Problem Set 03

1. **(Identification and Analysis of Components in a Binary Image)** Allow the input of any scalar image I. Apply a defined threshold T, $1 \leq T \leq G_{max}$, for generating a binary image by the following thresholding operation:

$$J(x, y) = \begin{cases} 0 & \text{if } I(x, y) < T \\ 1 & \text{otherwise} \end{cases}$$

   For the resulting binary image J, allow the following two options for a user dialogue:

   1) (Counting components) If the user selects this option, then it is possible to use either the key “black < white” or “white < black” for counting the number of black components in the binary image J.

   2) (Geometric features of a selected component) When a user selects this option and clicks on one black component, then the area, the perimeter, and the diameter of the component are calculated. For this exercise, it is sufficient to calculate the perimeter as the length of the 8-path describing the border of the component (i.e. the output of border tracing when assuming 8-adjacency). The *perimeter* of a component is the maximum distance between any two pixels in this component. (Thus, the perimeter is defined by two pixels on the border of the component.)

   Optional, small components with an area below a given threshold may be deleted prior to Options 1 and 2, and the selected components (in Option 2) may be colored to avoid repeated selection.

2. **(Evaluation of Co-Occurrence Measures)** Use as input scalar images I of reasonable size (at least 256 x 256). Apply recursively the 3 x 3 box filter or the 3 x 3 local median operator to an input image and produce smoothed and residual images $S^{(n)}$ and $R^{(n)}$ with respect to these two smoothing or noise-removal operations for $n = 0, \ldots, 30$. See Equation (2.33) in page 72 of the textbook.

   Calculate the co-occurrence matrices for I and images $S^{(n)}$ and $R^{(n)}$. Let T be the total sum of all entries in the co-occurrence matrix of I.

Calculate the homogeneity and the uniformity measures for images $S^{(n)}$ and $R^{(n)}$, and scale the obtained values by dividing by T, thus only having normalized values in the interval [0, 1].

Plot those scaled homogeneity and uniformity results as functions of $n = 0, \ldots, 30$ for both used smoothing operators.

Discuss differences or similarities of results for input images I showing different intensity distributions, such as uniformly illuminated indoor images or outdoor images showing lighting artifacts.

3. **(Features of Components Using Moments)** Generate binary images as described in Exercise 1. Before further processing, delete all black artifacts, for example by deleting all components having a diameter below a given threshold T or all components having an area below a given threshold.

   Provide a user interface that the remaining components can be selected (by clicking) one by one, calculate for each selected component its centroid, main axis, and eccentricity and visualize those values in some way for the selected component. For visualizing eccentricity, you may draw, for example, an ellipse of corresponding eccentricity or just show a bar at the selected component whose height corresponds to the value of eccentricity. For centroid and main axis, do similar as illustrated in Fig. 2.

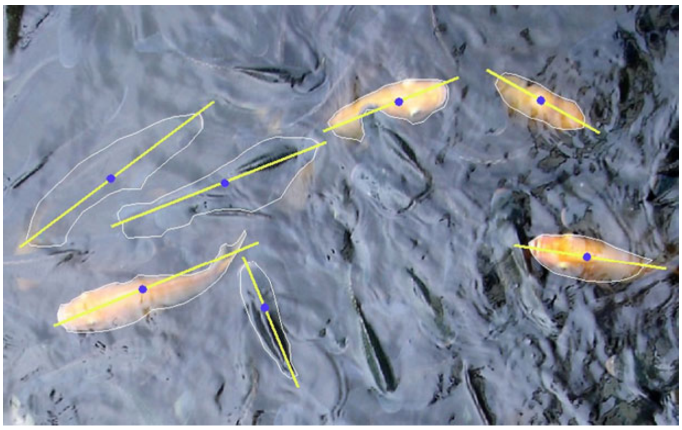

Fig. 2. Main axes and centroids for detected fish regions.

4. **(Generation of Noisy Line Segments and Hough Transform)** Write a program for generating noisy line segments as illustrated in Fig. 3. The program needs to support different densities of generated points and

different numbers, lengths, and directions of generated noisy line segments.

Apply your line-detection program (you may decide to write it yourself) based on the Hough transform for detecting these line segments, including their endpoints. Compare the results with the true data used when generating the line segments. Increase the noise and discuss the robustness of your line-detection program.

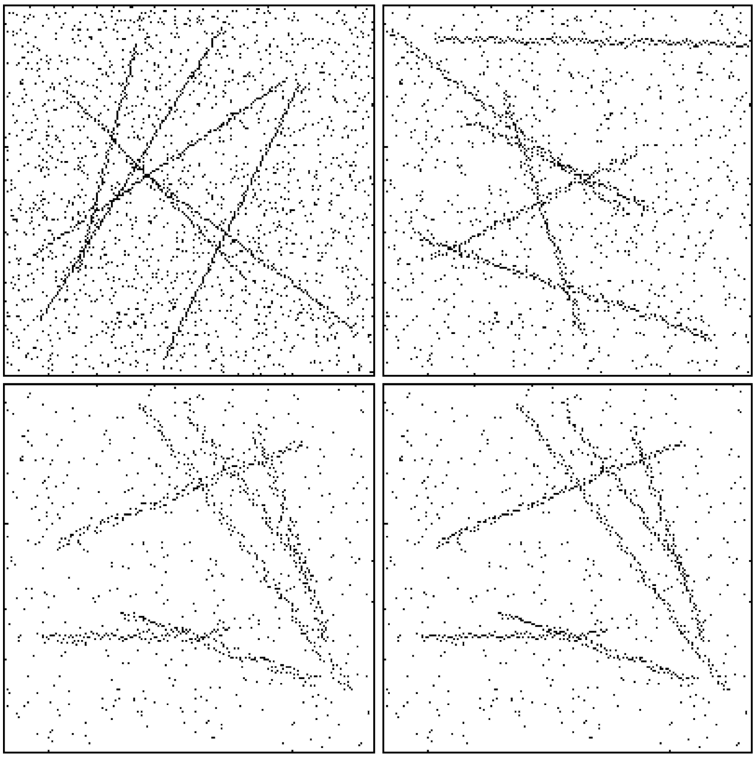

Fig. 3. Noisy line segments.