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Number of sheets handed in: .....

Exam in „Machine Vision“

Date of exam: February 27, 2018
Time of exam: 11:00-12:00

Question 1 (1+3+4 points)

The figure below shows an array of grey level values organized in a single row of an image. Let $p_1 = 1.25$ and $p_2 = 2.5$ be two positions at subpixel accuracy.

(a) Interpolate the grey value at position p_1 using nearest neighbor interpolation.

(b) Interpolate the grey values at positions p_1 and p_2 using linear interpolation.

(c) If you used cubic interpolation to interpolate the grey value at p_2, would the resulting value be larger, smaller or equal to the linear interpolation result? Explain!

pixel position	1	2	3	4	5
graylevel value	83	75	75	83	95

Question 2 (8 points)

The figures below show two filter masks F and G. The origin of both masks is in the left upper pixel. Create a new filter mask H in such a way that $g * H = (g * F) * G$ for any graylevel image g.

F: $\begin{array}{|c|c|c|}\hline 1 & 0 & 2 \\ \hline 0 & 1 & 1 \\ \hline \end{array}$ G: $\begin{array}{|c|}\hline -1 \\ \hline 1 \\ \hline \end{array}$

Question 3 (2+2 points)

Assume, we want to fit a line to a set of $N \geq 2$ points in the two dimensional plane using the RANSAC algorithm. The set of points is composed out of K points which are very close to the optimal plane (inliers) with $2 \leq K \leq N$ and $N - K$ points farther away from the optimal plane (outliers).

(a) How large is the probability that RANSAC picks two inliers in a single trial?

(b) How large is the probability that RANSAC picks two inliers in at least one of $L \geq 1$ trials?

Question 4 (8 points)

Implement a MATLAB function that takes a graylevel image, applies the dilation operator onto the image, and returns the dilated image. The dilation operator should consider the 8-neighborhoodship, i.e. it should consider the direct neighbors and the diagonal neighbors of a pixel. Your implementation should at least return correct results for all pixels of the image except the boundary pixels (topmost and bottommost row, leftmost and rightmost column). Do not use the MATLAB built-in function *imdilate*.

Question 5 (6+2 points)

(a) Assume a pinhole camera and a straight line in front of the camera. The line is assumed to be orthogonal to the optical axis of the camera. Prove that the line is mapped to a straight line on the image plane by the pinhole camera.

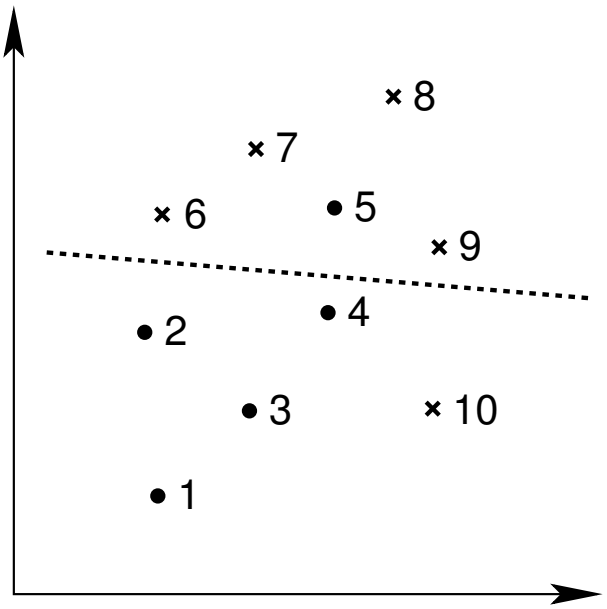
(b) Explain briefly why this property typically does not hold for cameras with lenses.

Question 6 (2+4 points)

Assume a pattern classification problem in a 2-dimensional space as depicted in the figure below. There are five positive training examples No. 1–5 and five negative examples No. 6–10. Let us assume that we use AdaBoost together with linear classifiers to solve the classification task. The dashed line in the figure below shows the linear classifier that was selected by AdaBoost in the first cycle.

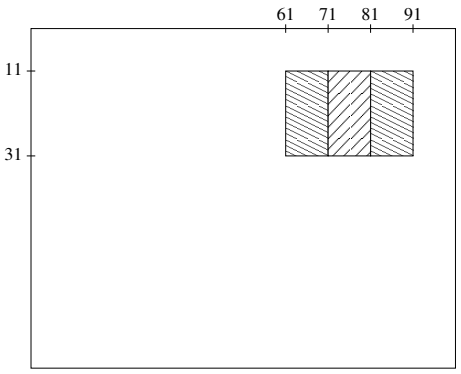
(a) For which patterns does AdaBoost increase its pattern weight γ_i in the first cycle and for which patterns does it decrease γ_i?

(b) Based on your results from part (a), which linear classifier will be selected by AdaBoost in the second cycle? Add a line to the figure that illustrates the decision boundary of that classifier. Justify your solution.



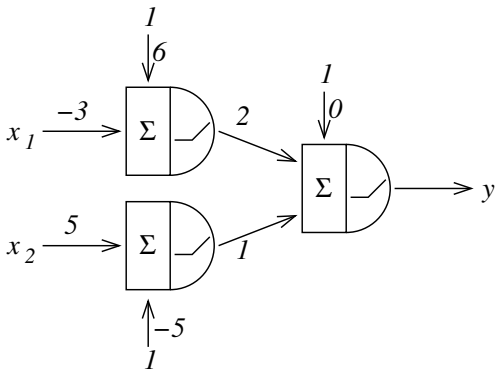
Question 7 (8 points)

Assume a Haar feature that is composed out of three rectangles as depicted in the figure on the right. The top left pixel of the leftmost rectangle has the image coordinate $(u,v) = (61,11)$, the top left pixel of the rectangle in the middle has the image coordinate $(u,v) = (71,11)$, and the top left pixel of the rightmost rectangle has the image coordinate $(u,v) = (81,11)$. All rectangles are 10 pixels wide and 20 pixels high. The Haar feature calculates the difference between the average gray value of the central area and the average of the joint left and right areas. Let $I(u,v)$ be the integral image. Provide a formula that calculates the feature value of the Haar feature given the integral image I. Simplify the formula as good as possible.



Question 8 (3+4 points)

Assume a multi layer perceptron with a two-dimensional input (x_1, x_2), two perceptrons in a single hidden layer, and one output perceptron. All perceptron use the ReLU activation function. The network structure is depicted in the figure on the right. Weights are shown as numbers next to the arrows. Bias weights are shown next to arrows that begin at the symbol "*1*".



(a) Calculate the output of the multi layer perceptron for the input vector $(x_1,x_2) = (1, -1)$

(b) Calculate for which part of the (x_1,x_2)-plane the network returns 0. You might illustrate this area in a diagram, if necessary.

Question 9 (1+2 points)

(a) How many perceptrons does an autoencoder network have in its output layer compared to its input layer?

(b) Why does an autoencoder network typically have less perceptrons in each hidden layer than in the input layer?