Detection of Inflammation from temperature profile using Arthritis knee joint Datasets

Parijata Majumdar[1], Kakali Das[2], *Niharika Nath[3], Mrinal Kanti Bhowmik[4]
[1,2,4] Department of Computer Science and Engineering, Tripura University (A Central University), Tripura (W), India.
[3]Department of Life Sciences, New York Institute of Technology (NYIT), New York, NY10023
er.parijata@gmail.com, kakalids54@gmail.com, nnath@nyit.edu, mrinalkantibhowmik@tripurauniv.in.

***Abstract*—In Arthritis, the self-limiting inflammatory process becomes continuous and as a result chronic inflammatory disease might occur. The skin surface is responsible for maintaining the core internal body temperature. Medical Infrared thermography (MIT) as a diagnostic tool is well known for its contribution in providing statistical quantification to detect acute to minute temperature deviation for accurate assessment of inflammation. Accurate assessment of inflammation helps in making early individual treatment plan and also offers an insight to the determination of severity of the disease. In this scope, we validate the importance of infrared imaging with a newly created datasets of Arthritis knee joints. After validation, the efficacy of infrared imaging is also proved as a complementary diagnostic tool to other clinical tests in detecting inflammation that lacks recognizable clinical findings in relation to Arthritis.**

Keywords—Arthritis; Thermography; inflammation; temperature distribution.

I. INTRODUCTION

Arthritis refers to any joint disorder featuring inflammation [1]. Inflammation is a complex biological response of white blood cells and immune proteins of our body that gives protection against harmful stimuli, infection, pathogens, damaged cells and irritants [2]. Increase or decrease in temperature has a direct expression with reduction or aggravation of inflammation [5]. Early detection of Arthritis helps in avoiding the chances of preventing further joint erosion, chronic pain and loss of function. Determination of inflammation on the joint is not possible through physical contact as it is not followed with a huge deviation from normal temperature. There are also subclinical conditions where the presence of inflammation may not be correctly confirmed clinically, by existing medical imaging modalities as it remains completely asymptomatic in early Arthritis. Thus, for accurate assessment of early stage in Arthritis, establishment of subclinical inflammation is a major challenging task. Ultrasound imaging (USG), Magnetic Resonance Imaging (MRI) and X-rays are existing diagnostic tools that can be used for detection of joint swelling but quantification of inflammation is user dependent, inaccurate and inconsistent, expensive, not suitable for repetitive use [3][4]. Erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP) are the two hematological tests that can be used for diagnosing inflammation in arthritis knee joint but these are poorly correlated with disease activity measures [6]. Our work will enhance the use of Medical Infrared Thermography in establishing even minute to acute inflammation present on the knee joints for early detection of Arthritis based on mild to severe temperature variation. In section II, approach of analysis have been discussed. We conclude in section III.

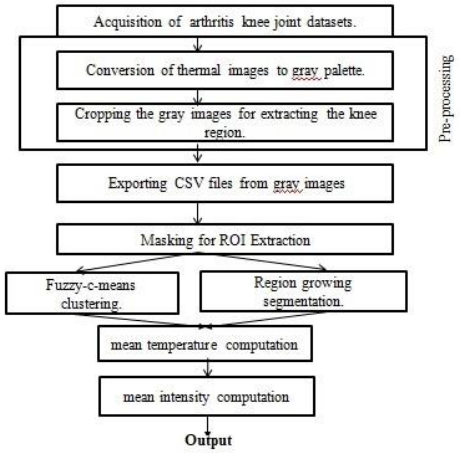

Fig. 1. Flowchart of the proposed approach of analysis.

II. METHOD OF ANALYSIS

The approach of analysis consists of three phase: pre-processing, ROI segmentation, and finding of correlation of the mean temperature of ROI with clinical benchmark datasets. Fig.1 provides the overview of the proposed approach.

A. Database Preparation

The proposed approach was tested in datasets created and collected from the Physical Medicine and Rehabilitation (PMR) Department, Agartala Government Medical College (AGMC), Govind Ballav Pant Hospital (GBP), Agartala, Tripura, India. The dataset comprises of thermal images of different inflammatory pain related diseases of knee joints such as Osteoarthritis, Rheumatoid arthritis etc. thermal images are captured using FLIR-T650sc thermal camera with sensitivity of 20 mK at 30^0C. Table-I represent the details of arthritis data used in this work.

Asterisk (*) indicates the corresponding author.

