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Human Face Mosaicing using Thermal Image

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Abstract- In this paper a simple face mosaicing technique is described to construct an apparent 2D thermal frontal face image from available profile image of a human being. The available face image may be frontal or semi-profile or side-view image of a person. Firstly, an apparent side view image (left or right) is extracted from the input image. Then the apparent side view thermal image is flipped left to right to find out the mirror image of it. This can be treated as the other half of the face image. Now, these two apparent available halves are mosaiced using simple concatenation methodology of Image Mosaicing and a frontal profile view is obtained. This used algorithm creates easily an apparent frontal face image and this mosaic face can be used by simple face recognition system. In this way, the challenge of the paper is to construct an apparent thermal face image of a person even if when only his single-side view thermal image is available.

Key Words: Thermal Image, Image Processing, Face Mosaicing.

I. Introduction :

Image mosaicing algorithms register or stitch a sequence of images into a composite image [1]. The concept of image registration, i.e. aligning two or more images of the same scene, and mosaicing has been in practice since the long before the era of digital photography [2]. Photographic technique was developed in the year 1839. After the invention, the use of photographs was demonstrated on topographical mapping [3]. The images that were taken from hill-tops or balloons were manually joined together to a single image. With the invention of airplane technology (1903), the era of aerophotography came. The limited flying heights of the early airplanes and the need for large photo-maps gave birth to the process of photo-mosaicing. The imaging experts used to construct mosaic images from overlapping photographs. Initially, this was manually done by mosaicing [4] images which were acquired by calibrated equipments. Later on, pictures sent on the Earth by the satellites were mosaiced. Thus the popularity of mosaicing had been increasing day-by-day. And at last, with the appearance of computer technology, manual mosaicing was upgraded to digital mosaicing.

Mosaicing is now-a-days used not only in the field of satellite images, but also in medical imaging. Tele-reality application and panorama are two vast area of real-life image mosaicing. Employing the same concept of mosaicing, a new chapter in face-recognition has taken birth. There are several works proposed for face-recognition with the help of face-mosaicing.

F. Yang et al. [5] propose an algorithm for creating panoramic face mosaics. They use ten different colored markers in each face image such that at least three of the markers are found to be common between each face view. Their acquisition system uses several cameras followed by a series of fast linear transformation of the images based on these common

markers or control points and thus generates a panoramic face mosaic. To get the final mosaic image, a smoothing process is carried out to smooth the first mosaiced image. The experiment gives a correct recognition rate of 97.46% and 93.21% in case of frequency representation and spatial representation, respectively. X. Liu et al. [6] propose face Mosaicing technique that uses a statistical model to represent the mosaic. The representational model (statistical) includes a mean image and a number of eigen-images. The novelty of this technique is, firstly, the use of spherical projection, as opposed to cylindrical projection, and it works better when there is head motion in both the horizontal and vertical directions and secondly, the computation of a representational model using both the mean image and the eigen-images rather
than a single template image. Though the authors claim their system can be used for face recognition, they site no experimental results for it. Again, X. Liu et al. [7] propose another algorithm in which the human head is approximated with a 3D ellipsoidal model. The authors report an identification accuracy of 90% on the CMU PIE database [8]. R. Singh et al. [9] propose a scheme for enhancing performance of 2D face recognition via face image mosaicing. In their paper, face mosaicing consists of three major steps like, (i) Determining the pair-wise transformation necessary to align the faces obtained during enrollment, (ii) Generating a mask, and (iii) Stitching and blending. Their proposed scheme is all about terrain transform to register the views and multiresolution splines to blend the views together. According to the experimental results, face mosaicing is a good alternative to store multiple views of a user's face. Emphasis is mainly given on improvement of registration process. In [10], R. Singh et al. propose another solution in face recognition for pose-invariant via mosaicing. The side profile images are aligned with the frontal image using a hierarchical registration algorithm that exploits neighborhood properties to determine the transformation relating the two images. The side profile images are blended with the front image using multiresolution splinning algorithm and the composite face image is generated. The C2 feature-based algorithm [11] is used to compare a probe face image with the gallery face mosaic image. In the modified C2 algorithm, the filter bank is generated with 2-D log polar Gabor transforms. Here the filter bank is modified to include the Gaussian low-pass information. Experimental results show that, the mosaicing scheme in the area of face recognition proposed by R. Singh et al. [10] is more efficient than the techniques proposed in others' ones. Roy et al. [12] design a system of constructing frontal face image from available single side profile views using face mosaicing. Main contribution of their system is the use of automatic eye-brow detection algorithm, alignment mechanism using eye-brow leveling for mosaicing and the eye-shifting algorithm. Their experimental results show that frontal face images may easily be constructed and can be used by simple face recognition techniques that perform with low computational effort. But the authors' algorithm finds some limitations in case of larger variations in pose, with too much rotation, with cut mark in side-profile views or the same existing in eye-brows. All the above mentioned techniques are briefly illustrated in Table I.

