Infrared Face Recognition Using Distance Transforms

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***Abstract*—**In this work we present an efficient approach for face recognition in the infrared spectrum. In the proposed approach physiological features are extracted from thermal images in order to build a unique thermal faceprint. Then, a distance transform is used to get an invariant representation for face recognition. The obtained physiological features are related to the distribution of blood vessels under the face skin. This blood network is unique to each individual and can be used in infrared face recognition. The obtained results are promising and show the effectiveness of the proposed scheme.

***Keywords*—**Face recognition, biometrics, infrared imaging.

I. Introduction

FACE recognition is an area of computer vision that has attracted a lot of interest from the research community. A growing demand for robust face recognition software in security applications has driven the development of interesting approaches in this field.

A large quantity of research in face recognition deals with visible face images [1], [2]. In the visible spectrum the illumination changes represent a significant challenge for the recognition system. Illumination change introduces a lot of errors during the recognition phase. Another challenge for face recognition in the visible spectrum involves the changes in facial expressions. Facial expression can lead to a poor performance of the face recognition system in visible images. To avoid these problems, researchers propose the use of 3D face recognition [3] and infrared face recognition [4]. Infrared face recognition is a growing area of research. Many of the techniques used in infrared face recognition are inspired from their visible counterparts. Known techniques used in visible face image recognition are also used with infrared images, like Eigenfaces or Fisherfaces [4]. More recently in [5] and [6], the authors propose a face recognition technique based on the extraction of physiological information from high temperature regions in thermal face images. The extracted physiological information is related to the network of blood vessels under the skin. This network is unique for each individual and can serve for face recognition.

In this work we extend the physiological extraction approach proposed in [5] and [6]. We present a new approach for face recognition in the infrared spectrum using a rich network of physiological features. The proposed technique extracts a unique faceprint from isotherm face regions. This faceprint represent medial axis regions of isotherms extracted from infrared face images. It gives a rich representation of physiological face features unique to each individual. Also, a distance transform is used to achieve an invariant matching during face recognition steps.

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II. Physiological Features

An infrared face image captures thermal information of the face. The face image is represented by regions with different temperatures (Fig. 1). This thermal map is related to the network of blood vessels under the face skin [6]. This network is unique to each individual. This makes the thermal face image different between two persons.

In this work, we use this characteristic and extract a rich physiological representation from thermal face images in order to build a unique thermal Faceprint of a person.

Fig. 1 Example of thermal face images in the mid-wave spectrum

III. Face Extraction

The first step in the proposed approach is to extract the face skin region in the grayscale infrared image of the face. The thermal face images are characterized by a high contrast between the background and the foreground. This is used to segment the face image.

Learned thermal information of the face skin is used to segment the face area. Then horizontal and vertical projections are used to eliminate the neck region.

The analysis of horizontal and vertical projections helps define a region of interest around the head. Sobel edge detection is then performed in this region of interest. The edge data is used to best fit an ellipse around the face. The ellipse mask is used to extract the face region (Fig. 2).

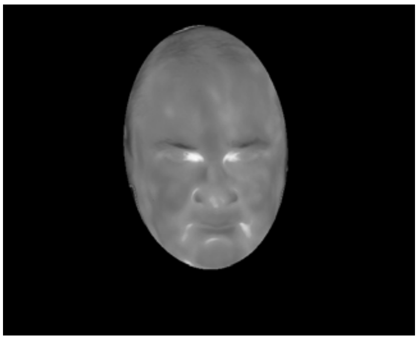

Fig. 2 Extracted face region

IV. Isothrms

In this work, we use regions of equivalent temperatures (called isotherms) to extract the thermal physiological face features. A clustering technique is used to construct facial isotherms. A PCT/Median cut technique [7] is used for clustering the image gray levels (Fig. 3).

Isotherm layers with the highest temperature values are extracted for further processing (Fig. 4).

