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IMAGE ENHANCEMENT FOR FACIAL IMAGE RECOGNITION USING OTSU'S METHOD

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Abstract *The internal surfaces of human hands and feet of have minute ridges with furrows between each ridge. Fingerprints have very distinctive features and have been used over a long period of time for the identification of individuals and are now considered to be a very good authentication system for biometric identification. For successful authentication of fingerprint, features must be extracted properly. The different types of facial image enhancement algorithms used in image processing all provide different performance results depending on external and internal conditions. External conditions include types of sensors and pressure applied by the subject etc. Internal conditions include the body temperature of a subject and skin quality etc. In this paper, we enhance an image using Otsu's method, which is one of the segmentation steps of image processing. This algorithm can improve the clarity of ridges and furrows of a facial image and enhances performance by reducing the total time for extraction of minutiae compare to other algorithms.*

Keywords: *Minutiae · Gabor filtering · Ridge ending · Ridge bifurcation Wavelet domain · Otsu's method*

1. Introduction

Experts use many details from a facial image for the authentication of a person. The process of facial image verification starts by investigating the quality of a finger image or input image taken by sensors and then proceeds by performing a number of pattern search algorithms. Image enhancement as well as ridge segmentation is done by using local orientated ridge to filter parameters. After segmentation, a thinning process takes place to obtain a thinned image so that minute features can be extracted. Spurious minutiae are removed at the post-processing stage.

The way an image is captured or its machine representation, determines the success of any matching algorithm that works in decision module [1]. The performance of an algorithm actually depends on how accurate and reliable the results it gives are. The overall quality of an input facial

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image plays a very significant role in the decision of the identification and verification algorithms used. This paper introduces a facial image enhancement method which is fast and actually improves the image quality of the valley and the ridge structures of input images, based on the orientation and frequency of the local ridges and thereby extracts the correct minutiae. The uniqueness of a person's facial image and its unchanging nature throughout an individual's lifespan make it a very important model for a biometric authentication system. A facial image consists of a unique pattern of what are called furrows and ridges. A ridge is a curved line or segment whereas a valley is the space between two adjacent ridges. A feature that is used for the identification of a person is called a minutia and is actually the discontinuity of a ridge segment. These discontinuities appear in the form of a bifurcation of a ridge, resembling a fork, whereas ridges end abruptly at a ridge ending. These minutiae are stored in the form of a template and are used for authenticating a person (Fig. 1).

Fig. 1 Facial image showing minutia points: crossover, core, bifurcation, ridge ending, is land, delta, pore etc.

Facial image Representation

The individuality of a facial image is determined by its ridge pattern and the occurrence of certain ridge anomalies called minutiae points. Normally, to make class of different kind of facial image the global design of ridges are used whereas the allocation of minutiae points is taken for matching between facial image and its template [2]. Automatic recognition and identification of a facial image matches query features against a large database of millions of different features stored with individual identifications. It depends on the pattern of ridges in the query image to refine their search in the database, a technique called indexing of fingerprints, and on the minutiae points to determine a precise matching fingerprint. The ridge pattern itself is hardly ever used for facial image matching.

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Minutiae

The local discontinuities in the ridge pattern called minutiae give the facial image features that can be used to authenticate a person's identity. Details such as the orientation, type and location of minutiae are taken as description when using minutiae as a facial image features. The two most important local ridges distinctive- ness points are the ridge bifurcation and the ridge ending, and these are generally used for pattern recognition.

Different types of pattern are found in facial image minutiae and these are:

- Ridge endings—Ridge endings are the points where a ridge ends suddenly.
- Ridge Bifurcation—Ridge bifurcation is the characteristic where an individual ridge is cut into two ridges and looks like fork.
- Independent ridge or island—An independent ridge is an individual ridge that starts at some point and ends after travelling a short distance. It looks like an island.
- Ridge enclosures—In a ridge enclosure, a single ridge divides like a fork and then joins again abruptly afterwards and continue as an individual ridge.
- Spur—A spur is actually a bifurcation and a short ridge branching off a long ridge.
- Bridge or Crossover—This type of pattern involves a short ridge which crosses between two parallel ridges (Fig. 2).

Minutiae also refer to any small point that is distinct to an individual. Not all minutiae are used for verification, only ridge ending and ridge bifurcation (Fig. 3).

