Institut für Mess- und Regelungstechnik
mit Maschinenlaboratorium
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(KIT)
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Surname: ....
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Matr.-No.: ....
Number of sheets processed: ....

Exam in „Machine Vision“

Date of exam: February 24th, 2016
Time of exam: 11:30 am to 12:30 am

Question 1 (6 points)

Let $f : \mathbb{R} \to \mathbb{R}$ be a function and $g(x) = f(x+1)$. Prove the following property of the Fourier transform:

$$\hat{g}(k) = e^{2\pi i k} \hat{f}(k)$$

Note, that $\hat{f}$ denotes the Fourier transform of the function f

Question 2 (8 points)

The figure on the right depicts a small gray level image. The numbers represent the gray value of the respective pixel. Gray values range from 0 to 7. Plot the gray level histogram for this image. Do not forget to annotate the axes.

1	1	4	6	6	7
1	2	3	5	4	5
0	1	2	3	4	3
1	0	0	2	2	1

Question 3 (6 points)

The image on the right shows a gray level ramp, i.e. the gray value linearly increases from left to right. Assume, we apply the Harris corner detector. Would it classify the pixel in the center of the image as corner pixel, edge pixel, or as a pixel in a homogeneous area? Justify your answer briefly.

Question 4 (8 points)

Which of the following properties are necessary, desirable, undesirable, or unsuitable for the error function $\rho(d)$ of an M-estimator? Assign one of the adjectives to each property and explain your answers briefly.

(a) $\rho(d) \geq 0$ for all values of d

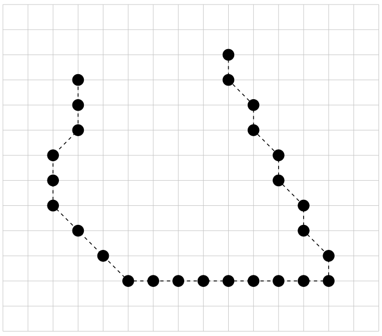
(b) $\rho(d)$ takes its minimum for $d = 2$

(c) $\rho(d)$ is decreasing for large values of d

(d) $\rho(d)$ grows more slowly than d^2

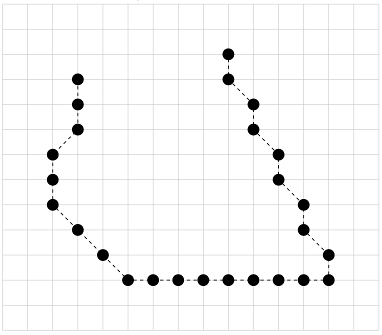
Question 5 (6 points)

The black spots in the figure on the right show a set of points on a rectangular grid. The points are ordered. The ordering is indicated by the dashed line, i.e. each point is connected to its predecessor and its successor.
Apply the Ramer-Douglas-Peucker algorithm to subdivide the set of points into subsets and create a polyline. The lateral deviation of points from the resulting polyline should be at most the width of one grid cell. Draw the initial polyline in the figure labeled with "initial polyline" and draw the intermediate polylines that are generated after each cycle of the algorithm in the figures which are labeled respectively. After how many cycles does the algorithm terminate?

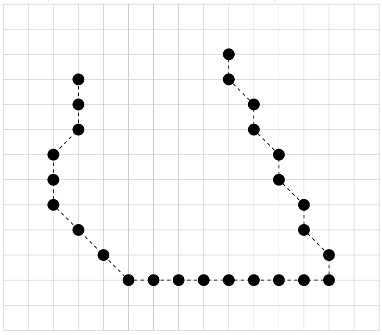


Remark: If the algorithm terminates earlier than after 8 cycles, leave the remaining figures blank.

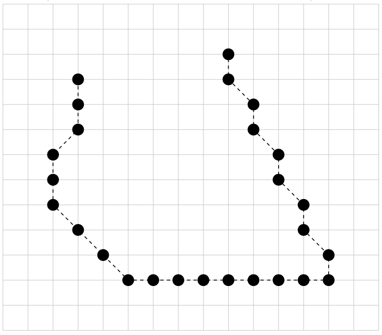
initial polyline:



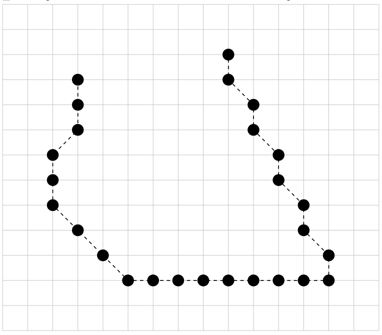
polyline after first cycle:



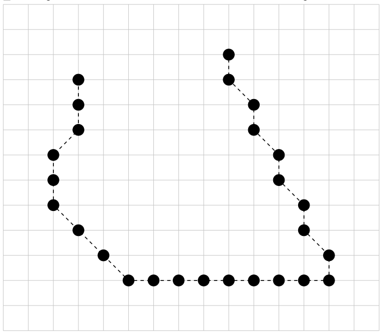
polyline after second cycle:



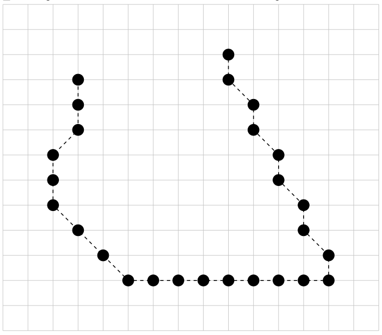
polyline after third cycle:



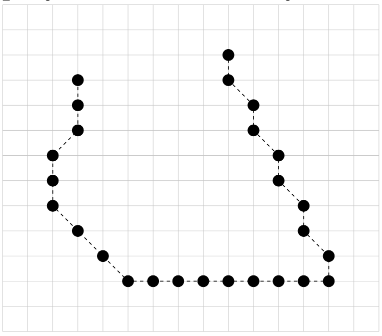
polyline after fourth cycle:



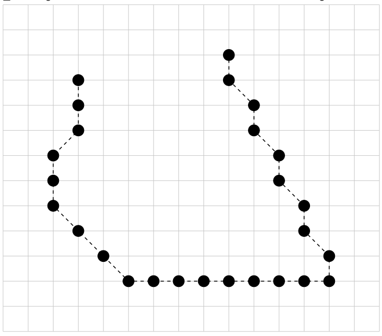
polyline after fifth cycle:



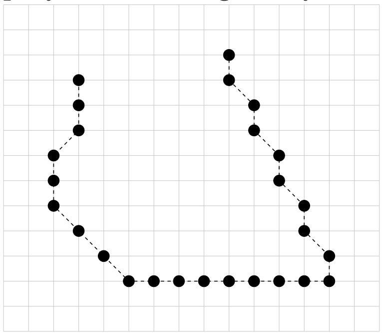
polyline after sixth cycle:



polyline after seventh cycle:



polyline after eighth cycle:



Question 6 (8 points)

Assume a level set evolution in which the boundary of the foreground segment should locally be expanded proportionally to the gray value of the pixel on the boundary, i.e. the boundary should be expanded quickly in bright areas and slowly in dark areas.

(a) Provide an evolution term $\frac{\partial \mathbf{x}}{\partial t}$ that implements this idea.

(b) Based on part (a) derive $\frac{\partial \phi}{\partial t}$. ϕ denotes the signed distance function.

Question 7 (6 points)

Assume a pinhole camera with intrinsic parameters $\alpha' = 800$, $\beta' = 900$, $(u_0,v_0) = (500{,}400)$ and skewing angle $\theta = 90°$. The camera images are 1000 pixels wide and 800 pixels high. Check which of the following points are mapped onto the camera image by the camera. The points are provided in camera coordinates. Justify your answers briefly.

(a) $(x,y,z) = (1, -8, 4)$

(b) $(x,y,z) = (1, -1, 10)$

(c) $(x,y,z) = (-1, 8, -10)$

Question 8 (6 points)

Answer the following questions and justify your answers briefly.

(a) In the hard margin case of a support vector machine (SVM), what happens if we remove the last non-support vector from the set of training examples and retrain the SVM?

(b) In the soft margin case of a support vector machine, which training examples become support vectors?

(c) Assume we have trained a support vector machine on a set of 100 training examples. 20 training examples have become support vectors. How often do we have to retrain the support vector machine at least if we want to calculate the leave-one-out error?

Question 9 (6 points)

Create a MATLAB function that implements the Histogram intersection kernel. The function should take as input two vectors `x` and `y` of the same length which represent the two histograms. The signature of the function should be:

```
function value = histogram_intersection_kernel ( x, y )
```