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Research Article

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Performance analysis of thermal imaging for face recognition

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ABSTRACT

Facial Recognition with unique feature extraction and matching of similarities from thermal infrared images is presented. The proposed work is an integrated approach that consolidates the extraction of consistent features through the use of morphological operators, registration using Image Registration tool and matching these features through newly developed similarity measures for authentication. The new approach is developed with a thermal signature template formed using four images which is to be taken at various instant of time ensured that it does not affects any biometric matching process based on consistent thermal features. Thirteen subjects were used for developing the algorithm in a thermal imaging system. The highly accurate results were obtained in the similarity measures for skeletonised signature and also for anisotropic ally diffused signature. The present work is implemented in MATLAB and the results clearly demonstrates the ability of the infrared system to extend its application to other thermal imaging based systems

Keywords: Image Morphology, Face recognition, thermal imaging, biometric, image registration

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INTRODUCTION

As technology advances, the information and intellectual properties are wanted by many unauthorized personnel. So many organizations have being searching ways for more secure authentication methods for user access. Identification systems rely on three key elements: 1) attribute identifiers 2) biographical identifiers and 3) biometric identifiers. It is rather easy for an individual to falsify attribute and biographical identifiers, however biometric identifiers depend on intrinsic physiological characteristics such as thermal emissions features of the eye-retina and iris ,fingerprints, hand geometry, skin pores ,wrist/hand veins that are difficult to falsify or alter [1] . The identification of facial features in the areas of medicine and security [1].Several other techniques and systems have been created for face detection in areas that use cameras in the visible spectrum but remain challenged by difficult issues related to light variability [2] and detecting facial disguises. The problem of light variability is solved by the use of thermal Mid-Wave Infrared (MWIR) portion of the Electromagnetic (EM) spectrum .Any strange object on a human face can be detected, as foreign objects have a different temperature range than that of human skin. These benefits leads to the development of human face recognition systems in the MWIR spectrum and the cameras used are available at a much higher cost than their visible band, several researches is done in human face recognition in the MWIR spectrum is still in its infancy. In current existence, researchers have realized the potential of thermal MWIR imagery for human identification using the vein structure of hands [3], finger vein patterns [4], and vein structure of the human face [5].

The use of thermal images for human identification [6]. However, the visual and thermal fusion of face images has been used in the face recognition field [7]. The work performed by the research group in [8] represents the first attempt at developing an algorithmic approach to face recognition using physiological information obtained from MWIR images. The research done by the group[9] presenting an integrated approach that consolidates unique algorithms at extracting thermal imaging features and matching these features through newly developed similarity measures for authentication. From the human vasculature, this present approach to face recognition using thermal images from android mobile is checked against another existing database to prove the reliability of the algorithms designed for feature extraction, template generation and authentication through similarity measures.

EXPERIMENTAL SECTION

The present work is implemented using three modules A) Data Collection B) Feature Extraction and (C) Feature matching. In each of these modules different instructive steps and safeguards starting from camera calibration to facial thermal signature extraction are taken to ensure that authentication is made through features that are consistent through several image acquisition times and are therefore more likely to be part of the vasculature of the individual.

A) Data Collection

The collection of thermal images was done using the android mobile camera system which operates in thermal vision. For this study, thermal infrared images from different subjects were collected. The recording of the thermal infrared images was done with an average room temperature of 300 K and the frontal view of each subject was taken. This process was repeated in different days and times and notes the variations that may occur over time. The time gap for acquisition of the images among and within subjects varied from a period of a week for some subjects up to three months for others.