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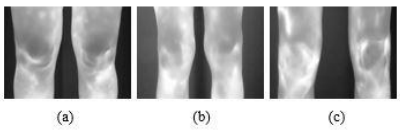

Fig.3. The gray palette of the thermal images of (a).a normal knee joint, (b). Rheumatoid arthritis knee (c)Osteoarthritis knee.

B. Preprocessing

Captured Thermal images incorporate company logo, color bar, maximum and minimum temperature points, etc. So, the thermal images are trimmed manually for further processing. The sample of acquired thermal images are depicted below in Fig 2. Here, gray-palate of thermal camera is used. Gray-palate of thermal images are of 24 bit (8 bit for 3 channel), but each channel consist same value and is equivalent to the converted gray image. These gray palate images are converted into gray image before processing. Proposed approach works on the gray thermal images. Table-I summarized mean temperature range of knee of Rheumatoid Arthritis and Osteoarthritis patients of a particular age-group, and gender.

C. Exporting Comma separated value (CSV) files from the gray images

Exporting Comma separated value (CSV) files from the gray images is required for showing all the temperature values corresponding to each pixel of the thermal image stored in excel sheets. This CSV of gray images are extracted using FLIR tool.

D. Masking of cropped gray images

Fuzzy-C-Means [7] clustering and Region growing [8] is used for extraction of the ROI from the thermal image. Fuzzy-C-Means and Region growing found efficient in segmentation of ROI from the thermal image. Segmented images are shown in Fig.4. This segmented ROI are considered as a mask for obtaining the mean temperature and mean intensity of the ROI from the original thermal image.

E. Mean temperature Computation

The masked binary images are multiplied with the cropped CSV files. Multiplication of the masked images with the CSV files will yield a resultant matrix with non-zero element only in the inflamed knee region. Experimental Results of the derived mean temperature of arthritis knee using Fuzzy C-means Clustering and Region growing Segmentation are shown in Table II and Table III.

F. Mean intensity Computation

The crop masked binary images are multiplied with the cropped gray images. Multiplication of the masked images with the cropped gray images will yield a resultant image matrix that will have non zero element only in the area of ROI. The mean of the non-zero intensity values are calculated to obtain the mean intensity on the inflamed ROI. Experimental Results of the derived mean intensity of arthritis knee using Fuzzy C means Clustering and Region growing Segmentation are shown in Table II and Table III.

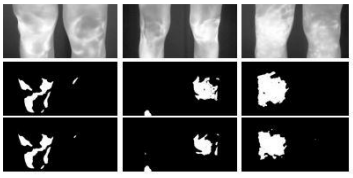

Fig.4. Segmented ROI of Knee infrared images. Row 1: Original Image, Row 2: Region Growing (RG), Row 8: FCM Clustering

TABLE I. DATA DESCRIPTION

Disease	Age-group	No. of Patients	Temperature Mean	Spread of Inflammation
RA	40-73 Years	20	31+0.50C	Chronic Inflammation
OA	45.8-76.0 Years	15	29.1-32.30C	Usually Non inflammatory but may lead to some inflammation

TABLE II. FEATURES EXTRACTED FROM THE ROI USING FCM

Disease	No. of Patients	Temperature Mean	Intensity mean	Temperature mean variance	Intensity mean variance
RA	9	29.64^0C	244.9386	3.3312	2.945
OA	9	30.87^0C	244.7072	2.5221	2.1624

TABLE III. FEATURES EXTRACTED FROM THE ROI USING REGION GROWING

Disease	No. of Patients	Temperature Mean	Intensity mean	Temperature mean variance	Intensity mean variance
RA	9	29^0C	192.6575	13.3645	3.5243
OA	9	29.48^0C	193.6575	6.4060	3.2377

G. Extracted ROI analysis

Features from the segmented ROI is calculated and detailed analysis is done to compare the features of thermal image with the benchmark clinically given features. Result of comparison will establish the significance and utility of thermal images in detection of inflammation in arthritis joint relating to temperature distribution. Features from ROI that are used for analysis are temperature mean, intensity mean, mean intensity variance.

II. CONCLUSION AND FUTURE WORK

Based on the result we can conclude that MIT can serve as a non-invasive, safe, cost-effective diagnostic tool in conjunction with other clinical examinations. Since, distribution of temperature is directly related to spread of inflammation, our future work will include grading of mild, moderate and severe inflammation in the arthritis knee joints.

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