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Number of sheets handed in: .....

Exam in „Machine Vision“

Date of exam:	August 9, 2017
Time of exam:	11:30-12:30

Question 1 (6 points)

Assume we want to sample with a sampling interval of δ from the function f defined as

$$f(x) = 4\cos(2\pi x) + \frac{1}{2}\sin(\pi x)$$

Which condition on δ must be met to avoid Moiré patterns?

Question 2 (4 points)

Implement a MATLAB function that takes an 8-bit encoded graylevel image `IN` and returns a binary image `OUT` of the same size that satisfies the equation below:

$$\texttt{OUT(v,u)} = \begin{cases} 1 & \text{if } \texttt{IN(v,u)} \text{ is overexposed} \\ 0 & \text{otherwise} \end{cases}$$

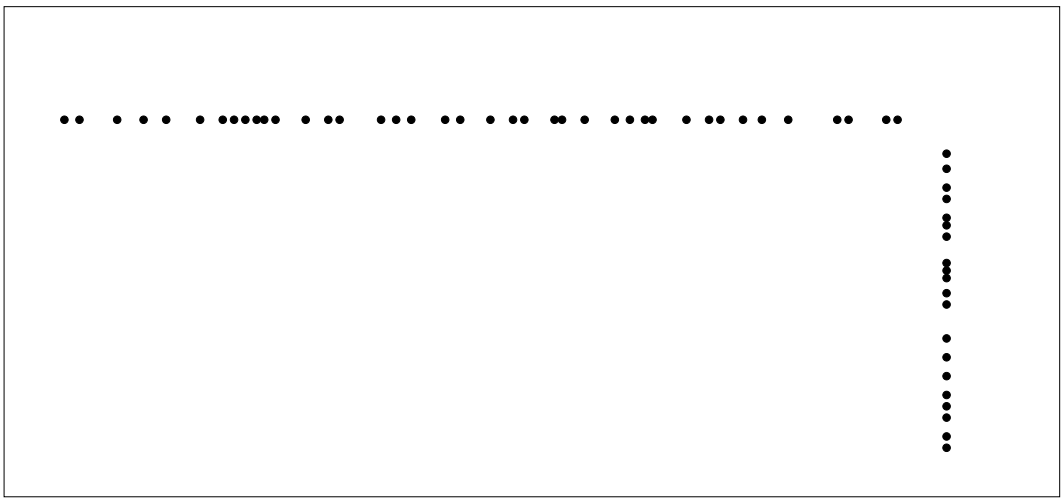
Question 3 (10 points)

The figure below shows in total 60 points in the two dimensional plane. 40 points have been sampled from a horizontal line, 20 points have been sampled from a vertical line.

(a) What would happen if we applied the total sum of least squares algorithm to fit a line to these 60 points? Which orientation would the estimated line have? Justify your answer briefly.

(b) What would happen if we applied the least trimmed sum of squares algorithm (LTS) to fit a line? In which way would the acceptance rate influence the result if we varied it between $\frac{1}{2}$ and 1? Justify your answer briefly.

(c) What is the probability that we obtain the horizontal line if we performed one trial of RANSAC? Derive or explain your solution briefly.



Remark: You may use and modify the figure above to explain your solution.

Remark: The subtasks can be solved independently.

Question 4 (8 points)

Depicted below is a square area of a color image in which color is represented in RGB values ranging from 0 to 255.

(108,100,64)	(113,111,80)
(97,89,80)	(122,100,96)

(a) Calculate the correction terms c_R and c_B for the white balance procedure that was introduced in the lecture based on these four pixels.

(b) Apply the white balance with the correction terms calculated before to a pixel with RGB values (55,80,160). What are the resulting RGB values?

Question 5 (5 points)

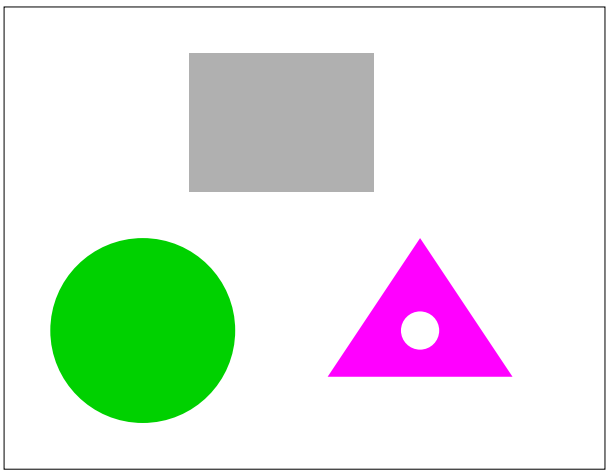
Let g be a binary image, i.e. all pixel values are either 0 or 1. Furthermore, let h_1 be the binary image that we obtain by applying the erosion operator to g and h_2 the binary image that we obtain by applying the dilation operator to h_1. Prove or disprove that $g = h_2$. For both operations, the erosion and the dilation, we use the 8-neighborhoodship.

Question 6 (8 points)

We want to segment a color image with a level set method. The image is represented in the HSV color space where $s(u,v) \in [0,1]$ refers to the saturation at pixel position (u,v). The level set evolution should shrink the foreground segment in low saturated areas and stop shrinking in highly saturated areas.

(a) Provide an evolution term $\frac{\partial \vec{x}}{\partial t}$ that implements this idea. You may assume that a signed distance function ϕ is given.

(b) The figure below shows an image with white background and three colored objects, a gray rectangle, a green circle, and a magenta triangle with a white hole. Assume we start the level set evolution with a foreground segment that contains the whole image, i.e. the boundary of the foreground segment equals the image boundary. How does the boundary of the foreground segment look like after convergence of the level set evolution? Draw the boundary into the image below.



Question 7 (7 points)

Assume a pinhole camera that is described by its matrix of intrinsic parameters

$$A = \begin{pmatrix} 500 & 0 & 1000 \\ 0 & 500 & 750 \\ 0 & 0 & 1 \end{pmatrix}$$

We want to reconstruct a 3d point P. We know, that P is mapped into the image at image position $(u,v) = (1250,500)$. Furthermore, we know, that P is located on a ball with radius $r = \sqrt{17}$ and center point $(m_x,m_y,m_z) = (0,0,1)$ in the camera coordinate system. Derive the 3d position of point P in the camera coordinate system.

Remark: The solution of an equation of the form $ax^2 + bx + c = 0$ is $x = \frac{-b \pm \sqrt{b^2-4ac}}{2a}$

Question 8 (6 points)

Are the following statements true or false? Justify your answers briefly.

(a) Support vector machines do not allow to solve non-linear classification tasks.

(b) In the soft margin case of a support vector machine, the number of support vectors is a lower bound of the number of misclassified training examples.

(c) The larger the parameter k in k-fold cross validation is, the more computational effort is required.

Question 9 (6 points)

Assume, we trained three different classifiers c_1, c_2, and c_3 for a binary classification task. We evaluated the classifiers on a test set with 50 positive examples and 50 negative examples. The positive examples are enumerated from 1 to 50 while the negative examples are enumerated from 51 to 100. The table below provides the test examples which were misclassified by the three classifiers.

(a) Calculate precision and recall for classifier c_1. You may provide the numbers in terms of fraction numbers.

(b) How many false positives and how many false negatives would an ensemble of the three classifiers c_1, c_2, and c_3 achieve?

classifier	misclassified test examples
c_1	5, 26, 42, 61, 62, 68, 99
c_2	3, 5, 49, 62, 91, 93
c_3	11, 34, 51, 62, 78, 93

Remark: The subtasks can be solved independently.