EN2550 Homework 1 on Python and NumPy

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1. Write a program to display the squares of numbers form 1 to 5 as seen below.

   ```
   1 :   1
   2 :   4
   3 :   9
   4 :   16
   5 :   25
   ```

2. Alter the code in 14 to print the square only of non-prime numbers. Use the isprime function in the sympy package for testing if a number is a prime.

3. Use a comprehension to do 14.

4. Use a comprehension to do 11.

5. Using NumPy carry out the following computations.

   (a) Matric multiplication

   $$C = \begin{bmatrix} 1 & 2 \\ 3 & 4 \\ 5 & 6 \end{bmatrix} \times \begin{bmatrix} 7 & 8 & 9 & 1 \\ 1 & 2 & 3 & 4 \end{bmatrix}.$$

   (b) Element-wise multiply

   $$A = \begin{bmatrix} 1 & 2 \\ 3 & 4 \\ 5 & 6 \end{bmatrix} \text{ and } B = \begin{bmatrix} 3 & 2 \\ 5 & 4 \\ 3 & 1 \end{bmatrix}.$$

6. Generate a 5×7 array of random integers in the interval $[0, 10]$ and extract the sub array consisting rows 2 to 4 and ~~columns 1 and~~ first two columns. What is the size of the resulting array?

7. Show three examples of broadcasting.

8. Consider the following code snippet

```
m, c = 2, −4
N = 10
x = np.linspace(0, N−1, N).reshape(N,1)
sigma = 10
y = m*x + c + np.random.normal(0, sigma, (N,1))
```

    (a) Append a column of ones to x to create $\mathbf{X}$.

    (b) Compute $[\mathbf{X}^\top\mathbf{X}]^{-1}\mathbf{X}^\top y$

9. (Advanced, optional) Write a function that computes the square root of a given number by

    (a) Computing the hyperbolic estimate of the square root as the initial guess. I.e., for $S = a \times 10^{2n}$ where $a \in [1,100]$[1]

$$\sqrt{S} \approx \left(\frac{-190}{a+20} + 10\right) \times 10^n.$$

    (b) Using this initial estimate as s_0 use Newton-Raphson method[2] to find the square root with a given precision (e.g., 10^{-5}

    (c) Compute the square root of 64, 75, 100, and 1600.

10. Use Gaussian smoothing to filter the noise in the image gal_gaussian.png shown in Fig. 1[3].

Figure 1: Image corrupted with Gaussian noise

11. Use median filtering to filter the salt and pepper noise in the image gal_sandp.png shown in Fig. 2.

12. Create a 40×60 grayscale image and change the color of the top-right quarter to 125.

13. Create a 40×60 color image and change the color of the bottom-left quarter to "Barbie Pink"[4].

14. Increase the brightness of the image tom_dark.jpg shown in Fig. 3.

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[1]https://en.wikipedia.org/wiki/Methods_of_computing_square_roots
[2]https://en.wikipedia.org/wiki/Newton's_method
[3]See Moodle for the original image files.
[4]https://en.wikipedia.org/wiki/List_of_colors:_A%E2%80%93F

Figure 2: Image corrupted with salt and pepper noise

Figure 3: A dark image