MUĞLA SITKI KOÇMAN UNIVERSITY

COMPUTER ENGINEERING

Senior Design Project I

GENDER CLASSIFICATION BASED ON FINGERPRINT BY USING THE CNN ALGORITM

Analysis & Design Report

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Gender Classification based on Fingerprint Using the CNN Algorithm

1. Introduction

Fingerprint is the trace created by the folds at the end joint and end of the fingers. Fingerprints are founded by using of the natural state of the human body and today it is a method that is used for a lot in personal identification.

There are pores in every fold on the outer skin of the human body. Each of them extends to the inner skin. Each pore looks like a nail there, with two rows of protrusions called Papila, as if nailed into the inner skin. For this reason, even if the outer skin is damaged or even completely spilled, these Papilas are still sufficient for the detection of fingerprints. Again, the marks on newly released leather become the same as before.
Fingerprinting has become very important in detecting the criminals today. It constitutes definitive evidence. Especially guns, pistols etc. Fingerprints have gained importance in crimes committed .
Fingerprints are preferred in terms of their inimitability, immutability and classifiability. Scientific research has shown that fingerprint is definitive evidence for identification. Since people's fingerprints are not exactly the same, fingerprints are very important evidence for detecting the offender. Fingerprints of the person do not change with aging and do not disappear. Since it is an easy and inexpensive method, fingerprinting is used quite frequently in identity detection today.
All DNA fingerprints of a creature are identical. The probability that two people could have the same genetic fingerprint by chance is at a level that is statistically low enough to be expressed in a billionth.
Today, it is possible to reveal the perpetrator of a crime by examining the genetic fingerprint he left. Over 99% success can be achieved with DNA fingerprints.

Some of the Fingerprint Characteristics:

Point: It consists of up to two sweat holes and is symbolized by (n).

Line: Consists of sequential ordering of more than two sweat holes, a short line.
It can be either a long line or a symbol (h).

Island: It is formed by dividing Papil line into two and joining in the future, symbolized by (a).

Nebde: In deep wounds, concentrated acid or burns of 1st and 2nd degree, if the area under the upper skin burns, the skin cannot be regained, fingerprint identification attributes of invariable and immutable
It is formed in case of losing part and is symbolized with (N).

There are three papillary lines on the fingerprints according to their location on the fingertips. These;

Basic Lines: On fingertips, it is parallel to the first neck and fingerprints

are the papillary forming the lower part.

Edge Lines: With the mouths facing the basic lines and entering from one edge of the finger, after going towards the tip, they are papillary that come out from the other side.

Centerlines: Filling the gap between the base and border lines, they are papillary. These lines are sometimes in the form of interlocking circles. In some cases the papillary hugs in a row and form a spiral like clockwork. Sometimes papillary, they enter from one end of the finger and make a lasso inside and exit from the same place. This
fingerprints will be different due to the differences in the shapes.

Delta: It is in the shape of an equilateral triangle. Base, edge and center in fingerprints lines are collected together, a shape that looks like a triangle at the collection site form. This shape is called delta.

All fingerprints in general according to their patterns and shapes.
It is possible to divide into 3 classes: (whorl) and arch (arches).

In researches, 65% of fingerprints are lasso, 30% are spiral,
It was determined that 4 of them were arc and 1% were right or left slanted arc. also made ethnic infrastructure may also be important in fingerprint types in research respectively.

For example; Caucasus and Africans often use lasso-type fingerprints
while having Asians and Indians generally have a spiral fingerprint respectively. These three main groups are based on 10 different classification systems used in the world.

