CSE185 Final exam Name: Michael Mendez

Academic integrity is the foundation of an academic community and without it none of the educational or research goals of the university can be achieved. Academic integrity applies to research as well as undergraduate and graduate coursework/exams. Existing policies forbid cheating on examinations, plagiarism and other forms of academic dishonesty. UC Merced students are held to high standards of personal and professional conduct in compliance with the UC Merced Academic Honesty Policy and the UCM Code of Student Conduct.

UCM Code of Student Conduct can be found here: http://studentconduct.ucmerced.edu

By completing this exam, I acknowledge and confirm that I will not give or receive any unauthorized assistance on this examination. It is a close-book exam and I will not look up any lecture notes or textbook for answering questions. I will conduct myself within the guidelines of the university academic integrity guidelines.

You must sign this form before taking the exam. You will not receive any credit if your signature (handwritten or digital) is not on this paper.

Name: Michael Mendez

Signature: Michael Mendez

Note: 20 questions on both sides, maximum 100 points. It is a close book exam. Explain all your answers to earn full credits for each question (including multiple-choice questions). Notice that for each multiple-choice question, you can answer with more than one choices. For example, you can circle d, e for question 5 if you think both d and e are correct (i.e., circle all the correct ones and explain your answers).

1. [5 points] Given an image $f[\cdot,\cdot]$, calculate the filtered output $h[\cdot,\cdot]$ at the red marked pixels by applying the filter $g[.,.] = \frac{1}{5}\begin{bmatrix} 0 & 1 & 0 \\ 1 & 0 & -1 \\ 0 & -1 & 0 \end{bmatrix}$ -------------→ h(1,3) = $\underset{}{\overset{-16}{\_\_}}$, h(3,5) = 24;

   Note: assume zero-padding at boundaries

$f[\cdot,\cdot]$

0	0	0	0	0	0	0	0	0	0
0	80	80	80	80	80	80	80	80	0
90	90	90	200	90	90	90	90	90	90
0	70	70	70	70	70	70	70	70	0
60	60	60	60	60	60	60	60	60	60
0	50	50	50	50	50	50	50	50	0
40	40	40	40	40	40	40	40	40	40
0	30	30	30	30	30	30	30	30	0
20	20	20	20	20	20	20	20	20	20
0	10	10	10	10	10	10	10	10	10

$h[\cdot,\cdot]$

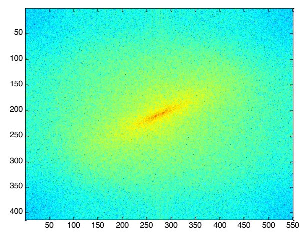
So we have h(1,3) which is 80 and since it is in the -1 matrix, we have -80. Then we divide by how many zeros we have so we -80 divided by 6 which leaves us with -16. For the h(3,5) we have the four ones, that are 80, 70, 200, 90. Now we organize them with the negatives, and add them together, which gives is 120, then divide by 5 which is the answer 24.

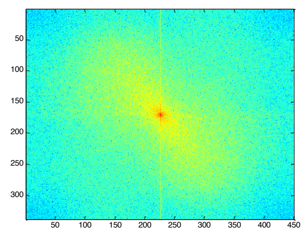
2. [5 points] Match the spatial domain image to the Fourier magnitude image. Explain your answers.

