Homework #2

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Problem 1:

1) H = $\log_2 1048576 = 20$
2) For each hierarchy, the data point needs to compute two times. The total height of the clustering tree is 20. So it needs to be computed 20 * 2 = 40 times.
3) For the node, it stores every data points in its data set, it also has two sets which is its left leaf and right leaf. Furthermore, it should contain its own cluster center prototype.
   For the leaf node, it stores every data points which has the less distance with this leaf node than the other leaf node in the same hierarchy, and its own cluster center prototype. It also has its left leaf and right leaf.

Problem 2:

1) To cluster the images using K-Means Clustering with K=25, first randomly select 25 images and labels as center. Calculate the minimum distance from these 25 images for each image, and find the average center images and labels, loop until the distance between previous center images and current center images is less than 1. The final center images and labels are stored in KMeansCenterImage.txt and KMeansCenterLabel.txt, the running time is about 6 minutes as Figure 2.1 shows.

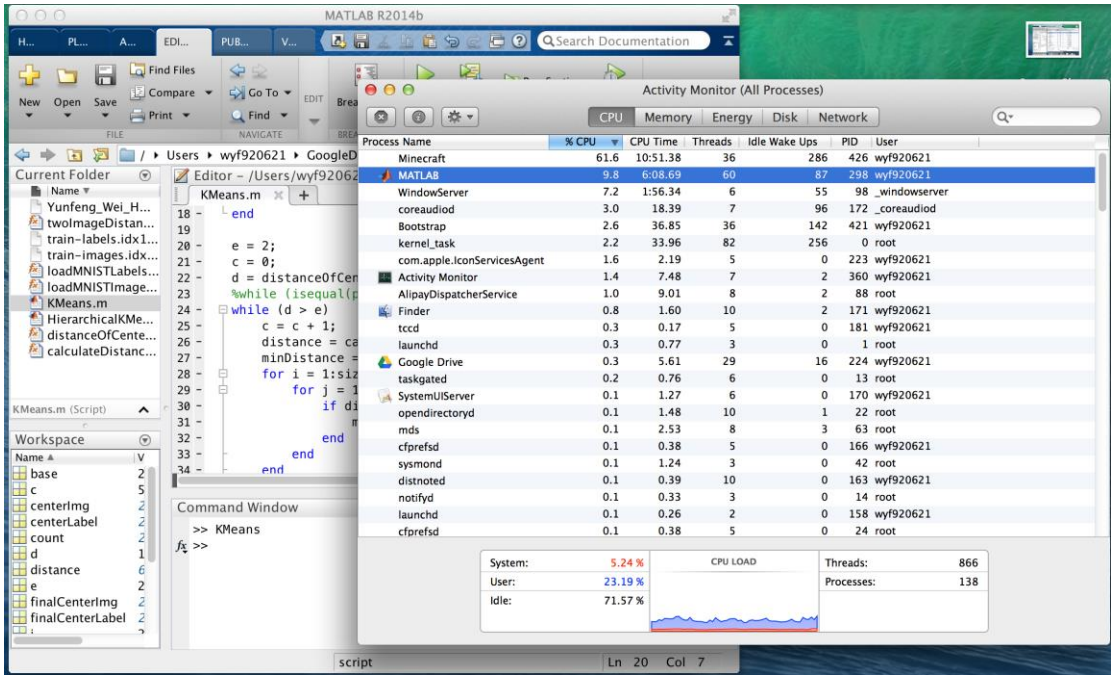


Figure 2.1

2) To cluster the images using Hierarchical K-Means Clustering with K=5, height=2, first randomly select 5 images and labels as center. Using K-Means Clustering with K=5 to cluster images, then for each cluster, using K-Means Clustering with K=5 to cluster images again. The final center images and labels are stored in HierarchicalKMeansCenterImage.txt and HierarchicalKMeansCenterLabel.txt, the running time is about 3 minutes as Figure 2.2 shows.

