PLANIMETRY OF THERMOGRAMS IN DIAGNOSIS OF BURN WOUNDS

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Abstract. The article discusses the problems connected with thermography and presents the application used for the analysis of thermograms taken by a infrared camera. The application enables the reading of the temperature of a particular place chosen on the thermogram and the estimation of the area of the same temperature, in a specified area, established by the user. It is very helpful in the diagnosis of burn wounds, in the estimation of burnt surface area and in the analysis of the wounds healing.

1. The basis of thermography

Thermography (thermovision) is a visualization process in the zone of an average infrared radiation (wave length from approx. 900 nm to 900 μm, see Fig. 1). It is based on a well-known physical phenomenon which involves emitting electromagnetic waves through each body with the temperature above 0 K. The radiation is called an infrared radiation due to the wave length, and thermal radiation because of its qualities. The intensity of thermal radiation is proportional to the body temperature. Thus, the process allows for the registry of the thermal radiation emitted by physical bodies in the range of temperatures found in everyday conditions, without the necessity of illuminating them with an outer source of light and, additionally, it allows for a precise measurement of the temperatures of the bodies.

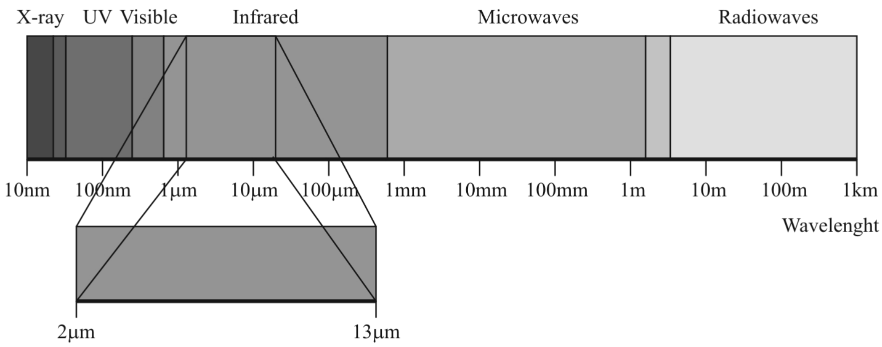

Fig. 1. Infrared band

The range of application is wide. It is more often used in medicine or army, space exploration, than in everyday life, in our work or home. Thermography can be applied in all cases where various abnormalities of machines, devices and buildings can result in the change of temperature layout on their surfaces. A modern infrared camera allows to identify the differences/variations in the temperature gradients with a very high precision, which oscillates on the 0.02 K level. Thereby we can define structure differences, imperceptible by other methods, and also thermal fluxes, and not only thermal, both on the surface and under the surface, often outwardly of a homogenous material.

We can distinguish two methods of thermography: passive and active. The first one is more popular and more often used in practice, since it doesn't cause any outside interference. It only involves registering of the existing condition. The latter one requires agitation with a thermal signal or for example acoustical (e.g. by impulse), and then appointing thermograms describing temperature changes according to the time. In fact its practical applications exceed typical engineering measurements and are mostly connected with scientific research.

2. Structure of the infrared camera

Infrared (thermovisual) camera consists of:
– single or matrix IR detector,
– cooling system (for single sensors required cooling methods including stirling cycle coolers and liquid nitrogen coolers),
– optical system containing filters and lenses,
– signal processing system, i.e. electronic paths of signal amplification and processing, which are used for analysis and registration,
– visualization system, usually an LCD monitor.

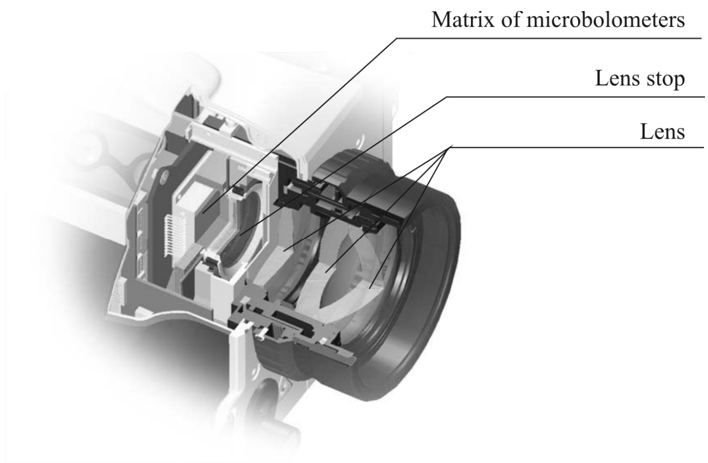

Fig. 2. Infrared camera [1]

The main element of the camera is the system of IR detectors. The factor responsible for the quality of the pictures, possibilities of application, sizes and the price is the level of their perfection. In general, IR detectors can be of thermal or photon type: individual, linear or matrix. Nowadays IR detectors used in infrared cameras have a fixed two-dimensional matrix made of so-called microbolometers. Resolution and sensitivity of the camera depend on the number of microbolometers and their measurements. In a thermovisual camera a typical matrix contains 320x240 or 640x480 single detectors, i.e. pixels.