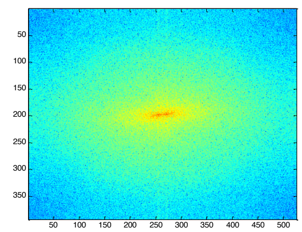
A

B

C

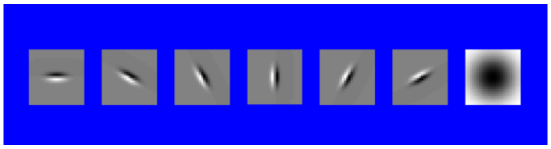


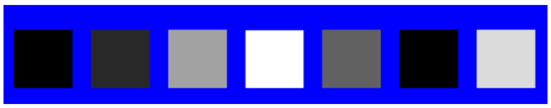




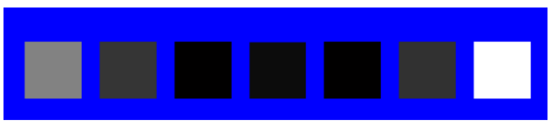
- This one is picture A, this is because you can see that the tree bark are vertical lines, which matches the picture intensity of the image above. Also, since the vertical lines are more crossed, you get the slight slant effect of the Fourier magnitude image, making this image A.
- This one is picture C, this is because it is harder to tell that there are strait lines in the image, matching it to the fourier magnituge image, we can see that the intensity is not in a line, it is more of a dot in the middle that shows that the image C has smaller strait lines.
- This one is picture B, as I said in the first fourier magnitude image. Picture B is tree bark that has a lot of strait line. Which makes the intensity of the fourier magnitude image more of a strait line, and because the tree bark is more strait down lines, we get the intensity of the magnitude image being more straint than the first one.

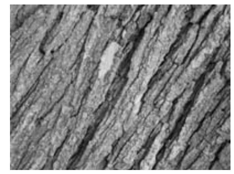
3. [5 points] Match the texture images to the mean absolute responses of filter bank. Explain your answers.



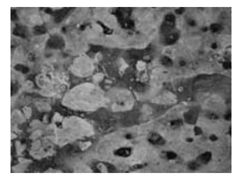
1.) 

2.) 

3.) 

A. 

B. 

C. 

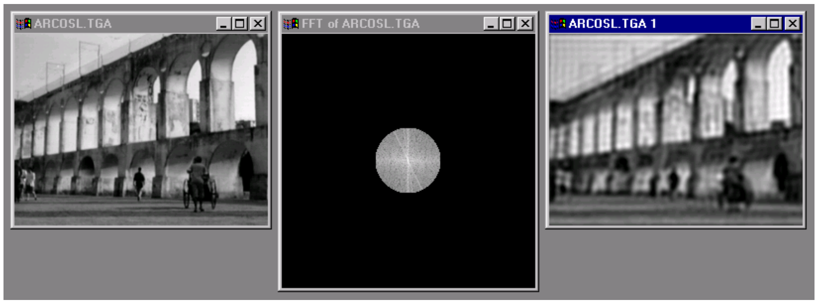
- Number one is picture B. As you can can see from the image, the tree bark has strait lines that go strait down, and there can be see some that are seen going slanted. This means that when the filter bank shows either a strait line down or slanted, it will show either white or grey. In contrary to the second option, we can see that the slanted lines are either white or a very dark grey. Which means that there are no slanted lines going to the right side. Which makes make number one B.

- Number two is picture A. As explained in the above answer. We can see that the striat lines are slanted in one direction. Which means that when the filter bank is reading it to the lines that are slanted to right side, then it will return back a dark grey image which means that it sees a low amount of right slanted strait lines. And since there is strait lines in the image, then it can be option 3.

- Number 3 is Picture C. This is self explanitory. Since there are no starit lines in the image, or close to no strait lines in the image, we can see that they all return a black image. While the last filter bank returns pure white due to the roundness in the picture, making it picture 3.

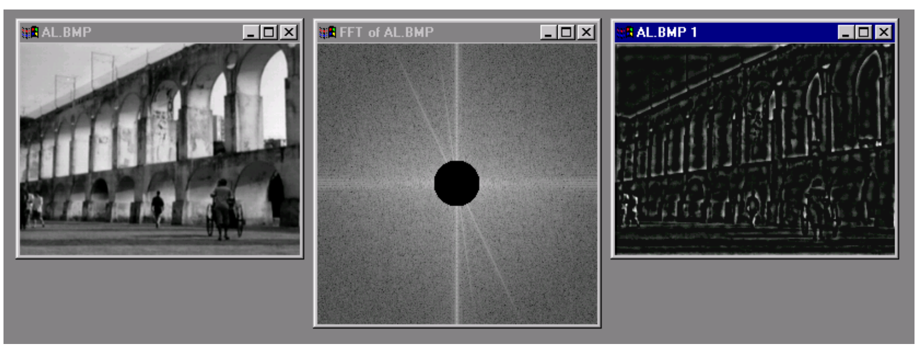
4. [5 points] Explain the type of filter we use on the Fourier domain and why we obtain the resulting images.

