# Fine Segmentation and Its Applications

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**ABSTRACT**

We first review two algorithms which are used in finding the boundary between the object and the background in an image. One is the statistical without-edge algorithm and the other is the generalized GAC (geodesic active contours). We modify these methods to adjust to the background extraction which requires more accurate and rapid detection of the boundary. Then we develop a variational segmentation model based on statistical information of intensities in an image. The model consists of both a local region-based energy and a global region-based energy in order to handle misclassification which happens in a typical statistical variational model with an assumption that an image is a mixture of two Gaussian distributions. We find a local ambiguous region where misclassification might happen due to a small difference between two Gaussian distributions. Based on statistical information restricted to the local ambiguous region, we design a local region-based energy in order to reduce the misclassification. This model, however, has defects in the sense that it depends on the initial curve for the curve evolution equation and tends to fail to detect the weak edges. Thus by modifying the force term of the evolution equation, we make three different region competitions. Based on these region competition, we finally propose a novel method which is called the statistically reinstating method (SRM). By combining three modified region competition efficiency we get a fine segmentation to extract objects in an image without visual loss of detailed shapes, which have both weak boundaries and highly non-convex shapes. Finally we provide applications of the SRM such as 3D VR content manufacture, size estimation of aphids on a soybean leave, and segmentation of MRI image.

## INTRODUCTION

Segmentation has been widely studied in the field of image processing and computer vision. It basically separates an image into several homogeneous regions according to a criterion. In the segmentation problems to extract objects from an image to make, for examples, 3D VR (virtual reality) contents or to estimate sizes of objects, a key issue is fine segmentation which means that the objects can be extracted without visual loss of detailed shapes. Our research is motivated by making 3D VR contents of commercial products. It makes an e- catalog that customers can browse a product in three dimensional virtual space on internet markets. A common way of making a 3D VR content starts from taking hundreds of photographs of a product with different view angles in a photo studio. The most difficult step is to extract the product from a background without visual loss of detailed shapes. The images taken in the studio have well-known difficulties in segmentation problems even though they usually have simple background colors

and small amount of noises such as JPEG artifacts. These mainly come from lighting conditions in the studio and complex shapes of products. Most of lighting conditions make shadows which cause weak boundaries between dark objects and the background. More serious weak boundaries are produced by a reflection on some parts of an object due to bright lighting conditions and properties of materials of the object. It changes colors of objects into almost white which is normally used as a background color. Note that other simple colors on a background except white are not usually used because of color bleeding effect. In addition, there is another difficulty; shapes of objects can be highly non-convex.

Methods of segmentation are classified into two categories; one is the boundary-based segmentation which uses gradient information of an image to detect abrupt changes in the image and the other is the region-based segmentation which uses similarity information of an image to separate the image into several regions.

As the basic boundary-based segmentation, there are filters by Roberts, Prewitt, Sobel [1,2], and Canny [3]. These filters have a problem of irregularity of a curve which detects a boundary of an object in an image. Recently based on active contours models [4], variational formulations on deformable curves have been developed in order to handle the irregularity problem. These models consider energy functionals which consist of smoothness and attraction of a curve. The energy for attraction of the curve commonly introduces an edge-detector function which makes a curve evolution converge at a boundary of an object as a minimizer of the energy functional. More advanced methods have been suggested in geometric active contours [5], geodesic active contours [6], and gradient vector flows [7]. With the help of the level set method [8,9], these methods are able to deal with topological change which is a problem in the parametric deformable model [4]. However, there still remains a problem to capture weak boundaries changed smoothly from strong boundaries because these methods depend on edge-detector functions.

As region-based segmentations, there were thresholding, region growing [10], active contours without edges [11], and region competition [12]. While the gradient-based segmentation uses local information on a deformable curve, the region-based segmentation uses global information of an image. In other words, an energy functional of the latter is formed by statistical information such as means and standard deviations of intensities on a region inside a deformable curve and a region outside the curve. Region competition [12] has been a fundamental framework in the region-based segmentation with an assumption that a given image is a mixture of two Gaussian distributions. Many region-based segmentations using the assumption have a problem of misclassification due to a small difference between two Gaussian distributions. The misclassification easily happens when an object we want to segment has various intensities inside a boundary of the object or outside the boundary.

A combination of the boundary-based segmentation and the region-based segmentation has been also studied. Geodesic active regions [13,14] combines geodesic active contours [6] and region competition [12] in order to segment a texture in an image. Region-aided geometric snake [15] adds the region force term in the geodesic active contours [6]. The region force is obtained from any region-based segmentation such as mean shift algorithm [16].

