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Arthritis Prediction by Thermal Image Processing & Neural Network

Rozina Naz[1,] Dr. Mohtashim Ahmad[2,] Mr. Manish Karandikar[3]
(Assistant professor at Sadabai Raisoni women's College Nagpur)
(Assistant Professor at AIIMS Bhopal)
(President JIGYASA Research And Development Society Nagpur)

Abstract: *Rheumatoid joint inflammation is characterized as a perpetual incendiary issue which influences the joints by hurting body tissues. Therefore, there is an urgent need for an effective intelligent identification system for Rheumatoid arthritis especially in its early stages. This paper is to develop a new intelligent system for the identification and prediction of Rheumatoid Arthritis of the joints utilizing thermal image processing techniques and neural network. The system have some principle stages. first we load a thermal image and then select a region of hand or affected area using matlab image processing. we then read the pixels and calculate the temperature based on colour of pixel in thermal images. Due to inflammation at joints the pressure in the veins get increase which cause blood to flow rapidly with rise in temperature, on the basis of temperature on joint we are trying to predict the arthritis in early stages. The extracted features are used then as inputs for the neural network which classifies thermal joints images as normal or abnormal (arthritic) based on temperature calculation using backpropogation algorithm.*

Keywords: *Rheumatoid Arthritis, backpropogation algorithm, inflammation, perpetual incendiary issue, prediction.*

I. Introduction

Thermal image processing using MATLAB plays a vital role in evaluation and monitoring the inflammation in joints. Thermal imaging is a non invasive method for detecting the pathogenesis of the joint disease compared to other diagnostic methods. The importance of this imaging technique is that it is a non-invasive thermo graphic examination, both from an operational and health standpoint. Inflammation in joints is known as a disease rheumatoid arthritis, Rheumatoid arthritis is a disease of unclear aetiology. It is a autoimmune disease which causes chronic and inflammatory disorders and affects the primary joints and it principally attacks flexible joints. This results in painful condition which may lead to substantial loss of functioning and mobility of body. The objectives of this study is i) to evaluate the rheumatoid arthritis based on heat distribution index and skin temperature measurements and to analyse the difference in skin temperature measurement in hand for RA patients and normal persons. ii) to automatically segment the abnormal regions of the hand especially for arthritis patients using fuzzy c means algorithm and Expectation Maximization (EM) algorithm. In this paper, thermal image analysis was done based on heat distribution index(HDI) and skin temperature measurement. The heat distribution value is obtained as 1.53±0.5 From the temperature analysis the results predicted was there is an increase in temperature of 0.96°c in hand region of RA patients compared to normal patients. The correlation between HDI and skin temperature measurement was statistically significant (r=0.63, p<;0.05). Fuzzy c-means algorithm has better results compared to EM Algorithm in evaluating the disease.In short The objectives of this study is to evaluate the rheumatoid arthritis based on heat distribution index and skin temperature measurements and to analyze the difference in skin temperature measurement in various parts of body of RA patients and normal persons using MATLAB image processing. Following fig. shows the stages of rheumatoid Arthritis.

II. Related Prior Work

Thermal imaging acquisition and digital analyses

The Seahorse Bioscience TSA ImagIR Thermal Imaging system (Seahorse Bioscience, N Billerica, Massachusetts, USA) was used in accordance with the manufacturer's procedures to image rats at every time point . The TSA ImagIR employs a platinum silicide 256×256 pixel detector array filtered to be sensitive to infrared radiation in the 3–5 μm wave length. This sensor returns signals to the processor that are proportional to the photons of infrared radiation detected. These data, combined with thermal reference devices, allow the instrument to detect the temperatures of all objects in the field of view simultaneously and in real time.

Thermal imaging work station and monoarthritis rats. (A) Work station with anaesthesia chamber (ac) and thermal imager acquisition station (as). The open compartment has a sliding platform where anaesthetised rats are positioned for image **...**

Preliminary investigation in thermal imaging on mammals(RATS) are conducted by professional laboratories and its findings are as mentioned ahead. Rats had anaesthesia induction in a sealed acrylic chamber by administration of 5% isoflurane in oxygen flowing at 2 l/min for approximately one minute. Following induction, rats were transferred from the acrylic induction chamber to the ImagIR imaging chamber's temperature controlled anaesthesia delivery module, where they received 2–3% maintenance isoflurane in oxygen. The rats' body temperatures were maintained at 36–37°C using a temperature controlled imaging platform with a constant temperature of 35°C (accurate to ±0.1°C). Legs were positioned in flexion and external rotation to expose the medial part of each ankle to the infrared sensor. Rats were imaged for a total of 10 minutes, with images captured every 15 seconds. Each captured image was generated by averaging 16 frames of video rate image data together to produce a clear still image. Both anaesthesia and the thermal imaging acquisition were done in a room with a constant temperature of 21–23°C.

