Assignment #1

Computer Problem Solution

a) Using the training data in **TrainingSamplesDCT8.mat**, what are reasonable estimates for the prior probabilities?

Solution:
Two priors probabilities, $P_Y(cheetah)$ and $P_Y(grass)$, could be estimated based on the number of vectors in the training set. The estimation of $P_Y(cheetah)$ and $P_Y(grass)$ are:

$$P_Y(cheetah) = N_{FG}/(N_{FG} + N_{BG}) \tag{1}$$

$$P_Y(grass) = N_{BG}/(N_{FG} + N_{BG}) \tag{2}$$

where

N_{BG} is the number of vectors in matrix **TrainsampleDCT_BG**

N_{FG} is the number of vectors in matrix **TrainsampleDCT_FG**

b) Using the training data in **TrainingSamplesDCT8.mat**, compute and plot the index histograms $P_{X|Y}(x|cheetah)$ and $P_{X|Y}(x|grass)$.

Solution:
According to training data, the frequency histograms is the following picture:

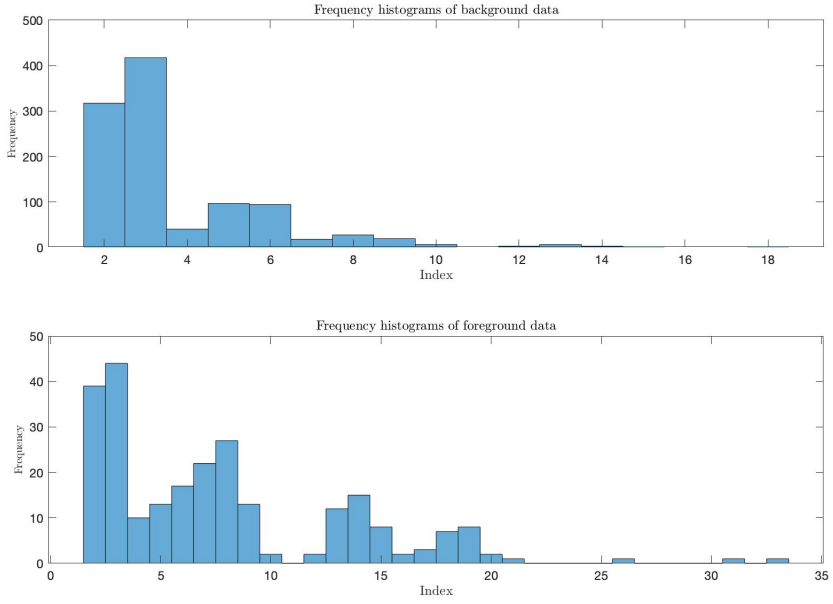

Figure 1: Frequency histograms

The index histograms of $P_{X|Y}(x|cheetah)$ and $P_{X|Y}(x|grass)$ is showed as following:

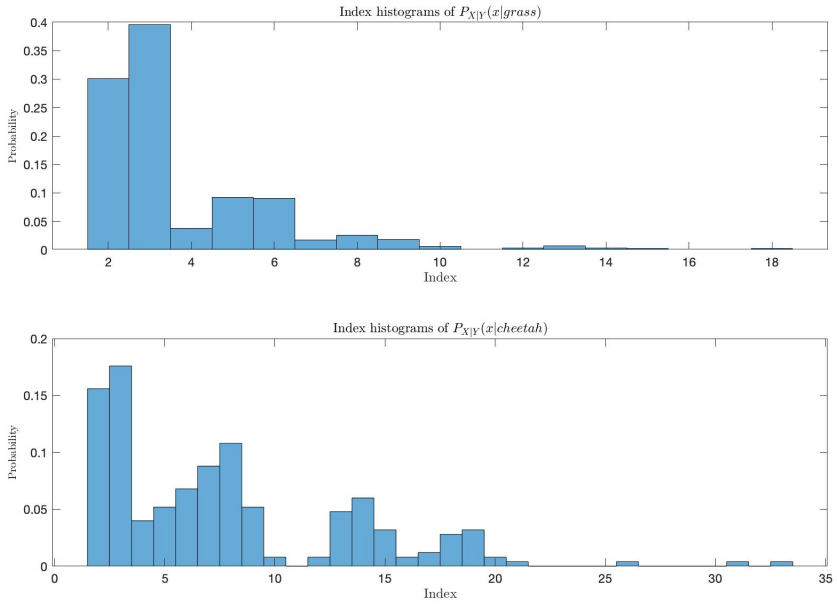

Figure 2: Index histograms

c) For each block in the image **cheetah.bmp**, compute the feature X (index of the DCT coefficient with 2^{nd} greatest energy). Compute the state variable Y using the minimum probability of error rule based on the probabilities obtained in a) and b). Store the state in an array A. Using the commands imagesc and colormap(gray(255)) create a picture of that array.

Solution:
Given a 8*8 block from the image **cheetah.bmp**, we can easily compute an array of 8*8 frequency coefficients by using funcition **dct2** on Matlab. Feature X would be index of the 2^{nd} greatest DCT coefficient. Given $X = x$ in one block, we can compute the $P_{Y|X}(cheetah|x)$ and $P_{Y|X}(grass|x)$ as following:

$$P_{Y|X}(cheetah|x) = \frac{P_{X|Y}(x|cheetah) * P_Y(cheetah)}{P_{X|Y}(x|cheetah) * P_Y(cheetah) + P_{X|Y}(x|grass) * P_Y(grass)} \quad (3)$$

$$P_{Y|X}(grass|x) = \frac{P_{X|Y}(x|grass) * P_Y(grass)}{P_{X|Y}(x|cheetah) * P_Y(cheetah) + P_{X|Y}(x|grass) * P_Y(grass)} \quad (4)$$

where

$P_{X|Y}(x|cheetah)$ and $P_{X|Y}(x|grass)$ are the estimation we get from training data.

$P_Y(cheetah)$ and $P_Y(grass)$ are the estimation we get from training data.

According to minimum probability of error rule, if $P_{Y|X}(cheetah|x) >= P_{Y|X}(grass|x)$, then we mask the top left corner of the 8*8 block as 1, regarding this pixel belongs to cheetah. Otherwise, we mask 0. By using a sliding window that moves by one pixel at each step, finally we get a array A containing the mask ndicates which blocks contain grass and which contain the cheetah.

d) The array A contains a mask that indicates which blocks contain grass and which contain the cheetah. Compare it with the ground truth provided in image **cheetah mask.bmp** (shown below on the right) and compute the probability of error of your algorithm.

Solution:
The comparision between ground truth and picture generated from array A is showed as following:

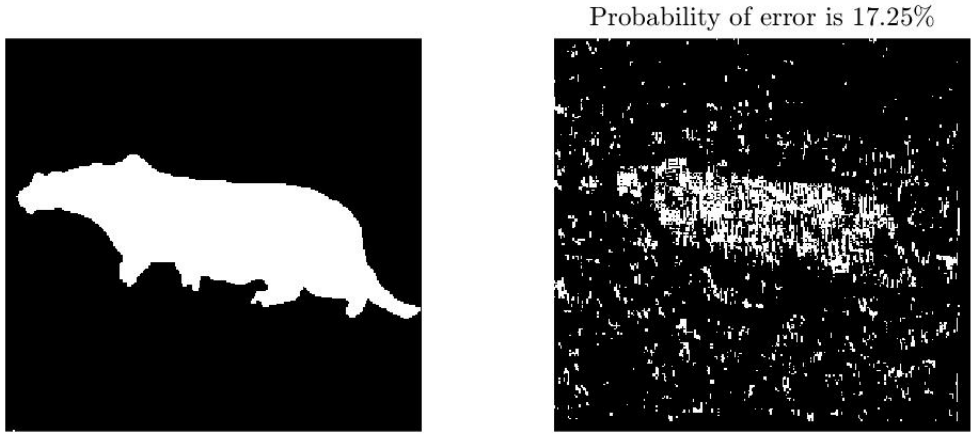

Figure 3: Comparision

The probabilities of error is 17.25%, as showed in the figure above.