Berkeley Segmentation Dataset and Benchmark - Lab 7 - Computer Vision

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1. Introduction

To obtain a quantitative evaluation method in applications with segmentation, the University of California created a database (BSDS500) that contained images of different natural scenes, where each image had annotations of different segmentations made by humans [1].

The objective of this laboratory is to use the BSDS500 to evaluate the two best segmentation methods performed by us, and compare them with the evaluation results of the UCM method [2]. Different functions in Matlab that approximate the fast version of the original BSDS Benchmark code will be used to obtain the recall-precision evaluation curves.

2. Materials and Methods

2.1. Segmentation Methods

The segmentation methods selected were the k-means method (RGB space and Lab-XY space) and the watershed method in the RGB Space. This selection was made because the level of segmentation for a given hyperparameter was much better with respect to the other methods.

For the segmentation with the k-mean, the hyparameter to be established is the number of clusters (k). In the case of the watershed method it is necessary to establish the number of markers.

To choose the number of clusters in the k-mean method and the number of markers in the watershed method, one must perform trial and error tests, taking a specific range for each hyperperameter, and executing the method for each value of the hyperparameter.

2.2. Test methodologies

The BSDS is a database that contains 500 images of natural scenes with different annotations made by humans. The images in JPG format are divided into three groups: training, evaluation and testing (200 training images, 200 evaluation images and 100 test images). The size of each image is 381x481 pixels. Groundtruth are the respective annotations (segmentations made by humans) that are available for each image in the database.

If the coverage that has the method is plotted with respect to precision for each hyperparameter value, a curve called ”precision-recall curve” is obtained, and it allows us to know how the evaluated method behaves in a more generalized manner. This form of evaluation is widely used in a standardized way to make comparisons with other different methods using the benchmark database.

The Benchmark code allows to obtain the precision-recall curves, by means of a set of matrices that represent the segmentations of the images for certain values of a hyperparameter.

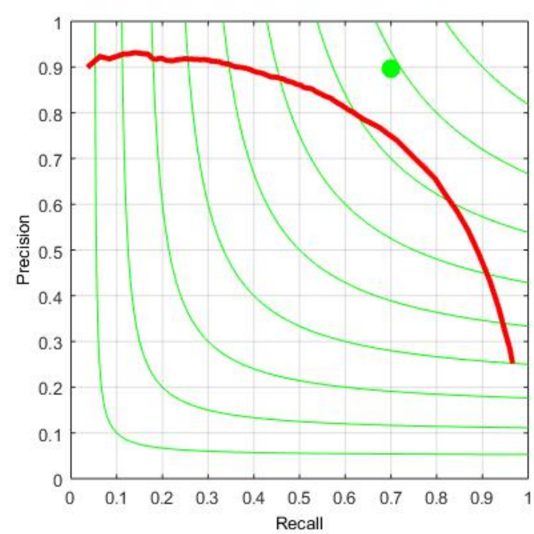

Figure 1. UCM

3. Results

The recall-precision curves for the watershed and kmean methods are shown in figures 2,3,4,5 y 6. The curves were calculated for the set of validation and test images. If we compare the validation set with the test set for each method, it can be deduced that the curves do not have any significant change.

When comparing the curves between the two methods, it is observed that the method of watershed is a little more precise than the kmeans, but the kmeans has a much higher recall. The curves of the methods evaluated are not very generalized; this occurs because of the following: For the Kmeans method, the number of clusters used was only 5 (k = 3, k = 6, k = 9, k = 12 and k = 15). For the curve to have a higher range of recall vs precision, the sweep of the clusters must be much greater.For the watershed method, the number of markers used was 5 (h = 90, h = 95, h = 100, h = 105 and h = 110), a case similar to of the Kmeans method.

If we compare the segmentation methods performed with respect to the UCM method (see figure 1), we can conclude that the UCM method has a much greater recall. In addition, the performance found is far above that of the kmeans and watershed methods. Figure 7 shows all the segmentation methods in the training stage. In the recall-precision curve for the kmeans method, the change of color space from RGB to LAB-XY does not matter much.

With the evaluation of the methods it can not be confirmed that the best segmentation method is still watershed, in the range of selected hyperparameters. This is because the method of kmeans has better recall (of almost 1), although the watershed does have better accuracy.

A possible option to improve the algorithms developed for the segmentation, could be using different types of representations of the image (Not only in spaces of color, but also take into account their shape and texture).Then, apply the clusters or markers to the combination of representations made.

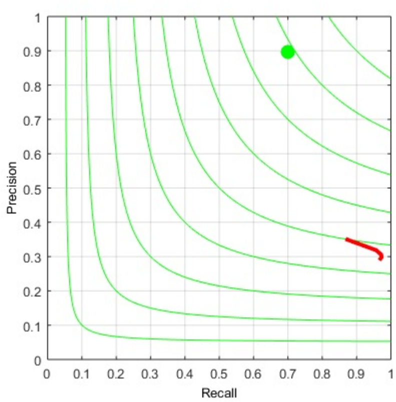

Figure 2. Val set Kmeans-RGB 3:3:15 Clusters

4. Conclusions

The methods of watershed and kmeans, have an average performance (watershed = 0.38 and kmeans = 0.35), so comparing it with the BSDS database are not good methods for image segmentation, taking into account only the range of hyperparameters used.

