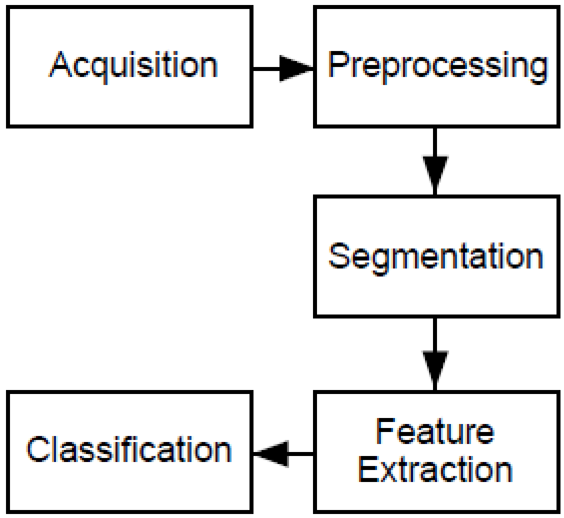
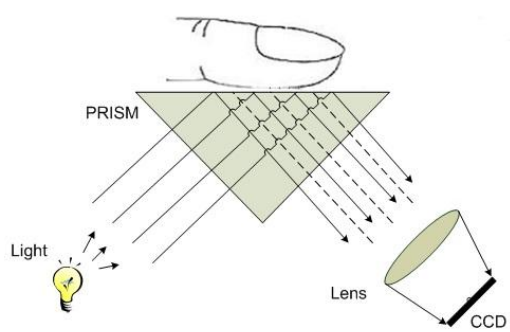
Fingerprint Classification with Neural Networks

Classification method can be divided into five stages as the figure below



1. Image Acquisition

A special device for the collection of fingerprint images was built based on a simple principle, which is employed in most of the commercial devices for this purpose. A right-angle prism was used to project the fingerprint ridge pattern over a CCD camera. One of the square sides of the prism was illuminated by a light source. As the incoming rays of light reflect on the diagonal side of the prism, they interact with the touching finger ridges, forming the correspondent image on the other square side of the prism. The formed image is then focused on the CCD camera by means of a lens.



2. **Preprocessing and Segmentation**

Due to the simplicity of the fingerprint acquisition device, a perfect focus on the entire area of the images could not be achieved. For this reason, a high-pass filter with high-frequency emphasis [6] was applied to the original images, in order to enhance borders and minimize the focus problem. After the high-pass filtering, the resulting images were submitted to a histogram equalization to enhance contrast.

original image

result of the preprocessing and segmentation

Once the preprocessing was done, it was necessary to find the region of interest within the images, where the feature extraction would take place. The segmentation was divided into two different processes. The first sample images of each class of fingerprints were converted from gray-scale to binary through a fixed threshold value. The binary images were then submitted to morphologic operations of erosion and dilation, respectively, leaving in the image a single area of black pixels corresponding to the center of the region of interest.

The next step was the detection of the boundary rectangle of the resulting black area, whose geometric center would be the center of a 128 x 128 pixels square image to be cropped from the corresponding preprocessed images. The central 32 x 32 pixels region of the first cropped image was stored as a reference region to be used in the cropping process of the remaining images. The remaining image samples of each fingerprint class were segmented in a different manner. The reference region of the first sample was slided across the remaining images corresponding to the same class. The correlation coefficient between the reference region and the local sub image was evaluated at each step and the position of maximal correlation was used as a reference for the 128 x128 pixels crop within the image.

3. Feature Extraction

The extraction of relevant features of a pattern is not a trivial task. For the particular case of the feature extraction from fingerprint images several approaches have been developed, most of them based on special characteristics from the fingerprint patterns, such as ridge orientation and minutia detection. A difficulty that follows from these traditional approaches is the use of specialized algorithms and operators to extract ridge orientation and minutia information. On the other hand, the use of mathematical transforms to map the patterns into a more suitable space in terms of representation is a plausible possibility. The use of a discrete wavelet transform as the feature extraction method was considered in this work for several reasons. One of them is that the FBI has achieved some motivating results with fingerprint data compression using a special specification of a wavelet transform. In fact, adequate wavelet transforms allow perfect reconstruction of the original signal, while providing good frequency-time localization at multiple scales. Furthermore, discrete wavelet transform algorithms seem to be more easily implemented on digital signal processors or specific hardware than the algorithms that follow from ridge or minutia-oriented techniques.

4. Neural Network Classification

To confirm the efficiency of our feature extraction method, a feed-forward neural network with a single hidden layer was trained with a gradient descent technique. This simple backpropagation network was composed of 64 input nodes (corresponding to the dimension of the feature vectors), 16 hidden nodes and 10 or 16 output nodes (corresponding to the number of concerned fingerprint classes of the first and second data sets, respectively).

The supervised training was done with 4 elements from each class for the first data set and with 5 elements from each class for the second data set. In both cases the training patterns were presented randomly to the neural network. The remaining elements of each data set were used to test the neural network.