IPA 2025 Lab Exercise 2

Assigned October 28th **Due Nov 12th 23:55**

Time you spent on this assignment: ____ hours

The maximum amount of points awarded for this assignment is **20 points**.

How to submit your report

Read carefully this document. Ask if you are unsure what to do, otherwise use common sense to solve the problems. The hand-in for this laboratory exercises is done by using **Moodle** before the deadline. (See `http://vda.univie.ac.at/Teaching/IPA/25w/grading.html` for more information.)

You should hand in a ZIP file **IPA_Lab2_YourLastname.zip** containing:

- **A written report of the lab** as a PDF/Jupiter Notebook document YourLastname_Report.pdf, including your results and, most importantly, a discussion of the results.
- **All Python code necessary to RUN your solution**
  - Feel free to define auxiliary functions where needed, but name your main files as specified in each task.
  - Please write your name and student ID as a comment at the beginning of each Python file and in the PDF report..
  - Please include many comments in your source code, as this is required..

You can discuss between colleagues the results and solutions, **but you have to submit your own work.**

Warning! Plagiarism will not be tolerated.

Be careful: If the attached code does NOT run, we will reject your exercise completely. It is NOT necessary to include a copy of all the code in the PDF document, although key parts can be included if they are needed to explain a point.

1 Boundary Signature (10 points)

This task corresponds to Problem 12.3, Gonzalez and Woods 4e

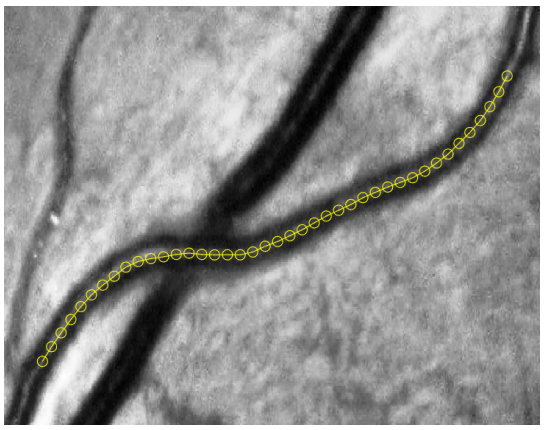
(6 points) Write a function `[dist,angle,xc,yc] = boundarySignature4e(b,xc,yc)` that computes the signature of boundary `b` (an np x 2 array of points). In the output, `(xc,yc)` is the point from which distances to the boundary are computed (see Fig. 12.10). If `(xc,yc)` is omitted, it defaults to the centroid of the boundary. In the output, `(xc,yc)` is the point used by the algorithm (it will either be the centroid or the coordinates input in the function call. Use one-degree increment in the signature).

(2 points) Read the images `Square-solid.tif` and `Square-rotated.tif`, showing a simple black and white image with the square on it. Compute and display their signatures using the above-written function. The two images are on the Moodle web page.

(2 points) The two signatures are identical, but they are displaced with respect to each other. Propose a solution to align the functions so that they start at the same point (the origin), regardless of which way the squares are rotated with respect to each other. Your solution can be applicable to just these two objects, but demonstrate that it does work for the two images.

2 Tortuosity Descriptor (10 points)

For this task, we will use the public dataset SCALE-TORT available from here: `https://health-atlas.de/data_files/606`. The dataset contains images of retinal vessels together with the annotated centerlines, provided in the `.mat` files.



(1 points) Read the data, and visualize a couple of examples by showing the image of the vessels and plot the centerline (together with the points forming it) over the image, like shown on the example above.

(6 points) Implement the following two tortuosity metrics used as baselines in the paper by *Grisan et al., A Novel Method for the Automatic Grading of Retinal Vessel Tortuosity*, `https://doi.org/10.1109/TMI.2007.904657`.

- (2 points) *Arc Length Over Chord Length Ratio.*
- (4 points) A *Measure Involving Curvature.* The ratio between the absolute curvature integral (or the squared curvature integral) and chord length (or vessel length).

(3 points) Sort the images in the SCALE-TORT dataset based on the two tortuosity metrics implemented above, separately for arteries and veins. Visualize the top 5 and the bottom 5 images, ranked by the particular tortuosity metric, for arteries and veins separately. Comment on whether the ranking corresponds to your subjective interpretation of the tortuosity, and which of the two metrics corresponds better. Which are on average more tortuous, arteries or veins?