The thermal imaging data were extracted from saved images using Animal Corral Software version 4.0.0 (Seahorse Bioscience). First, a region of interest (ROI) was drawn to delineate left and right ankles. The typical limits for the ROI were the ankle fur line (upper limit) and the midpoint of the mid-foot. The average temperature of all pixels within each ROI in each image was calculated and recorded automatically. Data quality at the beginning of each 10 minute imaging period was similar to that obtained at the middle and end of each imaging period. Additionally, it was determined that the initial images were the best reflection of pre-anaesthetic body and ankle temperatures (data not shown). Thus only data from the initial images were used, making the time to image each animal less than one minute and so minimising any anaesthetic induced effect on body temperature regulation.

Thermal images were obtained at 0 h (preinjection), 6 h, 12 h, 24 h, and daily on days 2 to 7 after intra-articular CFA (or saline) administration (monoarthritis model), and daily from day 0 to day 16 in PIA. In order to correct for each individual rat's own peripheral limb temperature, left ankle (CFA) thermal measurements were corrected for the right ankle (saline) measurements (left ankle minus right ankle) in the monoarthritis studies. In PIA, as both ankles are typically involved, thermal measurements were adjusted for the core temperature obtained with a rectal probe.

The similar analysis can be performed on humans and a software can be develop which can predict RA in its early stages. As a computer engineer I am planning to develop a new algorithm for RA prediction. The prototype is explained under the heading The current status of application.

III. Traditional Diagnostic Methods

The doctor examines each joint, looking for tenderness, swelling, warmth and painful or limited movement. The number and pattern of joints affected can also indicate RA. For example, RA tends to affect joints on both sides of the body. A specialist with specific training and skills diagnose and treat RA. In its early stages, RA may resemble other forms of inflammatory arthritis. No single test can confirm RA. To make a proper diagnosis, the rheumatologist will ask questions about the personal and family medical history perform a physical exam and order diagnostic tests. The doctor ask about personal and family medical history as well as recent and current symptoms (pain, tenderness, stiffness, difficulty moving).Physical Exam may reveal other signs, such as rheumatoid nodules or a low-grade fever. The blood tests measure inflammation levels and look for biomarkers such as antibodies (blood proteins) linked with RA. Erythrocyte sedimentation rate (ESR, or "sed rate") and C-reactive protein (CRP) level are markers of inflammation. A high ESR or CRP is not specific to RA, but when combined with other clues, such as antibodies, helps make the RA diagnosis .Rheumatoid factor (RF) is an antibody found in about 80 percent of people with RA during the course of their disease. Because RF can occur in other inflammatory diseases, it's not a sure sign of having RA. But a different antibody – anti-cyclic citrullinated peptide (anti-CCP) – occurs primarily in patients with RA. That makes a positive anti-CCP test a stronger clue to RA. But anti-CCP antibodies are found in only 60 to 70 percent of people with RA and can exist even before symptoms start. An X-ray, ultrasound or magnetic resonance imaging scan may be done to look for joint damage, such as erosions, a loss of bone within the joint and narrowing of joint space. But if the

imaging tests don't show joint damage that doesn't rule out RA. It may mean that the disease is in an early stage and hasn't yet damaged the joints.

During the physical exam, doctor checks patient's joints for swelling, redness and warmth. He or she will also want to see how well patient can move his or her joints. Depending on the type of arthritis suspected, doctor may suggest some of the following tests.

Laboratory tests

The analysis of different types of body fluids can help pinpoint the type of arthritis patients may have. Fluids commonly analyzed include blood, urine and joint fluid. To obtain a sample of joint fluid, doctor cleanses and numb the area before inserting a needle in joint space to withdraw some fluid (aspiration).So this kind of tests hurts the patients.

