International Journal of Computer Theory and Engineering, Vol. 2, No. 4, August, 2010
1793-8201

Euclidean Distance Based Color Image Segmentation of Abnormality Detection from Pseudo Color Thermographs

N.Selvarasu, Alamelu Nachiappan and N.M.Nandhitha

***Abstract*—Infrared thermography, non-contact, non-invasive technique is widely accepted as a medical diagnostic tool. An IR camera captures heat variations from the skin and maps into thermographs. Thermographs are acquired for the whole body or the region of interest. Thermographs either gray scale or pseudo color are processed for abnormality detection and quantification. However temperature variations are not normally visible to naked eye. Hence it is necessary to develop and analyze the feature extraction algorithms for abnormality detection. This paper proposes Euclidean distance based color image segmentation algorithm for abnormality extraction. Pseudo color thermographs of arthritis, stress fracture, ankle injury and fracture are considered.**

***Index Terms*—thermographs, pseudo color, Euclidean distance, feature vectors**

I. Introduction

Medical diagnosis is a process of identifying by signs, symptoms and results of medical imaging. Medical imaging techniques are used to evaluate an area of body that is not externally visible. Of the various medical imaging techniques that include endoscopic imaging, ultrasound imaging, gamma camera imaging, nuclear magnetic resonance technique, Radiography etc, Thermal Imaging is non-invasive, painless, hazardless application and its output is easy to interpret. Infrared thermography provides directly a digitized thermal map called thermograph. It provides a thermal pattern of the skin temperature at the area of observation. As color is a powerful descriptor, different colors are used for describing temperature variations.

For a normal person, the thermograph shows uniform and symmetric temperature variations. In case of abnormality, abnormal regions show abrupt variations in temperature. Temperature variations are measures of abnormality. Hence abnormality variations can be detected from thermographs by analyzing temperature variations. However these temperature variations can be nearly invisible to naked eye and may not interpreted directly. Hence it is necessary to enhance the quality of the image and then process the image for feature extraction. This paper proposes a color image segmentation algorithm for abnormality extraction in pseudo color tehrmographs.

The paper is organized as follows. Section II gives a brief review of Infrared Thermography in Medical diagnosis. Section III deals with thermographs depicting arthritis and stress fracture. Section IV provides an overview of the color image segmentation. Section V deals with feature extraction technique. Section VI deals with Results and discussion. Section VII is conclusion and future work. The functions are implemented in MATLAB.

II. Review of Infrared Thermography in Medical Diagnosis

Infrared thermography, a successful Non Destructive Testing (NDT) Technique is recently accepted as a successful medical diagnostic procedure. It is based on a careful analysis of skin surface temperatures as a reflection of normal or abnormal human physiology [1]. Infrared or thermal images are produced with Infrared camera. Based on these thermal images, accurate temperature measurements can be made to detect even the smallest temperature differences when looking at human bodies. Over the years thermal images taken using infrared cameras, liquid crystal thermography, and infrared tympanic thermometer have proven the human body is symmetrical right to left, extremities are cooler, and injuries to nerves, tendons, and muscles produce differentiating temperatures [2-3]. Human body temperature is a complex phenomenon. Man is homoeothermic, and produces heat, which must be lost to the environment. The interface between that heat production and the environment is the skin. This dynamic organ is constantly adjusting to balance the internal and external conditions, while meeting the physiologic demands of the body. Digital infrared thermography is a totally non-invasive clinical imaging procedure for detecting and monitoring a number of diseases and physical injuries, by showing the thermal abnormalities present in the body [2-5]. Content-based image retrieval system was developed for thermal medical image retrieval. Fractal encoding technique was developed to increase the linear size for fragments of the traced thermal medical images [6]. Computerized technique based on image processing of thermographs was achieved. However noise in thermographs was removed by wavelet based noise removal techniques [7].

From the literature survey it is understood that thermographs can be taken of the whole body or just areas being investigated. It diagnoses abnormal areas in the body by measuring heat emitted from the skin surface and expressing the measurements into a thermal map. For a normal person under healthy condition, thermographs depicted uniform and symmetrical pattern. On the other hand abnormality manifests itself either as hot spots or as cold spots. Hot spots correspond to the region of maximum intensity and cold spots correspond to the region minimum intensity and hence the temperature. Several image-processing algorithms were developed for computer-based

assessment of medical thermographs. However these techniques are application specific and are developed for that particular group of thermographs.