   A. Left: Input, Middle: filter. Right: result



- We are using a low pass filter on the fourier domain. The main reason to use this filter is to have a cut of frequency that allows us to keep the overall image structure, but with the draw back of it becoming blury.

   B. Left: input image. Middle: filter. Right: Result



- We are using high pass filter on the fourier domain. This is quite the same with the low pass filter using a cut of frequency that is different from the low pass filter that allows us to keep the images important parts, which are the edges, giving us the resulting image.

5. [5 points] Which of the following statements regarding Canny edge detector are true? Explain your answers.
   a. The non-maximum suppression is used to select pixels that are close to true edges
   b. The edges found by a Canny edge detector are determined by the Gaussian kernel scale
   c. In hysteresis process, we start with low thresholds and then high thresholds
   d. Canny edge detector is a low-pass filter
   e. Hysteresis process is used to connect short edges

- A is true because if it does not detect an edge it will go to the surrounding pixels and it will estimate in which direction there is an edge in

- B is true because in order for canny edge detector to find an edge it has to have a gaussian kernel scale or else it won't find it.

- E is true because using hysteresis process it chooses a strong edge, and with that strong edge, it uses it to find a less intense edge or in this case a short edge.

6. [5 points] Which of the following statements regarding stereo are true? Explain your answers.
    a. Given a pair of images from a calibrated stereo camera, for each pixel in one image, we can use the fundamental matrix to compute the corresponding epipolar line in the other image
    b. Give a pair of images from an uncalibrated stereo camera, for each pixel in one image, we can use the essential matrix to compute the corresponding epipolar line in the other image.
    c. All epipolar lines intersect at the epipole
    d. Epipolar lines are always horizontal lines on an image
    e. When we use larger window for search correspondence, we can capture more details but more noise

- C is true because it is the projection of the conjugate optical centre.

7. [5 points] Which of the following statements are true? Explain your answers.
    a. Given one point in one image, the corresponding point in the second image of a stereo par is on a line passing through its epipole
    b. We can use the essential matrix to map a point in one image to a line in the other image.
    c. Depth is inversely proportional to disparity
    d. a and b
    e. a, b and c

- E is true because

A.) By using a essential matrix that is computed directly with normalize imaging by using the essential matrix to find the corresponding epipolar line we find the given point in the correspoing second image

B.) Since A is true we can see that by computing the essential matrix we can find the corresponding epipolar line that gives us the point into the other image.

C.) Depth is inversely proportional to disparity because we can use triangles that are the same or quite the same in order to compute the depth based on disparity, which will make it inversely proportional

8. [5 points] Which of the following statements regarding optical flow are correct? Explain your answers.
    a. Assume brightness constancy: the matched pixels between two frames have very similar intensity value
    b. Can handle only small motion: assume points do not move far
    c. Assume spatial coherence: points move like their neighbors
    d. Small window size is robust to noise and occlusion
    e. Use weighted window (e.g., Gaussian) so that center matters more

- A is true because we are assuming brightness constancy we can estimate the intensity between two pixels and if they are around the same value we can match the pixels.

- B is true because when testing this in one of the labs we can see that there are some discrepencies when using images in large motions

- C is true because if we do assume spatial coherence then we can see that each point can be related to each point that is around them, so we assume that they move liek their neighbors.

- E is true because this can be seen using a gaussian filter or a low pass filter, we can see that by using a weighted window that the over all centre of the image is conserved throught the filter at the cost of being blurred.

9. [5 points] Which of the following statements are true when we use RANSAC to fit data points with an objective function? Explain your answers.
   a. RANSAC is robust to outliers
   b. Applicable for larger number of objective function
   c. Optimization parameters are easier to choose than Hough transform
   d. Computational time grows quickly with fraction of outliers
   e. Not good for getting multiple fits

- All options are correct

A.) RANSAC is robust to outliers because since it chooses random samples the outliers do not hinder the RANSAC algorithm

B.) It is application for larger number of objective functions because it always chooses its points in random so there is always a fit for the any function

C.) RANSAC chooses parameters at random, so when ever you have to configure a parameter you can tweak the code and optimize to the result you want to have.

D.) The more fraction of outliers the time will grow quickly because it has to compute the inliers through the whole data set until it finds the sample in which the most inliers are in the sample.

