PSYCH-GA.221 / NEURL-GA.2201 – Fall 2014
Mathematical Tools for Cognitive and Neural Science

MATLAB Homework 0

This homework is optional. If you choose to submit answers, the TA's will give you feedback on code correctness, programming style, and submission format, which may help you perform better on later non-optional homeworks. Please see the separate homework submission format instructions for full details on the correct format: in short, you should create a single main file called `hw0.m` and put your name at the top; make a separate section (`%%`) for each subproblem; use `display` statements to print out your final answer for each section; and zip and email your file as `hw0_Lastname` to both TA's: `catherio@nyu.edu`, `asr443@nyu.edu` .

1. **The basics.** Try the following quick exercises at the MATLAB command prompt

   (a) Create a scalar variable a and set it equal to 5. We say the variable is "bound" to the value 5. When you type a, matlab looks up the the variable in an internal table, and hands back the value it finds there. If it doesn't find the variable, it gives an error (try typing `b` at the prompt). Now set it equal to the square root of itself: `a = sqrt(a)`. What happened to `a`?

   (b) Define a 5-vector $\vec{x} = [1\ 2\ 3\ 4\ 5]$.

   (c) Press the up arrow key to get back the command you just entered. Now add a semi-colon at the end of the line and press enter. What did this do?

   (d) Go to the help menu and click on MATLAB help. Do a search for the function `rand`. Alternatively, at the command prompt, you can type `help rand`. What does this function do? Use `rand` to create a 3-element vector. Run this several times to get a sense for what's going on. Use `rand` to create a 100-element vector named `r`, but don't print it. Instead, display it as a spike plot using the `stem` command. Type `help stem` to understand what the function does and learn its syntax.

   (e) You can select individual elements of $\vec{r}$ by indexing into the vector using the notation `r(k)` where `k` is the index of the element in $\vec{r}$ you wish to select. What is the 50th element of `r`? What happens if you type in `r(0)` or `r(101)`? Why?

   (f) You can select multiple elements of $\vec{r}$ by using the notation `r(n:k)` where n is the starting element and k is the ending element. Examine the first five elements of $\vec{r}$.

2. **Vector math.** From doing problem 1, we now have several vectors and variables in our workspace. To see which variables exist and some information about them type `whos` at the command prompt. You'll see the names of the variables, and the type and size of object to which they're "bound". Now let's do some vector math.

   (a) Compute $a\vec{x}$ (scalar multiplication).

   (b) Define `y=rand(1,5)`, and compute $\vec{x} + \vec{y}$ (vector addition). Look at $\vec{x}$ and $\vec{y}$ and make sure the answer makes sense.

   (c) What happens if you try to compute $\vec{x} + \vec{r}$? Why?

   (d) Along with vector operations, MATLAB lets you do element-wise operations. Try typing in `z = x.*y` at the prompt. What difference did the period make? How are the dimensions of `z` different from `c`?

(e) Write the MATLAB expression for computing a vector whose elements are the squares of the corresponding elements of $\vec{x}$.

3. **Dot products**

(a) Write down the mathematical expression for computing the inner product (dot product) between $\vec{x}$ and $\vec{y}$. Using what we've learned so far, how would you implement this in MATLAB (hint: try `help sum`). Your result should be a scalar. You can verify this using the `size` command.

(b) MATLAB provides a function `dot` for computing the inner product. Try it, and verify it gives the same answer as the one you got in the previous problem.

(c) Create a 5 element vector called $\vec{w}$ where each element is equal to 0.2. Do this without typing 5 copies of 0.2! Hint: type `help ones` and use scalar multiplication. What built in MATLAB function takes as input $\vec{x}$ and returns the same answer as $\vec{w} \cdot \vec{x}$?. Verify this by comparing the answers on several random vectors.

4. **Dot product geometry.**

(a) Use `rand` to create two 2-element vectors $\vec{x}$ and $\vec{y}$. Use the `plot` command to plot both vectors on the same graph. Hint: try `help hold`. Bonus: plot $\vec{x}$ in red, and $\vec{y}$ in blue.

(b) Calculate $\vec{x} \cdot \vec{y}$ by taking the product of the components and summing them.

(c) Calculate the lengths of each vector.

(d) Calculate the angle (in radians) between $\vec{x}$ and $\vec{y}$, by computing the difference between each of their angles (use `atan`).

(e) Using the lengths and the angle calculated above, calculate $\vec{x} \cdot \vec{y}$ using the formula given in class. Verify that this matches the result from question 4b above?

(f) "Proof" by numerical verification: Re-run all of the steps above several times with different random numbers. Verify that your code is working with these new random numbers.