Table I: Related Works on Face Mosaicing

Author/ Year/ Reference	**Used Database**	**Total Number of Images**	**Used algorithm**	**Performance Obtained**
Yang et al. 2005 [illegible]	Their own Face Database	12 subjects	Registration: Affine using points Mosaicing: Concatenation Spatial Representation: PCA Frequency: FFT amplitude	Frequency Representation: 97.46% Spatial Representation: 93.21%
Liu et al. 2005 [illegible]	CMU PIE Database	68 subjects	Registration: Affine using triangles Mosaicing: Geometrical mapping Representation: statistical model	Identification Accuracy of 90%
Singh et al. 2005 [illegible]	West Virginia University(WVU) Database	15 individuals (9 images per individuals)	Registrations: Affine using regions	Time complexity of the algorithm(recognition with mosaiced image) took 1.11 CPU-time[2] (mosaicing algorithm takes 0.53 CPU-time and verification takes 0.58 CPU-time)
	Face Database used in [5]	12 individuals (12 images per individuals)	Mosaicing: Multiresolution splines Representation: Local binary pattern	
Singh, et al. 2007 [illegible]	CMU PIE Face Database	68 individuals	Recognition: Modified C2-feature-based face recognition method	The performance of the proposed face mosaicing and recognition algorithm lies between 96.85% and 100% for all three database
	WVU Multispectral Visible-light Face Database	48 individuals		
	WVU Multispectral SWIR Face Database	48 individuals		
Roy, et. al. 2009 [illegible]	Their own Face Database	–	Algorithm used mainly for eye-brow detection and eye-shifting along with face cutting and face mosaicing	–

In this paper, the 2D mosaic thermal face image is constructed using the algorithm proposed at [12]. The main contribution of the paper is to use thermal images instead of visual ones as the problem of shadow can be overcome in thermal images as thermal images are generated due to heat pattern of the human body and there is no need to use eye-shifting algorithm because the eye balls are not visible in thermal images. Thus the present algorithm described in this paper has low computational speed compared to others.

The reminder of this paper is as follows. The proposed face mosaicing algorithm is described in section II. In section III the experimental results are discussed. Finally, section IV concludes this work.

II. System Overview:

The main objective is to construct an apparent mosaic frontal 2D thermal image from the available thermal face image of a person. Here, a simple image mosaicing algorithm is applied. The mosaicing system elaborated with the help of a block diagram given in 1.

