Development of the Ateb-Gabor Filtration Method in Biometric Protection Systems

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Abstract. The Gabor filter for biometric images has been investigated. Introduced a new Ateb-Gabor filter to improve the quality of fingerprint images. The sequence of filtration and recognition of biometric data is developed. For reliable fingerprint recognition, image correction is required, since interference caused by scanning may distort the lines of the imprints, which creates errors in recognition. The mathematical apparatus of the Ateb-functions provides additional functions for controlling Gabor's filtration, since it has a wider range of filtering options. It has been shown that the use of the Ateb-Gabor filter has a more controlling influence on the image, because in addition there are two parameters of rational numbers that considerably extends the filtration process.
The method of filtering images based on the Gabor filter using Ateb-functions is developed. At present, work is being done on the application of a new filter to biometric images, bringing it to a finished software product. A two-dimensional Gabor filter is also developed, which in the future will allow people to recognize faces.

Keywords: Ateb-Gabor; Gabor Filter; Image processing.

1 Introduction

With the development of information technology, biometrics has become an essential part of our everyday lives. Biometric identification systems require constant improvement since they work fairly slowly and often give the wrong results. new methods have been developed for fingerprint analysis, which scans them without any contact [1]. Similarly, the scanning and recognition technologies in 3D space appeared [2]. As a result, professional systems for recognition were developed [3]. Using the technology of the "large data" processing, modern surveillance systems and access control systems identify individual fragments of biometrics more accurately, and technologies for identifying specific people in the stream are developed [4].

2 Gabor Filters and Image Processing

One of the most popular methods for selecting the edges in the image is the use of Gabor filters [5]. The real part of the nucleus of the Gabor filter are constructed using [6]. To construct an imaginary part of the Gabor filter, it is necessary to replace the cosine function with the sine calculation in the above formula.

3 Filtration

The filtration process involves the convolution of the filter and the input signal in the spatial domain. In this paper, it was done in the Wolfram Mathematica 11 computing environment [7]. Multiplication in the spatial domain is equivalent to convolution in the frequency domain [8].

$$r = image * filter \tag{3}$$

where r - is the result of filtration; * - convolution and $filter$ - Fourier transform of the Gabor filter. The Fourier transform of the Gabor filter is a Gaussian signal [8], whose center is located at the center frequency of the filter. As a result of multiplication in the frequency domain, the amplitude of the output frequency close to the sinusoidal signal increases, while others decreases.

3.1 Implementation of the Gabor filter

The width and height of the filter are determined by the width and height of the Gaussian component. Determining the correct width and height for the Gabor filter is essential while designing new filters. Experimentally established [9] that a good filter, capable of detecting narrow edges at a certain frequency should have boundaries in the plane z = 0 and also it should have two negative and one positive peak.

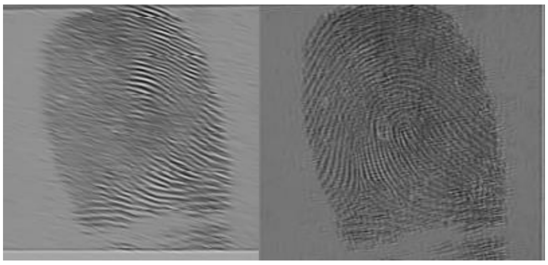
3.2 Generalized One-Dimensional Ateb-Gabor Filter

We construct a generalized one-dimensional Gabor filter basing on the Ateb-functions [10]. It will look like:

$$g(m,n,\omega) = e^{-\frac{\omega^2}{2\sigma^2}} \operatorname{ca}\left(m, n, 2\Pi, \theta, \omega\right),$$

where σ - is the standard deviation of the Gaussian nucleus, which determines the amplitude of the function, ω - is the frequency of oscillations, which is defined as $\omega = 1/T$, де $T(m, n)$ – is the period of Ateb function $\operatorname{ca}\left(m, n, 2\Pi, \theta, \omega\right)$, 2Π – period of Ateb-function.

The experimental results of the filtration are shown in the figure below. In fig.1 a is filtered by an ordinary Gabor filter, and fig.1 b filter is Ateb-Gabor with m=n=3 with the best results of filtration.



a b

Fig.1. Filtration a) ordinary Gabor filter b) Ateb-Gabor filter with m=n=3

The optimal correlation between frequency and width of the Gabor filter has been determined, which allowed performing filters automatically with the purpose of finding the edges of objects with different frequencies, sizes and directions. The optimal correlation is in each specific image of its own. The method of removing the average component of the Gabor filter is proposed, which allows reducing the value of the average filter to zero without deforming the filter. The results of numerous experiments demonstrate the successful selection of edges in the image based on the results obtained in the work of the Gabor filter parameters.

4 Image Processing Using the Gabor Filter

In each fingerprint, you can identify two types of attributes - global and local. Global signs are those that are visible to the naked eye. Another type of attributes is local.

They are selected because lines of the fingerprints are not straight. These points provide unique fingerprint information in the process of identifying a person. Each printout contains up to 70 minutia points [10].

The implementation of the Gabor filter for images takes place in five steps.

Step1. Image normalization. Normalization of the image is necessary in order to set the previous mean values and deviations.

Step2. Calculation of the orientation. The orientation image *Img* represents the matrix $N \times N$, in which each component *Img* (i, j) shows the local orientation, angle of inclination at a given point of the line with coordinates (i, j).

Step 3. Calculation of the frequency image. The frequency image is a matrix of size $N \times N$, in which each component *Img* (i, j) shows the local frequency of the lines at a given point, which is defined as the frequency of the crests directed along the orientation of the protrusion. On the next step, the skeletelization of the image is based on the wave method [11].

Step4. Binarization of the image.

Step 5. Apply to the binary image of the Gabor filter. The filter is configured for the local orientation of the speeches, applied to the pixels of the projections and vices of the image.

5 Conclusions

The Gabor filter for biometric images has been developed. A new filter of Ateb-Gabor has been investigated and its efficiency in application to biometrics has been proved. Work is carried out to filter images and study their characteristics based on one-dimensional and two-dimensional Gabor filter. We think that we will achieve significant results in the near future. The use of a generalized Gabor filter will allow for better filtration and have a large number of parameters to choose from for the best filtering options. The change of the parameters *m* and *n* provides different values of the period, which makes it possible to expand the number of filter options. To solve the problem of fingerprint identification, the Ateb-Gabor function allows you to improve identification, and, based on it, filtration of images with a large number of ridges. This provides better characteristics than the usual one-dimensional Gabor filter.

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