Exercises L2: Hopfield networks

Exercise 1

The goal of the exercise is to write a working implementation of a Hopfield network. In the files hopfield.py and test hopfield.py you will find a frame you can use to get you started.

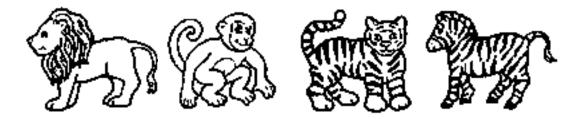
- a) Open file hopfield.py and read the docstrings to see how the functions that you'll have to write look like
- b) How can we go about testing them?
- c) Start writing tests for the update_activity function, and then implement it until the tests pass
- d) Now write tests and body for the function store pattern

Exercise 2 (optional)

The first version of the store_pattern function is likely to be quite inefficient for large networks. Optimize it by substituting the for-loops with the numpy.outer function.

Exercise 3

We would like to use our Hopfield network to store images of African animals:



The script animal.py contains three functions:

- load binary image: load a binary image and transform it in a +1/-1 activity pattern
- show pattern: display an activity pattern in a matplotlib figure
- random_flip: add noise to the pictures

There is already a snippet of code that loads the first three animals and displays the first one. (Note: you can use the larger versions of the animals if you wrote an efficient network.)

- a) Create new weights for an Hopfield network and store the first three animals
- b) In the file mistery.png there is a very noisy picture taken by an amateur explorer. What animal did he photograph?

- c) Explore the robustness of the Hopfield network:
 - write a function that computes the difference between two different activation patterns (it should return the number of different elements)
 - for each image, add random noise using the random_flip function, and try to reconstruct the image by updating the activity of the network for a few times
 - make a plot of reconstruction error as a function of the percent noise in the image
- d) Store the fourth animal in the Hopfield network and try recovering one of the animals What happened? Why did the network break down so quickly?