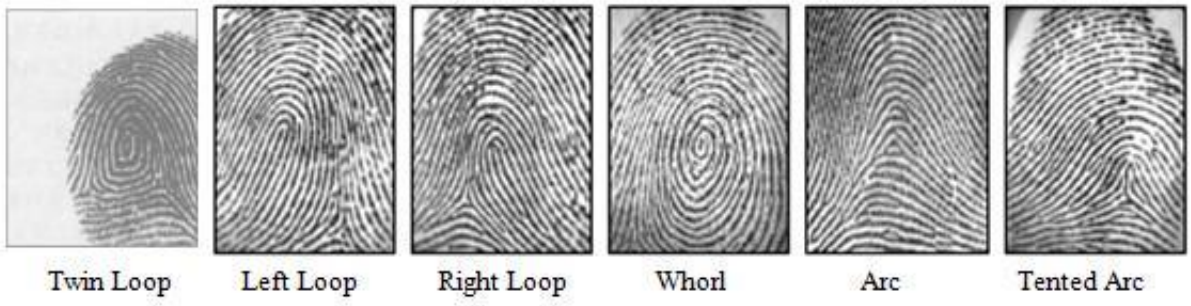

FIGURE 1 *fingerprint ridge patterns [1]*

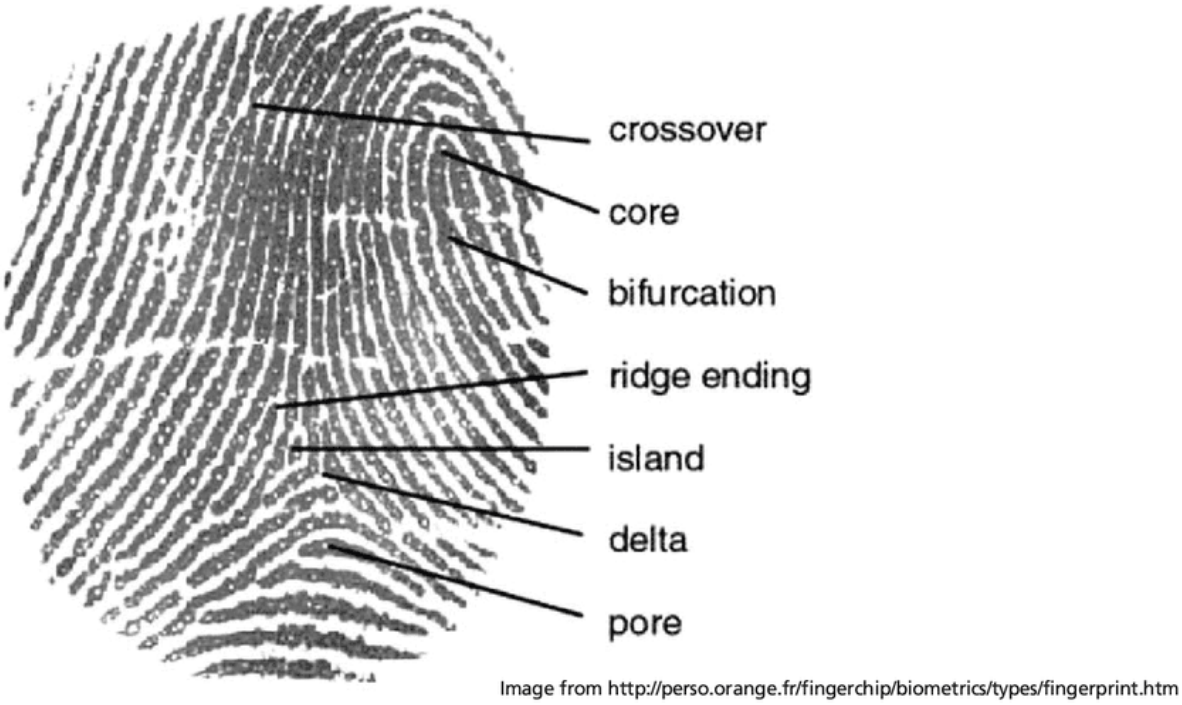

FIGURE 2 *fingerprint ridge characteristics [2]*

2. Motivation

Fingerprint is one of the most important effects that distinguish a person's identity. The motivation behind this study is to identify the gender of the person and increase the percentage of correct results, especially by using fingerprints in forensic cases.

3. Literature Review

Many methods have been used in the previous studies for the classification of fingerprints. I want to explain some of them in this section.