B) Feature Extraction

After the collection of thermal images from android mobile camera, the feature of the subject has to be extracted. Most challenging task of biometric system is the feature extraction process which is possible at the human facial vasculature. The skin temperature can be measured and visualized using a thermal infrared camera with a reasonable sensitivity. Morphological operations such as opening and top-hat segmentation .To generate a thermal signature template for each subject with most prevalent and consistent features, four thermal images is taken over a period of six months. The unique templates are generated for each individual through anisotropic diffusion and unique registration processes create facial signatures that include the most consistent features recorded over time. The steps carried out in feature extraction are as follows

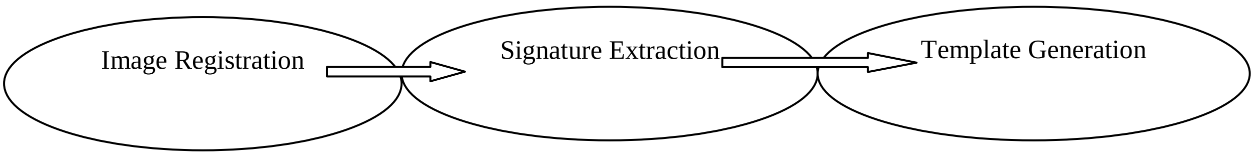


Fig. 1 Modules of Feature Extraction

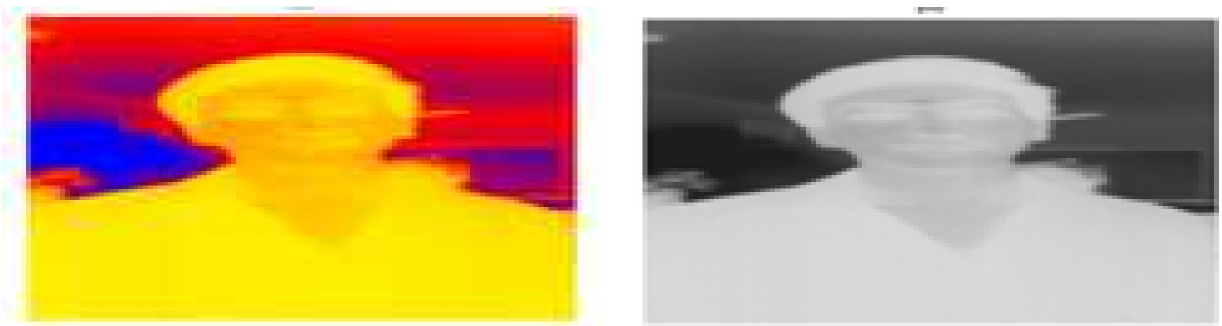


Fig. 2 a) Thermal Infrared image b) Registered Thermal image

1. Thermal Infrared Image Registration

The intra-subject image registration process was achieved using the MATLAB Registration Tool. Various techniques are available for image registration for medical images and for images in biometric applications [12, 13]. The MATLAB tool is used for registering the thermal image to database which is significantly faster and accurate in image registration as compared to other techniques such as simulated annealing of the genetic algorithms for Magnetic Resonance Imaging (MRI) applications [14]. Out of the four images taken from each subject one was chosen as the reference image and the rest were registered to the reference image. The purpose of the registration process is to account for any lateral and/or vertical movement from the subject that could have taken place during data collection. The signature and templates are used for similar measurements which is more effective. The various parameters that need to be addressed are cost function, degrees of freedom (DOF) and interpolation. It was found that for thermal images under consideration, the mutual information cost function gave us the best registration results. Mutual information formulation used for the registration of the thermal images was suggested [15]. Also degree of freedom are chosen for the study one each for the two dimensions of the image, one for rotation and one for the scaling. Various types of interpolations can be used, but since the images are fairly aligned with only slight shifts in position, a nearest neighbor interpolation was found to be sufficient.

