Analysis of Rheumatoid Arthritis through Image Processing

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Abstract

Rheumatoid arthritis (RA) is the most common inflammatory arthropathy worldwide, but may be less prevalent in Asian populations causing pain, swelling, stiffness, and loss of function in joints. The spectrum of magnetic resonance imaging findings encountered in the musculoskeletal system in this disease but these images often found non-productive due to noise present in the image and creates troublesome situation for analysis point of view. The role of image processing in rheumatoid arthritis lies, not in diagnosis, but in evaluation of the integrity of structures affected by the disease process. Since Magnetic resonance imaging is more sensitive to synovial changes than any radiography tech, and may permit quantification of changes in disease activity, as well as evaluation of the effects of drug therapy, and of complications of the disease and its treatment. So analyzing the Magnetic resonance images through image processing tool of Matlab provides easy going approach for diagnosis of the disease.

Keywords: *Arthritis, rheumatoid, synovial, MRI, Musculoskeletal system, Matlab, Image Processing.*

1. Introduction

Rheumatoid arthritis is the most common chronic inflammatory arthropathy worldwide. It afflicts approximately 1 to 2% of the Indian population, with 4 to 6% of people over the age of 50 suffering from this disorder specially in old women's.. In the present paper we demonstrate the Image analysis of MRI and its findings that may be encountered in the musculoskeletal system in association with this disease process. Within 10 years of diagnosis, 50% of patients have severe disability as well as a decreased life expectancy from 3 to 18 years. Early diagnosis of RA and initiation of aggressive therapy early in the course of the disease can diminish disease progression and, in some patients, even lead to drug free remission. Clinical signs of RA, pain and swelling of joints, are usually present and progressive. Swollen joints are among the criteria used to classify a patient as having RA and constitute the major indication for initiating therapy. Rheumatologists detect joint swelling by the classical examination technique. But in early stages of the disease, patients may suffer without apparent joint swelling and with negative radiographs. In these cases, techniques such as high resolution ultrasound (HRUS) or Magnetic Resonance (MR) imaging may reveal morphologic changes or hyperemia in the form of synovial thickening or enhancement and allow a much earlier diagnosis of RA [1].

Rheumatoid arthritis (RA) causes pain, swelling, stiffness, and loss of function in the joints. The disease usually affects the joints, particularly in the wrist and the fingers. Also other parts of the body besides the joints can be affected. Since there is no proven cure for RA available yet, current treatments mainly focus on pain relief, inflammation reduction, and slowing down or stopping joint damage. In order to prevent irreversible joint damage, early detection of RA is essential. For an effective medical treatment it is important that the disease can be monitored closely. Joint damage assessment in hand radiographs is a frequently used method for monitoring the progression of RA.

Patients with rheumatoid arthritis have an abnormal proliferation of synovium, known as pannus, within the joint, frequently associated with effusions. The diagnosis is based on a variety of subjective or nonspecific parameters, including stiffness, fatigue, pain and tenderness, and joint swelling, as well as laboratory measures such as erythrocyte sedimentation rate (ESR) and rheumatoid factor.[2] Numerous medical treatments have been devised, including anti-inflammatory agents, antimalarial agents, and gold salts, as well as more toxic compounds such as methotrexate. Response to therapy has been assessed by clinical parameters and laboratory

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findings. Unfortunately, imaging has played a relatively minor role in the diagnosis of early disease, and is relatively insensitive as a method for assessment of therapeutic response. The plain radiographic findings of rheumatoid arthritis have been extensively studied and are well documented. Classical findings include osteopenia, articular erosions, and joint space narrowing (typically symmetrical), as well as soft tissue swelling. Radiographic findings tend to appear within the first 2 years in 90% of patients with active rheumatoid arthritis [3].Large amounts of bone and cartilage can be destroyed, and advanced disease can produce a dramatic radiographic appearance [4].Plain radiographic changes are, for the most part, irreversible, although reports of partial healing have appeared [5].By the time radiographic changes are seen, the disease is far advanced [3]. Plain films are also difficult to use for study purposes, in that the scoring systems used to grade radiographic findings have limited reproducibility, and evaluation is highly time-consuming[6].Radiographic scoring has also been shown to be prognostically insensitive, and does not necessarily correlate well with functional health status.

