Chapter 46
Thermal Imaging in Medical Science

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ABSTRACT

Thermal imaging is a non-destructive, non-contact and rapid system. It reports temperature through measuring infrared radiation emanated by an object/ material surface. Automated thermal imaging system involves thermal camera equipped with infrared detectors, signal processing unit and image acquisition system supported by computer. It is elaborated in wide domains applications. Extensive focus is directed to the thermal imaging in the medical domain especially breast cancer detection. This chapter provided the main concept and the different applications of thermal imaging. It explores and analyses several works in the light of studding the thermograph. It is an effective screening tool for breast cancer prediction. Studies justify that thermography can be considered a complementary tool to detect breast diseases. The current chapter reviews many usages and limitations of thermography in biomedical field. Extensive recommendations for future directions are summarized to provide a structured vision of breast thermography.

INTRODUCTION

Temperature measurement is a significant characteristic in any infrared thermography, industrial process and various applications that revolutionized temperature measurement concept. Typically, traditional temperature measurements instruments such as thermometers, thermistors, resistance temperature detectors and thermocouples can only determine the temperature at explicit points. Most of these instruments required direct contact with the object/material. Conversely, infrared thermal imaging is a non-contact,

DOI: 10.4018/978-1-5225-5204-8.ch046

rapid, non-invasive and nondestructive monitoring of processes, which provides temperature mapping of the object/material (Puri *et al*., 2005). It allows the creation of new ways to examine operations that were not even accessible before.

Thermal imaging is a technique that converts the invisible radiation pattern of an object into visible images (Ishimwe *et al*., 2014). Afterward, feature extraction and analysis are applied to these thermal images for further processing. Consequently, the use of infrared thermal imaging become extensively increasing in numerous fields. It can be applied in all applications where temperature differences are required to support diagnosis, evaluation or analysis of a product or process. Thus, thermal imaging has established to be a precious tool for solving a wide range of scientific real time problems, such as in medicine (Ring, & Ammer, 2012; Izhar, & Petrou, 2012), veterinary (McDannold *et al*., 2000; Infernuso *et al*., 2010), industry (Zhang *et al*., 2003), civil engineering (Clark *et al*., 2003) and aerospace (Winfree, & Heath, 1998).

Recently, with the improvements in the camera technology, temperature is considered useful marker of various diseases (Ring, 2010) using infrared (IR) imaging. The camera is used to capture the natural thermal radiation emitted by any organ/ object above absolute zero (Jones, & Plassmann, 2002). Therefore, the body surface thermal distribution can be depicted using the IR imaging. This thermal distribution depends mainly on the complex associations describing the heat exchange processes between the skin tissue, inner tissue, local vasculature, and metabolic activity (Kakuta *et al*., 2002).

Medical thermal imaging is also known as Medical Infrared Imaging or Digital Infrared Thermal Imaging (DITI). For high-resolution diagnostic body images, the DITI is equipped with ultra-sensitive thermal imaging cameras along with sophisticated computers to detect, to analyze and to produce accurate diagnosis. The thermal cameras are the ideal tools in countless applications. For early pre-clinical control/ diagnosis during treatment, the medical Thermography is used. It is free from any limitations or contra- indications.

Generally, several modalities can be used to test the body anatomy in order to measure its structure, such as X- rays, computed tomography (CT) scans, ultrasound and the magnetic resonance imaging (MRI). Such modalities employ several medical image processing techniques in different applications (Tapia, & Corchado, 2009; Janssen *et al*., 2013; Hore *et al*., 2015; Fouad *et al*., 2016; Beagum *et al*, 2016; Hemalatha, & Anouncia, 2016; Dey *et al*., 2016; Samanta *et al*., 2016; Goswami *et al*., 2016; Fadlallah *et al*., 2016; Kotyk *et al*., 2016; Saba *et al*., 2016; Ahmed *et al*., 2016; Trabelsi *et al*., 2017; Dey *et al*., 2017; Ashour *et al*., 2017). On the contrary, the thermography is the unique imaging technique that has the ability to measure the physiological changes of the body metabolic processes (Bronzino, 2006). It provided safe imaging service using high-technology, revolutionary and digital thermal imaging cameras. In the past decade, due to various innovations, thermal imaging in medicine becomes the forefront of diagnosis. Some of the widespread applications that the thermography can be used are: breast pathologies (Arora *et al*., 2008), neuro musculoskeletal (Tkáčová *et al*., 2010), extracranial vessel disease (Okada *et al*., 2007), lower extremity vessel disease (Huang *et al*., 2011) and the vertebrae (Kim *et al*., 2003).

Breast cancer is the most recurrently diagnosed cancer of women. It remains the second leading cause of death, despite the progress in treatment which reduced the mortality. Generally, numerous well established techniques are used for breast cancer screening including ultrasound, mammograms and clinical breast exams. Recently, thermography introduced its potential as a screening tool that provides an efficient, non-invasive and low risk tool for the early detection of breast cancer (Smith, 2005).

Consequently, the motivation of the current chapter is to provide an extensive focus on the thermal imaging in detecting the breast cancer. The main concept of the thermography is introduced.