Trends of IR-thermal imaging in medical diagnostics

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Abstract

This is an overview of research and development trends of IR-thermal imaging in biomedical applications, mainly in medical diagnostics. There are still approaches to broaden the use of a classical thermograph to new fields of medicine or veterinary, especially by searching possibility of using inexpensive, room temperature bolometric cameras. One may observe also growing interests in inexpensive screening by distant recognition of patients, e.g. for fever prevention in airports, in behavioural study of patients with psychological deficiencies, what may be important for safety reasons etc. Another important research areas cover new in medicine NDT methods, as ADT or TSR that provide improved diagnostic quality.

1. Introduction

The aim of this presentation is to review the state of the art in IR-thermal imaging in medicine, by analysis of recent publications accepted to several conferences as QIRT – Quantitative InfraRed Thermography, EAT – European Association of Thermology, TTP – InfraRed Thermometry and Thermography and related journals or monographs. Showing the scope of related web sites and profiles of publishers should help authors to decide whether and where to publish results of their research. First, let's classify groups of different problems covering most of recent interests in Infra-Red thermal imaging listing only some of most important problems:

1. use of inexpensive quantitative IR-cameras combined with visual RGB imagers in new medical applications;
2. standardization of procedures in thermal IR-image registration;
3. introduction of improved algorithms of data analysis in IRI – IR-thermal Imaging;
4. development of fast screening procedures for prevention & safety;
5. advanced analysis for improved understanding of diagnostic content;
6. application of new in medicine NDT - Non-Destructive Testing methods;
7. introduction into clinical practice quantitative thermal analysis and active dynamic thermography procedures.

In each of the listed subjects several new practical approaches are recently published or prepared for publication. We discuss here advantages and weaknesses of selected approaches, procedures and algorithms which seem to be important for biomedical applications.

2. Observation remarks

The use of thermal IR-imaging in medical diagnostics was accepted in clinical practice around 60-ty years ago [1, 2, and 3]. Even the cost of applied instrumentation was very high the initial interest of this modality was enthusiastic, unfortunately within next few years it received many very critical opinions, as in [4], in some applications lasting till today. Such contradictory views may be today well explained. From one side there are important advantages of IR-thermography - interaction with a patient is contactless, diagnostic procedure is fully aseptic, images are very impressive, easy taken in real time (from early seventies), what was regarded as a fantastic achievement. On the other side there are also important disadvantages - at the beginning the technology was only qualitative and not sufficiently reliable in terms of diagnostic value of thermal images. Thermal processes are not specific therefore interpretation of images which are showing only temperature distribution at the surface of observed regions of interest is very difficult. There are many sources and reasons influencing superficial distribution of body temperature. There are also problems with measurement accuracy as especially external conditions may influence distribution of temperature at the surface of observed regions of interest. Additionally lack of standards and poor preparation of personnel to perform measurements as well as unprepared patients made a lot of problems in terms of accuracy of temperature readings, finally leading to high disappointment of this modality.

However, it should be underlined that during last thirty years progress in thermal IR-imaging and data treatment may be regarded as revolutionary causing that most of listed disadvantages are no more important and, what probably is of the highest practical value, the cost of instrumentation dropped down making this modality comparatively inexpensive and accessible. Broad discussion on most of IR-thermal imaging problems in modern medical diagnostics is comprised in [5, 6], see also *Thermology International* [7].

From the beginning, one of the most important questions was the choice of absolute temperature as a diagnostic symptom. Unfortunately, even after development of quantitative cameras in eighties, accuracy of temperature measurements still was limited due to strong influence of external conditions on surface temperature distribution as well as problems with knowledge of the values of the emission coefficient. Important improvements are noted after fundamental projects devoted to standardisation of image caption procedures, e.g. [8,9,10], on finding other thermal

descriptors, less dependent on environmental conditions, as active dynamic thermography [11,12] or application of advanced modelling combined with measurement procedures [13] and with external cooling [14]. There are a lot of papers dealing with analysis of different advanced methods of image analysis, e.g. [15, 16]. In effect real recovery of IR-thermal imaging in medicine is noted from the beginning of the XXI century. Important applications of thermal imaging in medicine, sport, and psychophysiology or veterinary are recently published in many papers and several monographs as [17, 18, and 19] and other. Breast cancer is still among most popular fields of interest [20].

3. Conclusions

Still there are several important problems to be solved in the nearest future: newly proposed NDT procedures in medical diagnostics as well as screening procedures for prevention & safety are not standardised; in many cases only several proposals were tested in university clinical conditions but still require development of specialised instrumentation for approval by FDA and similar administrative bodies for implementation into broad use by practitioners.

Development of modern thermal quantitative IR-cameras, including inexpensive portable bolometric solutions strongly increased interest on applications of thermal imaging in medical diagnostics. Very important are applications of multimodality procedures, e.g. combination of CT, MRI and thermography increased efficiency of breast cancer diagnostics from ~80% to 98% [21]. This is a fantastic result, unfortunately difficult for broad practical use due to high cost of combined multimodality approach. Other problems will be discussed during the conference.

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