IMAGING TECHNIQUES AND COMPUTATIONAL APPROACHES TO DIAGNOSE RHEUMATOID ARTHRITIS – A REVIEW

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ABSTRACT

Rheumatoid Arthritis (RA) is a disease, which is a common, chronic, systemic, autoimmune inflammatory disease that mainly affects the joints of the body; basically fingers, hands, knees and causes disability, premature, morality and chronic ill-health. It targets synovial joints, in which there is a massive accumulation of blood-borne cells such as T cells and macrophages. Blood vessels are formed to support this new tissue and the whole mass is called a pannus progressive erosion to cartilage and bone leads to disability in patients. Till today there is no proven cure for this disease, hence close monitoring of this disease is important in medical treatment. This paper describes the various imaging techniques and the existing computational methods for detecting Rheumatoid Arthritis (RA) in clinical applications.

Keywords: Rheumatoid Arthritis, Computational Techniques, Imaging Techniques, Computeraided Diagnosis.
1. INTRODUCTION

Rheumatoid is an autoimmune disease which affects the Hand joints, Wrist, Feet, Knee, Shoulders and other regions of the body. It afflicts approximately 1% to 2% of the Indian population, with 4% to 6% of people over the age of 50 are suffering from this disorder [1][2]. A hand image affected with RA is shown in Fig.1.

Rheumatology embraces a spectrum of diseases, most of which affect the Locomotors System. Arthritis is a general term which describes particular joint inflammation [3]. During the inflammatory process the Synovial Membrane which supplies lubricant to the joint becomes thickened & increased blood supply increases the Temperature [4].

The synovial tissue also begins to proliferate, causing the normally smooth synovium to form pannus—a rough, grainy tissue that grows into the joint cavity and erodes cartilage as shown in Figure 2.

The early detection and diagnosis of RA is a difficult and most important in diagnosis process [5] The following are the Symptoms of RA.

- Constant or recurring pain or tenderness in joints
- Stiffness and difficulty using or moving joints normally
- Swelling in and around multiple joints
- Warmth and redness in multiple joints
- Difficulty in performing daily tasks
- Arthritis in large and small joints in a more or less symmetrical pattern on both sides of the body
- Weight loss
- Low-grade fever
- Fatigue
- Prolonged morning stiffness (more than 30 minutes)

The remaining part of this paper is organized as follows: In section 2, various imaging techniques used for the detection and diagnosis of RA are given. The existing computational techniques for automating early detection of RA are given in Section 3. Conclusion is given in Section 4.
2. Imaging Techniques used for RA

The various imaging techniques such as X-ray, CT-scan, MRI, Ultrasound and RA scanner used to detect RA are described in this section.

2.1 X-ray Image
X-ray is a diagnostic test which uses invisible electromagnetic energy beams to produce images of internal tissues, bones, and organs onto film. X-ray imaging scan gives the image of patient’s joints which help to determine type of arthritis present. Several Xrays can help track the progression of rheumatoid arthritis in the joints over time. Various experimental results show that this imaging method produces the outline of RA accurately [6].

Rheumatoid arthritis attacks multiple joints and is usually symmetrical, affecting joints on both sides of the body, particularly the finger joints as shown in Figure 3.

2.2 CT-Scan
CT a diagnostic imaging that uses a combination of X-rays and computer technology to produce cross-sectional images in both horizontally and vertically in the body [7]. A CT scan produces a detailed image of any part of the body, including the bones, muscles, fat and organs. CT scans produce more detailed image than the general X-ray images.

Figure 4: Hand CT-scan image show the marginal erosions at the heads of the second to fourth metacarpals in a patient with RA

In the wrist, the early stages of RA cause tenosynovitis of the extensor tendons, causing swelling over the distal wrist. The ulnar styloid may become tender, which indicates inflammatory synovitis. Bony erosions and ankylosis of the carpal bones are also seen and appear to be prominent features in Asian patients. A sample CT-scan image showing the marginal erosion on hand is given in Figure 4.

2.3 MR Imaging
Magnetic resonance imaging (MRI) is a diagnostic procedure that uses a combination
of large magnets, radiofrequencies and a computer to produce detailed images of organs and structures within the body. MRI are more sensitive at detecting bone erosion than X-ray and CT scan images. MRI can able to detect the synovitis, inflammation of the lining of the joints and tendon abnormalities. In addition, MRI detects areas of increased fluid in bone marrow that is a predictor for the development of bony erosion. A T1 weighted MRI scan image of wrist is shown in Figure 5.

![Figure 5. T1 weighted postcontrast coronal MRI wrist scan of a patient with RA.](image)

2.4 Ultrasound Imaging

Ultrasound is extremely sensitive for identifying soft tissue ganglion cysts, tenosynovitis and pannus that can develop in association with rheumatoid arthritis. Ultrasound can also be used to image articular cartilage in certain joints in patients who cannot tolerate an MRI examination and can also be used to guide for diagnostic and therapeutic procedures [8].

![Figure 6: RA in metacarpophalangeal joint in Longitudinal ultrasound image.](image)

2.5 RA scanner

The rheumatoid arthritis (RA) scanner provides a new medical imaging technique, developed specifically for the diagnosis of RA in finger joints. RA scanner is an efficient imaging system used for diagnosing RA in finger joints. The RA scanner allows the in vivo trans-illumination of finger joints with laser light in the near infrared wavelength range. The scattered light distribution is detected by a camera and is used to assess the inflammatory status of the finger joint [9].

![Figure 7: Image of RA Scanner (a) Laser image of a healthy finger joint (b) Laser image of an inflamed finger joint. The inflammation changes the joint tissue’s absorption coefficient, giving a darker image.](image)
3. Existing Computational Techniques used for automatic detection of RA

This section depicts the existing techniques for automatic detection of RA. It will help the reader in understanding the potential and amount of research that have been carried out in this field.

Only few works has been done for automatic diagnosis of RA diseases. Mikhail et al. [13] have proposed Evaluation of a Thermo gram Heterogeneity based on the Wavelet Haar Transform. This method is based on a Statistical Processing of the Thermal Image Histogram. It reveals that the histogram transform analysis gives much new information about change of the human organism state. This method also searches for the quantitative criteria of the image heterogeneity and uses algorithm for evaluating the heterogeneity degree.

Maria et. Al [14] have proposed a Multidimensional Filtering approaches for PreProcessing Thermal Images. This Method effectively corrects some blurring effects which are typically found in thermal infrared images. Christopher et al.[15] used quantitative assessment of pain related Thermal dysfunction through Clinical Digital Imaging. It is an automated computerized evaluation method applied for thermal images in order to facilitate the physician to make proper decision. The potential regions of interest are obtained using fixed dermatomal subdivisions of the body through this method. A method given in [16] uses a Gaussian filter method to bring the presence of disease. This method focused only the reproducibility aspects of the techniques.

4. Conclusions

Segmentation is one of the key tools in medical image analysis. The main application of segmentation in medical imaging facilitates to study the anatomical structures, to indentify region of abnormality, and to help in diagnosis and treatment planning. Therefore, the development of automated segmentation algorithm to detect bone erosion in the images obtained from various imaging techniques finds greater important in the early detection and treatment of RA. This study reveal the fact that the designing of efficient computer-aided tool to diagnose RA is a most necessary and challenging task in the automated diagnostic process.

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