Over the last two decades, traditional techniques such as bone scintingraphy, ultrasound, and contrast enhanced US [1] and most recently MR, especially contrast enhanced MR, and were used in two ways: first for early diagnosis, and second to assess the effectiveness of expensive and often fairly toxic therapies. However, MR remains incompletely accepted clinically [7][8][9].

Over the past fifty years, infrared imaging has been applied to many fields. The major limitations encountered in early work were its low resolution, the large size of sensors, and the limited power of computers for the image post processing [10].Anecdotal clinical studies have demonstrated that heat distribution provides a quantitative measure of disease activity and especially of inflammation in knee joints [11][12][13].

2. Imaging Features

Synovium and Effusions in normal joints, synovium either cannot be seen, (as with the SE sequences), or can be visualized only as a thin line (3DFT spoiled GRASS). Abnormalities of the synovium are the earliest lesions seen in rheumatoid arthritis (Figure 1).

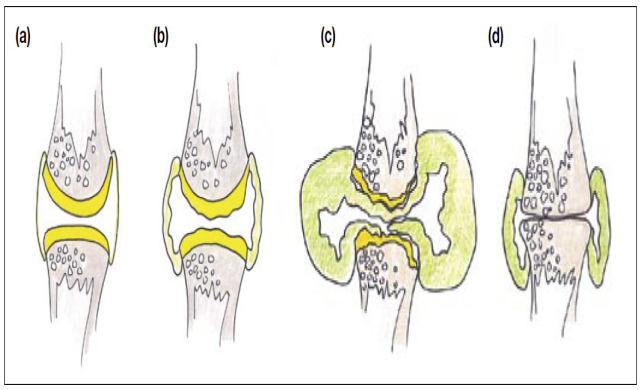

Fig1: Diagrammatic representation of stages in rheumatoid arthritis (RA). (a) Diagrammatic representation of a synovial joint. The cartilage surface of the joint is shown in yellow, with the capsule of the joint being outlined by a thin greenish line representing normal synovium; (b) early RA. The synovium is thickened and has an irregular and nodular appearance. Also note that the surface of the joint demonstrates slight irregularity of the hyaline cartilage due to release of proteolytic enzymes; (c) advanced RA. Gross hypertrophy of the synovium is now apparent and the synovium has migrated across the hyaline cartilage surface. The cartilage is grossly irregular and dramatically thinned, and at times may be completely denuded, with erosion and invasion of underlying bone; (d) end-stage burnt-out RA.Synovial hypertrophy has regressed. However, the normal joint structures have been badly damaged, and superimposed osteoarthritis has developed. Cartilage has been completely destroyed.

Vascular can be used to advantage if contrast agents are employed. Synovium becomes thickened and increasingly nodular as the disease progresses (Figure 2). As the synovium proliferates, the joint becomes filled with synovium, and the abnormal synovium begins to migrate across the hyaline cartilage surfaces of the joint, eventually producing erosions. With further progression, the bone and bone marrow can become invaded. Destruction of surrounding capsular structures and tendons can also occur.

2.1 Application of Image Processing

Processing of digital images include operations involving digital images such as acquisition, storage, retrieval, translation, compression, etc. Conventional examination of the hand radiographs is well established as a diagnostic as well as an outcome measure in Rheumatoid Arthritis (RA). The presence of early soft-tissue swelling is easily recognized on plain radiographs but not readily quantified. Although the presence of early osteoporosis is recognized in the affected hand, a mild osteoporosis may be extremely subtle to the eyes Use of magnetic resonance (MR)

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technique has been shown to sensitively detect early local edema and inflammation prior to a positive finding on plain film radiographs. However, MR is an expensive examination and may not be used as a routine technique. Recent improvements in hardware and software available for digital image processing have led to the quantitative assessment of radiological abnormalities in diagnostic radiology. In this work we present

- Image Acquisition: image is acquired and brought into the system (digital camera, CAT scan) usually requires pre-processing, e.g., scaling, sampling
  - Compression: image archive size is reduced (storage, transmission) error free, and error prune compression
  - Segmentation: image is partitioned into features (e.g., boundary of objects)
  - Representation: extract features are stored outside the image
  - Recognition: image objects are being identified (e.g., liver, kidneys, spine)
  - Image Enhancement: image is made clear to the user by enhancing some of the features of the image this is a subjective operation (it looks good)
  - Image Restoration: image is improved- this operation is objective (e.g., noise removal)