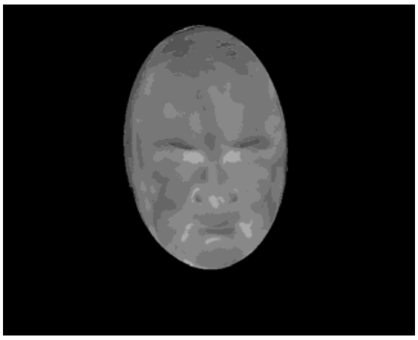

Fig. 3 Face isotherms

V. Faceprints

Medial Axis Transform [8] is applied in each isotherm layer image. The extracted medial axis represents the central part of isothermal regions. It models the central area of facial temperature distribution (Fig. 5).

In order to construct the complete faceprint, fusion of different isotherm faceprints is performed. The resulting image is a complete and rich faceprint (Fig. 6).

The obtained image is then cleaned using mathematical morphology. First, the image is passed through a bridge connection algorithm in order to eliminate small gaps between detected features. Then closing is used in order to eliminate isolated areas. Skeletonization is finally performed in order to extract the skeleton of the remaining features. The obtained image is a cleaner Faceprint (Fig. 7).

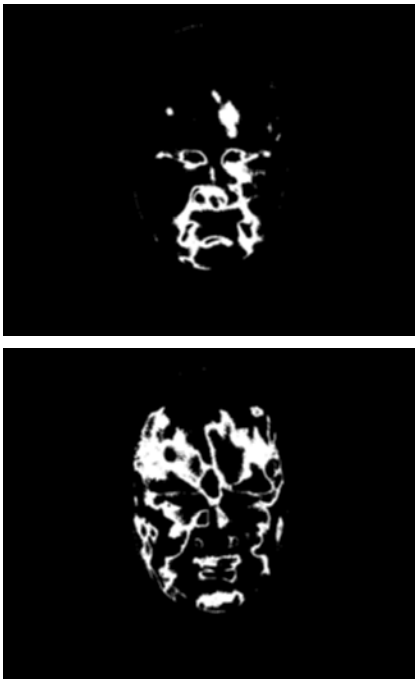

Fig. 4 Example of two high temperature isotherm layers

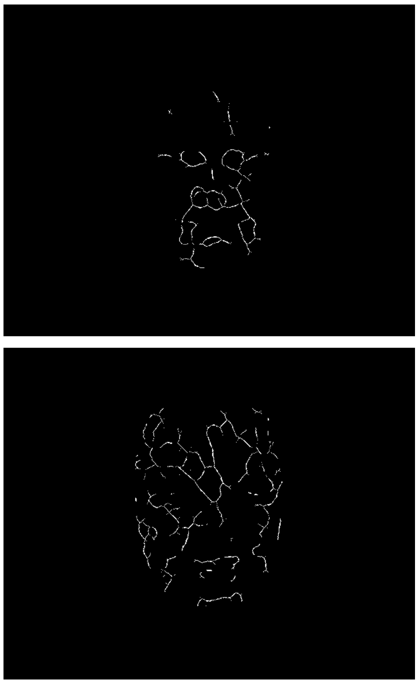

Fig. 5 Example of physiological features extraction from two isotherms layers

VI. Distance Transfom of Faceprints

Face recognition is performed in faceprints after distance transformation [8]. Distance transforms permit to achieve the necessary invariance in a matching process. An Euclidian distance transform is performed in the faceprint images (Fig. 8). The obtained images are then used for face recognition.

Face recognition is conducted using Euclidian distance measure between distance transformed images after size normalization.

Fig. 6 Fused faceprint image

Fig. 7 Cleaned faceprint image

VII. Experimental Results

Experiments were conducted in thermal images captured in the mid-wave infrared spectrum (3-5μm) using a FLIR Phoenix camera. Face images of multiple persons were captured in normal temperature conditions. The PCT/Median cut clustering was used to reduce the image intensities to 8 gray levels. This gives 7 levels for isotherms and 1 level for the background. The 6 highest temperature isotherms were kept for constructing the faceprint.

The obtained faceprints were transformed using an Euclidian distance transform (Fig. 9). Matching between these transformed images was conducted using an Euclidian distance measure.

Tests were conducted on thermal images and the obtained results show that the proposed approach achieves high performance rates (100% recognition was achieved on the available images).

