**Institut für Mess- und Regelungstechnik**
**mit Maschinenlaboratorium**
**Karlsruher Institut für Technologie**
**(KIT)**
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Number of sheets handed in: ...........

# Exam in „Machine Vision“

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| Date of exam: | August 7, 2018 |
| Time of exam: | 8:30-9:30 |

Question 1 (8 points)

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

$$\mathcal{F}\{f\}(x) = \mathcal{F}^{-1}\{g\}(x) \quad \text{for all } x \in \mathbb{R}$$

Note, that $\mathcal{F}\{f\}(k)$ denotes the Fourier transform of the function $f(t)$.

Question 2 (2+3+3 points)

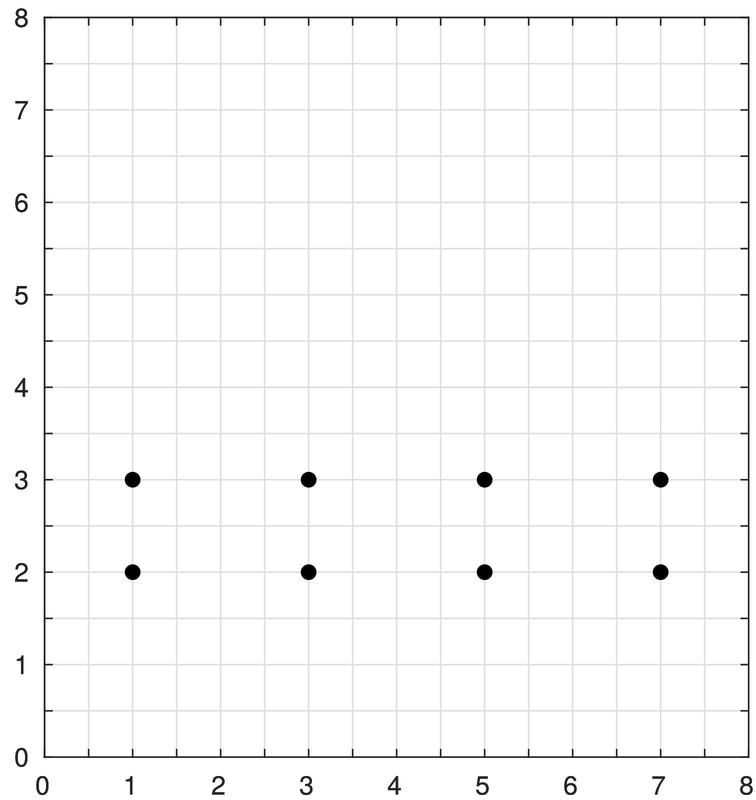
In the figure below, eight points are given that should be approximated using a line fitting algorithm.

(a) Draw the optimal solution of a total least sum of squares line fitting approximation into the figure below.

(b) Is it possible to obtain the line from part (a) using the RANSAC algorithm as introduced in the lecture? Either calculate the probability that RANSAC finds that solution in one trial or justify briefly why it is impossible.

(c) Draw all optimal RANSAC solutions with $\theta = \frac{1}{2}$. How many outliers do they have? Mark your solution of part (c) clearly so that it can be distinguished from your solution of part (a).

*Remark:* Note that the line $y = 3$ is not an optimal RANSAC solution for $\theta = \frac{1}{2}$



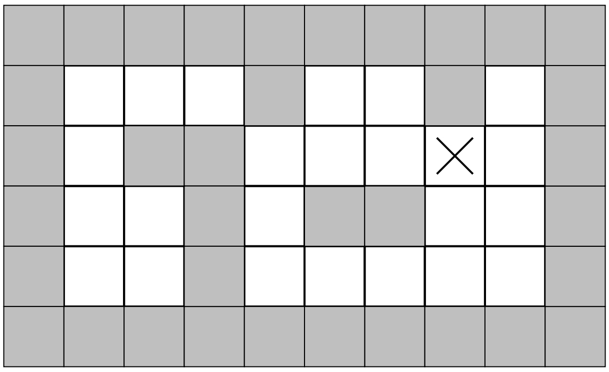
Question 3 (8 points)

In the lecture we introduced a white balance procedure for RGB encoded color images that used two correction factors $c_R$ and $c_B$ to modify the R- and B-channels while the G-channel was preserved. The disadvantage of this method is that the average image brightness changes. Modify the method in such a way that the average image brightness is preserved. For that purpose introduce a third correction factor $c_G$ to modify the G-channel. Derive values for the three correction factors $c_R$, $c_G$, and $c_B$ as functions of the average R-, G-, and B-values within a gray region of interest denoted as $\bar{R}$, $\bar{G}$, and $\bar{B}$, respectively, and the average brightness $\bar{L}$ of that area.

*Remark:* The brightness $L$ of an RGB encoded color pixel $(R,G,B)$ is calculated as $L = 0.299 \cdot R + 0.587 \cdot G + 0.114 \cdot B$. Note that $0.299 + 0.587 + 0.114 = 1$.

Question 4 (6 points)

Apply the *region growing* algorithm to the image shown in the figure below. Each pixel is either gray or white. The seed pixel is marked with a cross. Add pixels only if they share the same gray value. Use the 4-neighborhoodship (including the left, right, lower, and upper neighbor) for the growing step. Mark the added pixel with a number that describes in which region growing step the pixel has been added (start with 1 for the first region growing step). Leave all other pixels blank.



Question 5 (8 points)

Assume that we used Tsai's calibration approach to calibrate a camera. The approach returns as result for the $3 \times 4$ projection matrix $M = A \cdot (R|\vec{t})$

$$M = \begin{pmatrix} 200 & -200\sqrt{3} & 500 & 5000 \\ 200\sqrt{3} & 200 & 300 & 2600 \\ 0 & 0 & 1 & 6 \end{pmatrix}$$

where $A$ denotes the matrix of intrinsic parameters, $R$ the rotation matrix and $\vec{t}$ the translation vector between the origin of the world coordinate system and the camera coordinate system.

Calculate the translation vector $\vec{t}$.

Question 6 (2+2+2 points)

Which of the following functions can be used as kernel of a support vector machine? Justify your answers briefly.

(a) $f(x,y) = \sin x \cdot \sin y + \cos x \cdot \cos y$

(b) $g(x,y,z) = x \cdot y \cdot z$

(c) $h(x,y) = e^{-(x-y)^2}$

Question 7 (8 points)

Implement a MATLAB function that takes a graylevel image and returns the integral image. Do not use the MATLAB built-in function *integralImage*.

Question 8 (8 points)

Assume a small multi layer perceptron with two concatenated perceptrons. Both perceptrons use the ReLU activation function. Perceptron 1 takes the network input $x$ which consists out of a single real number. The output of perceptron 1 serves as the only input for perceptron 2. The output of perceptron 2 is used as network output $y$. The weights of perceptron 1 are denoted as $w_0$ (bias weight) and $w_1$ (weight for input $x$), the weights for perceptron 2 are denoted as $v_0$ (bias weight) and $v_1$. The figure below on the left illustrates the network architecture. Derive weights $w_0$, $w_1$, $v_0$, and $v_1$ such that the multi layer perceptron implements the function

$$f : x \mapsto \begin{cases} 0 & \text{if } x \leq 4 \\ \frac{x}{2} - 2 & \text{if } 4 < x \leq 8 \\ 2 & \text{if } 8 < x \end{cases}$$

which is illustrated in the figure below on the right.