1. Artificial Neural Networks

Artificial neural networks (ANN) [3] is a computing technology inspired by the information processing technique of the human brain. With ANN, the way the simple biological nervous system works is imitated. Imitated nerve cells contain neurons, and these neurons connect to each other in various ways to form the network. These networks are capable of learning, storing and revealing the relationship between data. In other words, ANNs produce solutions to problems that normally require a person's natural abilities to think and observe. The main reason why a person can produce solutions for problems that require thinking and observation skills is the ability of the human brain and hence the ability to learn by living or trying.

2. Convolutional Neural Networks

Convolutional neural networks [4] are a sub-branch of deep learning and are often used to analyze visual information. Common uses include image and video recognition, suggestion systems, image classification, medical image analysis, and natural language processing.

"Convolutional Neural Network" indicates that the neural network uses a mathematical process called convolution. Convolution (convolution) is a special type of linear (linear) process. Convolutional neural networks are simple neural networks that use convolution instead of the general matrix product in at least one of its layers.

3. Minutiae Extraction (Fingerprint Pattern Analysis)

Minutiae points [5] are the major features of a fingerprint image and are used in the matching of fingerprints. These minutiae points are used to determine the uniqueness of a fingerprint image. A good quality fingerprint image can have 25 to 80 minutiae depending on the fingerprint scanner resolution and the placement of finger on the sensor.
What is the definition of minutiae? Minutiae can be defined as the points where the ridge lines end or fork. So the minutiae points are the local ridge discontinuities and can be of many types. These types are –

- Ridge ending is the point where the ridge ends suddenly.
- Ridge bifurcation is the point where a single ridge branches out into two or more ridges.
- Ridge dots are very small ridges.
- Ridge islands are slightly longer than dots and occupy a middle space between two diverging ridges.

- Ponds or Lakes are the empty space between two diverging ridges.
- Spurs is a notch protruding from a ridge.
- Bridges are the small ridges that join two longer adjacent ridges.
- Crossovers are formed when two ridges cross each other.

Ridge endings and ridge bifurcations are the most commonly used minutiae types since all other types of minutiae are based on a combination of these two types. Figure below shows some of the common minutiae patterns.

4. Method

The method we will use will consist of three stages. The first stage will be data aquisition, the second stage is data preprocessing, and the last stage will be the cnn classification.

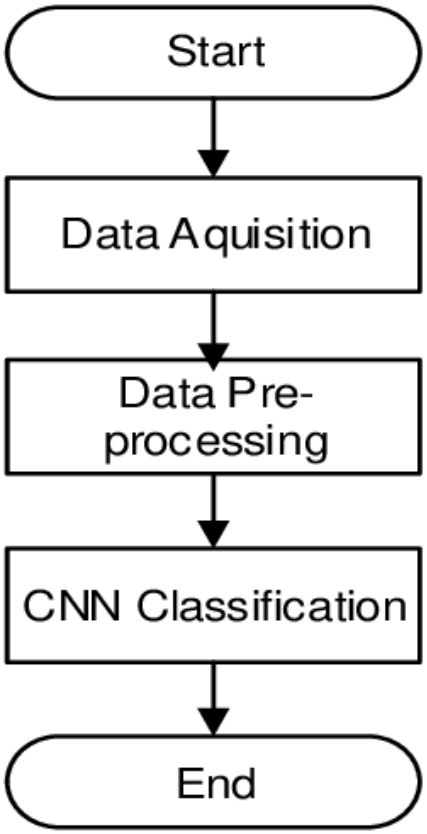

FIGURE 3 *cnn algorithm steps[6].*

Convolutional Neural Networks

Convolutional Neural Networks are very similar to ordinary Neural Networks: they are made up of neurons that have learnable weights and biases. Each neuron receives some inputs,

performs a dot product and optionally follows it with a non-linearity. The whole network still expresses a single differentiable score function: from the raw image pixels on one end to class scores at the other. And they still have a loss function on the last layer.
What is the difference? ConvNet architectures make the explicit assumption that the inputs are images, which allows us to encode certain properties into the architecture. These then make the forward function more efficient to implement and vastly reduce the amount of parameters in the network.