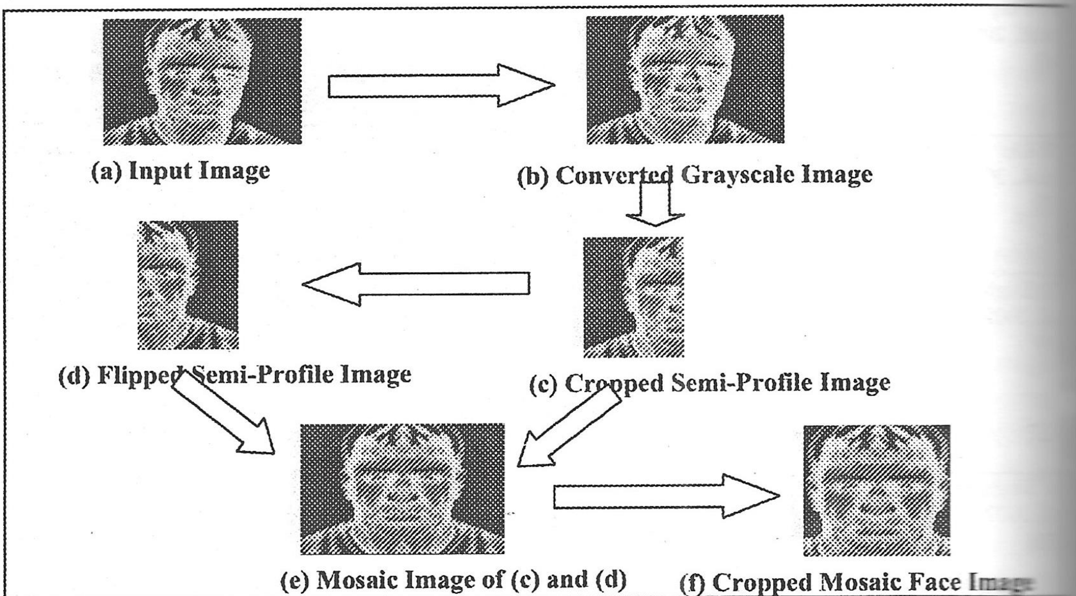


Figure 1: System Overview.

Firstly, color thermal image is converted into grayscale image. After that grayscale image is cropped so that it gives apparently the semi-profile view of the person. The grayscale semi-profile image is flipped to give mirror orientation of it and thus the obtained mirror image can be treated as the apparent grayscale opposite semi-profile view thermal image of the person. Finally, the available left profile grayscale thermal image and the apparent right profile grayscale thermal images are mosaiced together to generate the apparent grayscale frontal face image.

Algorithm

The used algorithm is depicted step by step below:

Step 1(Input Image): The system is using a thermal face image as input. Figure 2 shows the input thermal image with the image resolution of 320 x 240 pixels.

Figure 2: Input Color Thermal Image

2(Convert into Grayscale Image): RGB color image is converted into grayscale image in order flipping algorithm used in step 4.

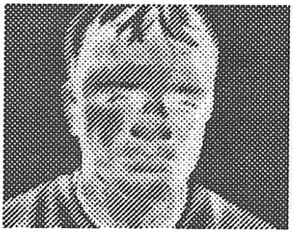


Figure 3: Grayscale Image of the Front Profile View

3(Crop Image): In this step, gray-scale image is cropped such that and the half portion of the face is obtained and the cropped left profile image shown in figure 4.

Figure 4: Apparent Grayscale Image of the Left (Front) Profile View

4(Flip Image): As the human face view is homogeneous, the left half of the frontal face of a can be considered as a mirror reflection of the right half of it, and vice-versa and this concept is in [8]. Applying the same concept, the obtained apparent semi-profile grayscale thermal image to generate the opposite semi-profile
scale thermal image. For that, the left profile (which is generated using step3) image is flipped left to generate the right profile image. Resulted flipped image is shown in figure 5. The flipping used here works as follows:
A be an input image such that

$$A=\begin{bmatrix} a_{0,0} & a_{0,1} & \cdots & a_{0,j-1} \\ a_{1,0} & a_{1,1} & \cdots & a_{1,j-1} \\ \vdots & \vdots & & \vdots \\ a_{i-1,0} & a_{i-1,1} & \cdots & a_{i-1,j-1} \end{bmatrix} \quad (1)$$

the resulted flipped image will be,

$$B=\begin{bmatrix} a_{0,j-1} & a_{0,j-2} & \cdots & a_{0,0} \\ a_{1,j-1} & a_{1,j-2} & \cdots & a_{1,0} \\ \vdots & \vdots & & \vdots \end{bmatrix} \quad (2)$$

Where, $a_{i,j}$ represents the matrix element at i^{th} row and j^{th} column of an i x j matrix.

