

Using of Canny Filter For Image Correspondence Finding

University of defense
Faculty of Military Technology

Ing. Petr Stružka
Department of AD Systems (K208)
e-mail: petr.struzka@email.cz

Ing. Miroslav Uher
Department of Communication
and Information Systems (K-209)
e-mail: uher@scova.vabo.cz

Introduction

This paper describes an application of the Canny edge detector for the image correspondence finding. The image correspondence is used as one method of the 3D reconstruction from the set of stereo images. Those images are taken from two cameras that are placed in front of the objective scene. The corresponding parts of each image are detected, and from their mutual distance and knowledge of cameras properties are counted the distance of the object. The Canny edge detector is used for speeding up the process of corresponding finding by concentrating on the significant point of each image – edges.

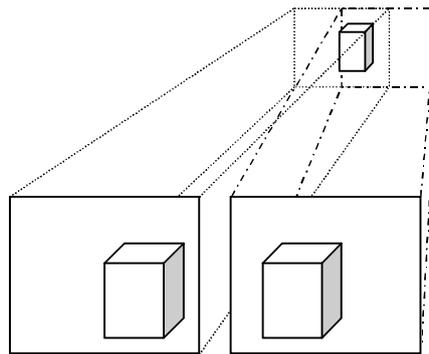


Figure 1 - Projection of an object to the stereo-camera

The correspondence finding is based on finding corresponding edges and determining their distance from the camera. The main assumption is that objects are detected by edges and they can be stored into a 3D model as shapes bordered by detected edges.

Canny edge detector

The principle of the Canny edge detector is based on a detection of one step edge, represented as a sign function of one dimension. It is also resistant against the noise (the assumed one is Gaussian noise). The approach is based on convolution of the image function with Gaussian operators and their derivatives.

Considering the Gaussian function in one dimension, this may be expressed

$$G(x) = \frac{1}{\sqrt{2\pi\sigma}} e^{-\frac{x^2}{2\sigma^2}}$$

and the first derivative is

$$G'(x) = \frac{-x}{\sqrt{2\pi\sigma^3}} e^{\frac{-x^2}{2\sigma^2}}$$

and the second derivative is

$$G''(x) = -\frac{1}{\sqrt{2\pi\sigma^3}} e^{\frac{-x^2}{2\sigma^2}} \left[1 - \frac{x^2}{\sigma^2} \right]$$

Figure 2, below, shows the corresponding functions.

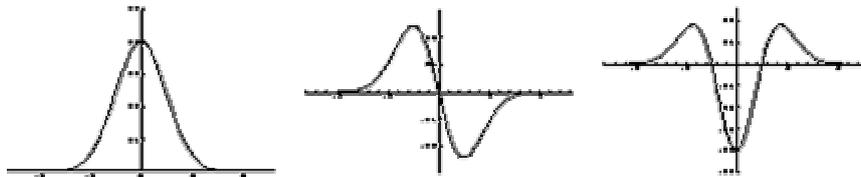


Figure 2 - The Gaussian, first and second derivatives

If we have an ideal step edge which is convolved with a Gaussian function it is resulting in a location of the edge (the first derivative shows peak, the second derivative zero crossing). Applying in two-dimensional allows edge detection in images.

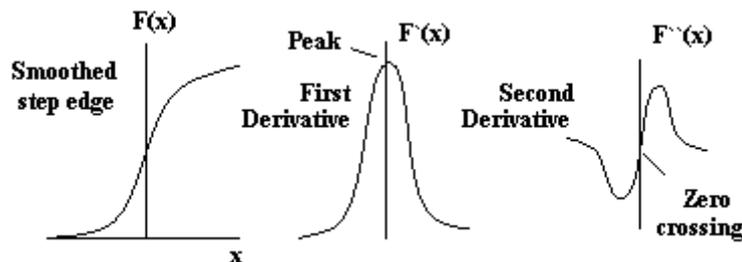


Figure 3 - Edge derivatives

The principle should be summarized in following steps:

1. Image smoothing. The Gaussian function is used in x-axis and y-axes to get the two dimensional smoothing.
2. Compute the magnitude of edge.
 - a. For each pixel the local edge normal direction n is counted
 - b. Compute non-maximal suppression - find local maxima in the direction perpendicular to the edge.
3. Thresholding. This is used to avoid multiple edge detection (streaking). Resulting on only single edge detection. Thresholding uses hysteresis method to eliminate streaking.