A microbolometer consists of an array of pixels, each pixel being made up of several layers. For example the bottom layer consists of a silicon substrate and a readout integrated circuit (ROIC). Electrical contacts are deposited and then selectively etched away. A reflector, for example, a titanium mirror, is created beneath the IR absorbing material. Since some light is able to pass through the absorbing layer, the reflector redirects this light back up to ensure the greatest possible absorption, hence allowing a stronger signal to be produced. Next, a sacrificial layer is deposited so that later in the process a gap can be created to thermally isolate the IR absorbing material from the ROIC. A layer of absorbing material is then deposited and selectively etched so that the final contacts can be created. To create the final bridge like structure, the sacrificial layer is removed so that the absorbing material is suspended approximately 2 μm above the readout circuit. Because microbolometers do not undergo any cooling, the absorbing material must be thermally isolated from the bottom ROIC and the bridge like structure allows for this to occur. After the array of pixels is created the microbolometer is encapsulated under a vacuum to increase the longevity of the device [2, 3].

3. Burn wounds - ways of examining, use of thermograms' analyzer

Despite numerous attempts and efforts, no objective or non-invasive method of burn classification has been worked out in burn diagnosis [4]. In medicine we can distinguish several basic methods of examining and estimating the surface of burn wounds, such as "Wallace rule of nine", "the rule of hands", "the rule of fives", or "chessboard diagram expansion method". The first three above-mentioned methods allow for an approximate estimation of the wound surface. The last one uses ready tables and diagrams containing information about the exact area of different parts of the body with regard to age groups, which allows for a more precise estimation of wound surface area [5].

The purpose of the present thesis is to define the possibilities of thermography methods in diagnosing burn wounds and monitoring burn healing progress.

Having the wound thermogram, thanks to the created application, we can define the temperature of the particular place appointed in the picture and estimate the surface area, which covers the body in the given temperature range. It often happens that the treatment of such wounds lasts long, which is why a doctor has no possibility to estimate whether there has been any burn wounds healing progress or, worse still, whether the wound has expanded. Comparing the results of wound treatment based on thermograms we have the possibility to estimate precisely the healing progress, being able to see whether there have been any changes in the examined body surface area.

4. Thermogram analyzer - performance description

The task of the created application is reading in the given thermogram, made in a particular palette of colors and then analyzing the temperature in the, appointed by the user, place in the photograph.

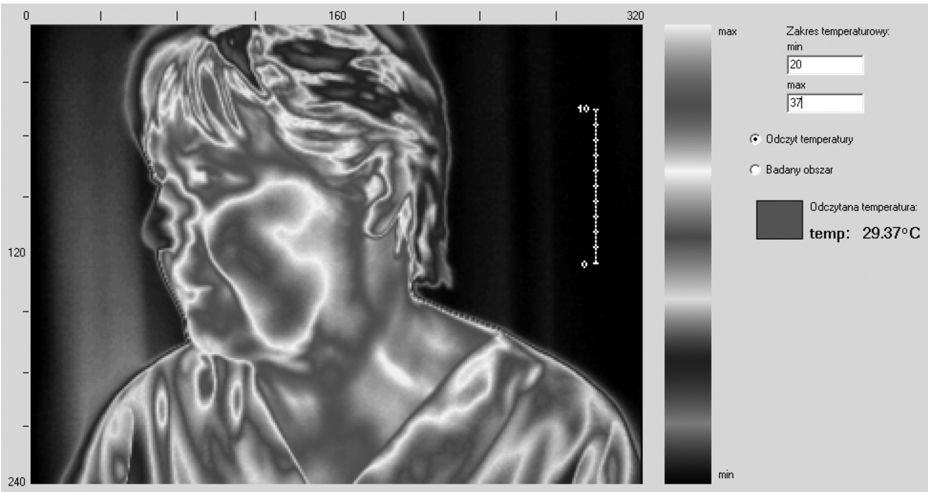

Fig. 3. Thermograms temperature detection

We assume that the accessible thermograms are written in BMP format. After the reading in, the user should submit the temperature range in which the photograph has been taken, i.e. the maximum and the minimum temperature which can be read. After the reading in and submitting the temperature range, reading all the colors from the color palette in the program takes place followed by assigning a particular temperature to each color, with respect to the minimum and maximum temperature of the thermogram. Then, the user choose the point in the thermogram in which the temperature is to be taken. The program reads the indicated pixel, shows the one we appointed. The RGB values of the read color are then compared to the color palette enclosed in the program. The program finds the read color in the color palette and, with respect to it, assigns a particular temperature. The value of the read temperature is shown on the screen in Celsius degrees with the accuracy of two places after point (Fig. 3).

