Minutiae Detection Algorithm for Fingerprint Recognition

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ABSTRACT

Among the main innovation prospects within the so-called Information Society, and in the framework of future communications systems, we find the design of database-access integral services, e-commerce and communication systems, together with remote control of terminals and devices, being the result of global services derived from last generation integration of Mobile Telephony and Internet. Some features standout from such future services: security (guaranteeing user's privacy while in operation) in human-machine interacting (thus offering the same degree of spontaneity found in human communication through speech). For to deal with security problems, the use of Biometric-based Technology (specifically through face, fingerprint, and speech) is proposed, because those technologies have reached a high degree of maturity, such as allowing successful application on secure authentication.

INTRODUCTION

The requirement for reliable personal identification in computerised access control has resulted in an increased interest in biometrics. Fingerprint recognition techniques have the benefit of being a passive, non-intrusive identification system and have the additional advantage to use low-cost standard capturing devices. However, recognition of the fingerprint becomes a complex computer vision problem, especially when dealing with noisy and low quality images.

This paper describes the design and implementation of a minutiae extraction algorithm for fingerprint identification systems. The final goal will aim to integrate the fingerprint recognition system with the face recognition system developed and presented at IEEE ICCST'00 [1].

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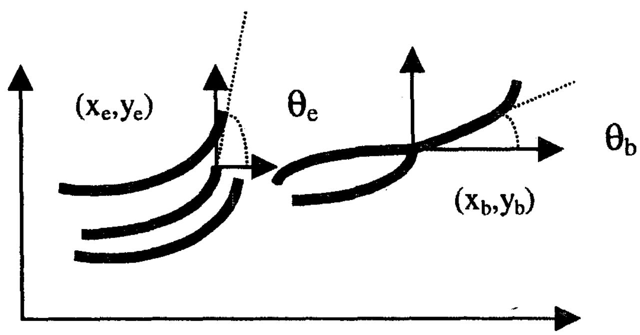

Fig. 1.

THE FINGERPRINT: A REVIEW

A fingerprint is the pattern of ridges and valleys; each individual has unique fingerprints. The uniqueness of a fingerprint is exclusively determined by the local ridge characteristics and their relationships. The two most prominent local ridge characteristics, called minutiae, are the ridge ending and the ridge bifurcation. The first is defined as the point where a ridge ends abruptly. The second is defined as the point where a ridge forks or diverges into branch ridges. A good quality fingerprint typically contains about 40-100 minutiae [3,4]. Examples of minutiae are shown in Figure 1.

DataBases

We have acquired two new fingerprint databases. The first one using an inkless optical capturing device manufactured by UareU. The optical sensor used can provide a 500dpi image, having a size of 15 × 15mm and a very low power consumption. The second database, on the other hand, has been performed using the classic method of ink over paper and later scanned. Note that the quality of the fingerprints in this second database depends heavily on the impression conditions.

The experiments have been performed utilising these two new fingerprint databases. Examples are shown in Figure 2, on next page.

The experimental results reveal that our system can achieve better performance on the classic database.

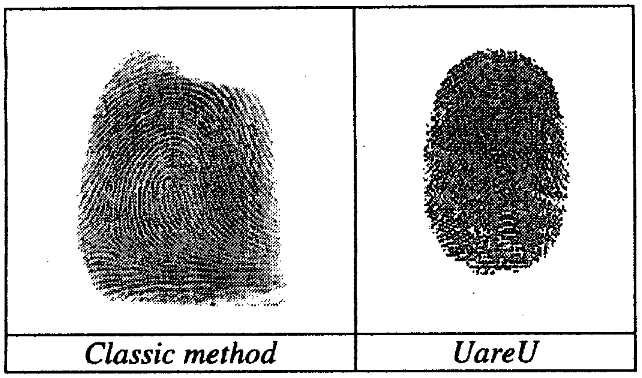

Fig. 2.