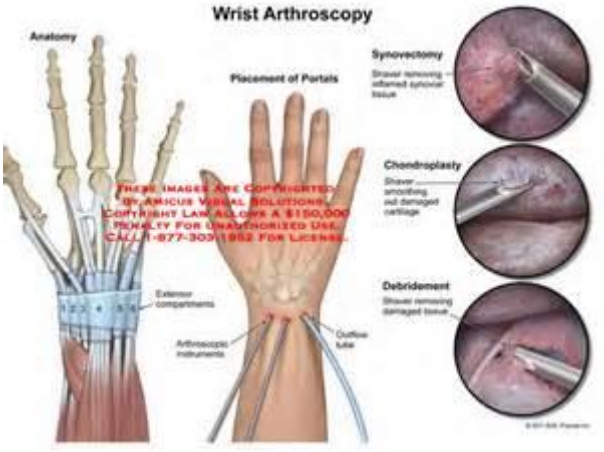
Imaging

These types of tests can detect problems within patients joint that may be causing his/her symptoms. Examples include:

- **X-rays**. Using low levels of radiation to visualize bone, X-rays can show cartilage loss, bone damage and bone spurs. X-rays may not reveal early arthritic damage, but they are often used to track progression of the disease.
- **Computerized tomography (CT).** CT scanners take X-rays from many different angles and combine the information to create cross-sectional views of internal structures. CTs can visualize both bone and the surrounding soft tissues. But cant depict the temperature of joints.
- **Magnetic resonance imaging (MRI).** Combining radio waves with a strong magnetic field, MRI can produce more-detailed cross-sectional images of soft tissues such as cartilage, tendons and ligaments. But it is more expensive than Thermal imaging.
- **Ultrasound.** This technology uses high-frequency sound waves to image soft tissues, cartilage and fluid-containing structures such as bursae. Ultrasound also is used to guide needle placement for joint aspirations and injections.

Arthroscopy

In some cases, doctor may look for damage in joint by inserting a small, flexible tube — called an arthroscope — through an incision near joint. The arthroscope transmits images from inside the joint to a video screen.



Amongst other techniques existing in the field our proposed system tends to be more effective as it depends on new methodologies that have been proved to be better and more consistent than others. Computer Aided diagnosis will provide more accurate and flexible rate of consistency that will help to improve the efficiency of the system. Why thermal imaging is more effective? X-RAY, MRI modalities are expensive and have radiation effects Thermal imaging allows us to visualise heat, where Different colour represent different temperature. As we know that all object emit infrared radiation in the form of temperature. Hot object emit more radiation compare to cold object. Thermal camera works as a heat sensor to detect tiny differences in temperature, This device collects IR radiation from objects in the scene and generate electronic image based on temperature variation. Thermal imaging converts invisible to visible with the help of thermal camera. Thermal imaging is a non invasive, non proactive and non contact technique. It's a safe method to show the temperature of living or electrical (non living) object. Thermal imaging can reduce (un)planned downtimes and cost of

treatment. What is RA according to my point of view? It is a Inflammation in joint which creates rushing blood flow in veins which can generate additional heat and will increase temperature of joints region. There is also the potential for more serious damage for joints bones and is the biggest cause of Arthritis. All joints deteriorate over time due to increased temperature, so thermal imaging can be used to detect Arthritis on the basis of temperature difference in joints. Thermal camera is the perfect tool for predicting joints temperature because they make the invisible visible.

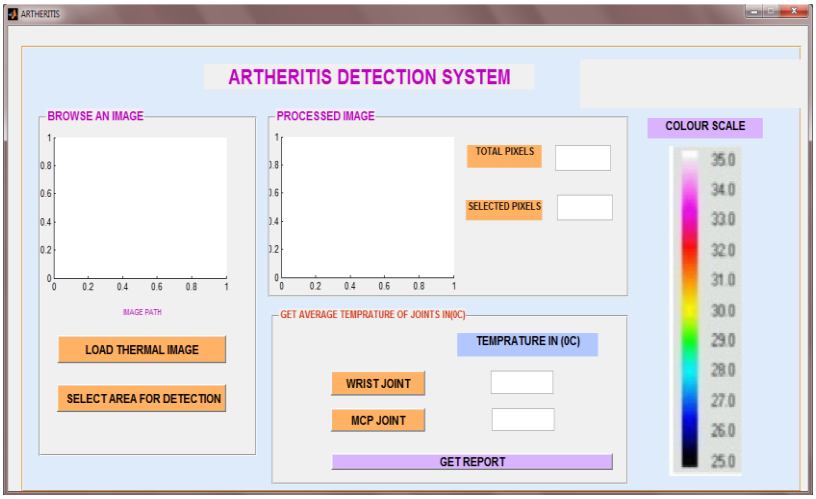
One of the biggest advantages of thermal imaging is the ability to perform inspections while the joints temperature is under load. Since thermal imaging is a non-contact diagnostic tool, so the diagnosis can be done from safe distance without any hurt to the patient. Thermal inspections can quickly locate hot spots, determine the severity of the pain by different colour in thermal image and help to make the prediction of Arthritis which should be treated in its early stage. Thermal imaging shows the temperature differences across a large area which can detect issues that an X-Ray and MRI may miss.