Figure 5: Apparent Grayscale Right-Profile Thermal Image.

Step 5(Mosaic Image). After getting both the apparent left and apparent right profile grayscale images, both images are mosaiced altogether to generate an apparent front profile face grayscale thermal image. The present system uses simple concatenation technique to mosaic the two images found in Steps 3 and 4. In figure 6, resulted mosaic image and it can be treated as the apparent front profile thermal grayscale image. For example, if concatenating the above two images A and B results the mosaic image C, then

$$C=\begin{bmatrix} a_{0,0} & a_{0,1} & \cdots & a_{0,j-1} & a_{0,j-1} & a_{0,j-2} & \cdots & a_{0,0} \\ a_{1,0} & a_{1,1} & \cdots & a_{1,j-1} & a_{1,j-1} & a_{1,j-2} & \cdots & a_{1,0} \\ \vdots & \vdots & & \vdots & \vdots & \vdots & \cdots & \vdots \\ a_{i-1,0} & a_{i-1,1} & \cdots & a_{i-1,j-1} & a_{i-1,j-1} & a_{i-1,j-2} & \cdots & a_{i-1,0} \end{bmatrix} \quad (3)$$

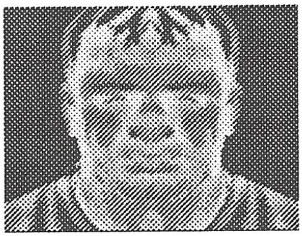


Figure 6: Mosaic Image

Step 6 (Crop Mosaic Face): The image generated in Step 5 is now being cropped to generate the cropped face thermal image.

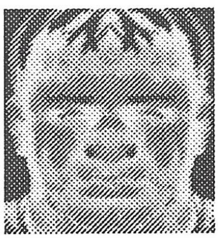


Figure 7: Cropped Mosaic Thermal Face Image

III. Experimental Result and Discussion:

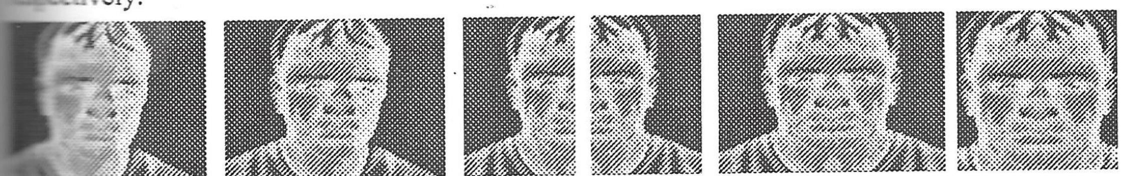
In order to check the validity of the algorithm designed here, several experiments are conducted to construct an apparent frontal view of a person. The input thermal face image is cropped for obtaining a semi-profile view and then the cropped image is flipped left order to generate the mirror image of it. Thus the opposite semi-profile view is obtained. These two semi-profile images are then mosaiced using the concatenation method. This work has been simulated using MATLAB 7.9.0.529 (R2009b) in a machine of configuration: Intel Xeon Quad Core Processor with 16GB Physical Memory. There have been used two databases named IRIS Thermal Database and Terravic Facial Infrared Database.

A. Thermal Image Database Description

a. IRIS Database: The IRIS [13] database simultaneously acquired unregistered thermal and visible face images under variable illuminations, expressions, and poses. Total no. of 30 individuals of RGB color image type with Exp1 (surprised), Exp2 (laughing) and Exp3 (anger) are available. Resolution of each image is 320 x 240. Illumination types available in this database are left light on, right light on, both lights on, dark room, left and right lights off with varying poses like left, right, mid, mid-left, mid-right. Two different sensors are used to capture this database. One is Thermal - Raytheon Palm-IR-Pro and another is Visible - Panasonic WV-CP234.

b. Terravic Facial Infrared Database: The Terravic Facial Infrared [13] database contains total no. of 20 classes of JPEG thermal faces. Size of the database is 298MB and images with different rotations are left, right and frontal face images also available with different cosmetic items like glass and hat. Among this datasets only frontal faces with glass images are taken for experimental purpose.