IMAGE PREPROCESSING

The basic problem when finding ridges consists of deciding if the pixel evaluated belongs to a rigde or not. Next, we will present the pre-processing steps computed in order to adapt the input fingerprint image to the next block requirements and to convert it in a set of these interest lines, named *Ridge Map.*

- Image Enhancement and noise reduction applying directional filters.
- Binarize the image using the Otsu method to obtain the best performance threshold [9].
- Thinning algorithm by means of mathematical morphology (like a kind of no lineal image processing) for extracting a set of interest lines [10], obtaining the *Thinned Ridge Map.*
- Depuration of the ridge map: involves the removal of the spurious elements, identified as undesirable spikes, and to join the broken lines using a smoothing procedure. This depuration process is carried out by simple rules like:
  - To remove small isolated lines.
  - To merge all the lines who have end points with similar direction and the distance between them is small.

Figure 3 shows a sample of the pre-processing described, over a fingerprint image of the second database.

FEATURE EXTRACTION

The Feature Extraction will consist of finding the ridge endings and ridge bifurcations from the input fingerprint images, being each minutia described by its location (x, y coordinates) and its orientation (θ). The final ridge structure will be used to generate a *fingerprint feature vector* or *minutiae map,* which will characterize the fingerprint. This one will be a template formed by a list of minutiae and a list of number of ridges between each pair of minutiae, and it will be stored by the system.

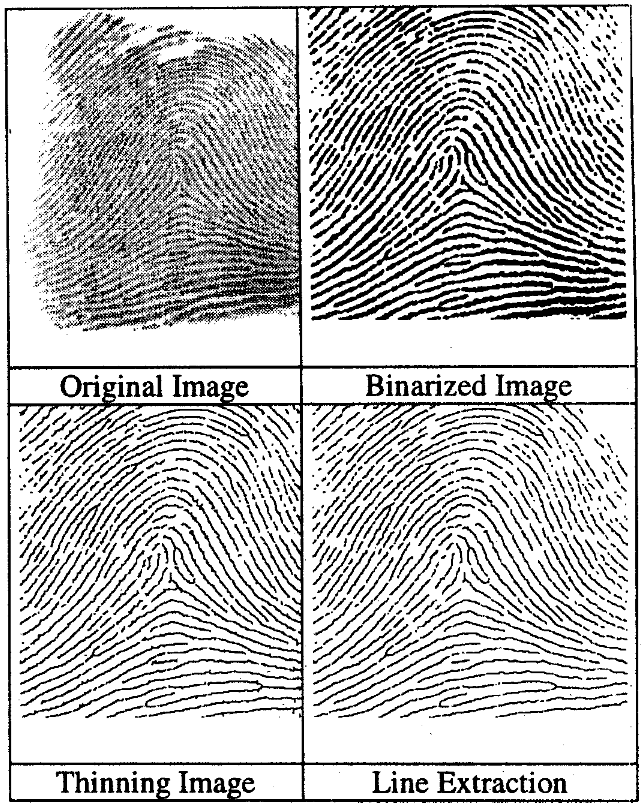

Fig. 3.

Minutiae Detection

A simple pattern recognition algorithm for minutiae detection in fingerprint is proposed. This one will be a trivial task when an ideal thinned ridge map is available. Without loss of generality, we assume if a pixel is on a thinned ridge (eight-connected), it has a value on one, and zero otherwise. Let (x,y) denote a pixel on a thinned ridge and $N_0, N_1, \ldots N_7$, denote its neighbours. A pixel (x,y) is a ridge ending if:

$$\sum_{i=0}^{7} N_i = 1$$

and a ridge bifurcation if:

$$\sum_{i=0}^{7} N_i > 2$$

However, the presence of undesired spikes and breaks present in a thinned ridge map may lead to detection of many spurious minutiae [3].

