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Fusion of Visible and Infrared Image Features for Face Recognition

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***Abstract:** In this paper we used Local Binary Pattern (LBP), Features from accelerated segment test (FAST), Scale Invariant Features Transformations (SIFT), Speed Up Robust Feature Transformations (SURF), Binary Robust Invariant Scalable Key points (BRISK), Maximally Stable Extremal Regions (MSER) feature extraction methods to evaluate the performance of face recognition system with fusion of visible and infrared images. These six feature extraction methods are tested and analyzed on OTCBVS database under various illumination and expressions of multiple persons. The results shows that FAST, SIFT and SURF provides high precision rate and recall rate than other methods.*

***Index Terms**: Thermal face recognition, Feature Extraction, Fusion, LBP, SIFT, FAST, SURF*

I. INTRODUCTION

In recent years face recognition had an achieved most attention and interest from researchers due to its broadly used applications in computer vision. Unlike other biometric i.e palm, iris, fingerprint etc., face biometrics are captured without users knowledge and later can be used for surveillance systems. Over the past decades of research a lot of face recognition techniques has been proposed to achieve good recognition rate for visible images. But in real time lighting conditions can vary because of various factors, for example, weather conditions, different time of capture and etc. The most of the face recognition techniques suffered from variations in illumination intensity. To overcome this problem in visible face recognition many researchers use infrared images (IR). Thermal images are captured from the thermal cameras under no light conditions also. To increase the precision of face recognition in low illumination intensity combination of visible and infrared images is the possible solutions for researches.

Most of the researchers have been proposed different methods for face recognition using infrared and visible images. However the use of face images under constant scene doesn't give better recognition rate, and also they are not evaluating the images at various situations. In this paper we analyze the face recognition methods under different illumination intensity and no light conditions and also considering rotation, occlusion, pose and artifacts invariant situations. To understand and analyze the performance of face recognition system we use different methods i.e LBP, SURF, FAST and then to perform a comparative study.

In section II discuss about the available thermal and face databases. Section III presents related work of the thermal face recognition methods. Section IV describes about the proposed developed system. Section V gives the face recognition experimental results and analysis of different methods. Section VII presents the conclusion of the work present in this paper.

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II. OCTCBVS BENCHMARK DATABASE

In this paper for testing and evaluating the face recognition methods we use OTCBVS Benchmark database is used [1]. This database consists of infrared and visible face images with various illumination, expressions and different poses. The images are captured by using Raytheon Palm-IR-PRO for thermal images and Panasonic WV-CP234 for visible images.

III. RELATED WORK

A. Visible Face Recognition

Randa atta et al., presented a feature selection technique with a combination of DCT and SPIHT coding for structuring of information for face recognition. The proposed technique has been tested on ORL and FERET databases then compared with wavelet based SPIHT feature extraction method and it achieves more accurate face recognition than Eigen faces and DCT with zigzag scanning in terms of accuracy and required memory [2]. Javier Galbally et al gives a general idea on his method in the field of antispoofing with special focus on various grownup faces [3]. Zahid Mahnood et al discussed about recent advances in face recognition and also presented comparative study of three methods i.e LBP, Ada Boost with LDA and PCA with respect to variation in pose, resolution and expression [4]. Amal Seralkhatem Osman Ali et al, presented a novel system for face recognition after plastic surgery. For evaluation purpose they used two feature extraction techniques i.e LBP and GIST [5]. Rasha Ragheb Atallah et al, provides a survey on changes in face features and age estimation for face recognition techniques [6]. Jie pan et al, presented a single sample face recognition algorithm using Locality Preserving Projection Feature Transfer (FT LPP) and compared the proposed method with the conventional methods like LDA, PCA, LPP.

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The proposed method gives better recognition accuracy than existing methods [7].

B. Thermal Face Recognition

Satyanadh Gundimada et al developed a new kernel Eigen spaces and implemented on the phase. Congruency features are extracted from the visual and infrared images separately. The proposed system provides high recognition rate under partial occlusions, expression and various lighting conditions. The proposed decision level fusion achieves good results compared with visual, thermal and data level fusion [8].Gabriel Hermosilla Vigneau et al analyzed the issues produced by temporal variations of thermal images in face recognition method. The thermal face recognition analyzed using LBP, WLD, GJD, SIFT and SURF. [9].Gabriel Hermosilla Vigneau proposed a new system using fusion of the thermal and visible images using Particle Swarm Optimization (PSO). These weights are utilized to fuse both images descriptors to accomplish good accuracy [10]. R Sumalatha et al, discussed about hand gesture recognition using color feature extraction method [11].