Layers used to build ConvNets
As we described above, a simple ConvNet is a sequence of layers, and every layer of a ConvNet transforms one volume of activations to another through a differentiable function. We use three main types of layers to build ConvNet architectures: **Convolutional Layer**, **Pooling Layer**, and **Fully-Connected Layer** (exactly as seen in regular Neural Networks). We will stack these layers to form a full ConvNet **architecture**.

- INPUT [32x32x3] will hold the raw pixel values of the image, in this case an image of width 32, height 32, and with three color channels R,G,B.
- CONV layer will compute the output of neurons that are connected to local regions in the input, each computing a dot product between their weights and a small region they are connected to in the input volume. This may result in volume such as [32x32x12] if we decided to use 12 filters.
- RELU layer will apply an elementwise activation function, such as the
- POOL layer will perform a downsampling operation along the spatial dimensions (width, height), resulting in volume such as [16x16x12].
- FC (i.e. fully-connected) layer will compute the class scores, resulting in volume of size [1x1x10], where each of the 10 numbers correspond to a class score, such as among the 10 categories of CIFAR-10. As with ordinary Neural Networks and as the name implies, each neuron in this layer will be connected to all the numbers in the previous volume.

In this way, ConvNets transform the original image layer by layer from the original pixel values to the final class scores. Note that some layers contain parameters and other don't. In particular, the CONV/FC layers perform transformations that are a function of not only the activations in the input volume, but also of the parameters (the weights and biases of the neurons). On the other hand, the RELU/POOL layers will implement a fixed function. The parameters in the CONV/FC layers will be trained with gradient descent so that the class scores that the ConvNet computes are consistent with the labels in the training set for each image.
In summary:

- A ConvNet architecture is in the simplest case a list of Layers that transform the image volume into an output volume (e.g. holding the class scores)
- There are a few distinct types of Layers
- Each Layer accepts an input 3D volume and transforms it to an output 3D volume through a differentiable function
- Each Layer may or may not have parameters (e.g. CONV/FC do, RELU/POOL don't)

- Each Layer may or may not have additional hyperparameters (e.g. CONV/FC/POOL do, RELU doesn't) [7]

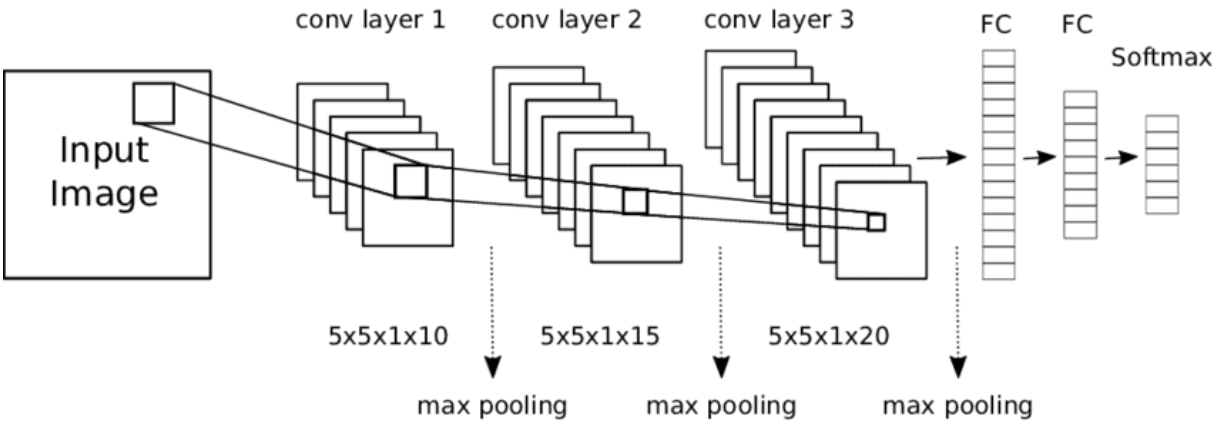

FIGURE 4 *cnn algorithm layers steps [8]*

5. Future Work

In the next stages of the graduation thesis, I will find a data set. After making the necessary installation and package downloads, I will use the cnn algorithm using python and try to get correct outputs based on the dataset.

6. References

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