Problem 1 r06946003

$K(\underline{x}, \underline{x}') = (\underline{x}^T, \underline{x}')^2 = \underline{\Phi}(\underline{x})^T \underline{\Phi}(\underline{x}')$

given $\underline{x} = [x_1, x_2]^T$

let $\underline{x}' = [x_1', x_2']^T$

$K(\underline{x}, \underline{x}') = (\underline{x}^T, \underline{x}')^2 = \left([x_1, x_2] \begin{bmatrix} x_1' \\ x_2' \end{bmatrix} \right)^2$

$= (x_1 x_1' + x_2 x_2')^2$

$= (x_1 x_1')^2 + 2(x_1 x_1')(x_2 x_2') + (x_2 x_2')^2$

$= \underline{\Phi}(\underline{x})^T \underline{\Phi}(\underline{x}')$

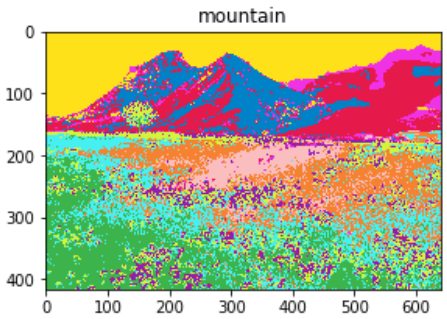
$= [\, x_1^2, \sqrt{2} x_1 x_2, x_2^2 \,] \begin{bmatrix} (x_1')^2 \\ \sqrt{2} x_1' x_2' \\ (x_2')^2 \end{bmatrix}$

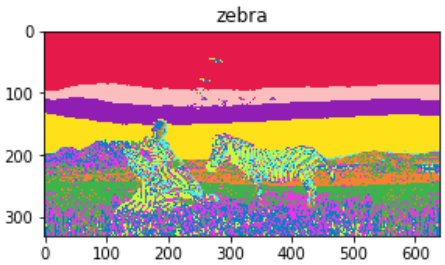
So, $\underline{\Phi}(\underline{x}) = [\, x_1^2, \sqrt{2} x_1 x_2, x_2^2 \,]^T \in \mathbb{R}^3$

Problem 2

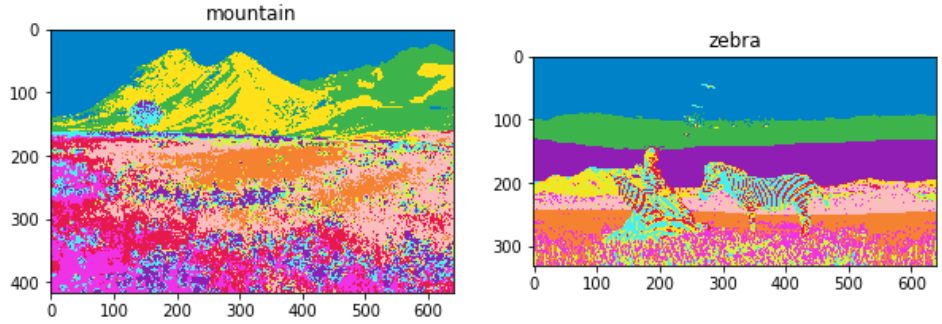
(a)

i. Plot the segmentation results for both images based on your clustering results



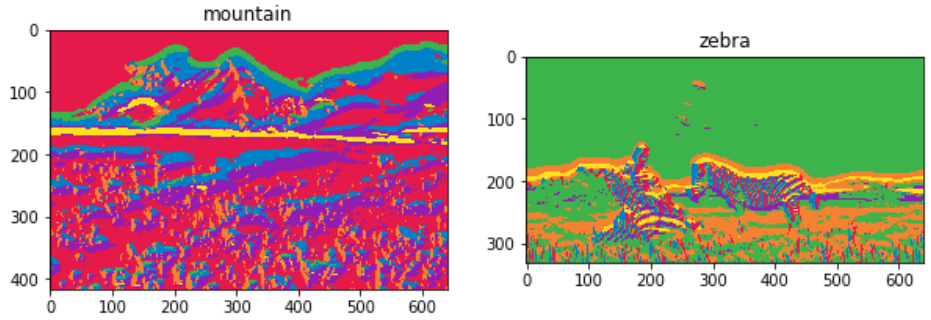


ii. Lab color space

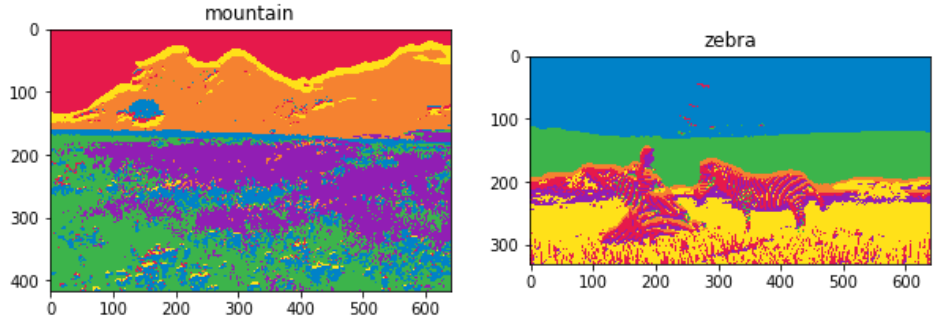


(b)

