Use of Neural Networks in Picture Recognition

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ABSTRACT

Currently, theoretical research and practical applications of artificial neural networks and parallel processing of problems are rapidly developing. Neural networks allow solving a large number of practical problems that have no analytical description and are given only by experimental data. The subtlety of algorithms in the synthesis of neural networks is the explanation of decision making. Many researchers are engaged in solving this problem

Keywords: Neural networks, visual perception, image comparison

Introduction

Today, the research conducted in the field of artificial intelligence is helping practical life in various fields, for example, let's take today's cameras, they perform familiarization and comparison work as well as observation. For this, we will explain some parts of the so-called Garbon filter so that we can analyze it from a mathematical point of view.

Main Part

In image processing, a Gabor filter, named after Dennis Gabor, is a linear filter used for texture analysis, which essentially analyzes the presence of specific frequency content in an image in certain directions in a localized region around a point or area. Many modern scientists claim that the frequency and direction representation of Gabor filters is similar to the human visual system. They have been found to be particularly suitable for tissue imaging and differentiation. In the spatial domain, a 2-D Gabor filter is a Gaussian kernel function modulated by a sinusoidal plane wave (see Gabor transform).

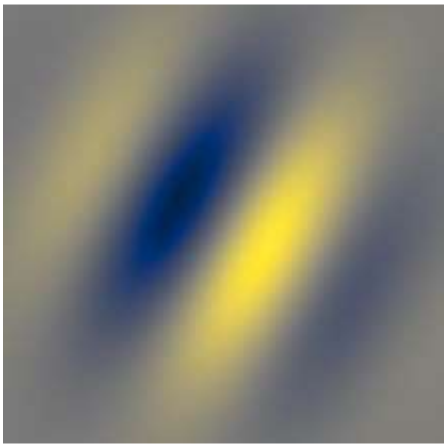


Figure 1. An example of a two-dimensional Gabor filter

Some authors claim that simple cells in the visual cortex of the mammalian brain can be modeled with Gabor functions. Thus, image analysis using Gabor filters is thought by some to be similar to perception in the human visual system. Its impulse response is a sinusoidal wave (a plane wave for 2-D Gabor filters) multiplied by a Gaussian function. Due to the Multiplication-Convolution Property (Convolution Theorem), the Fourier transform of the Gabor filter impulse response is a harmonic function (sinusoidal function) and the Fourier convolution of a Gaussian function. The filter has a real and an imaginary component representing the orthogonal directions. It can be constructed as two complex numbers or separate components.

Complex

$$g(x,y;\lambda,\theta,\psi,\sigma,\gamma)=\exp\left(-\frac{x'^2+\gamma^2y'^2}{2\sigma^2}\right)\exp\left(i\left(2\pi\frac{x'}{\lambda}+\psi\right)\right)$$

Real

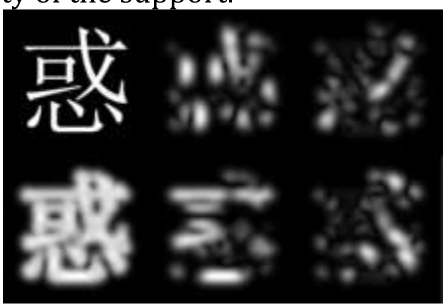
$$g(x,y;\lambda,\theta,\psi,\sigma,\gamma)=\exp\left(-\frac{x'^2+\gamma^2y'^2}{2\sigma^2}\right)\cos\left(2\pi\frac{x'}{\lambda}+\psi\right)$$

Abstract

$$g(x,y;\lambda,\theta,\psi,\sigma,\gamma)=\exp\left(-\frac{x'^2+\gamma^2y'^2}{2\sigma^2}\right)\sin\left(2\pi\frac{x'}{\lambda}+\psi\right)$$

where $x' = x\cos\theta + y\sin\theta$ and $y' = -x\sin\theta + y\cos\theta$.

In this equation, λ represents the wavelength of the sinusoidal factor, Θ represents the orientation of the Gabor function to the parallel lines of the normal, Ψ is the phase shift, σ is the sigma/standard deviation of the Gaussian envelope, and Y is the spatial aspect ratio, using the Gabor function -specifies the ellipticity of the support.



A demonstration of the Gabor filter applied to Chinese OCR. The four directions are shown on the right 0°, 45°, 90° and 135°. The original character image and the superposition of all four directions are shown on the left.

Gabor filters are directly related to Gabor wavelets in that they can be designed for a range of dilations and rotations. However, in general, the expansion does not apply to Gabor wavelets, as it requires the computation of bi-orthogonal wavelets, which can be very time-consuming. Therefore, a filter bank consisting of Gabor filters with different scales and rotations is usually created. The filters are combined with the signal, resulting in a so-called Gabor field. This process is closely related to the processes in the primary visual cortex. Jones and Palmer showed that the real part of the complex Gabor function corresponds well to receptive field weighting functions in simple cells in the cat's striate cortex.

A set of Gabor filters with different frequencies and directions can be useful for extracting useful features from an image. Two-dimensional Gabor filters in the discrete domain are given by:

$$G_c[i,j]=Be^{-\frac{(i^2+j^2)}{2\sigma^2}}\cos(2\pi f(i\cos\theta+j\sin\theta))$$
$$G_s[i,j]=Ce^{-\frac{(i^2+j^2)}{2\sigma^2}}\sin(2\pi f(i\cos\theta+j\sin\theta))$$

where *B* and *C* normalization factors are determined.

2-D Gabor filters have rich applications in image processing, especially feature extraction for texture analysis and segmentation. † specifies the frequency being considered in the texture. By varying Θ, we can look for a texture oriented in a certain direction. By varying s, we change the support of the base or the size of the analyzed image region.

Summary

In document image processing, Gabor features are ideal for identifying the script of a word in a multilingual document. Multi-frequency and multi-directional Gabor filters were used to localize and extract text-only regions from complex document images (both grayscale and color), since text is rich in high-frequency components and images are relatively smooth. Gabor filters, which have also been used for facial expression recognition, have also been widely used in pattern analysis applications. For example, it has been used to study the direction distribution within the bone of porous sponge trabecular bone. Gabor space is very useful in image processing applications such as optical signature detection, iris detection, and fingerprint detection. The relationship between activations for a given spatial location varies greatly between objects in an image. Additionally, significant activations can be extracted from the Gabor field to generate a sparse object image.

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