About Neural Network:

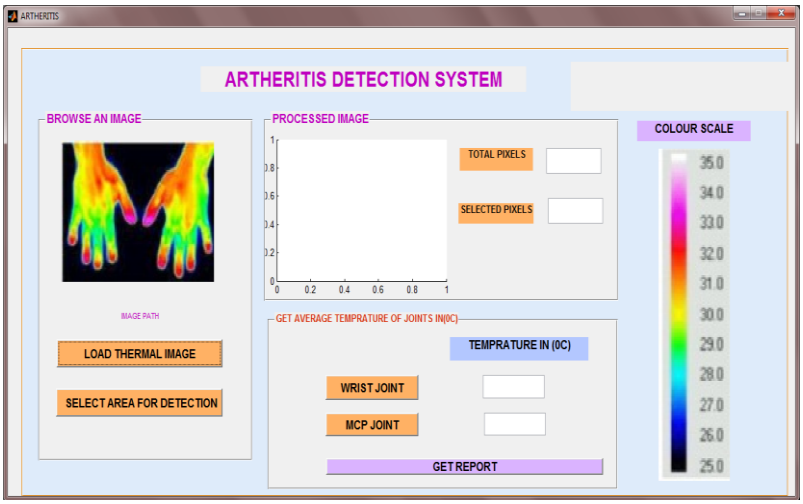
Different techniques are available for pattern recognition like statistical, syntactic or structural, hybrid, template matching and neural network. As neural network increases the efficiency of the network by using feedback information obtained from the difference between the actual and desired result. This information will then be used to adjust the interconnection between input layer neurons for matching the actual result with the desired one. backpropogation algorithm defined under this technique have self organising, self-adaptive characteristics which enhance the efficiency of pattern recognition. A neural network model is a more powerful tool for pattern recognition. Our system will be trained with the priori information available to obtain the result. Here the learning will be categorized as Supervised learning in which the desired result is known to the system.

The current status of application:

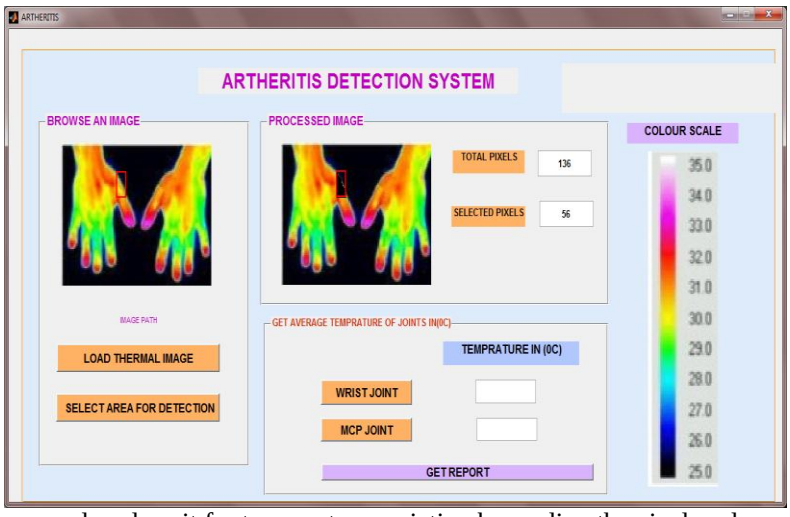
Till now we are done with the prototype in which we have tested the case of arthritis with random values. Our system works according to the following steps.
Below snapshot shows the main screen of the system.