III. Thermographs Depicting Arthritis and Stress Fracture

The thermal maps produced by infrared thermal imaging instruments are called thermographs. Thermograms can be captured fro the entire body or the area of interest. Thermogram is defined as a 2D radiance function g(x, y), where x and y denote spatial coordinates and the value of g at any point is proportional to the heat energy emitted from the scene at that location [8]. Traditionally, low intensities are represented by dark shades and high intensities by bright shades. Thermographs depicting arthritis, stress fracture, ankle injury and fracture are considered [9]. A stress fracture is a common overuse injury most often seen in athletes. When the bone experiences a very high force it causes the stress fracture. A stress fracture can occur in any bone, but is commonly seen in the foot and shinbones. Arthritis is a group of conditions where there is damage caused to the joints of the body. Ankle injury represents to bruise in ankle and fracture represents a crack in the bone. These abnormalities appear as hotspots (region of maximum intensity i.e. white) in thermographs. Arthritis, stress fracture, Ankle injury and fracture thermographs are as shown in Figure 1, Figure 2, Figure 3 and Figure 4 respectively.

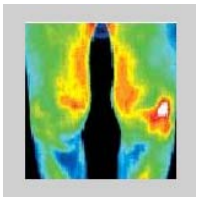

Fig.1: Arthritis

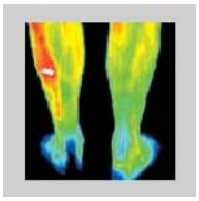

Fig.2: Stress Fracture

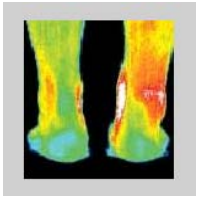

Fig. 3: Ankle Injury

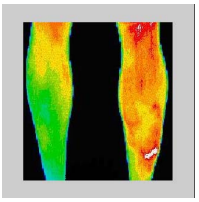

Fig. 4: Fracture

IV. Image Processing Operators-an Overview

Color is a powerful descriptor that simplifies object identification and extraction from a thermograph. Moreover human can discern thousands of color shades and intensities compared to about only two dozen shades of gray. The two techniques involved are full color image processing (processing with a full color sensor as in Television) or Pseudo color processing (assigning colors based to gray values based on a specified pattern) [10]. Of the various color models, RGB color model is considered for further processing of the image. In the RGB color model, each color appears in its primary spectral components of red, Green and blue. Each RGB color pixel is a triplet of values namely Red, Green and Blue.

Segmentation provides better results in RGB color model when compared to other color models. Segmentation in color domain is based on similarity detection rather than discontinuity based. Similarity based detection directly groups the similar pixels. The algorithm involves selecting an estimate of the average color that is to be segmented. Classifying each RGB pixel in the image as having the specified average color or not. I.e. similar pixels are grouped together. Euclidean distance is chosen as the measuring parameter. Let the average pixel chosen be represented as 'a' [10]. Any image pixel 'z' is said to be similar to 'a' if the Euclidean distance between them is less than a specified threshold D_0. The Euclidean distance between 'z' and 'a' is

$$D(z,a)=[(z_R-a_R)^2+(z_G-a_G)^2+(z_B-a_B)^2]^{1/2} \quad (1)$$

Where X_R, X_B and X_G denotes the intensities in Red, Blue and Green domains

V. Feature Extraction Technique

A representative pixel from the hotspot region can be chosen as the average pixel. Red, Green and Blue domain intensities of a hotspot pixel are chosen as the average pixel intensities. Euclidean distance is calculated for every image pixel from the average intensities. An output image is obtained by retaining the image pixels if the distance is less than the threshold value and zeroing the remaining pixel intensities are made as zero. In this way the output image finally contains only the hotspot region. After extracting the hotspot, it is quantified using boundary descriptors. The boundary descriptors used are area, major axis length and minor axis length. The flow chart depicting the feature extraction technique is as shown in Figure 5.

