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# Subpixel edge extraction algorithm for images

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## Abstract

**With the development of science and technology, digital image processing and application have become more and more frequent, and gradually replaced the traditional manual caliper measurement application. In digital image processing, the edge of the image is the most basic and most important image feature, which can provide some valuable and important feature parameters, Edge detection is the basic process and the key first step of image recognition and image analysis, and the performance of edge detection will be directly related to the measurement accuracy and detection efficiency. In this paper, the image is pre-processed, and the image is grayed out, Gaussian filtered and binarized, and then the pixel-level contours of the image are extracted using the canny operator, and the sub-pixel-level edge detection algorithm based on Gaussian curve fitting is used after the contours are extracted, and the sub-pixel edges of the image contours are finally obtained.**

## Keywords

**Image processing canny operator sub-pixel edges.**

## 1. Introduction

### 1.1. Background

Detection of the edges of target objects plays an important role in image recognition and computer analysis. Edges contain a wealth of inside information - a useful feature in image recognition to extract image features. Extracting the edges of an image is a very important process in segmenting borders. Subpixels play a very important role in improving the resolution or image quality. Extracting sub-pixel edges of an image is a more accurate method than traditional pixel edge extraction. Sub-pixel means that the coordinate value of each pixel in the image is no longer an integer but a floating point number. Using sub-pixel technology to increase the resolution to 1 0.1 pixels equals a 10-fold increase in image system resolution.

### 1.2. Literature Review

The so-called edge detection, commonly used many differential operators to perform convolution operations, locate the edges. Commonly used operators are the Prewitt operator[1], the sobel operator[2], the Log operator[3], the Canny operator[4], and so on. For the study of subpixel edges, HueckdM. F.[5] The parameters are processed by fitting, so that the accuracy of edge detection reaches the sub-pixel level; D. Anatassious and K. Jensen[6-7] applied nonlinear interpolation to achieve sub-pixel-level edge positioning accuracy.

## 2. Pre-processing of image

Image pre-processing is a prerequisite for image recognition, and the effectiveness of the image pre-processing algorithm has a great impact on the subsequent image recognition and understanding. The image in the process of acquisition, due to interference such as uneven illumination and the noise of the device itself, will cause the signal-to-noise ratio of the image

to decrease, so the image should be pre-processed with grayscale conversion and denoising before further processing.

### 2.1. Image grayscale

The process of converting an image into a grayscale image and then processing it is called image grayscale processing. The grayed image still reflects the basic features of the whole image, such as chromaticity distribution, brightness level, etc. Here we use the cvtColor function in OpenCV to process the grayscale image, and the resulting image。

### 2.2. Gaussian filtering

Gaussian filtering is a linear smoothing filter suitable for eliminating Gaussian noise and is widely used in the noise reduction process of image processing. In layman's terms, Gaussian filtering is the process of weighted averaging of the entire image, where the value of each pixel point is obtained by a weighted average of its own and other pixel values in its neighborhood.

Gaussian blurring is a very typical example of image convolution. Essentially, Gaussian blurring is a convolution operation of a grayscale image I and a Gaussian kernel:

$$I_\sigma = I * G_\sigma$$

where * denotes the convolution operation; $G_\sigma$ is a two-dimensional Gaussian kernel with standard deviation $\sigma$, defined as:

$$G_\sigma = \frac{1}{2\pi\sigma} e^{-(x^2+y^2)/2\sigma^2}$$

### 2.3. Non-Local Means filtering

Non-local mean filtering takes advantage of the fact that each small block in a natural image is correlated, and it achieves image denoising by first finding similar image blocks in the whole image and then assigning different weights to the image blocks according to their similarity magnitude.

### 2.4. Image binarization

Image binarization is the process of setting the grayscale value of the pixel points on an image to 0 or 255, which means that the entire image is rendered in a distinct black and white effect. In digital image processing, binarization plays a very important role in reducing the amount of data in an image, thus highlighting the outline of the target.

## 3. Sub-pixel edge detection algorithm

Image sub-pixel edge extraction is more accurate than the traditional pixel edge extraction methods. In this paper, we propose a subpixel-level edge detection algorithm based on a combination of bilinear interpolation and Gaussian integral curve fitting.