Experiment results are illustrated here. Experimental results obtained with frontal face thermal image and rotated face thermal image are shown in figure 8 and figure 9, respectively.



(a) (b) (c) (d) (e) (f)

Figure 8: Sample of (a) Thermal Image, (b) Grayscale Image of (a), (c) Apparent Left Profile View of (b), (d) Apparent Right Profile View of (b), (e) Mosaic Image of (c) & (d), (f) Cropped Mosaic Face Image.

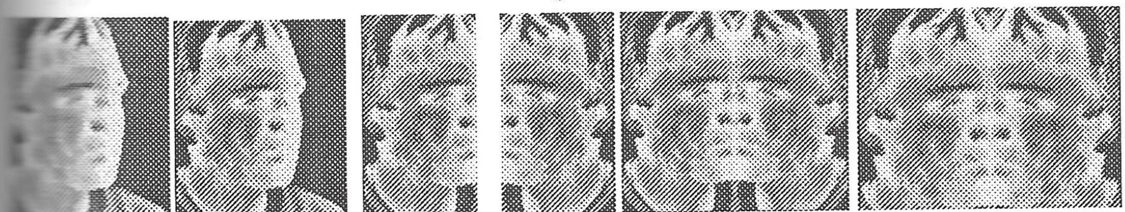
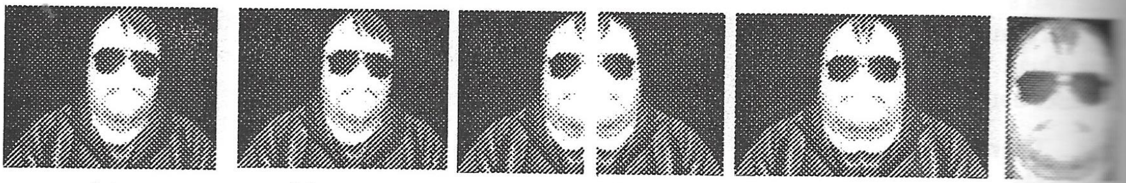


Figure 9: Sample of (a) Thermal Image, (b) Grayscale Image of (a), (c) Apparent Left Profile View of (b), (d) Apparent Right Profile View of (b), (e) Mosaic Image of (c) & (d), (f) Cropped Mosaic Face Image.

... obtained with disguise face thermal image is shown in figure 10.



(a) (b) (c) (d) (e) (f)

Figure 10: Sample of (a) Thermal Image, (b) Grayscale Image of (a), (c) Apparent Left Profile View of (b), (d) Apparent Right Profile View of (b), (e) Mosaic Image of (c) & (d). (f) Cropped Mosaic Face Image.

But this algorithm has some limitations too. In case of too much rotation, or large variations in pose found in input thermal face images, construction of apparent thermal mosaic frontal face image is very difficult. Figure 11 shows some of the cases where difficulties are found while mosaicing.

Figure 11: Left Profile Thermal Image with too much Rotation.

The algorithm is used simply to construct an apparent frontal thermal image from the available thermal image of the same person. This resulted image can further be used by simple thermal face recognition system.

IV. Conclusion and Future Work:

This algorithm uses thermal face images that does not need eye-shift algorithm that is proposed in [12]. The constructed mosaic face image can be further used as an input of a simple face recognition system. The authors are hopeful to use the resulted mosaic face image for face-recognition in their future work. This mosaic face image can also be used to check the semi-profile images are how much similar to each other in case of face recognition. The authors are also hopeful to introduce fusion in their future work.

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