

METHODOLOGY OF THERMOGRAPHIC ATLAS OF THE HUMAN BODY

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Abstract

Thermography allows contactless measurement of surface temperature of objects, digital temperature display and graduate fields. Currently, this issue received increased attention since it is based on global efforts to give medical thermography in normal clinical practice. It is a noninvasive diagnostic method by which the disease can be diagnosed as early vascular system diseases, skin diseases, cancer, etc. The essence of research is to establish a reference sample thermograms using thermovision devices that convert thermal energy emitted. The reference sample of thermography was a statistically relevant number of healthy subjects, which was the basis for the creation of thermal atlas of the human body.

Keywords

methodic, infrared thermograph, reference sample, atlas

Introduction

Advantages of infrared thermograph are that it is a contactless, noninvasive, painless and no-radiation image technique. [5]

In order to clearly state that the image describes the pathological changes, it is important to be able to compare the thermograms of the same healthy individual site.

The presented study deals with temperature distribution of healthy human bodies which were measured by infrared thermograph. We used Infrared Imager with detector type 320x240 Focal Plane Array, Vanadium Oxide (VOx), Uncooled Microbolometer. A database of 540 thermograms from different position or locality of human body was created. The following eight views of human body were captured: **TBA** (total body anterior), **TBD** (total body dorsal), **TBAA** (total body anterior abduction), **TBDA** (total body dorsal abduction), **CA** (chest - anterior view), **UB** (upper back), **RAA** (right arm anterior), **RAD** (right arm dorzal), **LAA** (left arm anterior), **LAD** (left arm dorzal),

RHA (right hand dorzal), **RHP** (right hand plantar), **LHD** (left hand dorzal), **LHP** (left hand plantar), **FA** (face), **FP** (foot plantar).

Basic Concepts

Physiological Temperature Distribution

Physiological temperature distribution means temperature distribution which are measured from some position and locality of healthy human. [1], [2]

Atlas of Normal Thermograms

Atlas of normal thermograms is a database, which were taken from physiological healthy human volunteers by the use of infrared thermography. [2], [3]

Medical Thermography

The technique that uses an infrared imaging and measurement camera to “see“ and “measure“ invisible

infrared energy being emitted from an object. It is a tool for the study of surface temperature distribution of living organisms. [4]

Methodics of Measurement

Skin temperature of the human body from our database (n=540) was measured with an infrared camera (Infrared Thermal Imaging Camera Imager, Fluke Ti55/20, Fluke, USA). This thermographic camera generates a matrix (representing image points) of temperature values. They feature 320 x 240 (76 800 pixels) detectors with industry leading thermal sensitivity ($\leq 0.05^{\circ}\text{C}$; 50mK NETD) for high resolution. The camera works in the spectral range from 8 to 14 μm (human body infrared radiation is the highest in the spectral range around 9.66 μm) and the calibrated temperature range from -20°C to 100°C . Data were obtained through high-speed (60Hz) analysis. [5]

Emissivity of the skin was set up 0.98 in the camera, the ambient temperature was measured with an infrared (laser) thermometer (Pyrometer Testo 810). The camera was calibrated using the system's internal calibration process before each recording. All thermograms (n=540) were processed using special software (SmartView 2.1, FLUKE, USA).

Conditions of Measurement

The room, where the thermographic measurements are done has to meet certain conditions including constant room temperature, certain humidity, lightness, and room equipment. In this case examining room had air conditioning by which we could reach needed temperature of 22,5 degrees of Celsius ($\pm 1.7^{\circ}\text{C}$). If we had higher or lower room temperature, examined person could end up sweating or having shivers; this would discard the measurements. Room temperature was controlled by TESTO 810 (a temperature measuring instrument with infrared thermometer). Having window blinds is an advantage. If we perform these kinds of measurements in daylight, we will get (except of a thermogram) a classical photography. There cannot be a heater in or close to the room. Metal objects and reflective surfaces have to be removed as well. The thermovision camera has to be at a sufficient distance from measured person (app 2 m), that means is a bigger room to do this. The optimal room dimensions are 3x4 m. [6]

Methodology of the sensing system preparation

Fluke IR-Fusion technology captures a visible light image in addition to the infrared image. It joins two images and makes one image or it makes a combination of picture in picture. IR-Fusion technology helps us to identify and record suspicious components and helps us to repair them right at the first time. The head of camera with lens is rotating

within 180 degrees and allows us to show and record images in areas that are hard to reach. Software Smart View provides us with tools that analyze infrared images, add explanations and prepare reports. It allows us to edit those reports in a way that will satisfy specific workflows and its requirements.

Before measuring, room temperature and emissivity have to be adjusted on Fluke Ti 55-20 and the right kind of lenses has to be chosen. The emissivity value for a human body is 0,98. The emissivity value is determined from "Table of emissivity" freely available on the internet.

Methodology of the thermovision somathometry

With a modern thermovision camera you should count with a fact that it takes a few seconds to start it working. First of all, camera has to be set properly away from the scanned subject. To have a thermogram on the entire screen of thermovision camera, it is necessary to decide on an appropriate distance, height and angle of measuring. It should be ensured that while measuring a subject, the image should not show heaters, reflective components or any other subjects.

We have to be able to see visible end points on the screen of a thermovision camera.

Software packages distributed with the camera are used for processing the obtained thermograms. Software allows us to archive images made with thermovision camera.

