DIGITAL PROCESSING TECHNIQUES FOR THE ASSESSMENT OF PAIN WITH INFRARED THERMAL IMAGING

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Abstract-**The assessment of pain is a difficult topic that may be facilitated by the quantification of some of the phenomena usually involved in the sensation of pain, such as thermal abnormalities. Digital thermal imaging is a technique that records the skin temperature distribution of the body and thus can provide some insight in thermal dysfunction associated with pain. In this paper, we propose several digital processing steps to analyze thermal images of pain patients and summarize the results with a computer-aided decision-support system. Results from our analysis are expected to be validated by a statistical comparison with actual medical outcomes for the pain patients considered in the study.**
***Keywords* – Digital infrared thermal imaging, thermography, pain assessment, image processing**

I. INTRODUCTION

It is now well known that thermoregulation of the human body is affected by a wide range of factors including pathological abnormalities. The recording of temperature distribution of a human body can therefore provide valuable information about the underlying physiological processes that cause those abnormalities. Human skin plays a major role in thermoregulation by dissipating or preserving heat. The dissipation of heat through the skin is mainly radiative and occurs in the infrared part of the spectrum, which makes infrared detectors particularly suitable for the recording of skin temperature distribution, and by extension of whole body core temperature distribution.

The assessment of pain is a difficult task since pain is a combination of various phenomena, some of which are still not fully understood. Pain has many subjective aspects that are linked to the person that experiences it and is thus hard to quantify. Current ways of evaluating pain rely on the ability of a person to formulate pain through words, facial expressions or to point out its level of pain on specific scales, which may be complicated for people with impairments or children. However pain also exhibits characteristic physiological or anatomical changes that may be studied in a more objective manner. One physiological change associated with many types of pain is an alteration of the thermoregulation of the human body [1].

Clinical infrared thermography or infrared thermal imaging is defined as the recording of the temperature distribution of the human body using infrared radiation emitted by the surface of the body i.e. the skin [2][3]. Thermograms (or thermal images) are difficult to interpret because the variations in temperature distribution may be very subtle; attempts to emphasize the variations, such as pseudo-color images, are usually not sufficient for a clinical thermographer to give an informed diagnosis.

As a result, the literature focused mainly on ways to quantify the analysis of thermal images. Among the various applications of medical infrared thermal imaging, oncology and particularly breast cancer detection has been the most thoroughly explored and is still under review by many recent studies [4][5][6].

Thermal dysfunction associated with pain was investigated in many past publications, starting in the early eighties, but most of these papers provided general quantification techniques and to our knowledge, none so far have proposed to apply comprehensive computerized techniques to the assessment of thermal images of persons experiencing pain [1].

II. MATERIALS AND METHODS

A. Data

The processing of thermal images rely mostly on the assumption that the temperature distribution of normal healthy people is symmetrical from a contralateral point of view, which has been confirmed by many clinical studies. However, some pathology may exhibit a contralateral symmetry in the temperature distribution of the body and it is therefore necessary to complement this approach by a more thorough search for hotter or colder areas.

We are currently investigating the main stages of image processing applied to thermal images. The programming work was carried out with MATLAB® and the Image Processing toolbox.

Hundreds of thermal infrared images of pain patients were digitally recorded on magnetic tapes by Professor Monique Frize and her team at the Pain Clinic of the Moncton Hospital, New Brunswick, Canada, between 1981 and 1984, with a medical infrared camera system (AGA Thermovision 680 medical and AGA OSCAR). The images are 128x128 pixels and have 256 gray intensity levels.

B. Digital processing steps

The analysis comprised several steps:

First, we preprocessed the images in order to improve the subsequent analysis. The noise was assumed to follow a Poisson distribution and removed using a wavelet-based removal technique proposed by Nowak and Baraniuk that preserved the sharpness of images acquired through a photon imaging system [7].

Then the thermal images were classified according to the part of the body they focused on (for instance, upper back, lower back, front legs, face, etc.). The classification was achieved through the extraction of the contours using edge detection and simple morphological operations and comparisons with templates of the parts of interest.

A display of isothermal regions and of intensity profile lines enabled us to perform a first simple analysis of abnormal high or low temperature areas.

Relevant regions of interest were selected either manually or in an automatic way using the results from the previous step. Symmetric regions of interest, with respect to their contralateral parts, were also selected automatically when appropriate by means of a reflection with respects to the left-right symmetry line and reflection.

We performed a statistical analysis and comparison of intensity distributions of symmetric or comparable regions of interest. The comparison included the computation of common as well as higher-order and Kolmogorov-Smirnov statistics. The statistical results were compared to standard values from the literature.

Finally, a computer-aided decision-support scheme was devised to summarize the results for each thermal image using the statistical analysis performed in the previous step and difference temperature distributions of normal subjects published in the literature [8][9].

III. Conclusion

Computerized quantitative techniques have been applied to the analysis of thermal images of pain patients in order to provide a decision-support scheme for clinical thermographers. The decision-support system will be validated by comparison with a population of normal patients as well as actual outcomes from pain patients. The final results are expected to provide a valuable tool for clinicians in the evaluation of pain associated with thermal dysfunction. The final results will be presented at the time of the conference.

IV. Future Work

A second set of thermal images will be taken on normal healthy volunteers upon approval from the local Ethics Committee and will serve as our control population. The same infrared camera system and image format as the thermal images currently available will be used.

The outcomes from our analysis will be compared to the actual outcomes determined by the clinical thermography specialist from the Pain Clinic of the Moncton Hospital who analyzed the original thermal images. Statistical analysis of the correlation between the computer-aided decision support scheme and the thermographic specialist will be carried out.

Pattern recognition techniques are also under investigation for the automatic detection of hot spots and thermal asymmetries.

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