Image Segmentation

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Abstract

Segmentation is a classical machine learning problem, with image segmentation presenting a plethora of applications. With this in mind, this work presents 4 different segmentation methods to analyze and produce segmentation data for a randomly selected subset of the BSDS500 Segmentation database.

Keywords: segmentation, unsupervised learning, superpixel

1. Introduction

Image segmentation refers to the separation of discrete objects portrayed in a digital image, with the ultimate goal of labelling pixels or groups of pixels according to the object they belong to. This problem can be approached using a supervised or an unsupervised approach, with this work focusing on unsupervised techniques, namely pixel clustering.

Four methodologies were implemented: K-Means, Gaussian Mixture Model (GMM), hierarchical segmentation and Watershed segmentation. They are briefly described in the following section.

2. Materials and methods

2.1. Segmentation algorithms

K -means clustering is an unsupervised algorithm that relies on the iterative refinement of cluster centroids according to the least euclidean distance between the centroid and the points assigned to that cluster.

The Gaussian Mixture Model addresses some flaws present in K-Means. Whereas K-Means works best with ”circularly shaped” data, GMM uses Gaussian Means instead of Euclidean distances, describing each cluster by its centroid, covariance and the size. In essence, instead of a distance to a centroid, each point is assigned a probability of being related to a centroid.

Hierarchical clustering consists on the construction of a hierarchy of clusters. It can be top-down (divisive) or bottom-up (agglomerative) as is the case in this work. Hierarchical clustering carries a significant memory overhead, limiting it's usability.

2.2. Preprocessing and Parameter Tuning

For all algorithms except hierarchical clustering images were considered using all available channels and original resolution. The hierarchical demands an excessive amount of memory, requiring the images to be downscaled by a factor of 5 and then be upscaled to the original dimensions in order to be evaluated.

When applicable, x and y channels were normalized to a 0-255 range, in order to guarantee they have a weight approximately similar to that of the color channels.

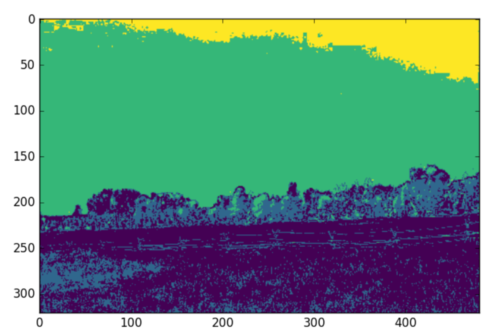

Figure 1. Example solution

2.3. Evaluation

Evaluation was performed using sklearn's adjusted Rand index because it doesn't take into account the absolute value of the labels but rather the similarity between assignments.

Perfect assignment corresponds to an adjusted Rand index of 1.0, with poor assignments resulting in negative or close to zero values. Results obtained using the methodology previously proposed result in values ranging from 0.13 for K-Means to 0.35 for hierarchical clustering when compared to the provided ground truths.

The relatively lukewarm performance obtained indicates that unsupervised segmentation might not be enough to solve this problem and supervised learning techniques might improve the accuracy of segmentation for the provided dataset.

3. Conclusions

A function was developed to perform clustering tasks using multiple methodologies. Results were evaluated and found to be at least superior to random cluster label assignment.

References