Geometrical Fusion Based on Chain Code Representation

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Abstract
In this paper, a new geometrical image fusion method introduced by using the representation of chain code for the image objects that been matched among the images to be fused. The input images are separated into number of objects. A matching method is applied to extract the matching objects from the overall objects that included in the origin images. Then the chain code string is calculated for each one. The run length encoding is applied on that code strings to reduce the space that required. The image resulted from the geometrical fusion is more informative which contain the more important features those included in the origin images.

I. Introduction
Fusion: It is a process of meaningful merging of multiple images to produce an image that will be more informative in case the process of fusion applied on images with different scenes. Image fusion has four levels of fusion: Pixel-Level Fusion: It produced an output image by applying the fusion process on all pixels in the source images [1], Feature Level Fusion: the fusion is done by using the important information of features level that extracted from the input images to be fused [2], Region-Based: This method has different rules for the different segmented region and the efficiency of the fusion result is depending on the results of the process of segmentation [3] and Decision-Level Fusion It combines the decisions of independent sensor detection or classification by Boolean (AND, OR) processes [4].

Chain code begins from the location of starting pixel then mask 3 * 3 is obtained and the starting point is refers to the mask center, looking at the values adjacent for starting point to identify values of next code in the string of chain, then window will be moved to next neighboring pixel that has selected in the previous step and the process is repeated [5].

II. Related work
Tawfiq A. Al-Asadi and Ali Abdul Azeez introduced a fusion method that used wavelet transform to calculate the effects of number of light sources to make the
image object look more informative than the source one which take into consideration the effect of each light source alone [6].

Changtao He, Quanxi Liu, Hongliang Li and Haixu Wang introduced a paper which perform the integrated fusion approach. PET images are shown in pseudo-color, and the MRI images are gray. The fused images must be distinct and do not contain false objects and any redundancy, to achieve that an IHS and PCA integrated fusion approach had introduced. [7]. Guihong Qu, Dali Zhang and Pingfan Yan calculated the wavelet transformation modulus maxima of origin images to produce an image fusion scheme. They emphasized the extraction of information that related to the edge and margin. The advantages of the proposed research over the others are: better preservation of both edges features and component information of the image [8].

III. geometrical image fusion method

The proposed system introduces a novel geometrical fusion method that merges information from more than fingerprint image as illustrated in figure (1).

![Figure (1) Block Diagram of proposed System](image-url)
The proposed system consists of four stages:

1- Preprocessing Stage: this stage consists of three steps: image rotation, image Binarization and image thinning.

2- Feature Extraction Stage: in this stage the important features those included in the image are extracted by using the eight neighbors technique as illustrate in the following equation.

\[ V_a = \sum_{k=0}^{8} N_k \quad \ldots \quad (1) \]

Where \( V_a \) is the number of black neighbors of the correspond pixel, \( N_k \), \( k=1,2,3,\ldots,8 \) are the eight neighbors of the correspond pixel. According to the value of \( V_a \) the type of feature are determine.

3- Matching Stage: This stage is very important to achieve the optimal results of fusion process. To determine if the object in any image is matching another object in any other image, equation (2) is applied to determine the similarity among object based on the topological neighbors information for the objects. The matching stage performs another processing which is calculating the equalization of the angle between the feature pixels and their nearest pixels.

\[
\begin{align*}
X_i &= \sum_{\theta_4=0}^{360} \sum_{\theta_r=-\pi}^{\pi} (X_c + R \times \cos(\theta)) \\
Y_i &= \sum_{\theta_4=0}^{360} \sum_{\theta_r=\pi}^{-\pi} (Y_c + R \times \sin(\theta)) \\
\end{align*}
\ldots \quad (2)
\]

Where \((X_c, Y_c)\) the coordinate of specific minutiae pixel, \((X_i, Y_i)\) the coordinate of the topology neighbor pixel, \(\phi\) is the angle between the minutiae pixel and its neighbor, \(R\) is the Euclidian distance.

4- Geometrical Fusion Stage: It consists of four steps. figure (2) illustrate the geometric fusion algorithm;

- Chain code representation: all the matched objects are converted into the cc format.
- Run length encoding: RLE is a simple method of compressing data by specifying the number of times a chain code repeats followed by the code of the pixel. Its use to reduce the number of bits used to represent the chain code sequence.
Geometric image fusion algorithm

Input: N of matching objects
Output: fused object

chain code calculation
Starting from Minutiae pixel as a center of chain code window
While not exist another pixel
Begin
  Travels all eight neighbors and find non zero value
  Add the correspond code to the chain code vector cc
  Move to next position
End while
Call algorithm of RLE encoding on vector cc

smoothing RLE
Save the code value in vector co and the counter value in vector cu
For k=2 to n-1 do
  If cu[k]<th1 and (cu[k-1]>=th2 Or cu[k+1]>=th2) then
    If cu[k-1]<cu[k+1] then co[k]=co[k-1] else co[k]=co[k+1]
  End if
End for

