Methods in Computational Neuroscience

Upload codes and report to Moodle before Friday 17th February, 14:00.

Problem set #1 - Tutorial

This is the first problem of the course, it goes through the very basics of what you will have to learn during this class. We will create a script, with an array, a loop and some basic plotting. Try and get used to writing down answers documented by figures in any of your favorite word processor. This is the most important part of the project reports grading you will have to hand in. The codes will be run and checked, but the grades are assessed by your scientific report.

A simple population growth model:
We will simulate a population of animals growing. We start with a fixed number of animals $N_0 = 2$, and we will model the growth per year over the time of a hundred years.
The first thing is to create a script: Now for the growth model, let's name p_n the population at year n. It is safe to assume that the population will grow by a factor of itself, that is, the bigger the population, the bigger the growth. So the number of new individuals born any given year should look something like αp, if p is the population that year. Noting the current year $n-1$, this means we will try to model this year with the following *map*:

$$p_n = p_{n-1} + \alpha p_{n-1}$$

first set $\alpha = 0.1$

$$p_n = p_{n-1} + .1 p_{n-1}$$

Organize your script:

1. Create an array named p, meant to hold on the population values every year.
2. Set the first value of the array, p_0, to the initial population value.
3. Given the map above, set the second value of the array by computing p_1.

We can repeat this for all consecutive years. To simulate for longer periods, we will have to program using a *loop*. A loop repeats the same chunk of code over and over. So we have some control over what happens, a variable (an integer) gets *incremented* (it will count 0, 1, 2, …until the bound we set). This integer is usually called *index*. To keep track of what we did in the loop, it is useful to create arrays, that can hold on to multiple values at the same time. Arrays have a fixed size, hence they must be *initialized* first. For this we need to know their size prior to the simulation.
This simple chunk of code creates an array of size 10 and writes 0, 1, … 9 inside the array elements:

```
import numpy as np # import the library
myarray = np.zeros(10) # create the array
for i in range(10): # write the loop
    myarray[i] = i # write the index of the loop in the array
print myarray
```

The above example should help you through the following questions. Notice how the array has length 10, but the loop indices only reach 9, this is because the first element of arrays (in Python, not in MATLAB) is “myarray[0]”, not “myarray[1]”.

1. Write down a loop that automates the computation of p_1 that you did before, to compute the remaining $p_2 \ldots p_{100}$ values
2. Plot the result and show it.
3. What is happening? Could we have predicted it?
4. Play around by changing the growth parameter α, how does it affect the result? Does changing the initial population affect the result sensibly?

Of course our model is very naive, and it seems that we could refine it a little bit. Let’s consider the general problem of resources, our population now lives in an environment where resources are limited. A good way of modeling that is simply to *modulate* the growth factor. This means that we will replace our α by some function of the population. We choose to write $\alpha\left(p\right) = 200 - p$.

1. Plot the function $\alpha\left(p\right)$ for population rates between 0 and 500 individuals.
2. Interpret the result, what does it imply for the growth rate of our population?

Now we have some intuition of the behavior of the population, but we might want to check it by simulating it again. Every next year the population grows by $\delta_n = \beta p_{n-1}(200 - p_{n-1})$. This means the population follows the *map*.

$$p_n = p_{n-1} + \beta p_{n-1}(200 - p_{n-1})$$

first set $\beta = 0.001$:

$$p_n = p_{n-1} + 0.001 p_{n-1}(200 - p_{n-1})$$

1. Simulate the system, and plot the variation of the population values over time. What happens?
2. Play around with the additional parameter β that we have introduced, how does it affect the simulation result?
3. Play around with the initial number of individual, can it also change the general trend of the system?

Don’t forget to scientifically report your results and answer the questions.