**ANLY503 Exam Fall 2017 In-Class Portion Gates:**

**(Note that Part 1** is take-home, was already assigned, and is due Dec 7 at 11:59pm ET)

**IN CLASS EXAM**  (called Part 2)

**Directions:** There will be no questions permitted during this exam. Carefully follow directions and make smart decisions. Do precisely what I ask and if what I ask is not clear to you, make a smart educated guess.

**Due by the end of class on Dec 4 (due by 7:15pm ET)** and will be submitted to BlackBoard. Answer all questions below. You will zip up this document (with your responses) \*and\* your code (.py) and will submit to BlackBoard as **Part2ExamYourName.zip**

**\*\*If your code does not run on my machine and on Spyder, points will be lost.**

**\*\*Place all answers directly into this document as requested**. Add space in this document as needed.

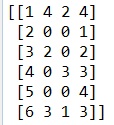
Be sure that your code PRINTS all parts asked for below.

Make this EASY for me to see all printed items when I run your code and EASY for me to visually see when I look at your answers below.

**IMPORTANT: Anytime you are asked to print something and then include it in this document, make sure that your code prints it, that you paste or type it here (your choice), and that your code notes what it is printing with a description. Here is an example...**

**Pretend example:** If you were asked to print/copy/paste/type the matrix M for number 1, you would print out (in your code) and also type/copy/paste (your choice) here in this document as the following. Note that when I print, I include the words, **“The matrix M for number 1 is”.**... I also include these same descriptive words with the matrix M that I copy/pasted here. This makes things clear and easy to read.

***The matrix M for number 1 is***

******

**End of Example**

**COMPLETE ALL OF THE FOLLOWING**

**Directions - for the following, start by using this matrix. Call this matrix M.**

[1 4 2 4

2 0 0 1

3 2 0 2

4 0 3 3

5 0 0 4

6 3 1 3]

The **shape** of this matrix, M, is **6 rows by 4 columns**.

Each vector in this matrix is a **column vector**. For example, the first vector in M is

[1

2

3

4

5

6]

Each vector in M is 6 by 1, and M is 6 by 4.

**\*\* ROUND everything that you need to print or show to 3 (three) decimal places \*\***

You will use Python3 for all of the following. YOUR CODE MUST RUN ON SPYDER.

**Complete all of the following - both as code if it requires coding - and by including any requested items below. All code will go into one (1) Python3 (.py) file. Comment your code to note each question and part.** You will also complete this document and all questions asked - and will submit this document along with your .py program to BlackBoard as noted above. **Use MS Word ONLY for this document.**

**Exam Questions:**

**1) Use Python to find the mean column vector of M.**

(a) What is the mean column vector (type or paste it here)? ( 5 points)

[[ 2.75],

 [ 0.75],

 [ 1.75],

 [ 2.5 ],

 [ 2.25],

 [ 3.25]]

(b) What is the shape of the mean column vector? (**2 points**)

(6,1)

**2) Use Python to create a matrix that is M minus the mean. Call this new matrix A.**

Type or paste the new matrix A here – the whole thing. **(5 points)**

[[-1.75  1.25 -0.75  1.25]

 [ 1.25 -0.75 -0.75  0.25]

 [ 1.25  0.25 -1.75  0.25]

 [ 1.5  -2.5   0.5   0.5 ]

 [ 2.75 -2.25 -2.25  1.75]

 [ 2.75 -0.25 -2.25 -0.25]]

**3) Use Python to find the true covariance matrix of A (the whole thing).**

Type or paste the covariance matrix for A here. **(10 points)**

[[  6.75  -2.25  -0.25  -5.5   -3.75  -3.75]

 [ -2.25   2.75   2.75   3.5    7.25   5.25]

 [ -0.25   2.75   4.75   0.5    7.25   7.25]

 [ -5.5    3.5    0.5    9.     9.5    3.5 ]

 [ -3.75   7.25   7.25   9.5   20.75  12.75]

 [ -3.75   5.25   7.25   3.5   12.75  12.75]]