Geometric fusion
While there exist a value in RLE vectors
  Calculate the angle among the codes of co vector according to unit circle
  If the angle is 0,45 or 90 then
    Calculate the average of cu vector and save in cuf vector
    Save the value of co in cof vector
  Else
    save the smallest of cu vector in cuf vector and Save the correspond value of co in cof vector
  End if
End while

fused image forming
Set the minutiae pixel as starting pixel with black color
For k=1 to n
  Set the position of the cof[k] to black color and repeat the process according to the value of cuf[k]
End for
End

Figure (2) Geometric fusion algorithm
• Smoothing the Compressed Code: It performed on the RLE compression chain code of the object. It’s used to eliminate the small segments of code that lying between two big segments of code. The size of the segments is determined by two threshold values (th1 and th2). The threshold (th1) is used to determine the size of small segment and (th2) is used to determine the size of big segments. Figure (3) show an example of the RLE smoothing where the segment (||1,1||) with red color lying between two segments (||2,9||) will removed and the number of its pixel will added to its neighbors.

![RLE smoothing example](image)

Figure (3) RLE smoothing example

• Fusion: The input to the system is N- images and the output is one fused image. Each image contains a specific number of objects. Those objects are in the form of sequences of chain code. To determine the new fused compression chain code, a similarity measure is used. Similarity measure among the matched objects is determined by values of angles among their codes in the compressed chain code. This measure used to determine the regularity among the matched objects. If angles among codes of matched object are (0°, 45° or 90°) in unit circle that illustrate in figure(4) then the matched objects are regular other wise consider them as irregular objects. The angles of unit circle are lying in four quarter as show in figure (4). Figure(5) show how can calculate according to unit circle the angle among objects and specify the regular objects with black color and irregular one with red color. Figure (8) illustrate the measure of the angle among codes of objects when it equall to (45°) . Figure (10) illustrate the measure of the angle among codes of objects when it equall to (90°). If the codes are equall in the RLE compression then the angle is equal to zero, other wise the objects are consider as irregular objects.
The compression chain code is separated into regular and irregular as illustrate below:

1- Irregular compression chain code of input objects when the angle among codes is not $0^0$, $45^0$, or $90^0$. In this case the compression chain code with less length is choose to form the chain code of the object shape of fused image as show in figure (6).

2- Regular compression chain code of input objects when the angle among codes is $0^0$, $45^0$, or $90^0$. The average of the length of all the RLE compression chain code is consider to form the fused image with the alternative code from the chain code of
input objects as shown in figure (7) when the angle is zero, figure (9) when the angle equal to $45^0$.

Figure (7) regular shapes with angle zero among chain codes

Figure (8) $45^0$ angle measure among the codes of objects

Figure (9) regular shapes with angle $45^0$ among chain codes

Figure (10) $90^0$ angle measure among the codes of objects
The resulted chain codes from the fusion process are translated into the fused image to form geometric shapes. The start pixel is the minutiae pixel itself.

**IV. Results and Discussion**

The proposed system is applied on fingerprint images. Fingerprints can be defined as the graphical flows of ridges in human fingers which are formed during infancy. There are two special contents: ridges and valleys. Ridges and valleys are considered to be the negative images of each other. Generally, the fingerprint image structure contains two categories of information: global information and local ones. The global information includes the singular points (core and delta). The local information is called minutiae, and is represented by the intersection in the ridges. In the proposed system the extraction feature stage include the extraction of Minutiae objects from the image. Fingerprint image considered as important challenges to the geometrical fusion system because it contained number of false object and the other problem related to the clarity of image. The input to fusion system is five fingerprint images and the output one fused image which contained the more reliable features that included in all input images. The overall stages of the system are illustrated in the following example:

The five input fingerprint images to the system are clarified in figure (11).

![Figure (11) input fingerprint images](image1)

The preprocessing stage applied on the input images included converted them to binary images then applied Gabor filter to enhance them, finally applied thinning process to thin all the objects to one pixel width as illustrate in Figure (12).

![Figure (12) Thinning fingerprint images](image2)
The feature extraction stage included extract the minutiae features from the image. In the proposed system seven type of features are extracted which are: Bifurcation, Ending, Spur, Lake, Dot ridge, Island ridge and Ordinary ridges. Figure (13) are illustrated the feature extraction of one image.

The next stage is matching which perform the matching process among input fingerprint images. The result of matching stage is (47) matching process. Figure (14) illustrated some of matching process among images. The final stage is Fusion stage. The geometric fusion is done among the feature objects with same type and by use of the Matching process result. Figure (15) illustrated fusion of bifurcation objects. The final fused image resulted are illustrated in figure (16).Where the different colors refer to different objects.
The proposed system performed a compression in the number of feature objects among the input images and fused image. This comparison used to specify the different of the total number of each feature objects in images and the probability of existing of false objects. Table (1) shows features objects comparison.
V. Conclusion and Future Work

The new minutiae pixels that resulted in the fused image differ from all input images in total number of them and the number related to each minutiae type, because the fused image does not contain false minutiae that may be exist in any one on the input images. So we can consider the fused image is more reliable by compare with all input images and can used for identification and verification purpose with higher level of accuracy. The fused image can store in data set instead of storing some images that related to same person in order to decrease the amount of storage. The proposed system can be applied on the map images.

VI. References

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