E.) As said in option D, it is not good for multiple fits because the computation time will grow exponentially with each fit you are trying to do.

10. [5 points] K-means clustering. Which of the following statements are true? Explain your answers.
    a. K-means algorithm is sensitive to outliers
    b. If we run K-means many times, we may get different clustering results.
    c. The performance of K-means clustering depends heavily on the number of clusters
    d. K-means is useful for segmentation, while agglomerative clustering is useful for summarization
    e. K-means is a supervised learning method

- A is true because this is true because as it tries to form the clusters if outliers exist, the clusters will have to form around the outliers in order to make the best cluster for each sample.

- B is true because it will always try to find the best fit for the sample points if outliers do exist, when running the algorithm again, you can find that the shape of the cluster might change depeding on how each data point is.

- C is true because if we are given more clusters there will be heavier computations time in order to find the correct clusters that satify each data entry and making sure that the outliers are not making the clusters overlap. In a sense, the more clusters you have, the harder it is to find the a way to cluster each data entry while including the outliers.

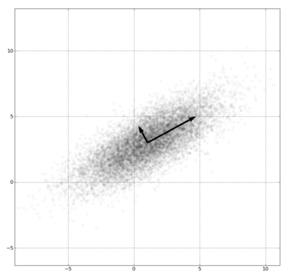
11. [5 points] Which of the following statements regarding eigenfaces are correct? Explain your answers.
    a. The directions that capture the maximum covariance of the data is the eigenvector corresponding to the smallest eigenvalue of the data covariance matrix
    b. If all the eigenvalues are of the same magnitude, then we do not need to use many eigenvectors.
    c. One of the problems with the eigenface approach is that it is sensitive to alignment errors.
    d. A face image in the dataset can be represented as a linear combination of eigenfaces.
    e. The eigenfaces can be extracted by the principal component analysis (PCA) method.

- C is true because since it is really sensitive to all of its parameters, any little change in detail will give it a negative effect. This happens with alignment as well, so if the environment in which you are using is off, the alignment will be off.

- D is true because the image is a matrix, and with the image being a matrix you can find the eigenvalues of a matrix. From there you can compute the eigenfaces of each image.

- E is true because it can catagorize the eigenfaces depeding on how many you have, seperating the details from each and combining them to give the given output.

12. [5 points] The following figure shows the data destruction and their principal components. Which of the following statements regarding the data points are true? Explain your answers.
    a. The first principal component is along 
    b. The first principal component is along 
    c. PCA is less useful for data points that are spread out uniformly in a circle.
    d. The direction of the maximal variance is always good for classification.
    e. The principal components are known as the eigenvectors.



- B is true because PCA starts from a point that is in the outer most area so we can see that the arrow for b is pointing to a farther part of the circle and through the itterations you will eventually be at the center.

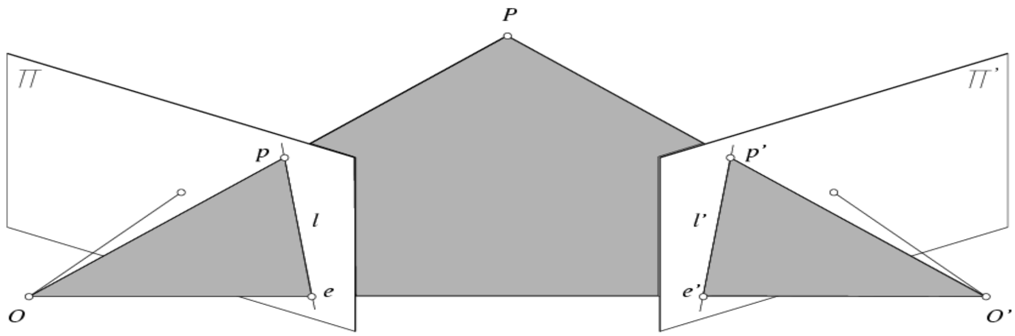
- C is true because it will be harder to predict in which direction each itteration needs to take to find the best result, so having points scattered around the area, makes it easier to decide if it is reaching the most optimal point.

- E is true because this is just something we should all know, it is basically a renaming of the eigenvector for PCA.