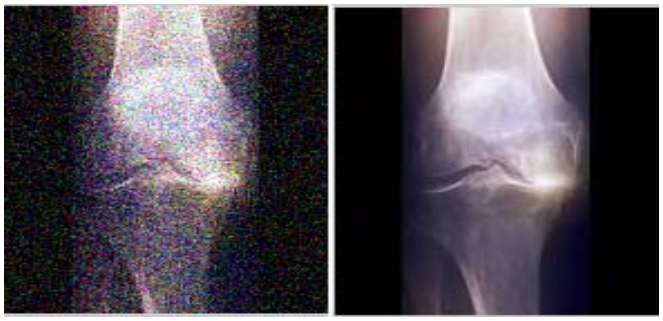
The basic data structure in MATLAB is the array, an ordered set of real or complex elements. This object is naturally suited to the representation of images, real-valued ordered sets of color or intensity data.

3. Methodology Used: Figures and Equations

Method-1

First step is to acquirement of images that can work as sample and then applying the basic techniques of image processing such as Image Enhancement and Image Restoration as in figure 2(a) we have noisy image of knee joint of a patient having Rheumatoid arthritis and 2(b) is the image after filtration through Gaussian filter method for more closer look of the presence of disease .Another important image analysis is done by applying image cropping tech for image 2 .Figure 3 presents the cropped image of knee joint only for easily diagnosis of the presence of disease. The presence of Rheumatoid arthritis as upper bone and lower bones are coinciding in left half segment. Image3 shows cropped image demonstration for patient having RA ,it is noticeable that the final image obtained after processing region of interest nearby at the joint of knee and only the portion of interest is considered for analysis point of view. The knee joint image of old person having Rheumatoid arthritis is compared with knee images of healthy person having perfect knee joint spacing in figure 4 along with cropping tech. Application to differentiate in more clear way. These are the tech by which any one can diagnosis of the presence of disease.

Experimental Results:



(a) Image with salt and pepper noise
(b) image using Gaussian filtering technique

Fig 2: Images With and Without Noise

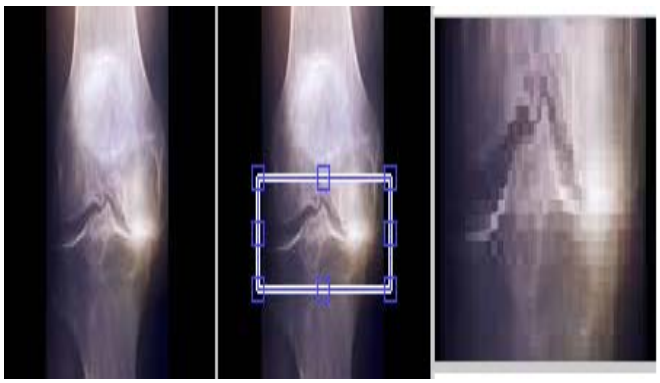


Fig 3: Cropped Images of Patient Having Arthritis

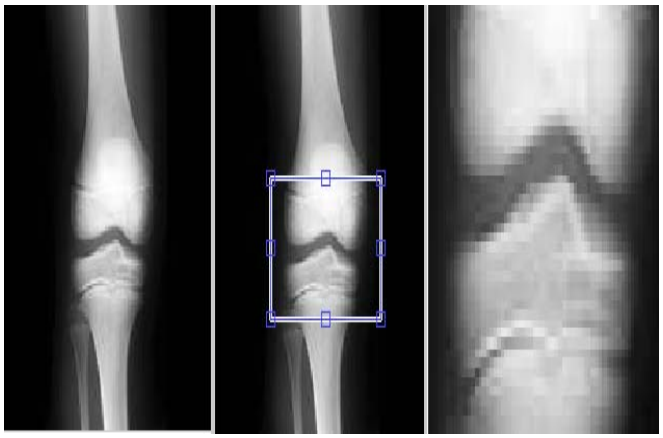


Fig 4: Cropped Images of healthy person without Arthritis

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Method-2

Another important for image analysis is provided in image 5 and techniques of Intensity adjustment along with Gamma correction tech are applied for analysis point of view for the knee image of old person having Rheumatoid arthritis. Similarly the difference between these two images can also be analyzed using through Histogram equalization tech and shown in figure 6 (a) for old person & (b) for healthy person