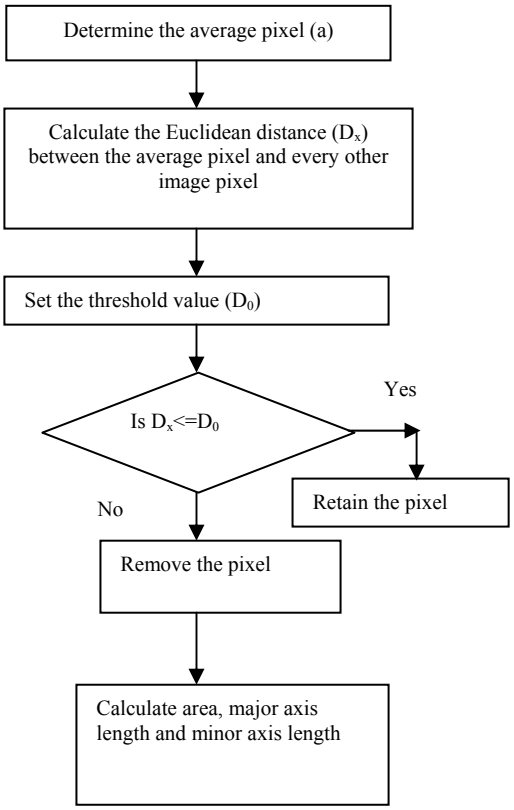

Fig. 6: Flowchart for hot spot extraction

VI. Results And Discussion

In original image, every pixel intensity is represented as unsigned integer with 8 bits. This data type is converted into double (fraction) for easier computation. Red, Blue and Green domain intensities of the average pixel are 0.9725, 0.9725 and 0.9725 respectively. The threshold chosen is 0.09. The original image and the output image consisting of hotspots for arthritis, ankle injury and fracture are as shown in Fig. 7, Fig. 8, Fig. 9 and Fig.10 respectively

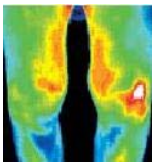

Fig. 7a: Original image

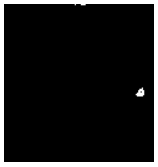

Fig.7b arthritis

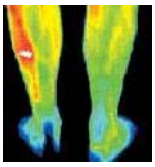

Fig. 8a: Original image

Fig.8b Stress fracture

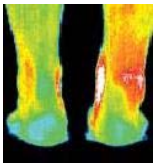

Fig. 9a: Original image

Fig.9b Ankle injury

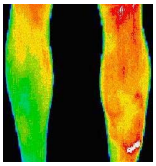

Fig. 10a: Original image

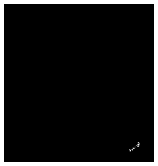

Fig.10b Fracture

Euclidean distance based color image segmentation technique is best suited for thermographs if they are available as pseudo color thermographs as it does not involve color to gray scale conversion which introduces quantization error. The feature descriptors used for representing hotspot are area, Major axis length and minor axis length. These vectors are represented as pixels which can be converted into SI units after calibration. The quantitative characterization of abnormality is as shown in table 1.

TABLE 1: Quantitative Characterization of Abnormality

Abnormality	Area in pixels	Major Axis Length in pixels	Minor Axis Length in pixels
Stress Fracture	5	3.3066	2.1292
Arthritis	31	7.7527	5.7995
Ankle injury	53	22.5252	3.4041
Fracture	27	18.9267	10.9415

The above feature vectors describe the seriousness of the abnormality.

VII. Conclusion

Euclidean distance based color image segmentation algorithm has successfully extracted and quantified the abnormality. This technique is dependent on the average pixel intensities and threshold. For medical thermographs with abnormality as hotspot, these parameters can be standardized. Hence color image segmentation algorithm is a parameter independent, image independent technique that can be standardized for abnormalities exhibiting as hotspot.

References

[1] H.Gray, Anatomy; Descriptive and Surgical (Fifteenth ed.). New York: Barnes & Noble Books, 1995.
[2] J.Green, “Neurothermography”, Seminars in Neurology, Vol.No.7(4), 1987, pp.313-316.
[3] R.A.Harway, “Precision thermal imaging of the extremities”. Orthopedics,Vol.No.9(3), 1986, pp.379-382.
[4] R.Sherman, R.Barja and G.Bruno, “Thermographic correlates of chronic pain: analysis of 125 patients incorporating evaluations by a blind panel”. Archives of Physical Medical Rehabilitation, Vol.No. 68, 1997, pp.273-279.
[5] Seok Won Kim, Seung Myung Lee, and Seong Heon Jeong, “Validation of thermography in the diagnosis of Acute Cervical Pain”, Journal of Korean Neurosurgical Society, Vol. No. 366, 2004, pp.297-301.
[6] F.Feldman, EL.Nickoloff. “Normal thermographic standards for the cervical spine and upper extremities”. Skeletal Radiol,Vol.No. 12, 1984, pp.235-249.
[7] S.Uematsu, DH.Edwin, WR.JankeI, J.Kozikowski, M.Trattner. “Normal values and reproducibility”. J Neurosurg,;Vol.No.69, 1988, pp.552-555.
[8] X.Maldague, Introduction to NDT by Active Infrared Thermography, Materials Evaluation, Vol. No. 6(9), 2002, pp.1060-1073.
[9] http://www.meditherm.net
[10] Rafael.c.Gonzalez, Richard E.Woods, Digital Image Processing, Pearson Education, Second Edition, 2002