiographs using fuzzy-c-means clustering algorithm, ARPN Journal of Engineering and Applied Sciences, Vol. 12.

[7] Shivanand S. Gornale et al. (2019).Study of segmentation techniques for assessment of osteoarthritis in knee x-ray images, I.J. Image, Graphics and Signal Processing, 2, 48-57.

[8] AbdelbassetBrahim et al. (2019).A decision support tool for early detection of knee osteoarthritis using x-ray imaging and machine learning, CMIG, 11-18.

[9] KarpagavalliKuppusamyet al. (2019).Diagnosis of osteoarthritis (OA) progression using image processing, International Journal of Research in Engineering, Science and Management, Vol.2, Issue 3.

[10] Mahrukh Saleem et al. (2020).X-ray image analysis for automated knee osteoarthritis detection, Signal,Image and Video Processing 2020.

[11] ChunsooAhn, Toan Duc Bul et al. (2016).Fully automated level set-based segmentation for knee mris using an adaptive force function and template: data from the osteoarthritis initiative, Biomed Eng online, 15:99.

[12] RJ Hemalatha, V Vijayabaskar et al. (2017).Automatic localization of anatomical regions in medical ultrasound images of rheumatoid arthritis using deep learning, J Engineering in Medicine, 1-11.

[13] SnehalathaUmapathy, Sowmiya Vasu et al. (2017)Computer aided diagnosis-based hand thermal image analysis: a potential tool for the evaluation of rheumatoid arthritis, J. Med. Biol. Eng.

[14] Chokkalingam Subramanian et al. (2017). Analysis of lymphocyte images for diagnosing rheumatoid arthritis using threshold segmentation method with slider control, The Online Journal of Science and Technology, 7, 1.

[15] U snehalatha, T Rajalakshmi et al. (2017).Computer-based automated analysis of x-ray and thermal imaging of knee region in evaluation of rheumatoid arthritis, J Engineering in Medicine, 231(12), 1178-1187.

[16] Ravindra S. Hegadi et al. (2017). Quantification of synovial cavity from knee x-ray images, International Conference on Energy, Communication, Data Analytics and Soft Computing.

[17] Kemal Oreten et al. (2019).Detection of rheumatoid arthritis from hand radiographs using a convolutional neural network, ILAR.

[18] Fang Liu et al. (2018).Deep learning approach for evaluating knee MR images: achieving high diagnostic performance for cartilage lesion detection, Radiology, 1-10.

[19] Ho Sharon et al. (2019).Classification of rheumatoid arthritis using machine learning algorithms, IEEE Student Conference on Research and Development.

[20] S. Shanmugam et al. IMPROVED FEATURE SELECTION AND CLASSIFICATION FOR RHEUMATOID ARTHRITIS DISEASE USING WEIGHTED DECISION TREE APPROACH (REACT), The Journal of Supercomputing 2019, 75,5507–5519.

[21] Yongping Li et al. (2019.)Construction of a knee osteoarthritis diagnostic system based on x-ray image processing, Cluster Computing, 22, S15533–S15540.

[22] Kento Morita et al. (2018).Finger joint detection method for the automatic estimation of rheumatoid arthritis progression using machine learning, IEEE International Conference on Systems, Man, and Cybernetics.

[23] AlekseiTiulpin et al. (2018).Automatic knee osteoarthritis diagnosis from plain radiographs: a deep learning-based approach, scientific reports, 8:1727.

[24] AghieszkaWasilewska et al. (2018).Image processing techniques for ROI identification in rheumatoid arthritis patients from thermal images, acta mechanica, vol.12 no.1.

[25] YafeiOu et al. (2019).Automatic radiographic quantification of joint space narrowing progression in rheumatoid arthritis using poc, IEEE 16th International Symposium on Biomedical Imaging.

[26] RafalCupek et al. (2016). Automated assessment of joint synovitis activity from medical ultrasound and power doppler examinations using image processing and machine learning methods,Rheumatologia ,54, 5: 239–242.

[27] FartashVasefi et al. (2016).Diagnosis and management of hand arthritis using a mobile medical application, SPIE, Vol. 9711. 97110U-1.

[28] RJ Hemalatha et al. (2018).Performance evaluation of contour-based segmentation methods for ultrasound images, HINDAWI, Article ID 4976372, 8 pages.

[29] S. Shanmugam et al. (2018). Design of rheumatoid arthritis predictor model using machine learning algorithms, Cognitive Science and Artificial Intelligence.

[30] Urban PAVLOVCIC et al. (2018).3d Profilometer Combined with Hyperspectral Camera For Simplified Rheumatoid Arthritis Diagnostics, Proceedings of 3DBODY.TECH.

[31] SanjeevakumarKubkaddi et al. (2017).Early detection of knee osteoarthritis using svm classifier, ijseat, Vol. 5, Issue 3.

[32] S. A. Bhisikar et al. (2018).Classification of rheumatoid arthritis based on image processing techniques, RTIP2R, PP 163-173.

[33] Hemalatha R et al. (2018).Histogram based synovitis scoring system in ultrasound images of rheumatoid arthritis, JCDR, Vol.12, Issue 8, p10-14.

[34] Mallika Arjuna Swamy et al. (2018).Detection of menisci tears in sports injured and pathological knee joint using image processing techniques, Computational Vision and Bio Inspired Computing, pp 528-541.

[35] Seiichi Murakami et al. (2018).Automatic identification of bone erosions in rheumatoid arthritis from hand radiographs based on deep convolutional neural network, Multimedia tools and applications, 77, 10921-10937.

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 4, 2021, Pages. 2275 – 2290
Received 05 March 2021; Accepted 01 April 2021.

[36] Jolanta Pauk et al. (2019).Infrared thermography sensor for disease activity detection in rheumatoid arthritis patients, MDPI, 19,3444.

[37] Kakali Das et el. (2019).Segmentation of knee thermograms for detecting inflammation, IEEE.

[38] Dattatray Ishwar Navale et al. (2015).Block based texture analysis approach for knee osteoarthritis identiication using svm, IEEE.

[39] Angi Wang et al. (2019).Semiautomatic segmentation of JIA -induced inflammation in MRI imagesof ankle joints, Medical imaging, Vol. 10949.

[40] Ahmet Sagili et al. (2019).Automated diagnosis of meniscus tears from mri of the knee, ISVOS Journal, 3(2): 92-104.

[41] Online: URL link (https://images.app.goo.gl/9SqEhymrJTSnHj2k6)

[42] Online: URL link (https://images.app.goo.gl/5fmqddCnRtrAr1eh8)

[43] Online: URL link (https://images.app.goo.gl/YQYpMiuvtbT1k1Lr6)

[44] Online: URL link (https://images.app.goo.gl/zRRMUtr4ubwiKPpcA)

[45]Online:URLlink (https://www.hss.edu/images/corporate/OA_NormalCartilage_800x800.jpg)

[46] Online: URL link (https://i.pinimg.com/originals/72/83/b4/7283b415f8679ba2aa67605010018b45.jpg).