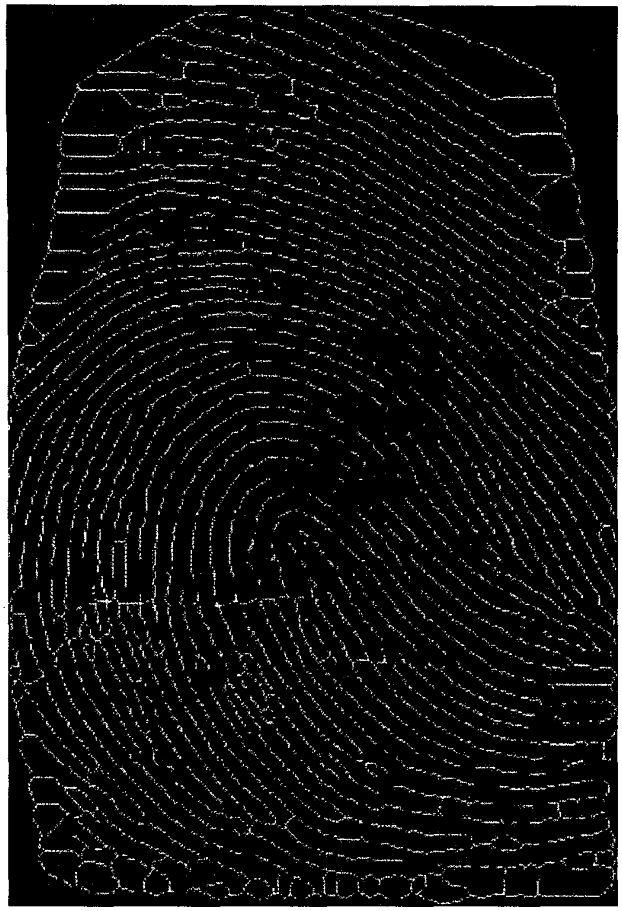

Fig. 4.

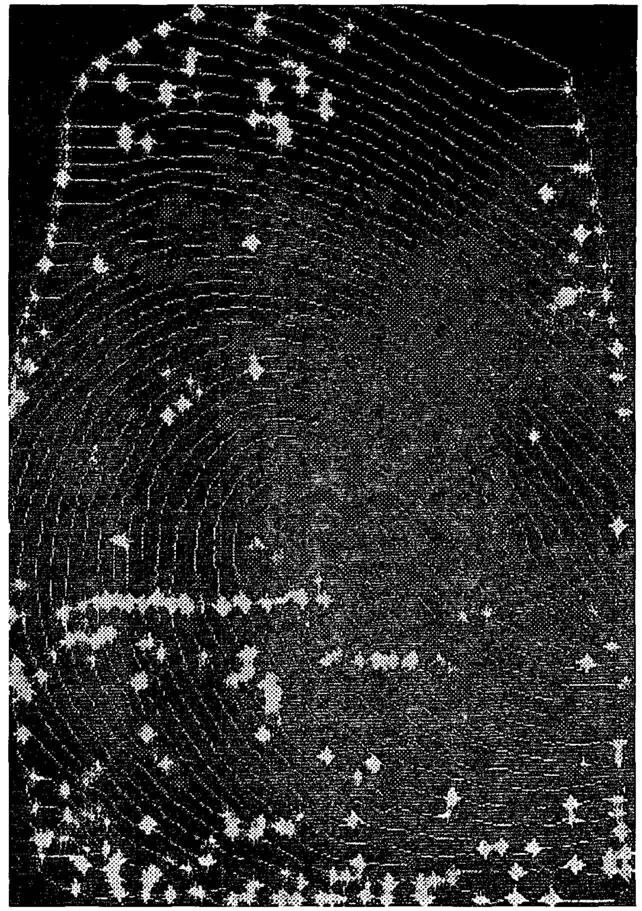

Fig. 5.

FINAL RESULTS

The experimental results reveal that our system identifies the most of minutiae present in the original acquired image. However, we note that the final number of minutiae obtained depend heavily of the acquired system used and the pre-processing stage applied. Next, we will report a sample of the final results obtained.

CONCLUSIONS

This paper presents a high performance minutiae extractor algorithm for fingerprint recognition using the two new databases acquired. Future work will try to improve this result, optimising the minutiae map involved. It also will try to eliminate the need to store any of the marginal minutiae, in order to reduce storage needs and the computer power required. The matching final process will be the identification process, comparing the minutiae map extracted with all the models (or templates) stored in the database of the system. Note that due to the fact that is not possible to catch always the same number of minutiae, the matching algorithm should be a special one in order to compare the feature vector obtained with the corresponding user's template. Anyway, for solving this final identification task, many other problems will have to be handled, and primarily, how to extract a clear and reliable ridge structure from a poor quality image, close to that seen by the human operator. This is a real challenge for researchers in image processing.

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