IV. PROPOSED SYSTEM

The block diagram shown in Fig.1. The system consists of the four steps.

1. Preprocessing
2. Feature Extraction
3. Fusion
4. Matching

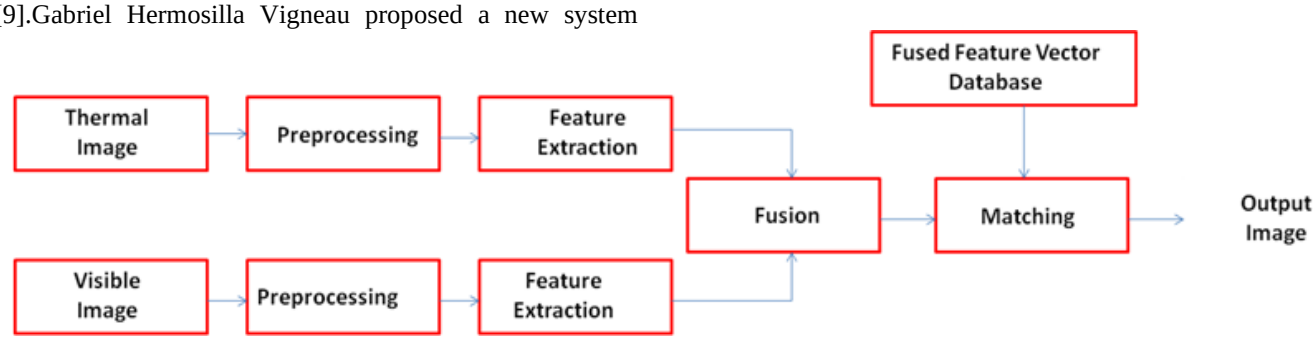

Fig.1. Proposed System Block Diagram

- During acquisition of images from cameras the quality may be degraded. To enhance the quality of the image in preprocessing we are using histogram equalization (HE). HE converts the uneven allotment of gray levels into even allotment of gray levels in the image. Hence each gray level value is having equal number of pixels.
- The features are extracted from preprocessed image using LBP, FAST, SIFT, SURF feature extraction methods. These feature extraction are discussed in section V.
- In this paper we are using feature level fusion for fusion of thermal image features and visible features. The obtained visible feature vector and thermal feature vectors are fused by using concatenation method.
- The fused feature vector of thermal and visible images is compared with each fused featured vector of both images in database.
- The match scores are calculated for each image with fused image. Based on the scores it produces the matched face image.

V. FEATURE EXTRACTION METHODS

As mentioned in literature survey, the face recognition performance is analyzed using the six methods under different expressions and illumination conditions.

A. Local Binary Pattern (LBP)

Timo Ahonen et al proposed a Local Binary Pattern (LBP) [12]. The template is designed for, but not limited to, six for extracting texture descriptors. First the image is segmented into several 3X3 neighborhoods. From each neighborhood texture descriptors are bring out and then form a feature descriptor for face recognition as a face descriptor. In this method caluculate similarity between each pixel intensity value with the center pixel of neighborhood to produce a binary code and the overall representation of the image is produced by combine the regional LBP extraction using histogram by regions.

B. Features from Accelerated Segment Test (FAST)

Edward Rosten et al introduce FAST feature detector for fusion of points and lines for real time high performance tracking system. This is fast feature extraction method for online tracking system. In this method a feature is extracted at a pixel q by considering a circle 16 points surrounding q.

A feature is selected if at least 12 adjacent pixels are above or all below the pixel q intensity value with threshold t. By comparing 1, 9,5,13 pixels intensity values with q pixel intensity value rejected candidate pixel very quickly. In general FAST algorithm is used to detect the corner points in an image to form a feature vector [13].

C. Scale Invariant Feature Transformation (SIFT)

David G. Lowe proposed a new approach to extract unique invariant features from images, and those are used to compare the two images with different viewpoints of an object. The extracted features are invariant to image size, rotation and light condition changes also. SIFT converts raw data into local features coordinates.

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SIFT generally used to find local features from images those are suitable to recognize generic classes of objects [14].

