Fingerprint Recognition

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Abstract. Abstract: Fingerprint recognition refers to the automated method of verifying a match between two human fingerprints which is used to identify individuals and verify their identity. A fingerprint sensor is used to capture a digital image of the fingerprint pattern. The captured image is digitally processed to create a biometric template (a collection of extracted features) which is stored and used for matching. In this project , we try to make recognition of a fingerprint by local robust features extraction and matching. In this approach, first the local features are extracted using Speeded-Up Robust Feature (SURF) algorithm. The backpropagation learning technique is used for the neural network training. Selected features are represented in a special way such that they are simultaneously invariant under shift, rotation and scaling.The proposed method is focused to be reliable for a system with a small set of fingerprint data.

Keywords: Multilayer Perceptron, SURF, Minutiae extraction, backpropagation, image processing

1 Introduction

Alphonse Bertillon was the first to use the body measurements for solving crimes. After his discovery, many major law departments saw potential of fingerprints in identifying people. All this because, many of the people used to change their names or aliases every time the got arrested. The law enforcement departments embraced the idea of "booking" the fingerprints of criminals at the time of arrest, so that their records are readily available for later identification. Fingerprints found an application in forensics.[1].
Biometry provides us with a userfriendly method for this identification and is becoming a competitor for current identification mechanisms, especially for electronic transactions. [2]. Fingerprint recognition has been an important branch of biometric systems. It is one of the most popular biometric techniques used in automatic personal identification and verification

1.1 Motivation

Biometric recognition (or simply biometrics) refers to the use of distinctive anatomical (fingerprints, face, iris) and behavioral (speech) characteristics, called biometric identifiers or characteristics for automatically recognizing individuals. Biometrics is becoming an essential component of effective person identification solution because biometric identifiers cannot be shared or misplaced, and they intrinsically represent the individual's bodily identity [1]. Consequently, biometrics is not only a fascinating pattern recognition research problem but, if carefully used, is an enabling technology with the potential to make our society safer, reduce fraud and provide user convenience.

This project is about how to recognize a fingerprint to know who the person is, it can be used as a security measure in smart-phones, computers and other electronic systems.

1.2 Problem Scope

This approach to Fingerprint Recognition is made using some classification algorithms. We attempted to use some deep learning algorithms and classification methods to achieve Fingerprint recognition. We tackled the problem using a description algorithm like SURF, multilayer perceptron. All this to produced learning in a computer and test it using similar samples to verify if it is capable to classify correctly a Fingerprint [3].

SURF (Speeded-Up Robust Feature) extraction is used because is a scale and rotation invariant algorithm, the fingerprint recognition system shows better recognition accuracy in presence of rotation, scaling and partial distortion of the test image [6].

2 Previous Work

The history of fingerprint identification begins in the late 19th century with keeping accurate records about individuals indexed according to some physical attribute. The cradle of the modern finger print system was colonial India where a workable identification system was desired for numerous purposes.[8] In 1977, the Royal Canadian Mounted Police began operation of the first AFIS (Automated Fingerprint Identification System). [9]

A.J. Willis and L.Myers (2001) developed of a robust algorithm allowing good recognition of low-quality fingerprints with inexpensive hardware is investigated. Features are extracted from the enhanced images using a number of approaches including a wedge ring overlay minutia detector. Finally, a number of neural net and statistically based classifiers are evaluated for the recognition task [10]

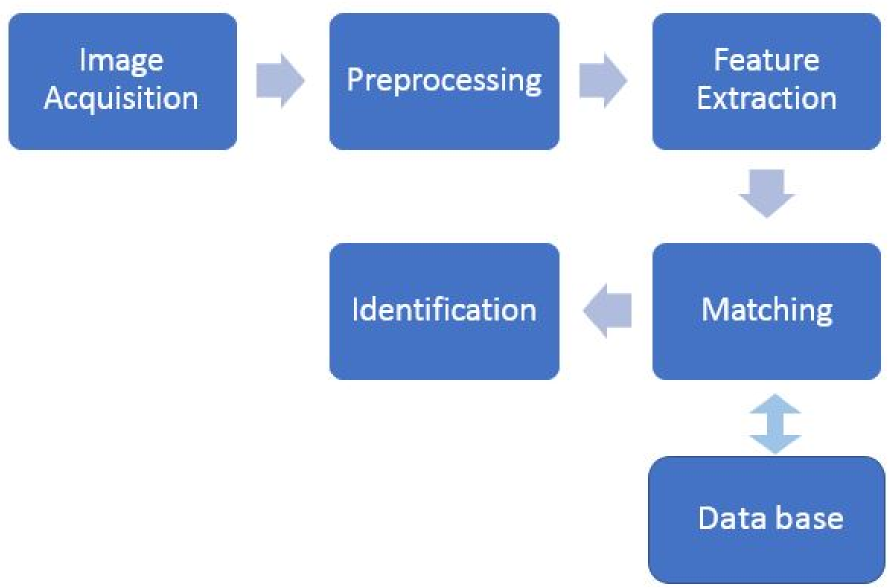
Taek Kim and Ho Kim (2005)provided a mobile communication device what includes a housing, a fingerprint recognition sensor and a process unit for performing a user identification process by analyzing the fingerprint data inputted from the fingerprint sensor using a fingerprint recognition algorithm [11]