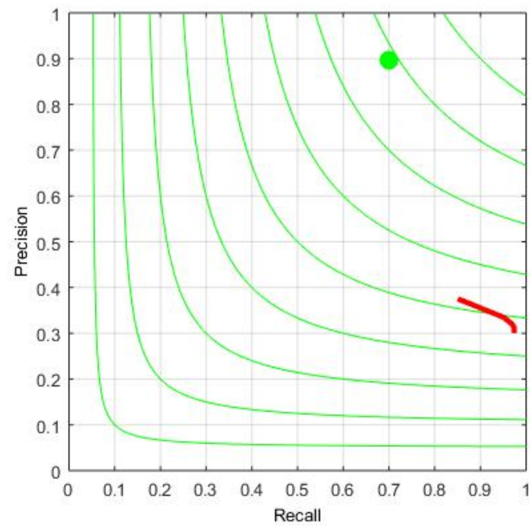

Figure 3. Test set Kmeans-RGB 3:3:15 Clusters

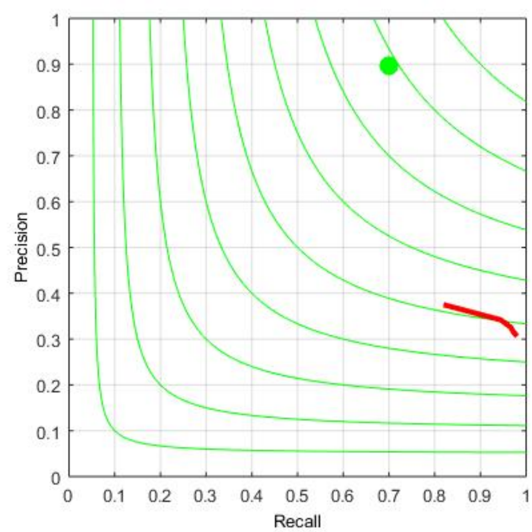

Figure 4. Test set Kmeans-LAB+XY 3:3:15 Clusters

The BSDS database allows us to evaluate different methods of segmentation in a more generalized way, allowing at the same time to compare them with segmentation methods.

The high performance of the UCM segmentation method is verified, by comparing the best methods developed in the previous laboratory.

There is no significant difference between the recall-precision curves in the evaluation and test stages for each method.

The segmentation error of the evaluated methods depends strictly on the defined hyperparameters. In order to observe the minimum error it would be necessary to use a very wide range of hyperparameters.

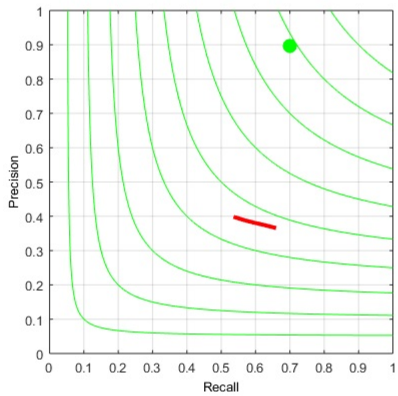

Figure 5. Val set WatershedsRGB 90:5:110 h

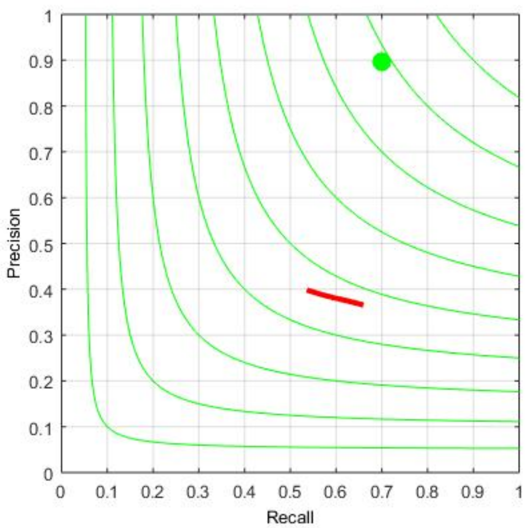

Figure 6. Train set WatershedsRGB 90:5:110 h

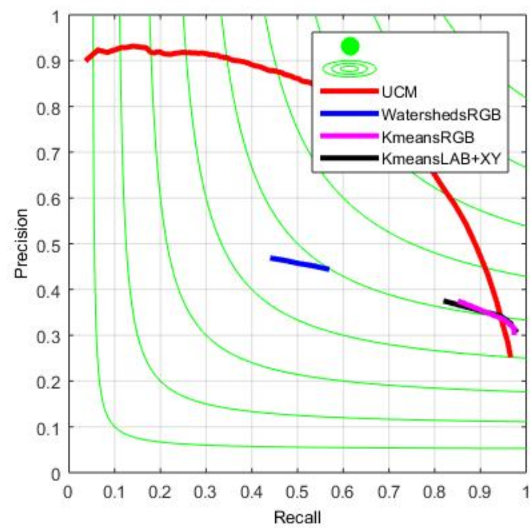

Figure 7. Train set ALL

References

[1] David Martin, Charless Fowlkes, Doron Tal, Jitendra Malik, "A Database of Human Segmented Images and its Applications to Evaluating Segmentation Algorithms and Measuring Ecological Statistics", University of California, 2001.

[2] Pablo Arbelaez, "Boundary Extraction in Natural Images Using Ultrametric Contour Maps",Worshop on Perceptual Organization in Computer Vision, 2006.