2. Thermal Signature Extraction

After registering the thermal images for each subject, thermal signature is extracted in each image. The thermal signature extraction process has four main sections:

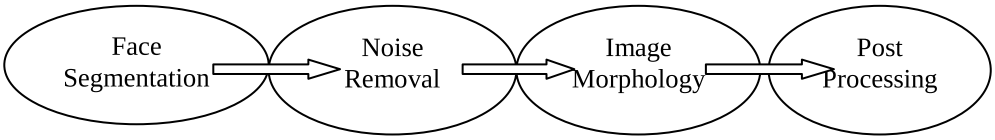


Fig. 3 Steps involved in Signature Extraction

2.1. Face Segmentation

After registering the thermal images for each subject, face segmentation is done for removing the neck and the hair region from the face using dual-front active contour region growing technique. Since the entire processing was carried out in MATLAB, a shell script was created to interact with and control the FLIRT algorithm through the MATLAB environment. The Yezzi energy [16] is used to model the energies of the interior and exterior of the contour for face segmentation which falls in local minima and yield poor results. The algorithm operates by first dilating the user selected initial contour to create a potential localized region R for finding the optimal segmentation [9] which is given by

$$R=\Omega\oplus S \quad (1)$$

Where S is the spherical structuring element of the localization radius and $\oplus$ is the dilation operator

2.2 Noise Removal

After the face was segmented, noise is to be removed to enhance the image for further processing. A standard anisotropic diffusion filter [17] is first applied to the entire thermal image which is used to reduce the image noise without removing significant parts of the image content The significance of the anisotropic diffusion filter in this particular application is to reduce spurious and speckle noise effects seen in the images and to enhance the edge information for extracting the thermal signature.

2.3 Image Morphology

Image morphology as a tool for extracting image components that is useful in the representation and description skeletons. Morphological filter consists of two operations are erosion and dilation. With A and B as sets in Z2, the erosion of A by B is defined as

$$A\Theta B=\{Z\backslash(B)z\subseteq A\} \quad (2)$$

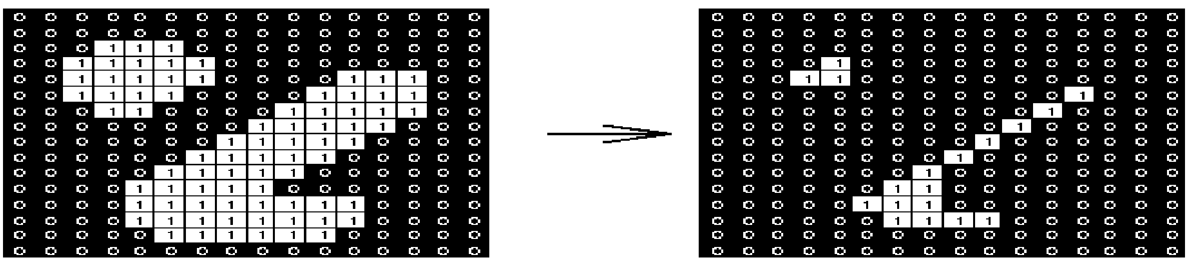


Fig. 4 Erosion of a 3x3 square structuring element

The result of erosion with a large structuring element being similar to the result obtained by iterated erosion using a smaller structuring element of the same shape. With A and B as sets in Z2, the dilation of A by B is defined as