3 Methods

Given the problem of "How do we know who the fingerprint is?" We think a computer system that could fix.

The process for Fingerprint Recognition involves Image acquisition, image processing, features extraction, training the Nerual Network, Testing the neural network, matching, and identification.

Fig. 1. Flow diagram.



3.1 About the samples

Samples are needed to test our methodology, so we needed a database of fingerprints. Fortunately, we found some databases with noise free samples. This was an advantage, because removing noise from images is the first step to prepare our input for the next stages. The Fingerprint database we use is composed for 8 different samples of the same fingerprint and there are 10 different fingerprints, that is, 80 different images in the database. We use 4 examples of 6 different fingerprint to train our Neural Network and 6 samples to test it.

3.2 Image processing

The first step in this stage would be noise removal, but as we discussed before, that part was skipped because of our samples (which are already clean). Next step would be resolution fixing, but once again, this is skipped because of our samples (which are already in a good resolution for this matter).

Hence, we went directly to processing the image so that we could have a gray scale and binary image. We used "rgb2gray", which is a MATLAB function that takes the average value between the 3 color layers and makes a new image with only that new value for this pixel, "im2bw", which is another MATLAB function that checks each pixel and according to a threshold, it converts that pixel value to 1 or to 0. Then the image has values only where interesting parts are located.

After that, we used a function called "bwmorph" to thin the image. "bwmorph" is another MATLAB function which can handle some different parameters to achive different results. For thinning the image we used the parameter "thin" and "Inf" to make the process of thinning until each ridge of the fingerprint is only 1 pixel wide.

3.3 Minutiae Extraction

Once the image is thinned, ridges are very clear and the interesting parts are easily detected. Interesting points are those points in a fingerprint where a ridge ends, a ridge forks or diverges into branch ridges. Collectively, these features are called *minutiae*[4].

The minutiae points are determined by scanning the local neighborhood of each pixel in the ridge thinned image, using a 3 x 3 window. Then a Crossing Number is computed, which is defined as half the sum of the differences between pairs of neighboring pixels [5].

Table 1. Properties of the Crossing Number

CN	Property
0	Isolated Point
1	Ridge Ending
2	Continuing ridge
3	Bifurcation
4	Crossing

3.4 SURF

Having the problem of not knowing how many points of interest Minutiae Extraction could detect, we turn to a descriptor algorithm that allows us to ask for as many points of interest as we require (SURF - Speeded-Up Robust Feature). SURF also solves the problems of accuracy and resolution in the images because it is invariant to rotation and scale.

To use improve the SURF function, we exaggerate each minutiae point through coloring with a 3 pixel radius each coordinate given by minutiae, so that SURF could detect the same regions that minutiae extraction. The advantage as we pointed out before, is that, SURF returns a vector of characteristics with an specified length. This is very helpful because in this way, we can easily input that vector into a Neural Network with some expected output and train it.

3.5 Neural Networks

To solve the problems of accuracy and time, decided do it with neural networks that, with proper training, can tell us whether a fingerprint is similar enough to make it match with another or not.
But by introducing the neural network we encounter the problem of the amount of information generated an image processing within the network, the size of the neural network grows exponentially according to the amount of data obtained from an image. Initially we tried to input each pixel of an image as input to the neural network, but being so large network can not be supported by a simple computer and does not run the program. Therefore, it not helped so far.

As we stated before, we turn to a description algorithm to help us feed the Neural Network, so we used SURF. SURF for this problem was used to return the 10 most significant points of each fingerprint. A 10 x 64 matrix is return, this is because SURF returns each characteristic as a 64 length vector.