13. [5 points] Optical flow. Let I(x,y,t) be one pixel value at (x,y) of frame t, and I(x,y,t+1) be a pixel value at (x,y) of frame t+1. With Taylor expansion $(x + \Delta x) = f(x) + \frac{\partial f}{\partial x}\Delta x$, derive the optical flow equation $I_x u + I_y v + I_t = 0$ where I_x, I_y, I_t, are first order derivative of I with respect to x, y, and t coordinate, and u, v are motion vector (displacement).

The optical flow equation is given by Ixu + Iyv + It = 0, where Ix, Iy, It, are first order derivative of I with respect to x.
First we are given the pixel value at (x,y) of frame t, and I(x,y,t+1). We can see that the optical flow equation is given a u and a v for the Ix, and Iy so we have I(x,y,t) = I(x+u, y+v,t+1). Now using the talyor expansion we have (x + deltax) = f(x) + df/dx deltax. Using our I(x+u,y+v,t): we get our f(x) = I(x,y,t) and our derivative, which is just the partial derivative of I(x,y,t) with respect to each variable, so we now have (x + deltax) = f(x) + df/dx deltax is given by:
I(x,y,t) + Ixu + Iyv + It. This now gives us that the taylor expansion:
of I(x+u,y+v,t+1) = I(x,y,t) + Ixu + Iyv + It substraction the original pixel
we get the optical flow equation: I(x+u,y+v,t+1) - I(x,y,t) = Ixu + Iyv + It

14. [5 points] Epipolar geometry. Given a point P in the world coordinate with two mapped points p and p’ on two image planes with two optical centers O and O’. Derive the following equations.



$$\overrightarrow{Op} \cdot [\overrightarrow{OO'} \times \overrightarrow{O'p'}] = 0$$

Explain all steps (what does the cross product of two vectors do and what does the inner product of two vectors do?) to get full credit.

The Cross Product of Vector OO' X O'p' gives us the right angle of the two vectors, which is perpendicular to the plane. After we have the right angle or the perpendicular vector to the plane, we do the dot product Op dot , in order to make the inner product equal to zero.

15. Extra credit [10 points] Let x=[2 5], y=[1 2] and z=[3 2], compute the covariance matrix.

Putting the three vectors into a matrix we get A = [2 5; 1 2; 3 2], then we get are u by adding the first row and dividing by the number of columns, and same with the second row. So we get u = [(2+1+3)/3 ; (5+2+2)/3] = [3;3]. To get the inverse of A. We have the following equation A' = A - u. From here we get A' = [-1 2; -2 -1; 0 -1]. We need the inverse in order to get the convariance matrix. We get the covariance matrix by C = A' dot A't (Just multiplying the matrixes together. We have the result as C = [5 0 ;0 6]

16. [5 points] Please **debug** the following optical flow code and write down the correct code in each blank line. Suppose 'frame01.jpg' and 'frame02.jpg' are gray-scale images, and we only compute the optical flow for one time. If there's nothing wrong, please write down "blank".

```
I1 = imread('frame01.jpg');
I2 = imread('frame02.jpg');
window_size = 45; r = floor(window_size/2);
[h, w] = size(I1);
Ix_m = imfilter(I1, [1, -1], 'replicate');
Iy_m = imfilter(I2, [1; -1], 'replicate');
u = zeros(h, w); v = zeros(h, w);
for i = 1 : h-1 -----------------------→ i = 1 + r : h - r
    for j = 0 : w ---------------------→ j = 1 + r : w - r
        Ix = Ix_m(i-r:i+r,j-1:j+1);
        Iy = Iy_m(i-r:i+r,j-1:j+1);
        It = I1(i-r:i+r,j-r:j+r)-I2(i-r:i+r,j-r:j+r);
        A = [Ix, Iy]; -------------------→ A = [Ix(:), Iy(:)]
        b = It; -------------------------→ b = -It(:)
        x = A / b; ----------------------→ x = A \ b
        u(i, j) = x(1);
        v(i, j) = x(2);
    end
end
```

