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Laboratory Approbation of a New Approach for Contrast Enhancement of Human Face Thermal Image Based on Selective Multifunction Pixel Brightness Conversion Function

Alyushin M.V.[1], Alyushin A.M.[2], Kolobashkina L.V.[3]

[123]*National Research Nuclear University MEPhI (Moscow Engineering Physics Institute), Moscow, Russia*

[1]*mvalyushin@mephi.ru*, [2]*amalyushin@mephi.ru*, [3]*lvkolobashkina@mephi.ru*

Abstract

The paper suggests a new approach to improving the contrast of the thermal image of a person's face in the deep infrared region. The approach involves the analysis and modification of the image histogram and is based on the use of a selective multivalued function for encoding the brightness of image pixels. The approach is focused on processing first of all thermal images of the person face, containing areas with various informativeness. The implementation of the approach in practice makes it possible to improve the contrast of the face image with preservation of all informative features regardless of the level of brightness of the corresponding pixels of the image.

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Keywords: Thermal image, Improvement of Contrast, Histogram Modification, Informative Areas

1. Introduction

Currently, the technology of obtaining and computer processing of the thermal image of the human body is widely used in various fields. Unfortunately, this type of radiation is almost completely absorbed by human clothing. For this reason, in practice, one often has to deal mainly with the thermal imaging of a person's face. The thermal image of a person's face is quite informative. With the use of modern computer processing algorithms, it is possible to determine a number of biometric parameters characterizing the work of its cardiovascular system, its respiratory system, and also its peripheral nervous system [1-3]. The thermal image of a person face is usually characterized by low contrast. The practical algorithms for improving the contrast of the thermal image usually operate with a histogram for the entire image frame. And this leads to significant distortions of personal bio-information and, in extreme cases, even to its complete loss.

For this reason, it is urgent to develop an approach aimed at increasing the contrast of the thermal image of a person's face and guaranteeing the preservation of all significant personal bio-information.

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2. Related Work

Currently, there is a fairly large number of scientific publications devoted to solving the problem of improving the contrast of infrared images. The basis in this plan should be considered the approach HE (Histogram Equalization), which allows to improve the contrast of the entire frame of the conventional or infrared image due to the application of the nonlinear function of pixel brightness correction. Unfortunately, the direct application of this approach to the processing of the thermal image of a person's face, as a rule, leads to the loss of personally important bio-information.

In [4-5], the realization of the HE approach for improving the contrast of primarily dark images is considered. It is assumed that the same approach to processing gray tones in the entire image will lead to an improvement in the contrast for the entire image. The informative significance of different areas of the original image is not considered and not taken into account.

In work [7] it is proposed to use the so-called adaptive approach AHE (Adaptive Histogram Equilization). It is based on the analysis and modification of the histogram for the entire image. The AHE approach is primarily aimed at improving the contrast of images with a large proportion of dark areas. For these types of images the approach leads to a significant improvement in contrast. The approach is not intended on thermo image processing with areas of different informativeness.

In the study [8], the authors proposed the CLAHE algorithm (Contrast Limited approach with AHE results) based on a combination of the method for processing non-overlapping image fragments with limited contrast and the above AHE technology [9-12]. This algorithm permits to improve the contrast of the original image, as well as to reduce the noise level. However, it does not guarantee the loss of personal significant bio-information in case of the thermal image of a person's face processing.

3. Histogram and face informative regions

Conducted laboratory studies of 276 thermal images of the human face allowed to obtain a typical histogram. Figure 1 shows the sample of typical histogram obtained for the thermal imaging of a person's face. In Figure 1, the value of I corresponds to the brightness of the pixels of the image. For thermal images in grayscale, this value varies from 0 to 255 for the 8-bit pixel brightness encoding. The value N(I) shows how many pixels of the image have a brightness equal to I.

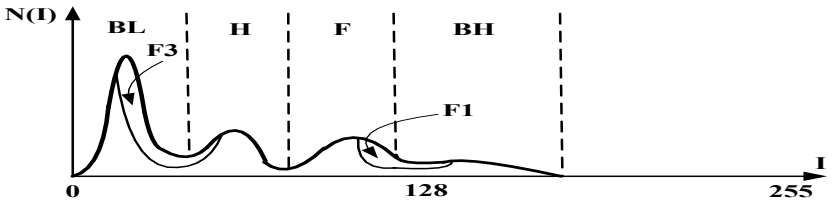

Figure 1: Typical histogram of pixel distribution of thermal image by brightness

The resulting typical histogram in the general case can contain four characteristic regions corresponding to the local maxima of N (I). The BL region includes pixels with a low brightness. The main mass of these pixels is the pixels of the dark background around the head. Area H is characterized by a higher brightness of the pixels compared to the background. This area is mainly made up of image pixels that represent human hair. The brightness of the pixels of the face area F in the absence of strongly heated background elements is usually the maximum. In the presence of hot elements, for example, cups of tea, the BH histogram area has a distinct maximum.

Figure 2 shows an example of a thermal image of a person's face with areas BL, H and F selected on it. Additional hot elements, characteristic for the BH region, are absent in this example.