VIII. Conclusion

In this work we introduced a new approach for infrared face recognition using thermal physiological features. These features are related to the network of blood vessels under the skin. They permit the construction of a unique thermal faceprint. A distance transform matching technique is performed on the obtained images and high success rates are achieved. The obtained results are promising and show the effectiveness of the proposed scheme.

Fig. 8 Distance transformed faceprint image

Future work includes tests with more images and at various temperature conditions. Tests with time lapse will be conducted in order to evaluate the performance of the proposed technique over time and in an operational scenario. Also, a probabilistic multimodal fusion scheme will be evaluated with the proposed approach.

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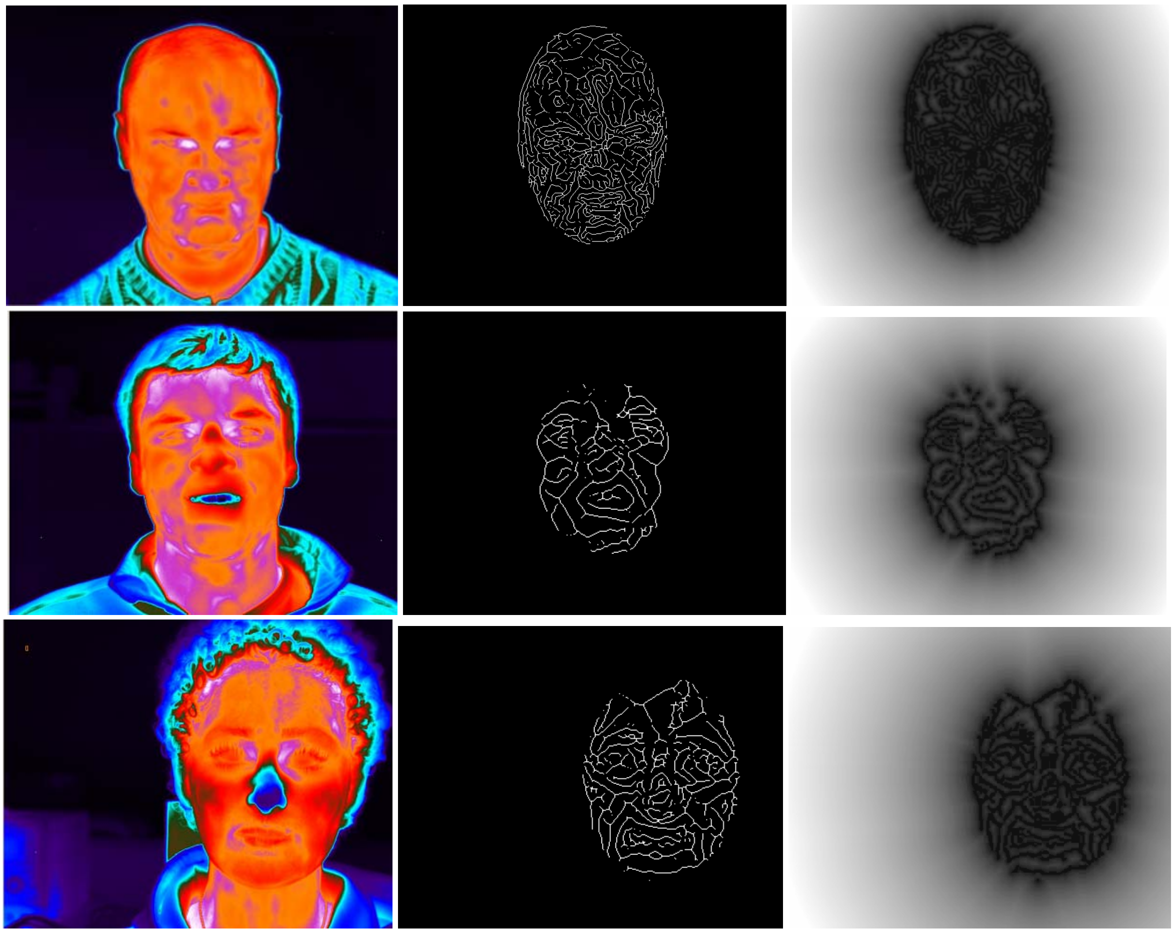

Fig. 9 Thermal images (left) ; faceprints (center) ; distance transformed faceprints (right)