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[Programming Assignment] (4)

Computer Vision

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Coding Standard and General Requirements

Code for all programming assignments should be **well documented**. A working program with no comments will receive **only partial credit**. Documentation entails writing a description of each function/method, class/structure, as well as comments throughout the code to explain the program flow. Programming language for the assignment is **Python**. You can use standard python built-in IDLE, or CANOPY for the working environment. Other commonly used IDLEs are the following: PyCharm Community Edition, PyScripter, CodeSculptor, Eric Python, Eclipse plus PyDev.

Following libraries will be used extensively throughout the course:

- PIL (The Python Imaging Library), Matplotlib, NumPy, SciPy, LibSVM, OpenCV, VLFeat, python-graph.

If you use CANOPY, make sure that you use version 2.7, which already includes many libraries. If you are asked to implement "Gaussian Filtering", you are not allowed to use a Gaussian function from a known library, you need to implement it from scratch.

Submit by **22nd of October 2015**, 11.59pm.

Segmentation via K-means Clustering [6 pts]

K-means algorithm is an unsupervised clustering algorithm that classifies the input data points into multiple classes based on their inherent distance from each other. The algorithm assumes that the data features form a vector space and tries to find natural clustering in them. The points are clustered around centroids μ_i for $i = 1, ...k$, which are obtained by minimizing the objective

$$V = \sum_{i=1}^{k} \sum_{x_j \in S_i} (x_j - \mu_i)^2 \tag{0.1}$$

where there are k clusters S_i for $i = 1, ..., k$ and μ_i is the centroid or mean point of all points $x_j \in S_i$.

[3 pts] Implement conventional k-means clustering algorithm for gray-scale image segmentation. Please use the attached image (input1.jpg) with appropriate input k (either manual or automatically found). Sample output segmentation file (out1.jpg) is available for you to calculate/evaluate accuracy of your segmentation. Please use TP rate, FP rate, and F-score for your evaluations which you implemented in PA#1.

[3 pts] Implement k-means clustering algorithm for color images. Please use the attached color image (input2.jpg), and let your algorithm to find parameter k automatically (Hint: look at histogram to estimate k). Sample output segmentation file (out2.jpg) is available for you to calculate/evaluate accuracy of your segmentation. Please use TP

rate, FP rate, and F-score for your evaluations you simply implemented in PA#1.

Data: Input image
Result: Output image segmented via k-means
Choose target number k of clusters (either manually or automatically);
Initialize the centroids with k random intensities;
for all other data points **do**
  Cluster the points based on distance of their intensities from the centroid intensities;
end
for all data points **do**
  Compute the new centroid for each of the clusters;
end

Algorithm 1: Pseudo-Code for k-means

Region Growing Segmentation [4 pts]

Implement region growing algorithm for gray-scale images where absolute intensity differences should be used for region definition. Your algorithm must accept one seed input from users via clicking a point in the image and immediately returns the segmentation results. Implement either 4- or 8-connectivity of pixels to do segmentation. Use the image "input1.jpg" (attached) along with its ground truth "out1.jpg", and report TP rate, FP rate, and F-score.

Gaussian Mean-Shift Clustering [Bonus: 5 pts]

Implement mean-shift clustering algorithm for the segmentation of the following RGB image: "input3.jpg". Set the parameters (h_s: spatial resolution, h_r: range resolution) according to the properties of the attached image. Briefly mention optimality of why and how you decide those parameters along with the output. There is no ground truth available for this image as this question is intended to be a blind-competitions among attendants. Best segmentation method will be decided and announced based TP rate, FP rate, and F-score (use isotropic Gaussian kernel). In the pseudo-code, $p(n|x)$ is posterior probability, and x's update means difference of x's values between consecutive iterations.

Data: Input image with N data points (pixels)
Result: Output image segmented via Gaussian mean shift
for $n \in \{1, ..., N\}$ **do**
  $x \leftarrow x_n$;
  while Update of x's > tolerance **do**
    $\forall n : p(n|x) \leftarrow \frac{exp(-0.5.\|(x-x_n)/\sigma^2\|^2)}{\sum_{m=1}^{N} exp(-0.5.\|(x-x_m)/\sigma^2\|^2)}$;
    $x \leftarrow \sum_{n=1}^{N} p(n|x)x_n$;
  end
  $z_n \leftarrow x$;
end
Use connected component in $z_n$to identify clusters (built-in function);

Algorithm 2: Pseudo-Code for Gaussian Mean Shift Clustering