Institut für Mess- und Regelungstechnik
mit Maschinenlaboratorium
Karlsruher Institut für Technologie
(KIT)
Prof. Dr.-Ing. C. Stiller

Surname: ....
First name: ....
Matr.-No.: ....
Number of sheets handed in: ....

Exam in „Machine Vision"

Date of exam: October 14th, 2016
Time of exam: 9:00 a.m. to 10:00 a.m.

Question 1 (6 points)

Calculate the Fourier transform of the following function g:

$$g(x) = \begin{cases} 2 & \text{if } -1 \leq x \leq 1 \\ 0 & \text{otherwise} \end{cases}$$

Question 2 (6 points)

Create a MATLAB function that calculates a gray level histogram from an image. It should take as input an $n \times m$ matrix of integers between 1 and 100. The function should return as output a vector `hist` that specifies the count for each gray value, i.e. `hist(i)` should be the count for gray value `i`. The signature of the function should be:

`function [hist] = gray_level_histogram(image)`

Do not use the MATLAB built-in functions `hist` and `histogram`.

Remark: You might find the following MATLAB functions useful for this task

- `A = zeros(n,m)` creates an $n \times m$ matrix filled with zeros

Question 3 (6 points)

Create a filter mask h such that $\frac{\partial^2 g}{\partial u \partial v} \approx g * h$ for any gray value image g.

Question 4 (6 points)

Draw the curves in parameter space that are created by the Hough transform for the points $(x_1, y_1) = (200, 0)$ and $(x_2, y_2) = (0, 150)$. Do not forget to annotate the axes.
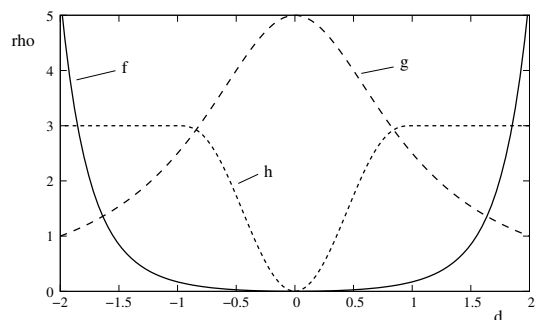
Question 5 (6 points)

Which of the three functions f, g, and h provided below can be used as error functions $\rho(d)$ of an M-estimator? The diagram on the right shows a plot of the three functions. Explain your answers briefly.

$$f(d) = \frac{1}{10}(e^{d^2} - 1)$$

$$g(d) = \frac{5}{d^2 + 1}$$

$$h(d) = \begin{cases} 3 \cdot (1 - (1 - d^2)^3) & \text{if } |d| \leq 1 \\ 3 & \text{if } |d| > 1 \end{cases}$$

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Question 6 (8 points)

The figure below shows a gray level picture with 5 rows and 6 columns. Apply the connected components labeling algorithm (CCL) to segment the image. Two gray values should be treated as similar only if they are equal, i.e. gray pixels and white pixels in the figure below are always dissimilar. Visualize the processing of CCL by inserting into each cell in the figure one of the following letters to indicate the processing step:

**N** if CCL initializes a new segment at this pixel

M if CCL merges two segments when passing this pixel

L if CCL assigns the pixel to the segment of its left neighbor, but not to the segment of its upper neighbor

U if CCL assigns the pixel to the segment of its upper neighbor, but not to the segment of its left neighbor

B if CCL assigns the pixel to the segment of its left neighbor and the left and upper neighbor already belong to the same segment

How many segments are finally found?

N	L	N	N	N	L
N	L	M	U	L	U
U	B	N	N	L	M
N	L	M	U	N	U
U	B	N	M	L	B

Number of segments finally found: **6**
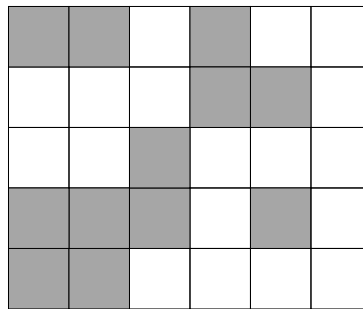
Question 7 (8 points)

The drawing below shows a camera with thin lens and an image plane. C denotes the center of the lens, F the focal point of the lens.

(a) Assume, the pinhole camera model applies to the drawn camera. In which order (from top to bottom) are the points P, Q, R, S, and T mapped onto the image plane? Explain your answer briefly in textual form or by providing a drawing. You might use the drawing on the questionnaire (i.e. the drawing below) for that purpose.

(b) Assume, the drawn camera is a telecentric camera. In which order (from top to bottom) are the points P, Q, R, S, and T mapped onto the image plane? Explain your answer briefly in textual form or by providing a drawing. You might use the drawing on the questionnaire (i.e. the drawing below) for that purpose.

(c) Explain why the lens of a telecentric camera must be at least as large as the object that should be observed with the camera.
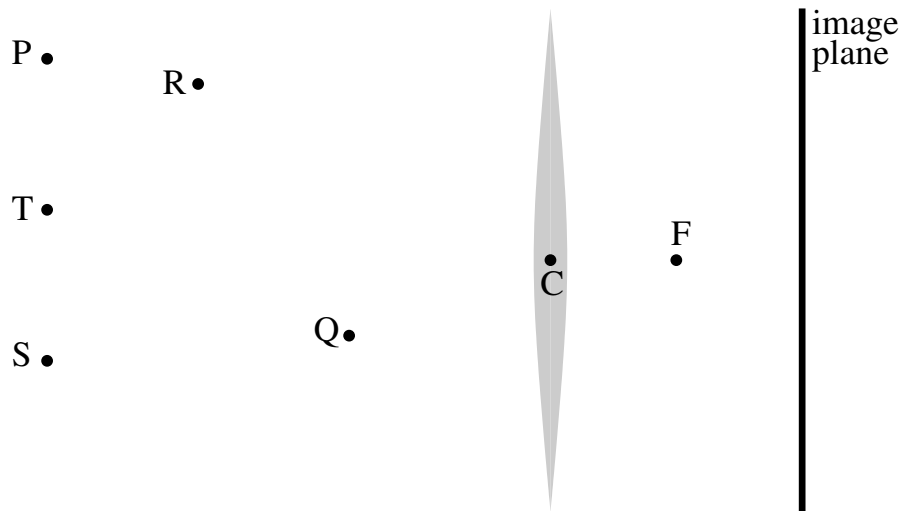
Question 8 (6 points)

Assume, we trained four different classifiers c_1, c_2, c_3, and c_4 on the same training set and evaluated all of them on the same test set. The table below provides the classification accuracy on the training and test set.

	c_1	c_2	c_3	c_4
training set accuracy	82%	89%	86%	98%
test set accuracy	82%	71%	87%	65%

Which classifier performs best? Justify your answer and discuss which of the classifiers suffer from overfitting and/or from underfitting.

Question 9   (8 points)
Which among the following properties are necessary for a kernel function K that is used in a support vector machine and which properties are not necessary? Justify your answers briefly.

(a) K must be symmetric, i.e. $K(x,y) = K(y,x)$ for all values of x and y

(b) $K(x,y)$ must always be nonnegative

(c) K must be differentiable

(d) $K(x,x) \geq K(x,y)$ must hold for any value of x and y