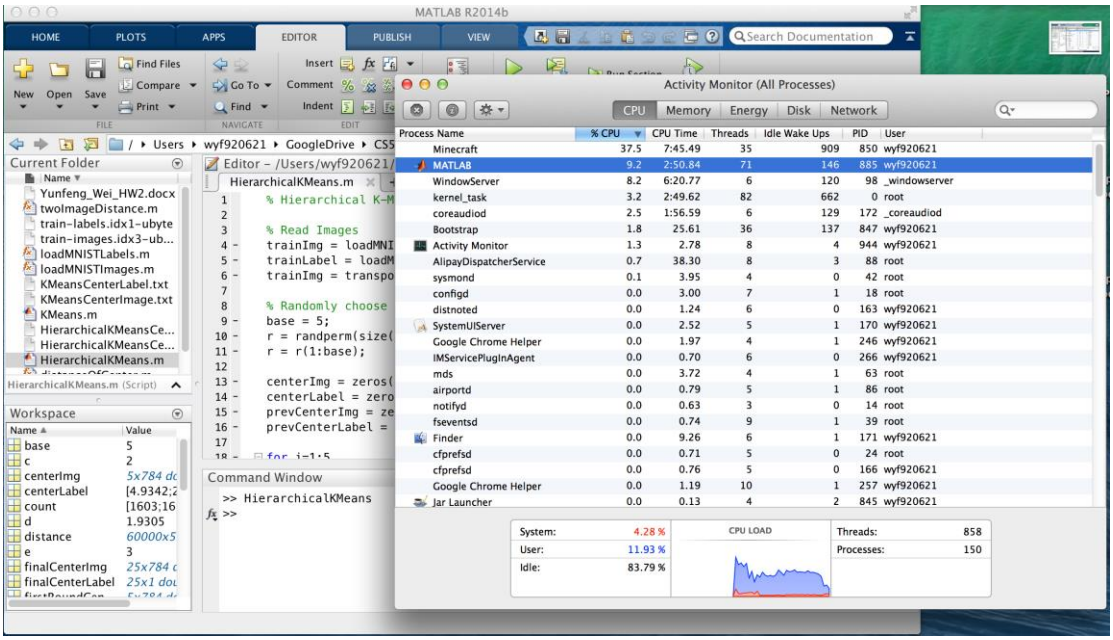
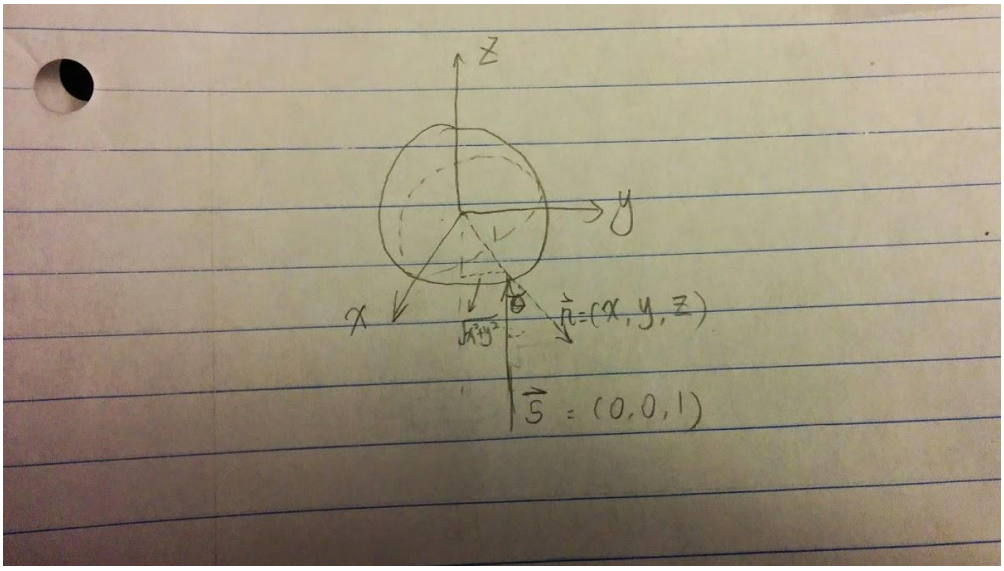


Figure 2.2

Problem 3:

Solution:



From the figure, we can see that the angle θ between the light source and the normal vector of a point at (x, y, z) in the surface of the sphere can be represented as

$$\sin\theta = \frac{\sqrt{x^2+y^2}}{R} = \frac{\sqrt{x^2+y^2}}{1} = \sqrt{x^2+y^2}$$

So we can calculate the shading field in the camera as

$$B(x) = \rho(x)\left(\vec{N}(x) \cdot \vec{S}(x)\right) = \rho(x)\left|\vec{N}(x)\right| \cdot \left|\vec{S}(x)\right| \cdot \cos\theta = \rho \cdot 1 \cdot 1 \cdot \cos\theta =$$

$$\rho\sqrt{1^2 - (\sin\theta)^2} = \rho\sqrt{1 - x^2 - y^2}$$