Methodology of the subject preparation

Day before the measuring subject has to be instructed to:

- The body is dressed in loose clothing. Tight clothing on the skin leaving body prints and causes a reduction in blood flow to the body
- Subject 4-6 hours before the measurement is does not food, hot drinks, alcoholic beverages, drugs, smoke
- Subject to 6 hours before measurement not to take part in any physiotherapy treatment, not to practice anything that needs increased physical
- Subject is instructed to come to the measurement without make - up, not to have any kind of cream
- Subjects to be in physical and mental well-being
- The body is made aware of the thermovision method of measurement, painless, noninvasive and safety measurements.

It is important to complete the "Questionnaire" by which we find out needed information for the statistical analysis of thermovision measuring. Thermal stabilization of the subject consists of acclimatization which takes 15 - 20 minutes.

Before the measuring, subject is informed about the positions that will be captured. For the "thermographic

atlas of human body" we have captured 18 body positions.

Report methodology

A report includes:

- Date and time of thermal image
- Information about the subject
- Technical parameters of the camera

The color scale can be set before the measuring. In this case we have set grey scale because we wanted to focus on the details of human body.

By processing the range of temperatures we will find isotherms which help to identify temperatures for the selected polygon. Using the software Smart View we can detect changes of temperature on the surface of human body. We can detect changes in symmetries on different parts of the body and deviations from the standards. Based on the measurements and other personal information about the subject, we can provide a general description of thermogram and make an evaluation of it together with histogram. On an evaluated thermogram we can see signs determining the center position, see center frame, pointer of the warmest and the coldest point on the body. Those signs can be turned over - that means we can set the sign which we want to have or do not want to have shown on the thermogram.

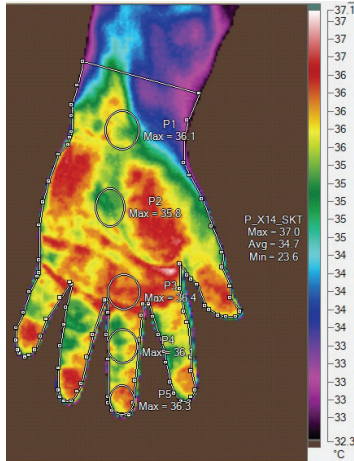


Fig. 1: Thermogram

Conclusion and results

Thermography enables us to measure the temperature of objects on the surface without any contact, to display it on the computer and to differentiate temperature fields.

Nowadays, the attention is paid to thermography worldwide because we want to start using thermography in everyday clinical practice. This project is following-up a worldwide research. Its aim is

to create a database of "normal thermograms" made with healthy people aged 16 to 28, living in Slovakia (mild temperature zone), with "normal anthropological parameters" like height, weight and proportions of body.

Our database consists of 30 physiological healthy volunteers (n1=30; 15 male, Mn1=15; 15 female, Fn1=15) to create „Thermographic atlas of the human body“. These subjects were captured by infrared camera in 18 different postures (1...18n30). We were able to get 540 thermograms (nTG=540). Average age of volunteers was 25 years.

A result of this study is database of normal thermograms and review of physiological temperature distribution. Obtained temperature values can be used as a reference for medical thermography, where positive/negative findings of the disease or injury can be quantitatively assessed.

Code	TBA - total body anterior TBD - total body dorsal
→ <i>upper edge of the image</i> : the most cranial point of the head	
→ <i>lower edge of the image</i> : soles of the feet	
The subject is standing straight, standing on a pad, arms and legs slightly abducted, palms (TBA) or dorsum (TBD) of the hands point forwards, head is a vertical position, neither rotated nor tilted to the side	

Fig. 2: Example, characterizing the first position in Thermographic Atlas of the Human Body.

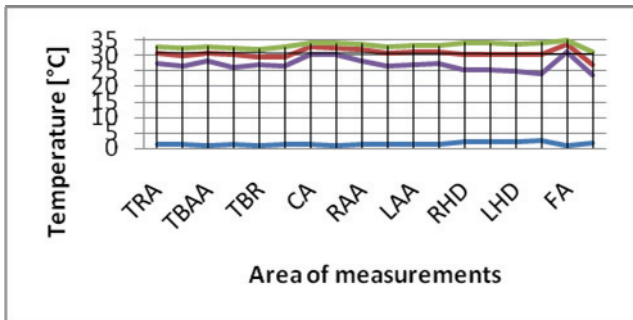


Fig. 3: Comparison of average temperatures, standard deviation, maximum and minimum temperatures. (BLUE LINE - standard deviation, RED LINE – mean, average, GREEN LINE – maximum, VIOLET LINE – minimum).

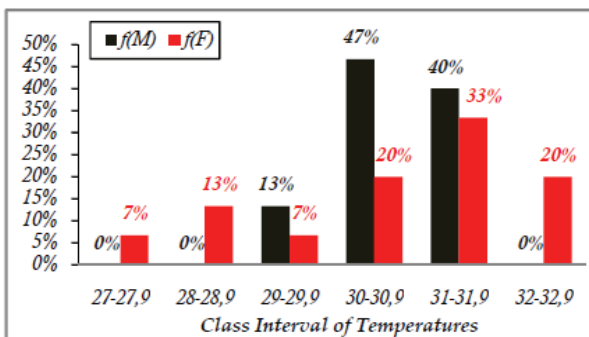


Fig. 4: Comparison Temperature between male and female volunteers, view in frontal plane ventral side.

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