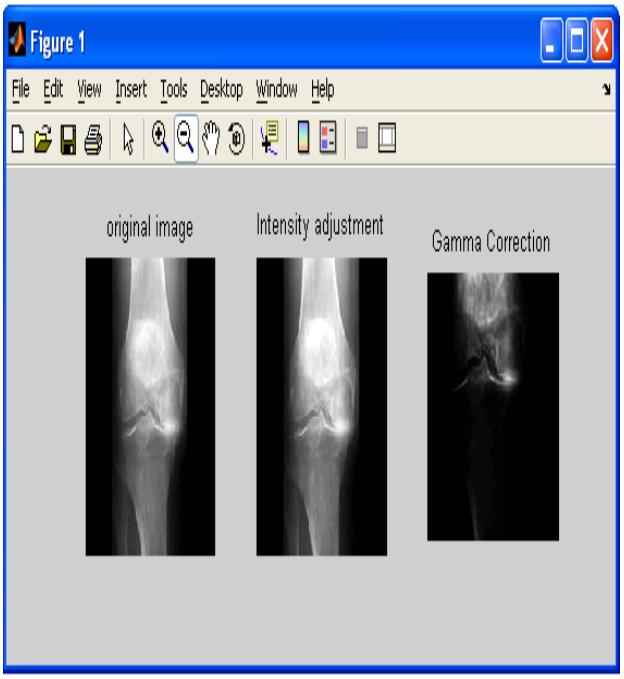

Fig 5 Intensity improved and gamma corrected Images of old person having Arthritis

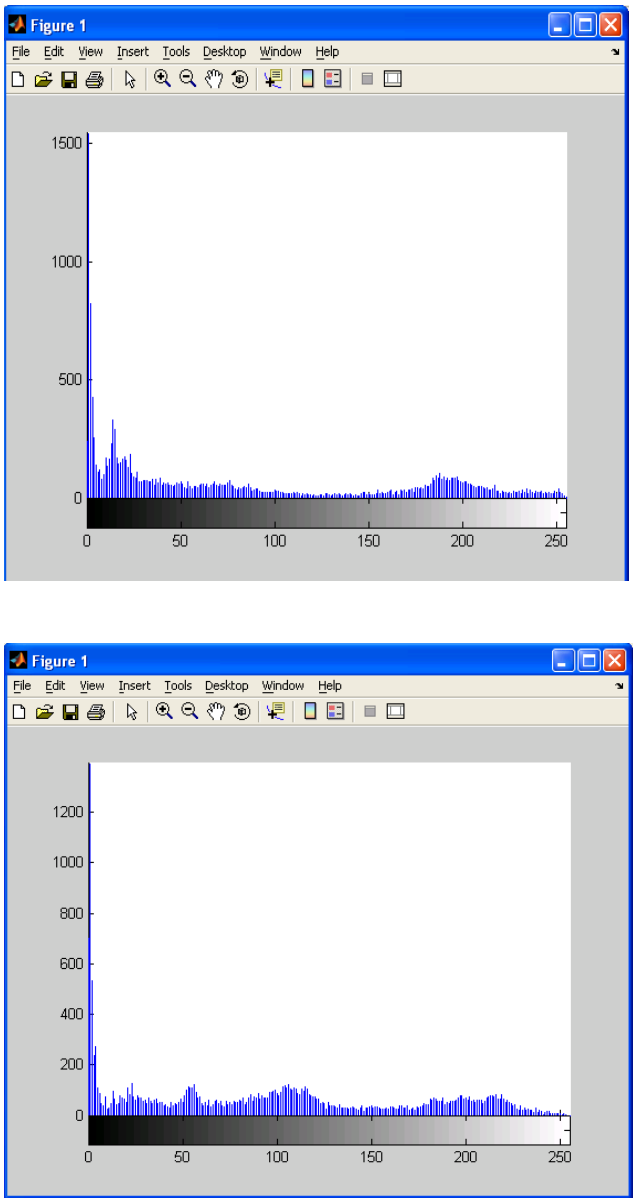

Fig 6: Histogram Equalization for (a) old person (b) for healthy person

Method-3

Another important tech for analyzing the images through median filtering and applying mask along with convolution .Since median filtering is a nonlinear operation often used in image processing to reduce "salt and pepper" noise. Median filtering is more effective than convolution when the goal is to simultaneously reduce noise and preserve edges.

