Chapter 12
Image Processing Tools for Biomedical Infrared Imaging

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ABSTRACT

Medical infrared imaging captures the temperature distribution of the human skin and is employed in various medical applications. Unfortunately, many of the conventional and commercial suites for image processing provide only very basic tools for the processing of medical thermal images which represent a challenging combination of both functional and morpho-structural imaging. In this chapter, several more advanced approaches are discussed which in turn provide tremendous help to the clinician. As an example, it is often useful to cross-reference thermograms with visual images of the patient, either to see which part of the anatomy is affected by a certain disease or to judge the efficacy of the treatment. It is shown that image registration techniques can be effectively used to generate an overlay of visual and thermal images to provide a useful diagnostic visualisation. Image registration can also be performed based on two thermograms and a warping-based method for this is presented. Segmenting the background from the foreground (i.e., the patient) is a crucial task and it is highlighted how this can be accomplished. Finally, it is shown how descriptors, extracted from medical infrared images, can be usefully employed to search through a large database of cases as well as to aid in diagnosis.

INTRODUCTION

Advances in camera technologies and reduced equipment costs have lead to an increased interest in the application of thermography in the medical field (Jones, 1998). Thermal medical imaging (or medical infrared imaging) uses a camera with sensitivities in the infrared to provide a picture of the temperature distribution of the human body or parts thereof. It is a non-invasive, non-contact, passive, radiation-free technique that can also be used in combination with anatomical investigations based on x-rays and three-dimensional scanning techniques such as CT and MRI and often reveals problems when the

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anatomy is otherwise normal. It is well known that the radiance from human skin is an exponential function of the surface temperature which in turn is influenced by the level of blood perfusion in the skin. Thermal imaging is hence well suited to pick up changes in blood perfusion which might occur due to inflammation, angiogenesis or other causes. Asymmetrical temperature distributions as well as the presence of hot and cold spots are known to be strong indicators of an underlying dysfunction (Uematsu, 1985).

While image analysis and pattern recognition techniques have been applied to medical infrared images for many years in astronomy and military applications, relatively little work has been conducted on the automatic processing of thermal medical images. Computerised image processing techniques have been used in acquiring and evaluating thermal images and proved to be important tools for clinical diagnostics (Plassmann & Ring, 1997; Wiecek, Zwolenik, Jung, & Zuber, 1999) but the available tools are rather limited and provide only basic functionality such as identifying isotherms, analysing image histograms or manually marking regions of interest for further investigation.

In this chapter we discuss several more advanced approaches to analysing medical thermograms. We start by showing how image registration techniques can be employed to generate an overlay of thermal and visual images of a patient as well as to align two thermograms. This proves useful for relating the patient's anatomy to any hot or cold areas that might show up on the thermal image and can be useful for the following of a disease and its treatment. We then present a simple technique that can be used to segment the patient from the background and can be used for region of interest identification. Finally, we we show how image features, extracted directly from the images, can be used to aid diagnosis and to search through a large database of cases.

THERMAL-VISUAL IMAGE OVERLAYS

Often visual and infrared images of the patient are taken to relate inflamed skin areas to the human anatomy which is useful for medial diagnosis as well as for assessing the efficacy of any treatment. Currently this process requires great expertise and is subject to the individual clinician's ability to mentally map the two distinctly different images. Therefore, an overlay of the two image types resulting in a composite image which makes it possible to cross-reference regions with unusual temperature distributions to the human anatomy will provide a useful tool for improved medical diagnosis.

Such an overlay can be achieved through application of an image registration technique (Tait et al., 2006). Registration is a method used to geometrically align or overlay two images taken from different sensors, viewpoints or instances in time (Zitova & Flusser, 2003). A reference (fixed) and a sensed (moving) image are aligned through a combination of scaling, translation and rotation, i.e. through an affine transform which is also the type of transform that we employ in our approach. Registration techniques can typically be classified as either intensity or landmark-based. Both techniques have advantages and disadvantages in their own unique approach. The main difficulty of landmark-based algorithms is the need to identify a set of corresponding control points in both images based upon which the best matching transform is sought. Landmarks can be found either manually or automatically. While manual selection of control points can be fairly time consuming and requires user interaction, automatic identification of landmarks constitutes a challenging problem and often requires a priori knowledge of the image features involved.

In order to provide a fully automated approach and require only little input and time of the clinician, application of an intensity-based technique is hence preferred. Here, all image information is