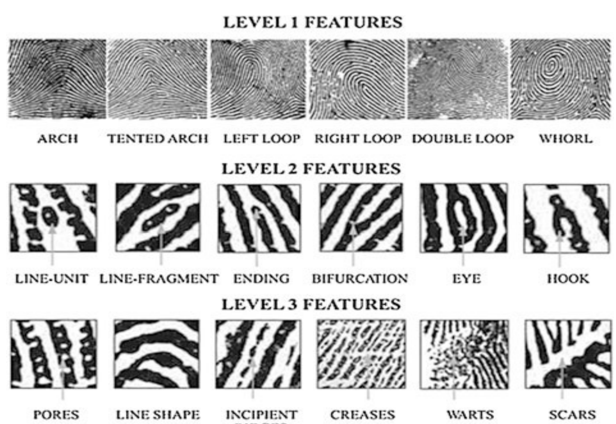


Fig. 2 Different minutia points showing crossover, spur, ridge bifurcation, and ridge ending that are used in facial image authentication systems

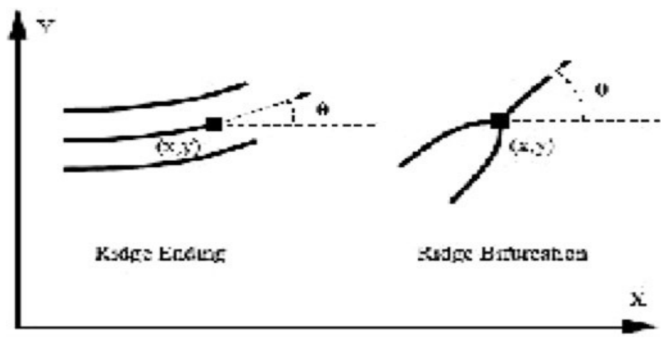


Fig. 3 Ridge ending and ridge bifurcation having its value using two points x and y with corresponding angle

2. Related Work

Sonavane and Sawant [3] offered a method by which an image of a finger is broken into a set of clean images and their orientation is estimated, giving a special domain facial image enhancement. Kukula et al. [4] proposed a method of applying different levels of force to investigate its effect on the performance of matching image scores in terms of quality, and the amount minutiae between capacitance and optical facial image sensors. Hsieh et al. [5] developed another method for facial image authentication where only ridge bifurcations are used and not ridge endings, using a different algorithm for ridge bifurcation that excludes unclear points. In addition, from a wide study into different research papers it is clear that there are a number of methods in use. A number of changes have occurred in different preprocessing techniques, such as segmentation by the use of external characteristics called morphological operations as well as an improved thinning process, different techniques for removing false minutiae, minutia marking using the triple branch counting method, breakdown of minutia unification into three terminations, and matching in the unified x-y coordinate system after a two-step conversion. An online facial image identification and recognition method using a hashing technique which is very fast and tolerant to distortion.

Facial Image Enhancement

A facial image enhancement algorithm takes its input from a facial image. Facial image enhancement is either done on (i) a binary image or (ii) a gray level images. The database for this research consists of fingerprints which have been scanned to give an impression of the finger using an ink and paper technique because this method introduces a high level of noise to the image and helps to evaluate performance with different types of finger [6]. The main aim of using an image enhancement process is to enable the designing of an authentication system that works in the worst conditions as well as to enhance performance and so get the best results possible.

Direct Gray-Level Enhancement

Using a gray-level facial image, ridges and valleys in a local neighborhood appear in the form of a sinusoidal-shaped wave, which has the properties of a well-defined orientation and frequency. There is a need to estimate these local orientations and frequencies to improve the quality of gray-level facial images [2]. For the filtering, a Gabor filter is used which employs these orientation and frequency properties to enhance the image. Otsu's algorithm is a simple and popular thresholding method for image segmentation, which falls into the clustering category. The algorithm divides the image histogram into two classes by using a threshold such as the in-class variability being very small. This way, each class will be as compact as possible.

Algorithm

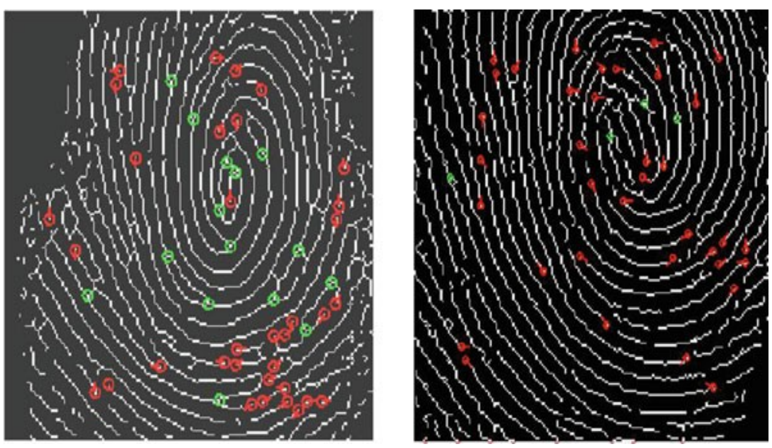
Algorithm: Thresholding segmentation using Otsu's method