17. [5 points] Please **explain** the corresponding operations of the following MATLAB code to compute eigenfaces. Assume there is a variable "face_training" with dimension h x w x num_train and k is the number of eigenfaces.

```
1. X = reshape(face_training, h*w, num_train);
2. mu = mean(X, 2); ----------->
3. X = bsxfun(@minus, X, mu); ->
4. C = X * X'; ---------------->
5. [U, S, D] = svd(C); -------->
6. U = U(:, 1:k); ------------->
```

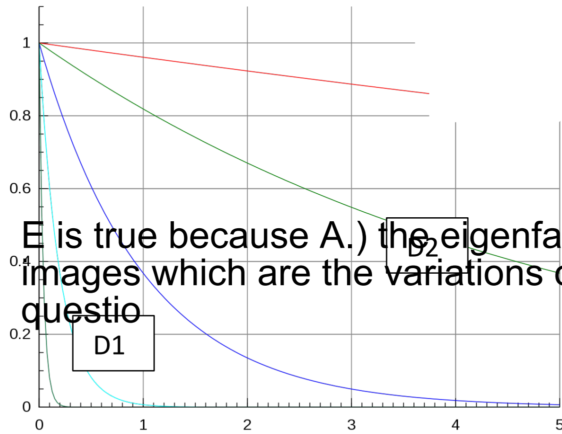
2. → This computes the mean value of x
3. → this subtracts the calculated mean of x from x
4. → From number 15 this gives us the covarance Matrix
5. → This computes the eigenvectors of the covarance matrix
6. → This takes in you, and leaves the first column alone (takes everything without altering) Then takes the first column of U as the eigenfaces.

18. [5 points] Which of the following statements regarding agglomerative clustering are true? Explain your answers.
    a. We will have the same clustering results even when we use different metric functions
    b. Some clusters may have more points than other clusters
    c. We can easily generate a tree based on the hierarchical clustering results
    d. Unlike K-means, we do not need to select the number of clusters
    e. a, b, d are true

- B is true because each data point has to be appointed to a cluster so in order to catagorize each cluster, all data points will need to be chosen. When this happens there can be more data points in one cluster than there is in another.

- C is true because that is how afflomerative clustering works, it forms clusters and adds them together through the proccess forming a hierarchical tree by each cluster it is made.

19. [5 points] Given two image datasets, D1, and D2, where both datasets have the same number of data points and each is represented by a vector of grayscale pixel values, we can compute the corresponding eigenvectors/eigenvalues from two covariance matrices. For each dataset, we plot the eigenvalues in the descending order. The eigenvalues with respect to D1 drop faster than D2 as shown in the following figure (ignore all the other curves).



E is true because A.) the eigenfaces represent the reconstructions of the images which are the variations of the original face images. B.) As seen on questio

Which of the following statements are true? Explain your answers.

a. The images in D1 are more similar than those in D2
b. The eigenvectors we need to represent images in D1 are much smaller than those for D2
c. When we project the data points in each dataset onto the subspace spanned by the top two eigenvectors, the scatter plot of the projected points for D2 is much smaller than that for D1
d. It takes more time to compute the eigenvectors for D1 than D2
e. a, b, d are correct

- A is true because by looking at the graph we see that there is a faster decrease in the line, meaning the eigenvectors/eigenvalues are not similar to one another. Making it decrease at a faster rate than D2

- B is true because since D2 shows a more high value in eigenvectors we see that the difference in images of D1 represents a smaller eigenvector making it decrease faster, while D2 always has similar images, making the eigenvectors more similar, hence the slower decrease in the line.

20. [5 points] Which of the following statements regarding eigen-representation (e.g., eigenfaces) are correct? Explain your answers.
    a. Eigenfaces describes holistic (global) appearance variation of faces
    b. Eigenfaces are sensitive to alignment error (e.g., eigenfaces will not perform well when the face images are not aligned well)
    c. Eigenfaces are not sensitive to heavy occlusion (e.g., eigenfaces still perform well when 20% pixels of a face image are occluded)
    d. The first few eigenfaces corresponding to the largest few eigenvalues describe low-frequency components of faces.
    e. a b and d are correct

E is true because A.) the eigenfaces represent the reconstructions of the images which are the variations of the original face images. B.) this is true because refering back to question 11 it is sensitive to each paramater and causes an alignment error. D.) when first calculating the eigenfaces, you get the low frequency components of the faces, and this allows us to get the core features in later itterations.