에지 추출 향상을 위한 Mean Shift 알고리즘의 이용

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Using Mean Shift Algorithm Enhance Edge Detection Effect

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요 약

Edge detection always influenced by noise belong to the original image, therefore need use some methods to sort this issue, mean shift algorithm has the smooth function which suit for the edge detection purpose, so adopted to fade out the unimportant information, and the sensitive noise portions. After this section, use the Canny algorithm to pick up the contour of the objects we focus on, meanwhile select the Soble operator that has the orientation attribute to support the method work well. In final, take experiment and get the perfect result we wanted, make sure this method make sense and better than the sole Edge detection algorithm.

Keyword : Edge Detection, Mean Shift Algorithm, Canny Algorithm

I. Introduction

Edge detection is a important task in image processing and model recognize domains. Hitherto there are so many methods of edge detection, such as statistic method, differential method, and curve fitting and so on.

Regular detection algorithm considers the contour is the lightness or brightness discontinuous result. Majority edge detection algorithms adopt the rectangle window data weight average in order to assume the gradient vector of discrete region.

The approach mentioned in this paper base on region density estimation, and regards the different value of density as the metrics of edge detection. Process the input image using mean shift cluster method, than use Canny algorithm with Sobel operator detect edge. Not only find out the precise edge information effectively and efficiently, but also eliminate the not important information and noise influent.

II. Mean Shift

Generally speaking, the mean shift algorithm is an iteration process finding cluster centers. Its basic idea is move a shift window on the gradient direction of the feature space, starting at a randomly selected point. The convergence point of the shift window center is a cluster center;hence its kernel that the significant features of the image represent high density regions in the features space of the image and the highest density regions correspond to cluster centers.

Suppose x is d-dimensional Euclidean metric, $\{x_i, 1 \le i \le n\}$ is the isolated identically distributed sample set, $k(x)$ is kernel function, h is radius bandwidth, then the kernel density estimator definition of x becomes the well-known expression $f(x)=\frac{1}{nh^d}\sum_{i=1}^{n}K(\frac{x-x_i}{h})$ [1], and the kernel function usually used is Epanechnikov kernel;

$$K_\varepsilon(x)=\begin{cases}(2c_d)^{-1}(d+2)(1+x^Tx) & \|x^Tx\|\le 1\\ 0 & otherwise\end{cases}$$

, and the Gaussian kernel function $K_G(x)=(2\pi)^{-d/2}\exp(-\frac{1}{2}\|x\|^2)$. After a succession of calculation, get the kernel density assumption

$$\hat{\nabla} f_{h,k}(x)=\frac{2c_{k,d}}{nh^{d+2}}[\sum_{i=1}^{n}g(\left\|\frac{x-x_i}{h}\right\|^2)]\bullet\left[\frac{\sum_{i=1}^{n}x_ig(\left\|\frac{x-x_i}{h}\right\|^2)}{\sum_{i=1}^{n}g\left\|\frac{x-x_i}{h}\right\|^2}-x\right],$$

and the vector of Mean Shift is

$$M_h(x)=\frac{\sum_{i=1}^{n}x_ig(\left\|\frac{x-x_i}{h}\right\|^2)}{\sum_{i=1}^{n}g(\left\|\frac{x-x_i}{h}\right\|^2)}-x,$$

and from it can make out the Mean Shift iteration function is

$$y_{j+1}=\frac{\sum_{i=1}^{n}x_ig(\left\|\frac{x-x_i}{h}\right\|^2)}{\sum_{i=1}^{n}g(\left\|\frac{x-x_i}{h}\right\|^2)}$$

[2].

From the above description of relationship between Mean Shift and probability density function, we make it clear that the Mean Shift algorithm is a adaptive search for peak along the rise of gradient method, illustrate in this figure, if the data set $\{x_i, i=1,\dots n\}$ obey the probability density function, given a original point, mean shift algorithm will move step by step, finally converge at the first peak.

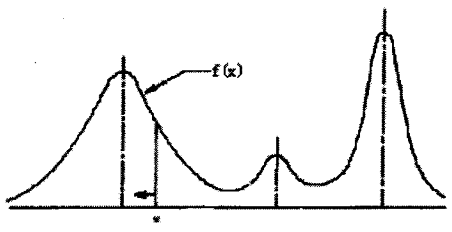

Fig.1 Gradient Method

Comparing with the other smoothing methods, such as Gaussian filter template, which take convolution according to the weighted average of the pixels and their continuity not only eliminates the noise but also salient information, but the mean shift is depending on the probability density gradient see the whole pixels from other perspective, refrain from making mistake.

