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Original Research Article

Methods of face localization in thermograms

*Mariusz Marzec**, *Robert Koprowski*, *Zygmunt Wróbel*

Department of Computer Biomedical Systems, University of Silesia, Institute of Computer Science, Sosnowiec, Poland

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ABSTRACT

This paper presents an algorithm for determination of the head centre in thermograms. The paper includes a comparison of the method developed by the authors with the known methods presented in the literature for locating the head in thermal images. The proposed method enables automatic localization of the head centre, which is essential for practical applications when there is a need to locate the head in an image. Application areas may include the process of face recognition in biometrics, recognition of emotions, the creation of a human–computer interface. The presented method is reproducible and enables to obtain correct results in cases of large interindividual variability of the test subjects.

1. Introduction

The process of face localization in thermograms may be similar to the one carried out in visible light. Similar solutions are proposed, wherein the characteristic is the fact that the widespread methods based on the analysis of the colour cannot be used directly [1,7] because each thermogram pixel represents the value of temperature and not the colour (or the grey level in the case of thermal images without the temperature value). Due to the use of specific characteristics and advantages of thermal images [8], the silhouette or head detection in an image with background suppression is greatly simplified. In the case when there are no other sources of heat in the background and images are taken in the right conditions (appropriate ambient temperature, humidity), extracting the human silhouette is relatively easy. In some cases when the images meet the above criteria, a simple method based on specific values of temperature and thresholding can be applied. In Ref. [14] the authors proposed a fast algorithm based on the fact that the maximum brightness/temperature in the image related to the highest temperature is in the facial area. In the described solution, it enabled to locate this area correctly and, what is more important, quickly. It was followed by determination of the face centre. This method was not sensitive to the head rotation or position. However, in cases when some part of the torso has a similar temperature (not covered with clothing), face detection can be problematic. In Ref. [4], specially prepared (based on data sets) thermal models of the facial skin, the other obscured areas of the skin, and the background were used to locate the face. An ellipse of any orientation and a variable position and size was used as the temperature model of the face. For each change of model

* Corresponding author at: Department of Computer Biomedical Systems, University of Silesia, Institute of Computer Science, ul. Będzińska 39, 41-200 Sosnowiec, Poland.
E-mail address: mariusz.marzec@us.edu.pl (M. Marzec).

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parameters, the probability of matching was determined. On the basis of the maximum values, the location of the face in the image was determined. Filipe and Alexandre [5], on the other hand, apply the method of projection on the x and y axes. This method is often used in the case of both images after initial binarization and images before binarization directly for a grayscale image. In the aforementioned publication, the authors used the projection of an image in grayscale. This method enables to specify the area and the centre of the head as well as to eliminate, to some extent, the impact of the torso area on the localization results. Because of these features, it was chosen as the second one of the reference methods discussed in this paper. Cho and Wang proposed in Ref. [3], a face segmentation method in thermal images based on the contour and morphological operations. In order to detect the edge, the Sobel edge detector was used, taking the assumption that only the largest contour represents the face. In the next step, morphological operations on a pre-determined contour were applied. Their task was to combine the gaps in the contour and eliminate small areas. Based on thus determined curves, the centre of the head was determined.

2. Material

The research material was a set of 125 thermograms taken with several types of thermal imaging cameras from FLIR (AGEMA 590 PAL (sensitivity of 0.1 °C)), ThermaCam S65 (sensitivity 0.08 °C), A310 (sensitivity 0.05 °C), T335 (sensitivity 0.05 °C) and at 320 × 240 pixel optical resolution of detectors. The set included 51 thermal images of men and 47 thermal images of women. When taking the images, the main principles of taking thermal images for medical purposes were preserved [12], including:

- adequate preparation of the test room. Temperature in the range of 20–24 °C and humidity of 45–55%, no radiation sources or the air flow;
- measurements made at a distance of about 1 m in order to eliminate the interference caused by slight movements of the test subject.

In the test set, the aforementioned large variation of images, due to the conditions of thermogram acquisition (clothes, hair) and interindividual variability, can be observed (Fig. 1):

- distortion of the shape of the head area – due to e.g. hairstyle, external elements;
- temperature distribution in different areas of the face;
- varying degrees of visibility and detection of individual face parts, which may affect the operation of the compared methods – eyebrow line.

Accordingly, it was possible to test the three algorithms in terms of their efficiency in determining the centre of the head as well as to consider their application in practice. Each of the solutions was implemented in MATLAB. An interface in the form of a simple application was developed which enabled to carry out the process automatically by each of the methods. The test set of 125 thermograms was subjected to the process of locating the centre of the head. For each method, the coordinates of the head centre were designated. The data were saved in work files and also presented in graphical form Figs. 7 and 8. The chapter V presents examples of the results in graphical form and as a graph of δ_E error which is the Euclidean distance of the coordinates H_C designated using each algorithm from the reference coordinates H_{CW}.

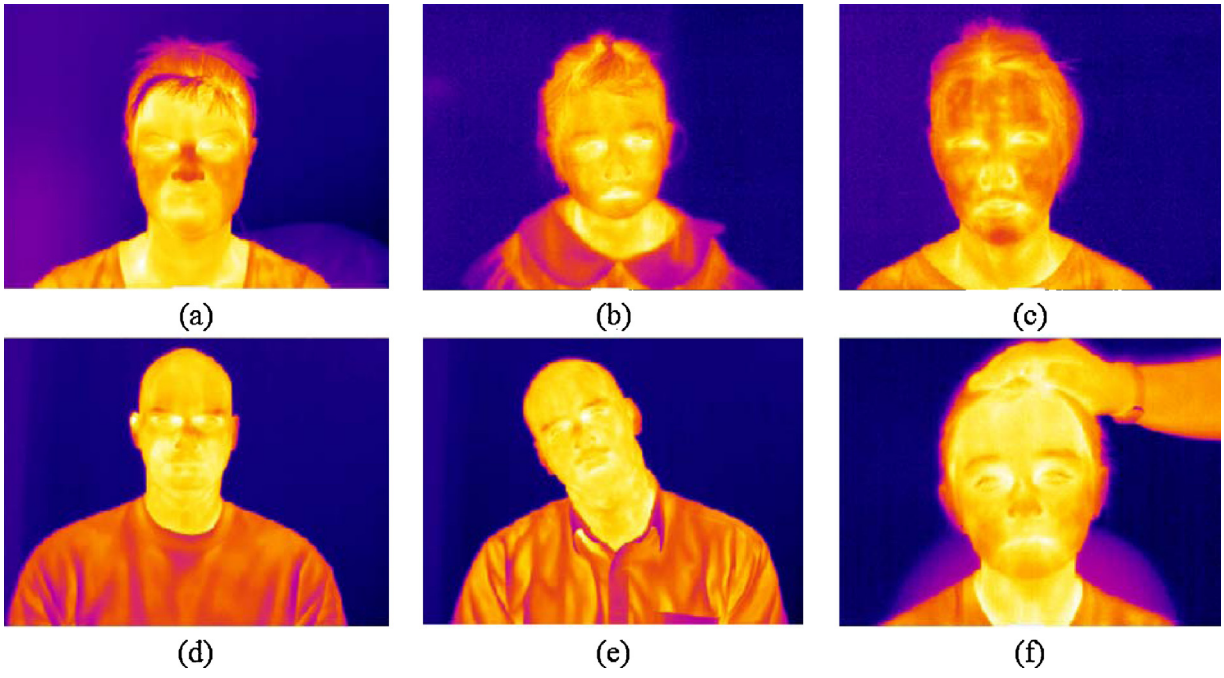

Fig. 1 – Examples of test set of thermograms.