**4) Using the covariance matrix from (3) above, use Python to determine the eigenvalues and eigenvectors.**

Sort the eigenvalues. Round them to 3 decimal places. Print or paste them all here. **(10 points)**

[ -0.   ,   0.   ,   0.   ,   5.185,  10.597,  40.968]

**5) Sort the eigenvectors (based on the eigenvalues).** Round them to 3 decimal places. Print or paste them all here. **(10 points)**

[[-0.498, -0.201,  0.26 ,  0.26 ,  0.51 ,  0.672],

 [-0.14 , -0.02 , -0.009,  0.259,  0.708,  0.708],

 [-0.105,  0.183,  0.249,  0.249,  0.262,  0.421],

 [-0.648, -0.53 ,  0.197,  0.321,  0.321,  0.326],

 [-0.418, -0.418,  0.029,  0.433,  0.505,  0.689],

 [-0.494, -0.48 , -0.027, -0.027,  0.376,  0.494]]

**6)** **Use Python to calculate Turk and Pentland’s “reduced” covariance matrix (ATA).** Paste it here**. (10 points)**

[[ 40.75,   3.75,   3.75,  20.5 ],

  [-22.25,   4.75,  -5.25, -12.5 ]

 [-30.25, -13.25,  -2.25, -21.5 ],

  [ 11.75,   4.75,   3.75,  13.5 ]]

**7) Sort the eigenvalues for the Turk and Pentland reduced covariance matrix.** Round them to 3 decimal places. Print or paste them here. **(10 points)**

[ -0.   ,   5.185,  10.597,  40.968]

**8) Sort the eigenvectors (per the eigenvalues) for the Turk and Pentland reduced covariance matrix.** Round them to 3 decimal places. Print or paste them here. **(10 points)**

[[-0.741, -0.442,  0.073,  0.117],

  [-0.679, -0.297,  0.308,  0.448],

  [-0.101,  0.469,  0.721,  0.834],

  [-0.442, -0.176, -0.115,  0.84 ]]

**9) Are the eigenvalues for the regular C=AAT covariance matrix for A the same as the eigenvalues for the reduced Turk&Pentland covariance matrix C’= ATA? (Choose yes or no and then answer the following…) (15 points) NOTE: This question does not require coding and should be answered here.**

**If yes**, use linear algebra to show why this should be. Type the linear algebra proof here and show all needed steps so that I can see that you know what you are talking about.

**If no**, use linear algebra to show why this cannot be. Type the linear algebra proof here and show all needed steps so that I can see that you know what you are talking about.

No, using the Turk and Pentland method can reduce the dimension of the resulting matrix to (4, 4) and the concept can be shown in below equation:

*AT Avi* = *uivi where vi is an eigenvector*

Then, multiplying the both sides by the normalized matrix A,

*AAT Avi* = *Auivi* → (*AAT* )*Avi* = *u*(*Avi*) → *Avi* = *u*(*Avi*) *where u is a scalar*

Proves that Turk and Pentland method can be used for reducing dimension of the matrix.

**10) Convert (also known as projection) the largest Turk&Pentland eigenvector from ATA (the eigenvector associated with the largest eigenvalue) back into our original space. (You must determine what this is, what this means, and how to do it). T**ype/paste the projected eigenvector here. **Also, type out the steps of what you did to do this. You will also code this and so it will be in the code under #10. (**

**13 points)**

[[ 1.285],

 [-1.658],

 [-1.679],

 [-2.085],

 [-4.409],

 [-3.161]]

After getting the eigenvectors and eigenvalue, the program takes out the index of eigenvalues with sorted order. Then flip the order with the largest on the left side of the list. Then the program acquires the top1 in the eigenvector list. Then turns into an array, and the program perform a matrix multiplication using the M(original matrix) and the eigenvector matrix. Lastly using numpy reshape to reshape the matrix into original shape (6,1).

**\*\*REMEMBER - your code must also clearly print out all of the above except #9 so that when I run it I will see everything.**

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