592 Project Proposal
Efficient Graph Based Segmentation

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1 Efficient Graph Based Segmentation

Efficient Graph Based Segmentation was published in 2004 in the International Journal of Computer Vision. It approaches the problem of image segmentation by approaching an image as a graph, and attempts to optimally segment the graph by using a pairwise region comparison predicate, defined in this paper.

Felzenszwalb and Huttenlocher consider two forms of graphs that an image can be transformed into, one based only on pixel location and one that takes the color of a pixel into account. In the first approach, each pixel is considered a node, and an edge is added between a pixel and its eight neighbors. In the second approach, the pixels are projected into a feature space, where each pixel's features are defined to be its (x, y) location in the image and its RGB values. Each pixel is then connected to its n nearest neighbors in the feature space. This second approach allows an image to have non-contiguous segments. In both graph types, the edges between each node are weighted to reflect the dissimilarity of the pixels being connected.

Two metrics are introduced to aid segmentation of these graphs, the *internal difference* ($Int(C)$) and *difference between* ($Diff(C_1, C_2)$). The $Int(C)$ of a component C is the largest weight in the minimum spanning tree of the component. The $Diff(C_1, C_2)$ between two components C_1 and C_2 is the minimum weight of an edge connecting the two components, or ∞ if they are not connected. Evidence of a boundary is shown by considering the relative difference between $Diff(C_1, C_2)$ and $max(Int(C_1), Int(C_2))$, where a large difference is indicative of an edge.

These two metrics are used to define the concepts of segmentations that are *too fine* or *too coarse*. A segmentation that is too fine is one in which there is no evidence for a boundary between any two segments, and a segmentation that is too coarse is one that can be refined to a segmentation that is not too fine. These definitions create the existence of an optimally segmented image which is neither too coarse nor too fine. The segmentation algorithm in this paper uses this definition as well as the pairwise comparison technique to optimally segment an image, based on the author's definition of optimal [1].

The algorithm developed in this paper is tested using the COIL database [3] and a datast of synthetic images, and example resulting segmentations are shown in the paper. The algorithm is not tested against any other algorithm, and the resulting segmentations are not compared against human-segmented images.

2 Research Hypothesis

This research will seek to show that adaptively adjusting the segmentation criteria based on the degree of variability in neighboring regions of the image improves the segmentation over other graph-based segmentation techniques, where improving the segmentation means that it is closer in quality to a hand-segmented image.

This is similar to the hypothesis put forth by the paper, with the addition of a comparison test and numerical evaluation. The lack of empirical tests left the article's hypothesis untested. I propose introducing a third data set, the Berkeley Segmentation Dataset and Benchmark, which contains 500 images that have each been hand-segmented by several people [2]. The images from this dataset can be used to evaluate the segmentations produced by this algorithm and will allow for comparison with other segmentation algorithms that also use this data set.

3 Research Plan

In order to test this hypothesis it will be necessary to replicate not only the algorithm proposed in this paper, but also segmentation algorithms that do not use variability in neighboring regions as segmentation criteria. I intend to implement a similar algorithm that instead uses a constant threshold for inter-region and intra-region variability for segmentation. Additionally, I hope to locate the results of other algorithms to compare.

Although image segmentation is a widely studied problem, it is not uncommon for new algorithms to be put forth without an empirical evaluation. Even when an empirical evaluation is performed there is no standard technique used. There have been many evaluation techniques proposed, and I will select from these to evaluate the algortithm proposed by [1]. For example, several metrics for segmentation evaluation have been proposed that measure the "goodness" of a segmentation based on the intra-region uniformity, the inter-region contrast, the number of mis-segmented pixels, the location of the mis-segmented pixels, and the shape and number of the segmented regions [4]. The first two techniques evaluate a segmentation without the use of ground truth data while the others require it.

Segmentation is a hard problem even for humans. A quick glance at the segmented images from the Berkeley dataset reveals that different people segment the same image in differently. Although the overall segmentation is similar, the detail varies greatly. As a result, it is necessary to evaluate the variability in human-segmented images in order to determine whether the computer segmented image is on par.

Timeline:	
Date	Goal
Feb. 10	Obtain necessary datasets
Feb. 17	Implement pairwise region comparison predicate
Feb. 24	Implement both types of graphs
March 2	Implement segmentation algorithms for comparison
March 9	Implement segmentation evaluation techniques
March 23	Finish testing on all data sets, consider extentions
April 11	Finish presentation and paper

References

[1] P.F. Felzenszwalb and D.P. Huttenlocher. Efficient graph-based image segmentation. *International Journal of Computer Vision*, 59(2):167–181, 2004.

[2] D. Martin, C. Fowlkes, D. Tal, and J. Malik. A database of human segmented natural images and its application to evaluating segmentation algorithms and measuring ecological statistics. In *Proc. 8th Int'l Conf. Computer Vision*, volume 2, pages 416–423, July 2001.

[3] S.A. Nene, S.K. Nayar, and H. Murase. Columbia object image library (coil-20). *Dept. Comput. Sci., Columbia Univ., New York.[Online] http://www. cs. columbia. edu/CAVE/coil-20. html*, 1996.

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