D. Speed Up Robust Feature Transformation (SURF)

Herbert Bay et al presented a new Scale rotation invariant detector and descriptor. The SURF uses integral data to decrease number of operations for convolutions, independent of scale by using Hessian matrix. Hence the speed of the detector is increased. They find out the precision of quick Hessian detector for the use of camera self adjustment and 3D reconstruction [15].

E. Binary Robust Invariant Scalable Key Points (BRISK)

Stefan Leutenegger et al proposed BRISK for key point detection, description and matching key points without sufficient prior knowledge on scene and camera poses [16]. This algorithm is suitable for tasks hard real time constraints or limited computation power. This algorithm provides good quality of matching at less computation time.

F. Maximally Stable Extremal Regions (MSER)

J.Matas et al proposed an efficient detection method for an affine invariant stable subset of extremal regions, the maximally stable extremal regions (MSER) [17]. They used MSER algorithm for robust matching of local features.

VI. FUSION LEVELS

Fusion levels are classified into two types. They are (i) before matching and (ii) after matching. Sensor level and Feature level fusion techniques are before matching. Score level and decision level fusion techniques are after matching.

A. Sensor Level Fusion

In senor level fusion the thermal image data is fused with visible image data in spatial domain. In frequency domain the spatial information converted into frequency information and then fuse the two images in frequency domain. The important one is fusing the two images obtained from two sensors of the same person face.

B. Feature Level Fusion

In feature level fusion first the features are extracted from the thermal and visible images using feature extraction methods or the thermal image features are extracted by one type of feature extraction method and visible image features are extracted by another feature extraction method. This type of extraction is called as hybrid feature extraction method. Then the two features are fused by using any one of the fusing technique like concatenation method and weighted sum method.

C. Score Level Fusion

The similarity between the input and template biometric feature vector can be measured using a match score. The match score is obtained by combining the different matchers. The score normalization technique is used to map the scores on to a same range, due to non homogeneous obtained scores.

VII. EXPERIMENTAL RESULTS AND DISCUSSION

In this section we compare the results obtained by using different face recognition methods on fusion of thermal and visible images in terms of precision rate and recall rate. The Precision Rate and Recall Rate is given by

$$\text{Precision Rate} = \frac{\{\text{Relevant Face Images}\} \cap \{\text{Retrieve Face Images}\}}{\{\text{Retrieve face Images}\}} \quad (1)$$

$$\text{Recall rate} = \frac{\{\text{Relevant Face Images}\} \cap \{\text{Retrieve Face Images}\}}{\{\text{Relevant face Images}\}} \quad (2)$$

(a)

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(b)

Fig.2. (a) Visible face Images (b) Thermal Face Images with various Expressions

Table 1 Comparison between Six Feature Extraction Methods on OTCBVS Database

	FEATURE EXTRACTION METHODS					
	FAST	***LBP***	***MSER***	***BRISK***	***SIFT***	***SURF***
Precision Rate	**0.76**	0.50	0.64	0.56	**0.85**	**0.96**
Recall Rate	**0.62**	0.41	0.52	0.46	**0.64**	**0.78**

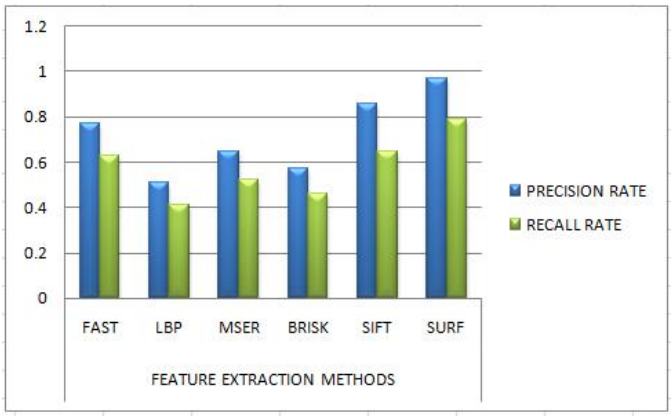

Fig.3 Comparison of precision and recall rate values between six feature extraction methods

VIII. CONCLUSION

In this paper six face recognition methods are used to analyze the robustness of selected methods to several expression and under different lighting conditions on fusion of thermal and visible face images. The results obtained by SIFT, FAST and SURF methods achieve better precision and recall rates when compared with the other face recognition methods. Out of six methods SURF is superior to the remaining methods for proposed face recognition.

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