Then we took that vector and pass it as an input to our MLP Neural Network. Our Neural Network is configured to use the *Gradient descent with adaptive learning rate backpropagation* algorithm. This algorithm is a network training function that updates weight and bias values according to gradient descent with adaptive learning rate[7].
Once it is trained, we test it using 6 new entries and each one receives a class. Our classes for the 6 different fingerprints are:

4 Results

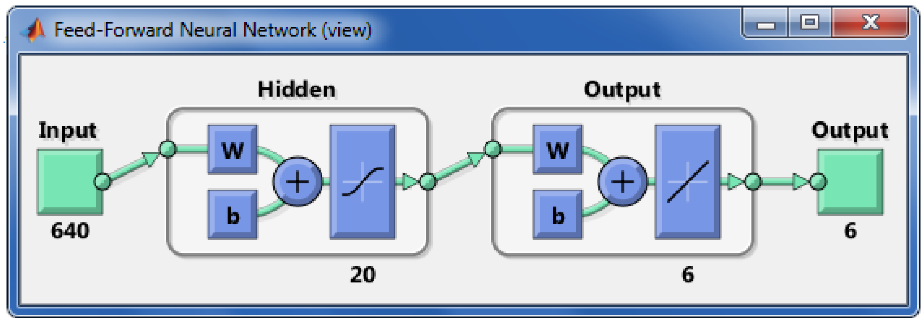
5 Discussion

The hypothesis of comparing fingerprints was discarded because the process is slow and the results were not favorable since the only way to make the compar-

Table 2. Fingerprint classes

Class 1	1 0 0 0 0 0
Class 2	0 1 0 0 0 0
Class 3	0 0 1 0 0 0
Class 4	0 0 0 1 0 0
Class 5	0 0 0 0 1 0
Class 6	0 0 0 0 0 1

Fig. 2. Arquitecture of the MLP.




```
ans =

    0.8925    1.3340   -0.0816   -0.1288    1.1254   -0.4946
    0.6351    1.4061    0.3798    0.8230    0.7651    0.1354
    0.5914    0.9748    0.5512    0.1788    0.7934    0.2060
   -0.0805    1.4648    0.8591    0.7056    0.6500   -0.1958
   -0.1296    1.4810    0.3157    0.5301    1.1168    0.3377
    0.5755    0.3523    0.0544    0.7158    0.5409   -0.3888
```

Fig. 3. Results using 10 SURF characteristics

```
ans =

    0.8925    1.3340   -0.0816   -0.1288    1.1254   -0.4946
    0.6351    1.4061    0.3798    0.8230    0.7651    0.1354
    0.5914    0.9748    0.5512    0.1788    0.7934    0.2060
   -0.0805    1.4648    0.8591    0.7056    0.6500   -0.1958
   -0.1296    1.4810    0.3157    0.5301    1.1168    0.3377
    0.5755    0.3523    0.0544    0.7158    0.5409   -0.3888
```

Fig. 4. Results using 20 SURF characteristics

ison correctly was to compare the same image.

The processing of the image is considered as the most important process in

Fig. 5. Results using 25 SURF characteristics.

```
ans =

  -0.0880   -0.5410   -0.3940    0.7382    0.1535    0.1889
   0.4085   -1.9120    0.6876   -0.6624    1.6892   -0.1318
   1.0285   -0.5158    1.1358   -0.3528    0.7445    0.1011
  -0.5248    0.0640    0.1286    1.3726   -0.0839    0.3756
   0.2333    0.6373   -0.5988    0.5061    0.7323    0.3631
   0.4065   -0.3009    1.7375    0.2663   -0.4234    0.7729
```

Fig. 6. Results using 30 SURF characteristics.

```
ans =

  -0.2569   -0.3453    0.2562    0.7852    1.2054    0.5943
  -0.0072    1.1782    0.9272   -0.9817    0.7206    0.8604
   0.1227   -0.6319   -0.2470    0.9910    1.4357    0.7677
   0.5243    1.0950    0.9699   -0.7093    2.1207   -0.5802
   0.5139   -0.3593    1.1303    1.2759    1.1422    0.6164
   1.7187   -0.8018   -0.9634   -0.1816    0.2050    0.7945
```