B = medfilt2 (A, [m n])

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Performs median filtering of the matrix A in two dimensions. Each output pixel contains the median value in the m-by-n neighbourhood around the corresponding pixel in the input image. If the input image A is of an integer class, all the output values are returned as integers. If the number of pixels in the neighborhood (i.e., m*n) is even, some of the median values might not be integers. In these cases, the fractional parts are discarded. Logical input is treated similarly. Medfilt2 uses ordfilt2 to perform the filtering.

Convolution tech utilizes conv2 command and uses a straightforward formal implementation of the two-dimensional convolution equation in spatial form. If a and b are functions of two discrete variables, n_1 and n_2 , then the formula for the two-dimensional convolution of a and b is

$$c(n_1, n_2) = \sum_{k_1=-\infty}^{\infty} \sum_{k_2=-\infty}^{\infty} a(k_1, k_2)\, b(n_1 - k_1, n$$

In practice however, conv2 computes the convolution for finite intervals.

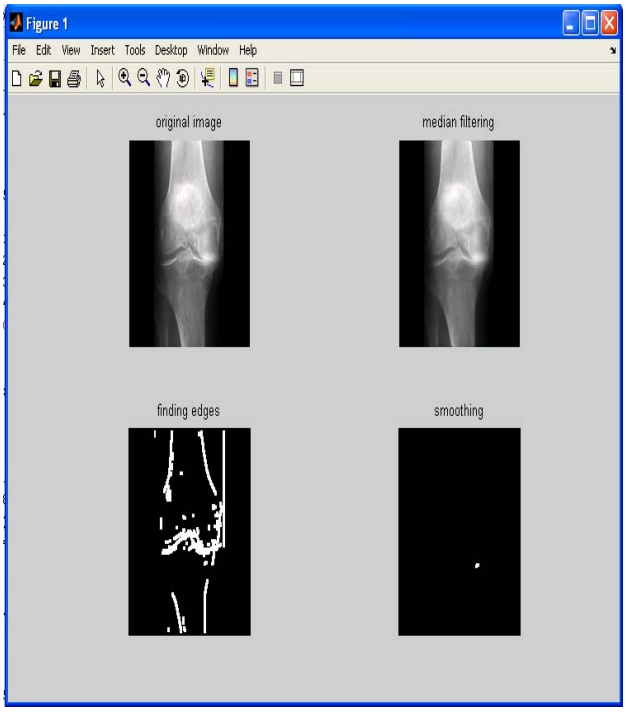

Fig 7: Images of old person having Arthritis

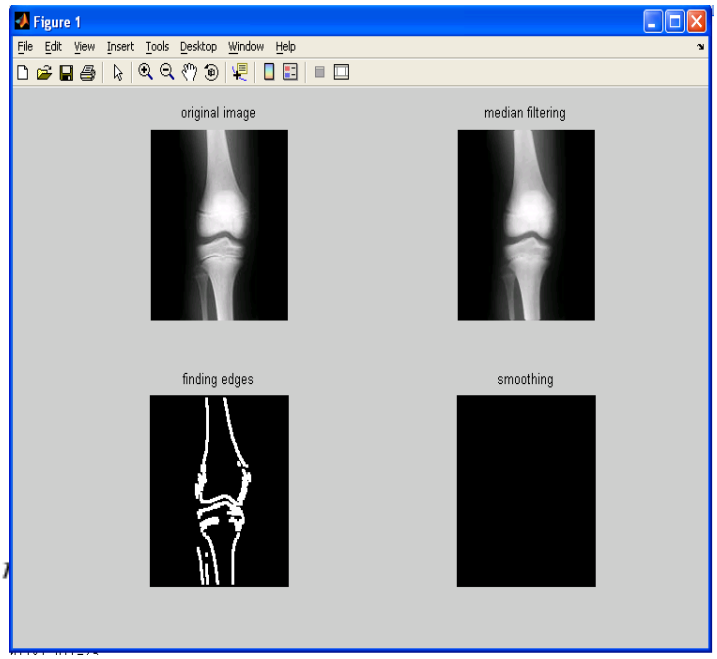

Fig 8: Images of healthy person without Arthritis

4. Conclusion

In this paper a radiographic Image processing based methodology is presented to accurately and reliably diagnosis of the presence of disease Rheumatoid arthritis. The results presented here are preliminary and focused only the reproducibility aspects of the technique. This technique is being applied towards monitoring early stage rheumatoid arthritis patients in an ongoing clinical trial. Results obtained from the clinical trial data should provide a better understanding. The present article provides thought of better understanding towards the disease in comparative way.

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