This method used on image smooth aspect, define one image as p dimensional vector on two-dimensional lattice, every point of lattice stand for a pixel, $p=1$ indicate this image is a gray image, $p=3$ indicate it is chromatic image, $p>3$ indicate it is a more spectrum image, the coordinate of point in the lattice denote the space information of image. We consider all the space and color information together, combine $p+2$ dimensional vector $x=(x^s,x^r)$, where x^s denote the coordinate of point in the lattice, x^r denote the p dimensional vector features. We use kernel function K_{h_s,h_r} assume the distribution of x, K_{h_s,h_r} has the following format,

$$K_{h_s,h_r}=\frac{C}{h_s^2h_r^p}k\left(\left\|\frac{x^s}{h_s}\right\|^2\right)k\left(\left\|\frac{x^r}{h_r}\right\|^2\right)$$

, where h_s, h_r decide the smooth definition, and c is a normalized constant.

We use x_i and z_i , $i=1,2,\dots n$ indicate the original and undergone processed image respectively. The step of mean shift algorithm application is as follow:

1. Initialized $j=1$, and make $y_{i,1}=x_i$
2. Adopting mean shift algorithm to calculate $y_{i,j+1}$ till convergence. Make the result as $y_{i,c}$.
3. Evaluate $z_i=(x_i^s, y_{i,c}^r)$

According to the vector of Mean Shift, this procedure make true on computer like this:

Initialize data set;
For $j=1$ to n
Initialize $k=1$, and $y_k=x_j$.
Repeat;
Use mean shift iterative formulas calculate y_k+1
$k \leftarrow k+1$;
Until fulfill convergence condition ($y_{k+1}-y_k<\varepsilon$).
Evaluate ($x_j(1)$, ($x_j(2)$) $=y_k(3)$.

III. Edge Detection After Smooth Formality

Using mean shift method process in stead of the Gaussian filter template ahead of time, benefit at least three advantages. Firstly, remove the noise point which is not useful to depict the contour of main object or not useful detail information; secondly, tidy the edge so that make more precise outline; thirdly, get the more average light effect, meanwhile simplify the neighborhood range (because majority edge detection algorithm through calculate the neighborhood gray differential then achieve the result).

Then we should select the proper edge detection operator, in this paper we adopt Canny algorithm detect the edge, therefore should choice the operator which can supply the edge direction information, the suitable operator is Sobel operator, include the most precise edge orientation estimation.

The Sobel operator include two first derivative masks, one convolve the image along the horizontal orientation, the matrix is $\begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{bmatrix}$, the other convolve the image along the vertical orientation, the matrix is $\begin{bmatrix} -1 & 0 & -1 \\ -2 & 0 & 2 \\ -1 & 0 & -1 \end{bmatrix}$ [3], in order to find out the image gray value partial derivative (G_x, G_y), and figure out the gradient is $|G| = \sqrt{G_x^2 + G_y^2}$. Then work out the orientation of the gradient depending on the above result $\theta = Arc\tan\left(\frac{G_y}{G_x}\right)$ [4].

According to the previous result, generally separate the gradient orientation into 4 kinds (horizontal, vertical, 45 degree, 135 degree), the details of this separation is like this: divide 0~180 degree into 5 parts, 0~22.5 degree and 157.5 degree ~ 180 degree seemas horizontal orientation; 22.5 degree ~ 67.5 degree seem as 45 degree orientation; 67.5 degree ~ 112.5 degree seem as vertical orientation; 112.5 degree ~ 157.5 degree seem as 135 degree orientation. Reminded these orientations are the gradient directions, and the orthogonal directions of the edge directions, in order to find out the adjacent pixel along the special pixel's gradient direction [5].

After that is the entire image traversal, if someone pixel's gray value is not the largest among its former and later connection neighbors along the gradient orientation, equal it to 0, manifest it not the edge.

Then use accumulative histogram calculates the both thresholds. Everyone larger than the bigger threshold must be the edge; in opposition, everyone smaller than the other threshold must not belong to the edge; but if the pixel locate the crack of both thresholds, we should go further to see if one of his adjacent pixel has exceeded the bigger threshold: if someone exist, this pixel must be the edge, vice versa.

Till now, we can get the achievement. The binary image includes the precise contour of main objects.

IV. Conclusion

Taking the experiment to compare the original Canny with the improved Canny add with mean shift ahead of time, the different is obvious:

Fig 2. The result directly use Canny algorithm.

Fig 3. The result use Canny algorithm and mean shift algorithm.

The image processed by the method mention in this paper is better depict the contour of the main objects and fade out the mess outline of grass texture, and suit human vision system.

By besides, compare the time consumption, the mean shift plus Canny prolong the time nearly to double, but consider the effect enhance, it deserve indeed.

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