Exercise 0: Introduction to Python

February 19, 2019

Exercises

0.1 You are given a function $f(x) = x + \sqrt{x} + \frac{1}{x^2} + 10\sin(x)$. Create a function `ex0(a,b,c)` that plots $f(x)$ where x are c equally spaced numbers in the range of $[a, b]$. In the case of $b < a$, the function returns -1 and does not plot, otherwise it returns 0 and plots the function.

0.2

- Write a function `create_image` that generates an image with the height/width dimensions of n x m with uniform randomly distributed black and white pixels. Add a single red pixel at a random location.
- Next, write a function `find_pixels` that finds the indexes of pixels with the values `pixel_values` in an image `img`
- Using the image `img`, compute the euclidean distance of each white pixel from the red pixel without the use of any for loops
- Display the computed distance vector `dist` in a histogram (with 100 bins), compute the mean, standard deviation and the median. Display the values as a title above the plot.
- Hint: Your functions should be callable in this manner:

```
img = create_image(h,w)
dist = compute_distances(img)
visualize_results(dist)
```

0.3 Using the image `stopturnsigns.jpg` from ilias, search for threshold values t_{min}, t_{max}, such that a mask m contains only pixels of the stop sign. An example of such a boolean binary mask can be seen below.

0.4 Considering two 1 dimensional arrays, calculate the mean square error between them. Check your function for arrays of known difference.

- Define two arrays x,y of length 100, and assign random values to them.
- Write a function `mse(a,b)` that calculates the MSE (mean square error) between two 1-d arrays of size N. The MSE between two arrays x and y is defined as $MSE(\mathbf{x}, \mathbf{y}) = \frac{1}{N} \sum_{i=0}^{N-1} (x_i - y_i)^2$. Can you think of a way to calculate the MSE without using any for loop? (hint: Check numpy's dot product function)
- Calculate the MSE between arrays x and y.
- Check your function through the degenerate case of the MSE between array x and itself.
- Define an array with an offset of 2 from the values of x. What do you expect the MSE to be? Confirm by using your function.
- Assume you have the function of 0.1 ($f(x) = x + \sqrt{x} + 1/(x^2) + 10 * \sin(x)$), for $x \in [1, 200]$ and you want to approximate it with the line $g(x) = a \cdot x, \quad a = 1.2$. Plot the two lines on the same figure, and visually check if this is a good approximation.
- Calculate the MSE between f(x) and g(x) for the given range.

- Try to tune the parameter a of the function g(x) so that you achieve a lower error. (hint: try different values of a in an interval that makes sense for you, e.g. $a \in [0.5, 5]$). Plot the MSE for the different values of a and use the numpy.min() function to choose the optimal a with respect to the MSE. Print the minimum MSE value, and the value of a for which it was achieved.