i. Plot the texture segmentation results for both images

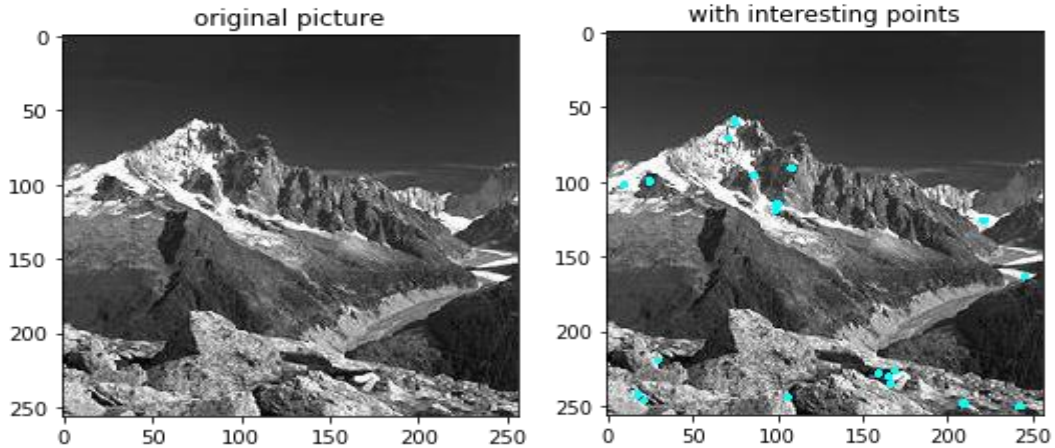


ii. Combine both color and texture features (3 + 38 = 41-dimensional features) for image segmentation

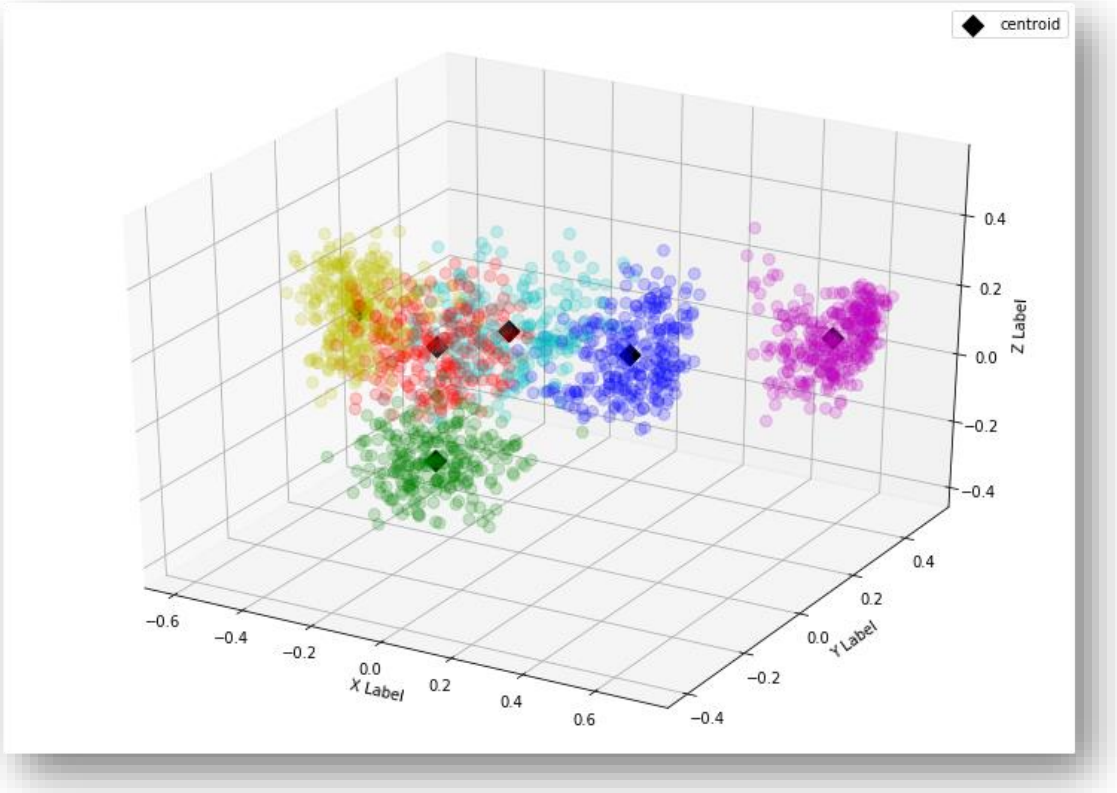


Problem 3

(a) Plot your interest point detection results



(b) Plot the visual words and the associated interest points in this PCA subspace



Each cluster is represented by different color and the diamonds among them denotes centroid (visual word).

(c) Plot Hard-Sum, Soft-Sum, and Soft-Max for each category, respectively

Can you expect which BoW strategy results in better classification results and why?

I think Soft Max would perform better on the task for two reasons. First, Soft-Max operation seems to be common in many other tasks. Second, from the above plot, Soft-Max integrate the features of Hard-Sum and Soft-Sum, e.g., discrimination and smoothness

(d)

i. *Use Train-10 as the training data and Test-100 for testing. Report the classification accuracy using Hard-Sum, Soft-Sum, and Soft-Max. Are the results as expected (based on your observation on different BoW features in (c))? If not, why?*

hyper-parameter: number of neighbor = 7, number of cluster = 50, Max iteration of k-means = 5000.
The classification result is shown below. Soft-Max feature performs best in this case.

Method	Accuracy
Hard-Sum	0.502
Soft-Sum	0.532
Soft-Max	0.554

ii. *Using Train-100 as the training data*

hyper-parameter: number of neighbor = 10, number of cluster = 100, Max iteration of k-means = 5000.
As the training data increase, we have bigger range to fine-tune the number of neighbor and cluster. After several experiments, the above parameters work well. The result is shown below.

Method	Accuracy
Hard-Sum	0.604
Soft-Sum	0.656
Soft-Max	0.722

Although the Soft-Max performs best in this set of parameters, Soft-Sum may outperform in some the other sets (but could not reach 0.7).