# CS 6601: Assignment 5

Due Nov 20th, 2016 by 11:59PM UTC-12 (Anywhere on Earth)

**Abstract:**
You will implement and evaluate several algorithms, including the Gaussian mixture model, to perform basic image segmentation.

**Motivation:**
Expectation Maximization is an important Machine Learning algorithm. Here, we try to provide a practical application wrt image compression, with an aim to give you a deeper understanding of the mechanics behind it.

**Evaluation:**
This time we are providing the tests with the notebook so Bonnie is only for submission purposes. The tests on Bonnie will be similar to the ones provided to you, but the images being tested against and the values for calculations will be different.
You will be allowed only **5 submissions** on Bonnie. So make sure you test everything before submitting. Score for the last submission counts. The code will be allowed to run for not more than 2 hours per submission. In order for the code to run quickly, make sure to vectorize the code. Refer to notes on this in the notebook provided.

## 1. The Challenge

Automatic image processing is a key component to many AI systems including facial recognition and video compression. One basic method for processing is segmentation, by which we divide an image into a fixed number of components to simplify its representation. For example, we can train a mixture of Gaussians to represent an image and segment according to the simplified representation, as seen in Figure 1 with the original on the left and the segmented version on the right, which can be represented by 3 Gaussian distributions.


Figure 1: Original image (left) and segmented (right, 3 components)

## 2. Your Assignment

Your assignment is to implement several methods of image segmentation, with increasing complexity.

1. Implement k-means clustering to segment a color image.
2. Build a Gaussian mixture model to be trained with expectation-maximization.
3. Experiment with varying the details of the Gaussian mixture model's implementation.
4. Implement and test a new metric called the Bayesian information criterion, which guarantees a more robust image segmentation.

We have provided *mixture_model_notebook.ipynb* with detailed instructions to complete each part. Copy the methods and tests over to *mixture_model.py* as you go on working. You will complete and submit *mixture_model.py*, following the instructions from the notebook. We have provided the tests that you will need.

We will provide the following additional files:

| File | Description |
|---|---|
| doge_color.png | color image to test k-means clustering |
| k2 - k6_doge_color.png | pre-segmented images for comparison |
| party_spock.png | grayscale image to test your Gaussian mixture models |
| em.pdf | explanation of k-means, mixture models and expectation maximization |

## 3. Grading

The grade you receive for the assignment will be determined as follows:

| | |
|---|---|
| 20 points | k-Means Clustering |
| 40 points | Gaussian Mixture Model |
| 20 points | Model Performance Improvements |
| 20 points | Bayesian Information Criterion |

## 4. Due date

The assignment is due **November 20th, 2016 by 11:59PM, UTC-12** (Anywhere on Earth time) on T-Square [How to change your T-Square time zone].
The deliverable for the assignment is:

- A completed *mixture_models.py* file.

## 5. Resources

- The attached chapter (*em.pdf*) gives a good explanation of implementing and training mixture models, particularly 424-427 (k-means) and 435-439 (mixture models and EM).
- The book "Elements of Statistical Learning", pages 291-295 (in the ebook version from the link provided).