$$A \oplus B=\{Z\backslash(B^{\wedge})z\cap A\neq\phi\} \quad (3)$$

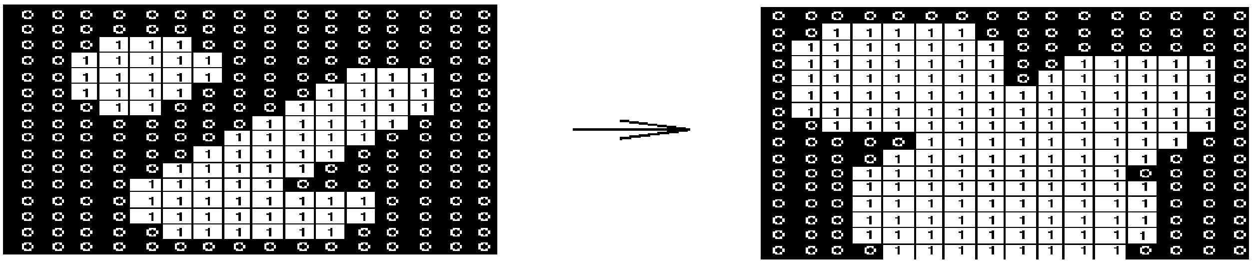


Fig. 5 Dilation of a 3x3 square structuring element

The operators used in this experiment are opening and top-hat segmentation. The effect of an opening operation is to preserve foreground regions while eliminating all other regions of foreground pixels. The opening segmentation [9] is described as

$$I_{open} = (I \ominus S) \oplus S \qquad (4)$$

Where I and are the face segmented image and the opened image respectively, $\ominus$ and $\oplus$ are the morphological erosion and dilation operators. The top-hat segmentation has two versions which we use is known as white top-hat segmentation as this process enhances the bright objects in the image; this operation is defined as the difference between the input image and its opening. The selection of the top-hat segmentation is based on the fact that we desire to segment the regions associated with those of higher intensity, which demark the facial thermal signature. The result of this step is to enhance the maxima in the image and the top-hat segmented image [9] is given by

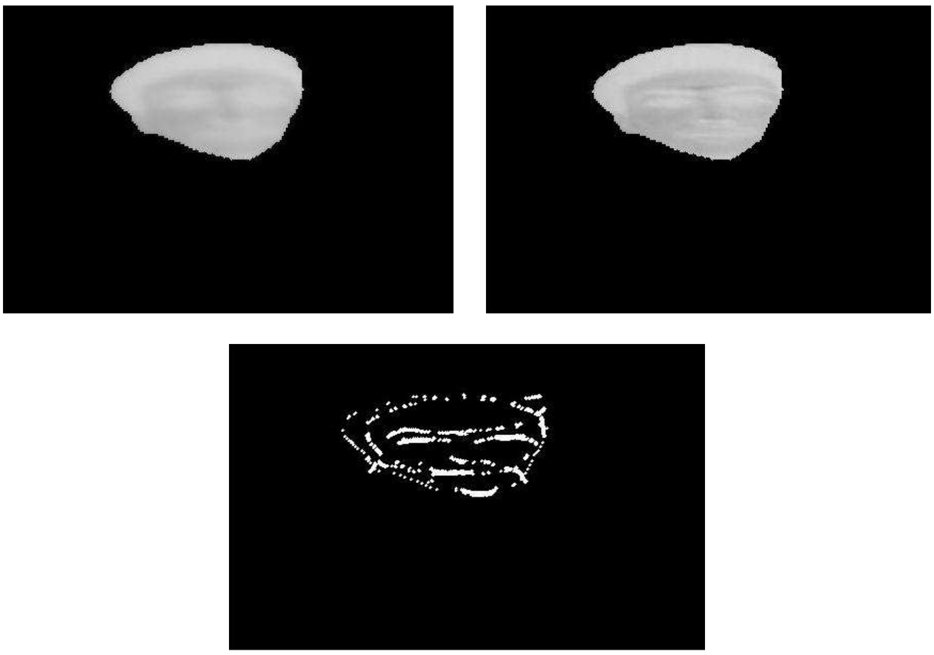
$$I_{top} = I - I_{open} \qquad (5)$$

2.4 Post Processing

After obtaining the maxima of the image, skeletonization is done for reducing foreground regions in an image to a skeletal structure that largely preserves the extent and connectivity of the original region while throwing away most of the original foreground pixels.

3. Generation of Thermal Signature Template

Thermal signatures in an individual vary slightly from day to day due to environmental changes, temperature of the imaging room [18]. Taking into consideration the various factors that may affect the thermal signature, the proposed approach works on establishing a thermal signature template that preserves those characteristics in a person's thermal signature that are consistent over time.