In this talk we first review two algorithms which are used in finding the boundary between the object and the background in an image. One is the statistical without-edge algorithm and the other is the generalized GAC (geodesic active contours). These methods are based on the active and adaptive segmentation for vector valued image [17] and the region-aided geometric snake [15] which are originated to the segmentation or edge (boundary) detection in an image by minimizing the energy functional. We modify these methods to adjust to the background extraction which requires more accurate and rapid detection of the boundary.

Then we develop a variational model based on statistical information of intensities in an image. The model consists of both a global region-based energy and a local region-based energy. The former roughly captures outlines of objects which we want to segment in an image. The latter reduces misclassification which happens in a typical statistical variational model with an assumption that the image is a mixture of two Gaussian distributions. We find a local ambiguous region where the misclassification happens due to small difference between two Gaussian distributions. Using statistical information restricted to the local ambiguous region, we design the local region-based energy in order to reduce misclassification. We suggest an algorithm to avoid the difficulty of the Euler-Lagrange equations of the proposed energy functional.

This model, however, has defects in the sense that it depends on the initial curve for the curve evolution equation and tends to fail to detect the weak edges. Thus by modifying the force term of the evolution equation, we make three different region competitions. They are different in which information they use for the design of the force term in the curve evolution equation. Based on these region competition, we finally propose a novel method which is called the statistically reinstating method (SRM). Furthermore the method adopts the multi-resolution idea to reduce the computational cost. By combining three modified region competition efficiency we get a fine segmentation to extract objects in an image without visual loss of detailed shapes, which have both weak boundaries and highly non-convex shapes. Finally we provide applications of the SRM such as 3D VR content manufacture, size estimation of aphids on a soybean leave, and segmentation of MRI image.

## REFERENCES


1. Gonzalez, R. C. and Woods, R. E., *Digital Image Processing*, Prentice- Hall, New Jersey, 2002.
2. Jain, A. K., *Fundamentals of Digitial Image Processing*, Prentice-Hall, New Jersey, 2003.
3. Canny, J., "A computational approach to edge detection", *IEEE Trans. Pattern Anal. Machine Intell.*, Vol. 8, 1986, pp. 679-698.
4. Kass, M., Witkin, A. and Terzopoulos, D., "Snakes: Active contour models", *Int. J. Comput. Vis.*, Vol. 1, 1988, pp. 321-331.
5. Caselles, V., Catte, F., Coll, T. and Dibos, F., "A geometric model for active contours in image processing", *Numer. Math.*, Vol. 66, 1993, pp. 1-31.
6. Caselles, V., Kimmel, R. and Sapiro, G., "Geodesic active contours", *Int. J. Comput. Vis.*, Vol. 22, 1997, pp. 61-79.
7. Xu, C., Yezzi, A. and Prince, J. L., "On the relationship between parametric and geometric active contours", *Proc. of 34th Asilomar Conference on Signals, Systems, and Computers*, Vol. 1, pp. 483-469, 2000,
8. Osher, S. J. and Sethian, J. A., "Fronts propagating with curvature dependent speed: Algorithms based on Hamilton-Jacobi formulations", *J. Comput. Phys.*, Vol. 79, 1988, pp. 12-49.
9. Sethian, J. A., *Level Set Methods*, Cambridge University Press, New York, 1996.
10. Adams, R. and Bischof, L., "Seeded region growing", *IEEE Trans. Pattern Anal. Machine Intell.*, Vol. 16, 1994, pp. 641-647.
11. Chan, T. and Vese, L., "Active contours without edges", *IEEE Trans. Image Processing*, Vol. 10, 2001, pp. 266-277.

12. Zhu, S. C. and Yuille, A. “Region competition: unifying snakes, regions growing, and Bayes/MDL for mutiband image segmentation”. *IEEE Trans. Pattern Anal. Machine Intell.*, Vol. 18, 1996, pp. 884-900.
13. Paragios, N. and Deriche, R., “Geodesic active regions and level set methods for supervised texture segmentation”, *Int. J. Comput. Vis.*, Vol. 46, 2002, pp. 223-247.
14. Paragios, N. and Deriche, R., “Geodesic active regions: A new framework to deal with frame partition problems in computer vision”, *J. Vis. Commun. and Image Represent.*, Vol. 13, 2002, pp. 249-268.
15. Xie, X. and Mirmehdi, M., “RAGS: Region-aided geometric snake”, *IEEE Trans. Image Processing*, Vol. 13, 2004, pp. 640-652.
16. Comaniciu, D. and Meer, P., “Mean shift: A robust approach toward feature space analysis”, *IEEE Trans. Pattern Anal. Machine Intell.*, Vol. 24, 2002, pp. 603-619.
17. Rousson, M. and Deriche, R., “A variational framework for active and adaptive segmentation for vector valued image”, *Research Report*, N. 4515, INRIA, July 2002.