In the second stage the user has the possibility to select the area of a rectangular shape, which will be subject to a more precise expertise (Fig. 4). Having chosen this option, the temperature will be taken only in the area of the selected rectangle, other pointers will not be taken into account. After appointing a place in the thermogram, with a specified temperature, being in the examined area, the user has the possibility to mark all places in the examined area with the same temperature as the appointed one. The program examines thoroughly pixel after pixel each part of the selected area, checking its color and also the temperature. All the places with the same temperature as the indicated one are automatically highlighted in grey. Having the area of our interest selected, we can now estimate its surface area. Before we do it though, we have to select some reference system, in other words, point on the examined thermograph how many pixels are included in one centimeter. We do so by marking with a mouse a distance of 1 cm on the thermogram. Depending on the distance from which the picture was taken, the user can mark 1 cm, 5 cm, or 10 cm. Thanks to that, the measure of the surface area will be more precise. The program reads the chosen arrow pointer positions and thus calculates how many pixels are included in 1 cm, and also the length of a pixel side. It enables us to estimate the surface of one pixel knowing that each pixel is a square. Next, we can estimate the surface of the area marked in grey. The program counts down all the pixels in grey color which are in the selected area and thus estimates the surface. The result is shown in square centimeters with the accuracy.

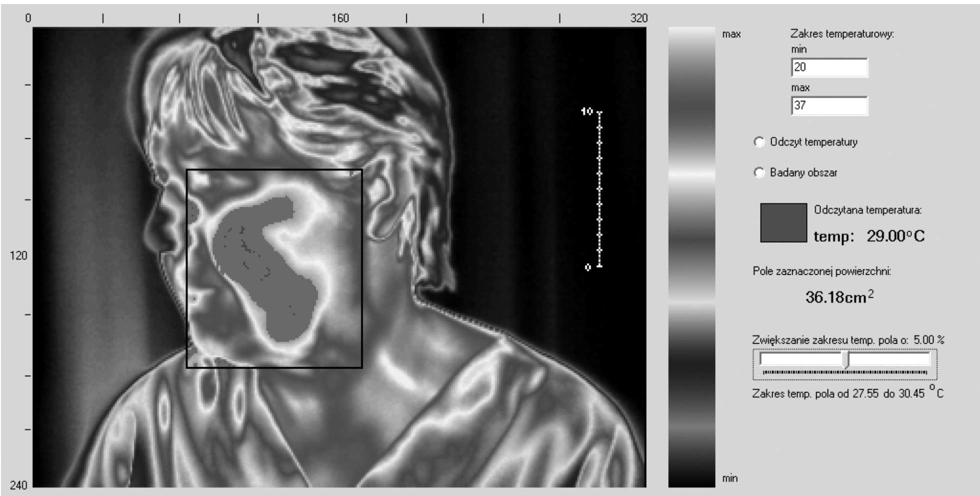

Fig. 4. Mensuration of wounds area

In case it turns out that the selected area of a particular temperature occupies too little space, we have the possibility to expand it with a range of ± 10% in relation to the indicated temperature.

Conclusions

Application of plane geometry of wounds in conjunction with thermography greatly facilitate the diagnosis and evaluation of healing progress of burn wounds and wounds difficult to heal.

Acknowledgement

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References

[1] Infratec, 2009.
[2] Hongchen Wang, Xinjian Yi, Jianjun Lai, Yi Li, Fabricating microbolometer array on unplanar readout integrated circuit, International Journal of Infrared and Millimeter Waves 2005, 26, 5.
[3] Yon J.J., Biancardini L., Mottin E., Tissot J.L., Letellier L., Infrared Microbolometer Sensors and their Application in Automotive Safety, Advanced Microsystems for Automotive Applications, Springer, New York 2003.
[4] Nowakowski A. (red.), Postępy termografii - aplikacje medyczne, Wydawnictwo Gdańskie, Gdańsk 2001.
[5] Jabłońska S., Majewski S., Choroby skóry i choroby przenoszone drogą płciową, PZWL, Warszawa 2005.