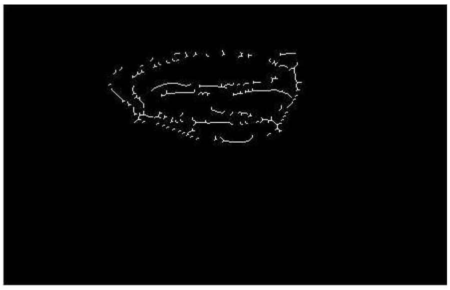
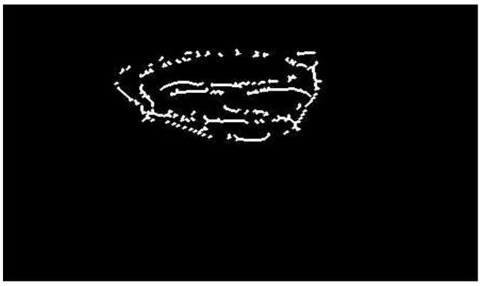




Fig.6 Results of Signature Extraction a) Face Segmentation b) Anisotropic Diffusion Noise removal c) Top-Hat Segmentation Image d) Fill Image Regions And Holes e) Image Skeleton f) Skeleton zed Facial Thermal Image

C) Feature Matching

Matching techniques are developed mostly for the recognition of objects under several conditions of distortion whereas similarity measures are used in applications such as image or document retrieval, for example a query image is a partial model of the user's desires and the user looks for images similar to the query image in the database. In this study a distance based similarity measure is implemented find a thermal infrared template similar to the query thermal infrared signature.

RESULTS AND DISCUSSION

This section presents results of similarity measurements of subject 10 to the template for all subjects in the database. The similarity values obtained from applying the distance-based similarity measure between the reference template of subject 10 and the templates for all subjects in the database. The values show that the template for subject 10 is correctly matched to its own template with a similarity value of 1 or 100%.The next highest value is 0.3620 or 36.20% similarity between subject 10 and 9

Table.1 Similarity Values for Skeleton zed Template vs. Template Matching

Template	Subject 10 as reference value
Subject 10	1.0000
Subject 9	0.3620
Subject 2	0.3481
Subject 3	0.3452
Subject 4	0.3034
Subject 11	0.3021
Subject 6	0.2734
Subject 7	0.2712
Subject 8	0.2587
Subject 5	0.2553
Subject 12	0.2432

The below table provide the similarity values for a single subject using the template of subject 10 as the reference image, and thermal facial signatures from all subjects in the database as the non-reference images. The results show that the highest similarity value, 0.5432 or 54.32%, is obtained between the signature and the template of subject 10, this is a positive match. The 36 similarity value for the positive match between template and signature for subject 10 is less than the positive match between the templates for subject 10, this is expected as the template vs. template similarity is a one-to-one match and thus the resulting distance between features is zero. However when the template and the signature are compared the one-to-one correspondence no longer exists.

Table.2 Similarity Values for Skeleton zed Template vs. Template Matching

Template	Subject 10 as reference value
Subject 10	0.5432
Subject 5	0.3235
Subject 3	0.3124
Subject 2	0.3011
Subject 6	0.2845
Subject 4	0.2836
Subject 11	0.2431
Subject 8	0.2422
Subject 1	0.2286
Subject 7	0.2263
Subject 9	0.2134

CONCLUSION

The presented work introduces a integrated approach in biometric facial recognition based on extracting consistent features from multiple thermal images. The proposed method is implemented in MATLAB for thermal image registration and region based contouring algorithm to segment the each subject. A morphological image processing technique was developed to extract features from the thermal image and to create the thermal signatures. The matching between template and signature was done using the similarity measure based on Euclidean distance based on consistent features. The accurate results obtained in the matching process along with the generalized design process clearly demonstrate the ability of the thermal infrared system to be used on other thermal-imaging-based systems and their related databases.

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