### 3.1. Sub-pixel level edge detection algorithm based on Gaussian curve fitting

Since the fitting process has a filtering effect on noise, the positioning accuracy is relatively high. Therefore, based on this theory, this paper proposes a sub-pixel edge detection algorithm based on the combination of bilinear interpolation and Gaussian integral curve fitting. First, use the canny operator to extract pixel-level edges, perform cubic curve fitting on the extracted pixel-level edges, perform equidistant scatter on the fitted curve, and determine the normal intercept line of the fitted curve at discrete points, through bilinear The interpolation method performs gray value interpolation on the normal section line; then performs Gaussian integral curve fitting on these points; finally, determines the sub-pixel edge coordinates by calculating the average point of the Gaussian integral curve.

The ideal edge of the image is a one-dimensional ideal step edge, and the gray value of the unilateral step edge of the image can be expressed by a Gaussian function, which is expressed as follows:

$$P(u)=\frac{1}{\sqrt{2\pi}\sigma}\int_{-\infty}^{u} e^{-\frac{(t-\mu)^2}{2\sigma^2}}dt$$

In the formula, $t$ represents the distance from the discrete point on the normal section line to the pixel-level edge point, $u$ represents the distance from the pixel-level edge point to the sub-pixel-level edge point, and the Gaussian integral curve model is shown in the figure.

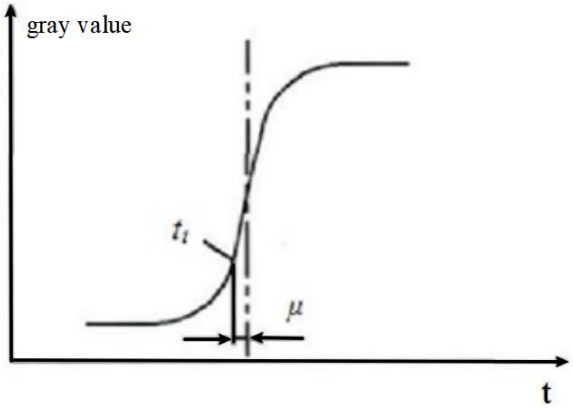


Fig1 Gauss curve fitting point

## 3.2. Sub-pixel level edge

According to the nature of the Gaussian integral curve, the point of the menu in function is the maximum point of gradient in function, which is the sub-pixel edge point of the image, so the value is the distance between the point of the sub-pixel and the point of the pixel level edge along the normal direction of the intercept, and then the coordinates of the sub-pixel edge of the image can be determined through coordinating transformation.

Subsequently, we selected a few pictures for processing, and finally we can get the subpixel edges of the image shown in the following figure, which can be seen that the extraction effect is good and more accurate.

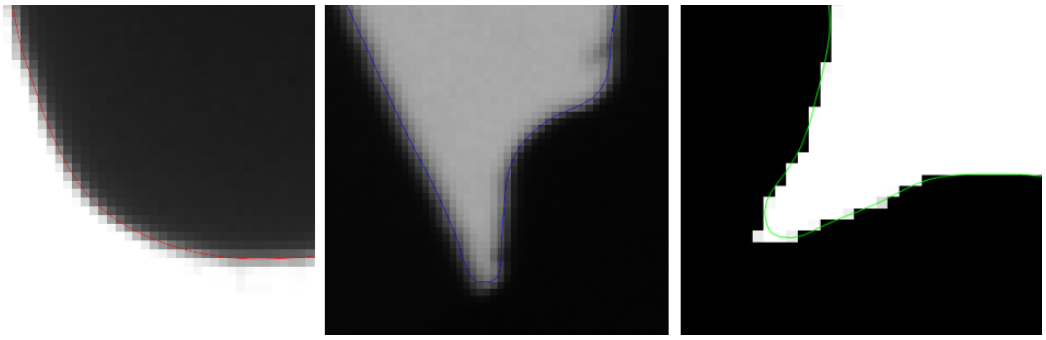

Fig2 Sub-pixel edge of the image

## 4. Conclusion

Image processing In this paper, we use a sub-pixel precision contour extraction algorithm with 1/10 pixel accuracy to extract the edges of the image, and use color graying, binarization, and Gaussian filtering to greatly eliminate the interference information of edge burrs and shadow parts. It makes the edge extraction more accurate, and the final image accuracy is more than 10

times higher than the traditional pixel-level contour extraction method. This extraction algorithm can be used in a large number of practical applications and has an important role for further image processing.

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