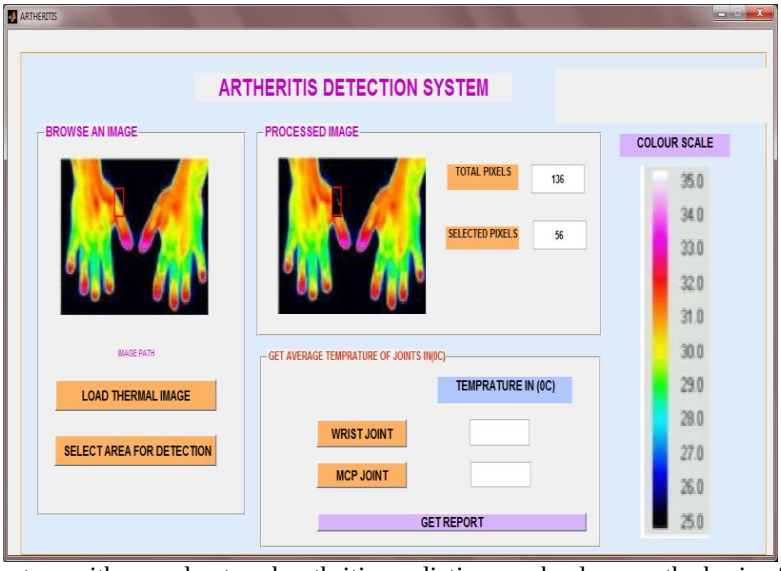
Step 1: We load image in the system for examination.



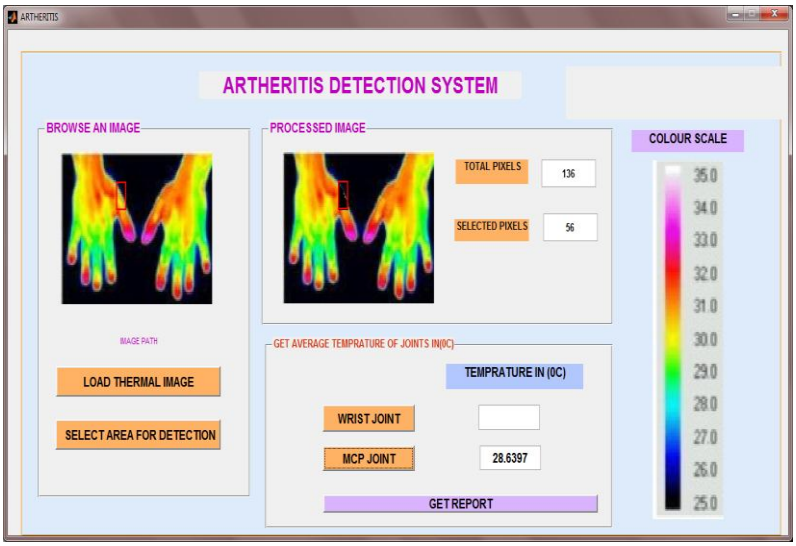
Step 2: Select the suspected area .

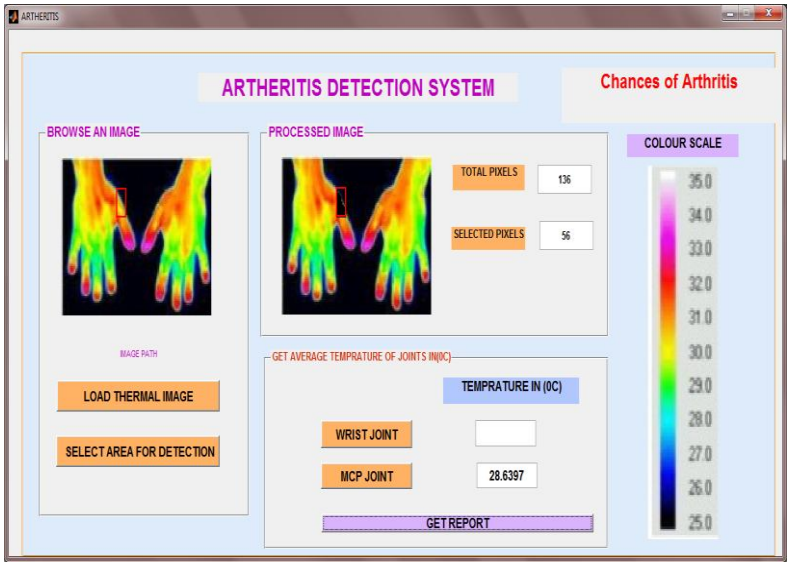


Step 3: Cut image and analyze it for temperature variation by reading the pixels coloured information.



By comparing this system with neural network arthritis prediction can be done on the basis of report.





Expected Results

This system would be able to predict the arthritis in the early stages. Using the thermal imaging technique it is possible to detect and analyze temperature in inflammatory joints in image form. Further these image samples would be used as database samples for neural network where we will implement backpropogation algorithm for corrective results.

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Ms.Rozina Naz (Assitant Professor at Sadabai Raisoni Women's College Nagpur)