Images Recognition Using the Fast Fourier Transformation (FFT) Algorithm

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Розпізнавання Зображень за Допомогою Fast Fourier Transformation (FFT) Алгоритму

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***Abstract* – In the field of computer vision and image processing, the search for efficient and accurate image recognition methods is constantly evolving. The Fast Fourier Transform (FFT) algorithm is a powerful tool that has found wide application in various fields, including image processing. This article explores the use of FFT in image recognition problems, elucidating its principles, methodologies, and practical implementations.**

***Анотація* – Пошуки ефективних і точних методів розпізнавання зображень постійно розвиваються у сфері комп’ютерного зору та обробки зображень. Алгоритм швидкого перетворення Фур’є (ШПФ) є потужним інструментом, який знайшов широке застосування в різних сферах, включаючи обробку зображень. У цій статті досліджується використання ШПФ у задачах розпізнавання зображень, з’ясовуються його принципи, методології та практичні реалізації.**

Keywords – Fast Fourier Transform (FFT); Discrete Fourier Transform (DFT)

Ключові слова – швидке перетворення Фур’є (ШПФ); дискретне перетворення Фур’є (ДПФ)

I. Introduction

Image recognition is an important task in the field of artificial intelligence, which has a wide range of applications such as computer vision, image processing, medical diagnosis and many more. The task of image recognition is to identify and classify objects in an image.

One of the most common image recognition methods is the use of the Fast Fourier Transform (FFT) algorithm. FFT is a fast Discrete Fourier Transform (DFT) algorithm that is used to analyze the frequency spectrum of data. The Fast Fourier Transform is used in a wide range of applications such as image analysis, filtering, reconstruction and compression.

II. FFT Algorithm Overview

In image processing, the most common way to represent pixel locations is through spatial domain. But sometimes image processing routines can be slow or inefficient in the spatial domain, requiring conversion to another domain that provides compression benefits.

Transformation from the spatial to the frequency (or Fourier) domain is common. Frequency domain is the basis of many image filters, which are used to remove noise, sharpen an image, analyze repeating patterns, or highlight features. In the frequency domain, the location of a pixel is represented by its frequencies, and its value is represented by its amplitude.

The Fast Fourier Transform is an important image processing tool that is used to decompose an image into sine and cosine components. The transform input data represents Fourier or frequency domain images, while the input image is the spatial domain equivalent. The FFT completely converts the image into the frequency domain and also retains all the original data. In a Fourier domain image, each point represents a specific frequency contained in the spatial domain image [1].

The specific result of a two-dimensional discrete Fourier transform is a matrix of complex numbers. The dimensions of this matrix are the same as the original image. The difference is that the row/column indices now correspond to frequencies rather than positions in the image. The norm of complex numbers is the amplitude of that particular repeating pattern.

When Fourier transforming an image, it is common to also shift the frequencies so that the zero frequency is in the center of the matrix and the higher frequencies are at the edges. Low frequencies represent a gradual change in the image; they contain more information because they define the overall shape or pattern in the image. High frequencies correspond to sudden changes in the image; they provide more image detail but also contain more noise. There is usually a huge difference in amplitude between the low frequencies (at the center of the image) and the high frequencies.

III. Basic principles of FFT

Discrete Fourier Transform is a mathematical operation that transforms a discrete signal from the spatial domain to the frequency domain. This allows you to visualize the distribution of signal energy at different frequencies. Fast Fourier Transform is a fast DFT calculation algorithm that significantly reduces the time required to perform the transformation.

FFT – works by splitting a signal into smaller sub-signals and recursively computing the DFT of each sub-signal. These DFTs are then combined to produce the final DFT signal [2].

IV. Applications of FFT for image recognition

FFT is used in many different areas of image recognition. Some of the examples include:

- Medical Diagnostics: Using FFT to analyze medical images such as X-rays, computed tomography (CT) or magnetic resonance imaging (MRI) to automatically detect abnormalities or pathologies.
- Security and video surveillance: Application of FFT to recognize faces, movement and other objects in video recordings to ensure security in public places, transport and industrial premises.
- Manufacturing Automation: Using FFT to detect defects in machined parts or products based on images, allowing defective items to be automatically sorted and improve production quality [3].
- Automotive: Using FFT to analyze environmental images from cameras built into vehicles to detect traffic signs, pedestrians, other vehicles, and obstacles on the road to support an autonomous driving system.

V. Algorithm results

The examples below show the original image, transformed by FFT and the image after the inverse transformation has been performed.

Fig. 1. Initial image

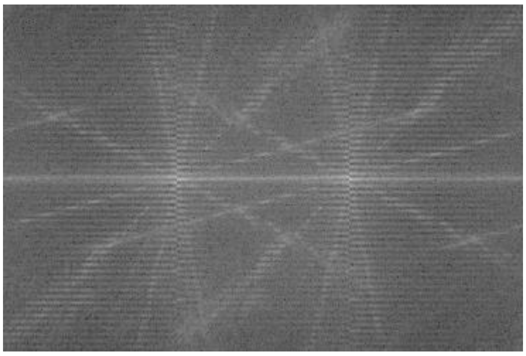

Fig. 2. Transformed image

Fig. 3. Inverse transformed image

VI. Conclusions

The Fast Fourier Transform algorithm is a powerful tool for recognizing objects in images. Using a frequency domain representation of images, FFT enables efficient object detection, noise removal, and image enhancement.

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