

COMP9517

Lab 6, S1 2018

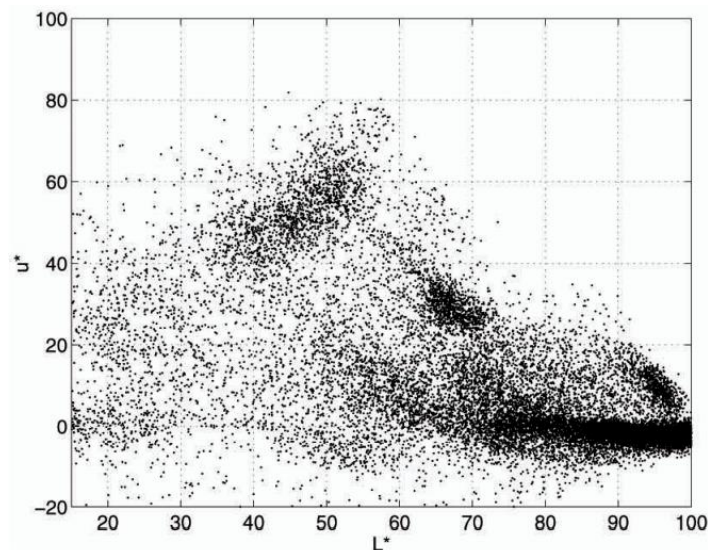
MeanShift (Fukunaga and Hoestetler, 1975) is a well-known algorithm that has been widely used in computer vision and machine learning. When seen as a clustering algorithm it belongs to the expectation-maximisation family of algorithms which includes k-means and Gaussian mixtures models. Meanshift is a mode finding algorithm.

The MeanShift algorithm works as follows:

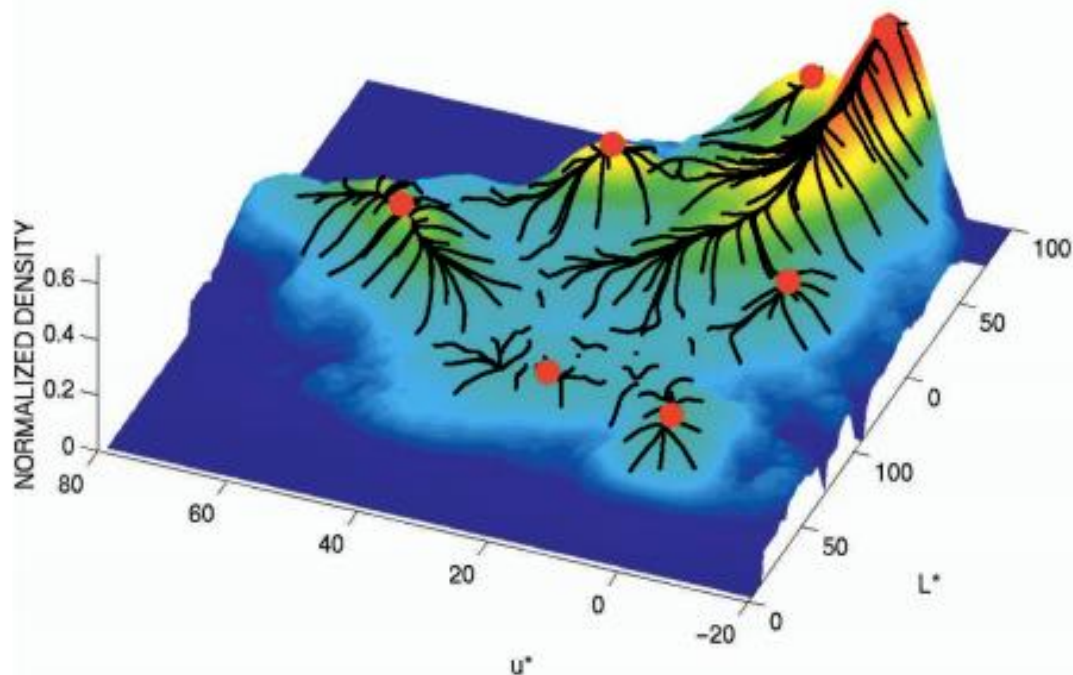
For each data point x :

1. Fix a window around each data point x .
2. Compute a smoothed mean of the data within the window.
3. Shift the window to the mean and go to 1 until convergence.

It can be shown that every data point converges to a stationary point. Geometrically, consider the graph of set of pixels of an image represented in the L^*u^*v colour space. (The L^*u^*v colour space plots luminosity vs green-to-red vs blue-to-yellow).



This set of points has a particular probability distribution, the insight of the MeanShift algorithm is that you can use a smoothing function to locally compute the probability distribution in the window. This smoothing function is called a kernel which is an unfortunate name as these functions are not the same as the kernels considered in our study of convolutions. Using these smoothing functions, we can obtain a smooth probability density function for these set of points which is pictured in the following graph:



The points in red are stationary points. All the data points in the picture move to stationary points, and some of the paths which they follow are highlighted in black. Points which converge to the same stationary point are assigned to the same cluster.

In this tutorial we apply MeanShift and K-Means to the problem of unsupervised image segmentation in computer vision. Image segmentation is one of several common image understanding tasks in computer vision.

Scene classification



Is this a park, a restaurant, or a museum?

Object classification



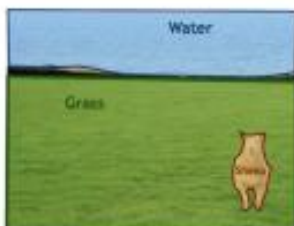
Are there any chairs? Any cats?

Object detection



Where are the objects?

Image segmentation



What is shown in every pixel?

Object parts



Where is the left shoulder? The right foot?

Attributes



Is this scene an open area?



Which shoe is more ornamented?

Image segmentation can be thought of as labelling pixels in an image. It is a large area of research in computer vision, and it comes in many different flavours: interactive segmentation, semantic segmentation, instance segmentation and many more. An important distinction is between segmentation algorithms which require training with labelled data and those that don't. In this tutorial, we will adapt the k-means and MeanShift clustering algorithms to the problem of unsupervised image segmentation.

QUESTIONS

It may be helpful to consult the scikit image documentation for the answers to some of these questions.

Q1. (ASSESSABLE) Adapt the sample code to cluster the 5 sample texture images with both k-Means and MeanShift.

Q2. Explain a difference between k-means and MeanShift.

Q3. What kind of kernel does the MeanShift implementation in scikit-learn use?

Q4. What is the complexity of MeanShift? What is the complexity of k-means?

REFERENCES:

Fukunaga, Keinosuke, and Larry Hostetler. "The estimation of the gradient of a density function, with applications in pattern recognition." IEEE Transactions on information theory 21.1 (1975): 32-40.

Comaniciu, Dorin, and Peter Meer. "Mean shift: A robust approach toward feature space analysis." IEEE Transactions on pattern analysis and machine intelligence 24.5 (2002): 603-619.

Kovashka, Adriana, et al. "Crowdsourcing in computer vision." Foundations and Trends® in Computer Graphics and Vision 10.3 (2016): 177-243.

<https://saravananthirumuruganathan.wordpress.com/2010/04/01/introduction-to-mean-shift-algorithm/>