Input: finger image (grayscale), overridden threshold value

output: output image

```
Read (finger_ image)
N = finger_image.width × input imnumberage.height      initialize variables
threshold, var max, sum, sumB, q1, q2, μ1, μ2 = 0
max intensity = 255
for i = 0; i <= max intensity; i++ do
histogram[value] = 0 accept only grayscale images
if num channels(input image) > 1 then
return error compute the image histogram
for i = 0; i < N; i++ do
value = input image[i]
histogram[value] + = 1
if manual threshold was entered then
threshold = overridden threshold
else auxiliary value for computing μ2
for i = 0; i < = m ax intensity; i ++ do
sum + = i × histogram[i]update qi(t)
for t = 0; t < = max intensity; t ++ do
```

```
q1 + = histogram[t]
if q1 == 0 then
continue
q2 = N − q1update μi(t)
sumB + = t × histogram[t]
μ1 = sumB/q1
μ2 = (sum–sumB)/q2 update the between-class variance
2 b (t) = q1(t)q2(t)[μ1(t) − μ2(t)]2update the threshold
if 2 b (t) > var max then
threshold = t
var max = 2b (t)build the segmented image
for i = 0; i < N; i++ do
if finger_image [i] > threshold then
output image[i] = 1
else
output image[i] = 0
return output image
```



(a) **(b)**

Fig. 4 a Minutiae extraction with enhancement (green dots show true minutiae, red false minutiae. **b** Minutiae extraction without enhancement (green dots show true minutiae, red false minutiae)

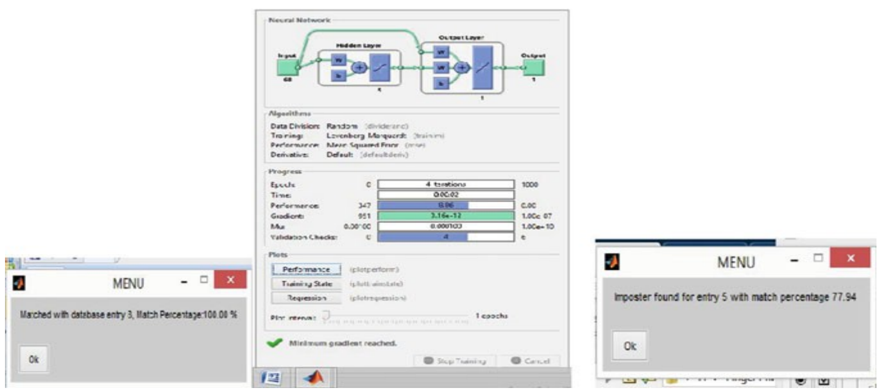
3. Experimental Results and Discussion

Facial image enhancement plays an important role in authentication systems because the performance of the system depends upon the false acceptance rate and false rejection rate. So minutiae must be extracted properly. By using Otsu's method for the segmentation phase, the performance of the system increases compared to its performance without the enhancement process (Fig. 4).

Different minutiae extraction algorithms [7] are present in the literature which we use a CN technique that is able to accurately detect all valid bifurcations and ridge endings from the skeleton image. The false acceptance rate and the false rejection rate determine the performance of the system. We evaluate the performance of both enhanced images and non-enhanced images and it can be seen that the matching rate is low, or that the false acceptance rate (FAR) is greater in non-enhanced images compared to enhanced images. We use a neural network for decision making by selecting a threshold value (Fig. 5).

4. Conclusion

Although there are different types of algorithm available for segmentation in the image enhancement process, the performance of the system is greatly affected by applying the enhancement algorithm. Otsu's method efficiently enhances the clarity of the minutiae (ridge structures). Using Otsu's method, ridge ending and ridge bifurcation are efficiently calculated during the image enhancement process and the noise level is reduced. A number of thresholding algorithms are available for the



(a) **(b)** **(c)**

Fig. 5 Without enhancement FAR is high (**a** 100% match is not possible). **b** Neural network tool for matching minutiae. **c** With enhancement FAR is reduced

segmentation process, but Otsu's method is easily implemented and the time taken to extract minutiae also decreases due to inaccurate estimation of the orientation as well as to ridge frequency parameters. The performance of a biometric authentication system is evaluated by the false acceptance rate (FAR) and the false rejection rate (FRR). Without enhancement FAR increases compared to enhanced images at different threshold values. Gabor filter is also less effective due to presence of noise.

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