Heterogeneous thermograms: the methods of attack

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Oral presentation.

Quantitative characterization of pronouncedly inhomogeneous thermograms is not a problem that can be cracked easily. At the same time, thermograms of this sort occur universally in infrared imaging applications. They can be obtained both from inhomogeneous media or processes and from living objects. In [1] it is shown that heterogeneous thermograms displayed by human organism with disturbed inner equilibrium can be analyzed in terms of statistical parameters of related surface-temperature histograms, such as the mean temperature and standard deviation of temperature. Symmetry breakdown and variation of histogram shape may serve as indicators of homeostasis shift and can be used for quantitative characterization of this shift. It demonstrates an importance of thermal pattern inhomogeneity investigation in physiological studies. Likewise, medicine needs sometimes rigorous analysis of thermograms in question. It was substantiated in [1] on the basis of a general principle of neurohumoral regulation.

It is evident that pixels of a heterogeneous thermogram can be redistributed over the image in such a way that temperature gradients be minimized. This mental experiment allows one to become cognizant of the fact that sharply heterogeneous and non-heterogeneous thermograms can give out identical histograms of temperature distribution. Thus, the degree of heterogeneity and the temperature distribution function generally offer two independent characteristics of the thermal pattern. This notwithstanding, infrared data demonstrate sometimes a strong correlation between the degree of visual heterogeneity of the pattern and statistical parameters of the corresponding histogram [1].

From what has been said, it might be assumed that the heterogeneity as a separate characteristic of 2D pattern merits detailed consideration and quantitative estimation. However, up to the present it normally was approached just by sketchy qualitative descriptions. The present contribution is among the first works dedicated to solving this problem which is of crucial importance in a wide range of applications of quantitative infrared thermography.

An example of heterogeneous thermogram is given in figure 1 on the left. In view of the fact that a pattern represented in such kind of thermograms shows a general resemblance to a scene that is characterized by a quasi-periodic structure, in [2] a quantitative estimate of thermogram heterogeneity is made on the basis of the wavelet Haar transform. The wavelet transforms has a wide use in analysis of texture frequency properties [3].

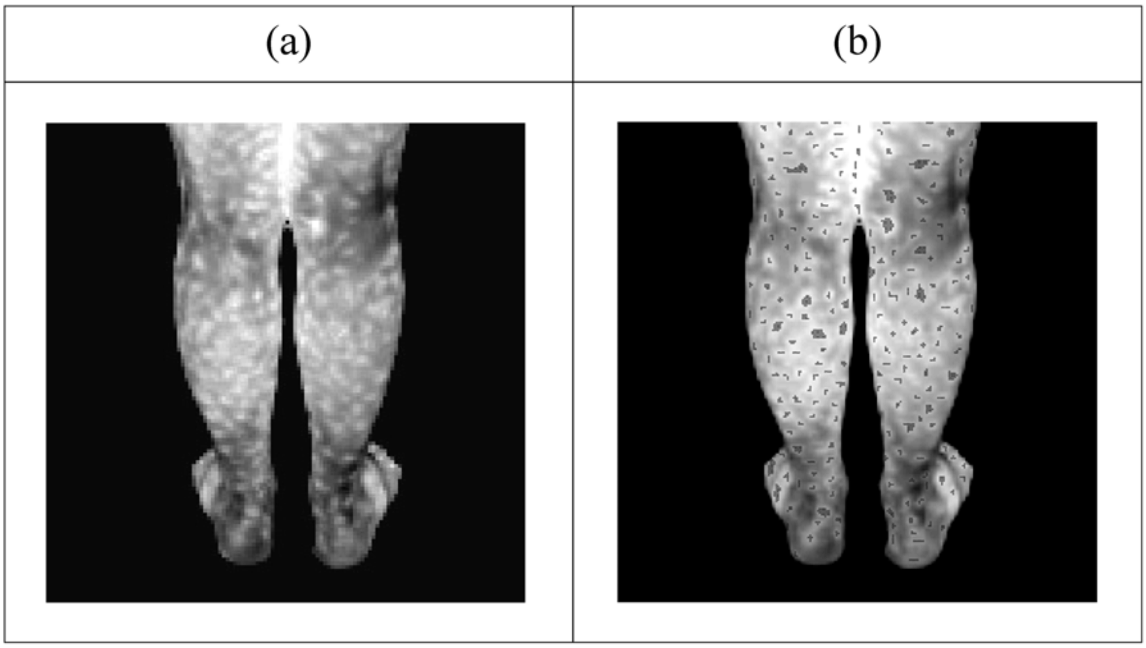

Fig. 1. (a) An example of heterogeneous thermogram (the lower extremity).
(b) Hyperthermic foci (grey spots) found in pattern (a) with the described method.

It is shown in [2] that the Haar transform allows getting the evaluation of a heterogeneity to be adequate to visual perception of the degree of heterogeneity.

In addition to review and summarizing of previous results, a new computer-assisted method developed for quantitative estimation of thermal pattern inhomogeneity is presented in the paper. It comprises recognition, identification, showing up the effective sizes, and direct statistical analysis of surface hyperthermic (or hypothermic) foci. Computer simulation and full-scale experiments have shown that the higher is the sensitivity or spatial resolution of infrared camera, the more accurate is the method.

Special attention is paid to the "roughness" of temperature-coordinates 3D surface $T(X,Y)$. On the well-grounded assumption that the equation

$$\frac{dS}{S} = \frac{dT}{T \ln \frac{T}{T_0}} \qquad (1)$$

expresses a satisfactory approximation of spatial distribution of temperature within hyperthermic focus it is shown that step-by-step analysis of ratio dS/S as temperature monotonically changes provides a means of estimating foci parameters with a good accuracy. In Eq. (1) S is the current area of a focus-associated 3D-"hill" cross-section taken at temperature T, T_0 – temperature maximum within a separate thermal focus.

The spectra, which are representative of the foci area distribution, are also plotted and analyzed. The obtained results are in fair agreement both with the input data and with common sense. One of the examples of the just said is demonstrated in figure 1.

REFERENCES

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