Towards Real-time Image Segmentation Using Polynomial Functions

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Abstract. We present current development towards a real-time method for segmentation of images for robotics applications. Our algorithm follows a fast scan line procedure (rows and columns), thus breaking the 2D segmentation problem in two 1D processes. In this first phase we use polynomial functions to find possible 1D boundaries in the image columns and rows separately. In a second step, a fusion method is applied, removing redundancies and false boundaries to find the regions of interest in the segmented images. We try to improve the algorithm by using a coarse to fine multi-resolution approach. Preliminary results demonstrate possible applicability in real-time.

Segmentation Approach

We use a segmenting algorithm over multi-resolution images obtained by using a technique similar to [1]. Basically, the segmentation results from each level are used as an estimation for the next finer level. This allows to refine the boundary in regions that does not satisfy a given criterion (an error limit or threshold in the Euclidean space). The proposed segmentation technique consists of two stages (as in [2]). In the first stage the pixels of each row (and column) are processed and represented by means of a set of quadratic bivariate polynomial of the type $y = Ax^2 + Bx + C$. Figure 1 (left) illustrates the plotting of one column (say n) from the final processing level of the image in Figure 3. This process is applied first to the rows of a given image and next to the columns. Thus, the contour of the different surfaces, crease and jump edges, that define the objects contained in the image, are detected. We only consider the first and last point of each quadratic approximation (right of Figure 1). In order to speed up further processing we work with a reduced quadratic approximation (bivariate polynomial). Moreover, a fast splitting algorithm [3] has been implemented to obtain each approximating curve, instead of using the classical least squares criterion to obtain the curve that best fit to the data points.

In the second stage the points that define each quadratic approximation are fused, given rise to the sought segmented image. This stage is responsible for merging the points selected by using the aforementioned technique. Figure 2 show the result of the fusion process, applied after all levels are processed. In the current experimentations, the algorithm takes less than 5 milliseconds to process each row (our final levels are 208×188 pixel images). The multi-scale approach improves the quality of the results and also the performance of the process.

References

[1] L.M. Garcia, R. Grupen, A. Oliveira, D. Wheeler, and A. Fagg. Tracing Patterns and Attention: humanoid robot cognition. *IEEE Intelligent Systems and Applications Magazine*, July/August 2000.
[2] X. Jiang and H. Bunke, "Edge Detection in Range Images Based on Scan Line Approximation", Computer Vision and Image Understanding, 73:2, 1999, pp. 183- 199.
[3] R. Duda and P. Hart, Pattern Classification and Scene Analysis, Wiley, New York, 1972.

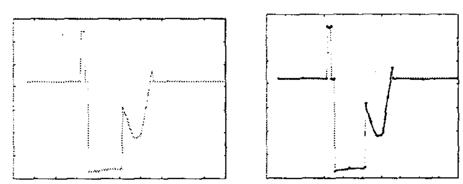

Figure 1: Process evolution.

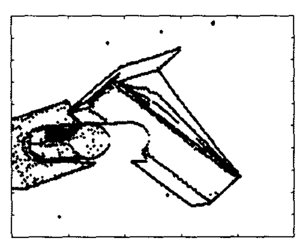

Figure 2: Final process result.

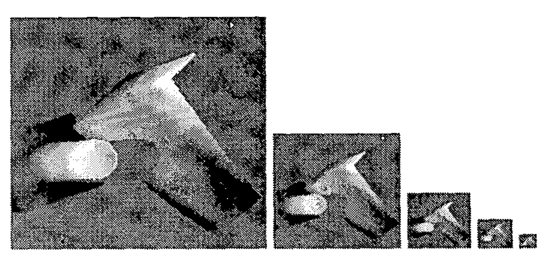

Figure 3: Multi-resolution image.