Fig. 7. Results using 35 SURF characteristics.

```
ans =

   0.1223    0.8576   -0.8767    1.5960   -0.8506   -0.0342
   0.1081   -0.9747    0.1841    0.0241   -0.2225    0.4189
   1.6346    1.3196   -0.6343    0.6695   -0.0101    1.5154
  -1.3331   -0.4998    0.7566    0.7406    1.1650   -0.9277
   0.7873    0.7384   -0.2771   -0.1089    0.0650    0.1466
   1.3016    0.5993    0.5632    0.2806    1.0256    0.8397
```

Fig. 8. Results using 50 SURF characteristics.

```
ans =

   0.6072   -1.2935   -0.9120    0.6904    0.2273    1.1954
   0.7407    1.2715   -0.4499    1.0855   -0.9537    1.5943
  -0.8251   -0.9824   -1.1932    0.6247   -0.8148   -0.0658
  -0.4787   -0.1951   -0.1858    0.9171    0.3978   -0.9546
  -0.6902    1.0083   -1.3031    0.0662    0.8325    0.2190
  -0.0749   -0.9149   -1.7960   -0.3262   -0.3841    0.3807
```

the comparison of fingerprints, this process helps us to remove the noise and see the structure of the fingerprint with greater clarity, therefore the differences of a fingerprint can be observed fingerprint compared to other.

Fig. 9. SURF points

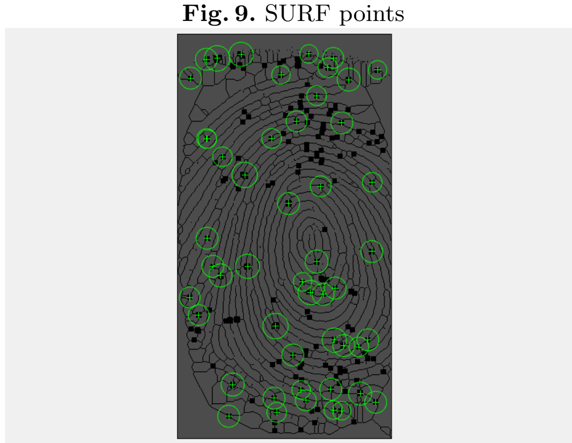
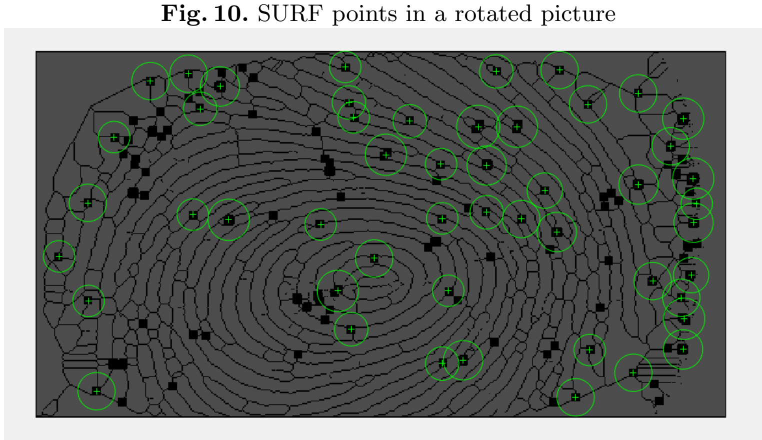


Fig. 10. SURF points in a rotated picture



The extraction of minutiae is, until now, the best way to obtain the location of unique points of a fingerprint, although this process is better than the comparison of fingerprints due to the fact that the amount of data to be compared is lower, being a problem because you have to match the location of the points in both images.

SURF is an algorithm used for the recognition of patterns in images, it works finding ”points of interest” and calculating the Euclidean distance between the points found. when calculating the Euclidean distance between points makes it invariant to the rotation and to the scale of the images

The points of interest sought by SURF will be the same as the extraction of minutiae, but with a code, the position of these points becomes more evident by marking black points in those positions.

The neural network is responsible for recognizing the similarity between the points delivered by SURF and thus be able to identify if one fingerprint resembles another. A drawback is that SURF can not deliver different points each time the image is analyzed, this is because SURF receives all the points of interest that minutiae extraction gave us, and from all those points we ask only a small one vector to SURF

Future plans to correct these errors will be to have a better training for the neural network and use a support vector machine using probably a kernel function like Radial Basis

6 Conclusion

This project did not achieve the goal, because not all the time our description algorithm selected the same interesting points in different images. Is important to point out that sometimes the MLP classified better when a vector of characteristics was smaller.

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