Finally, aggregation or feature synthesis used. The correct scale of the operator is dependant on image content. Several parameters for Gaussian deviation σ used, also a changing thresholding level can be applied. At this moment, no algorithm for finding optimal parameters is known.

Image correspondence

Images, that are retrieved from stereo-cameras contain objects seen from the different angles. From the position of the object in both images it's possible to determine the distance of object from cameras. This principle is similar like the human brain uses two eyes for observing objects and determines their distance.

Assume that a pixel in the right camera image is found in the left camera image on the different position. We suppose both cameras are fixed on the same height, so the task is simplified to finding a proper pixel horizontal position (vertical must be same). The similarity of the pixel neighborhood is used to determine its position. The proportion of differentiation can be described by the following formula:

$$D_{xy} = \sum_{i=x-1}^{x+1} \sum_{j=y-1}^{y+1} (p_{1ij} - p_{2ij})^2$$

where p_{1ij} , p_{2ij} are intensity of pixels from the image 1 and image 2.
 D_{xy} is differentiation in x, y

We count an 8-circumambience of a pixel. The expected edge correspondation is found in the distance where D_{xy} is minimal.

The algorithm of correspondence finding works that for every pixel in the image 1 is scanning line in the picture 2 and computing proportion of the differentiation D_{xy} .

$$C_i = \min(D_{xy_i})$$

where i is current pixel index while scanning the line in the picture 2

The Figure 4 shows the differentiation function D_{xy_i} while scanning images 1 and 2.

The range of i variable is from 0 to n and it's given by the camera mutual distance (the maximum shift of pixel (object) in images, when the distance of object in front of cameras is minimal)

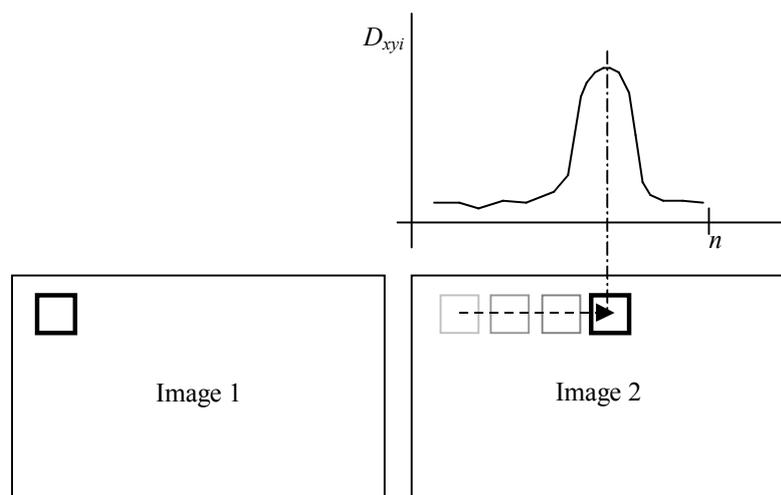


Figure 4 - Defferentiation function (approximated)

When the index is found, the pixel distance is determined and can be copied into a deep map (or into 3D raster, if proper pixel's color required). Then several vectorization algorithms can be used for the 3D vectorization.

Application of Canny filter

The Canny filter is used to obtain edges of objects in pictures. The algorithm is modified (or optimized) the following way: The scanning starts not for all pixels in the picture 1, but only for pixels, where the edge was detected (as a result of application of Canny filter). The same situation is for the picture 2. Only the 8-circumambience of the pixels where the edges are detected is taken in count. This significantly speeds up the computing of the deep map. Also only the distance of edges are resulting, which means that the deep map (or the 3D raster) will have better property for the vectorization process.

Conclusion

The Canny filter used for image correspondation leads not only in algorithm speeds up, but also in better performance of vectorization process.

The value of the differentiation D can be stored into the deep map as an additional attribute of pixel. This value figures out the rate of conformity of pixels. When iterative vectorization algorithms used (for example in image sequence), the rate of conformity of pixels could be a base for counting the indeterminacy of objects seen in scene.

References

- [1] Jiang, M.: Digital Image Processing, Peking University
<http://iria.math.pku.edu.cn/~jiangm/courses/dip/html/node93.html> (April, 2005)
- [2] Šonka, M., Hlaváč, V.: Počítačové vidění, ISBN 80-85424-67-3, Grada, 1992
- [3] Price, S.: Edges - The Canny Edge Detector, The University of Edinburgh, (July, 1996)
http://homepages.inf.ed.ac.uk/rbf/CVonline/LOCAL_COPIES/MARBLE/low/edges/canny.htm