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Surname: ....
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Number of sheets handed in: ....

Exam in „Machine Vision“

Date of exam:	February 28, 2017
Time of exam:	13:30–14:30

Question 1 (7 points)

Let $f : \mathbb{R} \to \mathbb{R}$ be a function and $g(t) = f(\alpha \cdot t)$ with $\alpha \in \mathbb{R}$, $\alpha > 0$. Prove the following property of the Fourier transform:

$$\hat{g}(k) = \frac{1}{\alpha} \cdot \hat{f}(\frac{k}{\alpha})$$

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

Question 2 (6 points)

The figure on the right depicts a small gray level image. The numbers represent the gray value of the respective pixel. Apply the median filter to the image. The median filter should consider a block of 3×3 pixels to calculate the median. Leave the boundary pixels blank.

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

Question 3 (8 points)

(a) Which function $c(\phi)$ in parameter space is created by the Hough transform for the point $(x,y) = (0,0)$?

(b) For which image point (x,y) does the Hough transform generate the curve $c(\phi) = -100 \cdot \sqrt{2} \cdot \sin(\phi + \frac{\pi}{4})$ in parameter space?

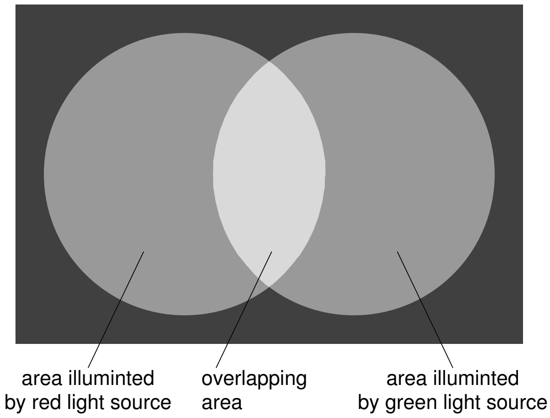
Remark: $\sin(\frac{\pi}{4}) = \sin(\frac{3\pi}{4}) = \frac{1}{2}\sqrt{2}$

Remark: you might apply appropriate values for ϕ to solve the task

Remark: The subtasks can be solved independently.

Question 4 (6 points)

Assume that a white surface is illuminated by two light sources, a red light source and a green light source as depicted in the figure below. There are no other light sources involved. Explain why humans perceive the color of *yellow* in the overlapping area which is illuminated by both light sources.



Question 5 (6 points)

Create a potential function ϕ for a random field based image segmentation that models that pixels close to the left boundary of the image more likely belong to the segment labeled with 1 while the other pixels more likely belong to the segment labeled with 0. ϕ should depend on the position of a pixel (u,v) and its label $l(u,v)$ where u denotes the image column and v the image row.

Question 6 (6 points)

Assume a pinhole camera with intrinsic parameters $\alpha' = \beta' = 500$, $(u_0, v_0) = (300,200)$, and skewing angle $\theta = 90°$. The images of the camera are 600 pixels wide and 400 pixels high. Assume that we rescale the images to half width and half height, i.e. the scaled images are 300 pixels wide and 200 pixels high. What are the values of α', β', u_0, and v_0 for the scaled images? Explain your solution.

Question 7 (8 points)

Which of the following strategies are appropriate to improve the classification performance of a classifier? Justify your answers briefly.

(a) collect additional examples and add them to the set of training examples

(b) add all validation examples to the set of training examples

(c) generate variations of the existing training examples by rotating the examples slightly

(d) randomly change the label of a subset of the training examples

Question 8 (7 points)

Assume that we trained a Support Vector Machine (SVM) on the three one-dimensional training examples that are given in the table below. The SVM uses the kernel function

$$K(x,y) = (x \cdot y + 1)^2$$

The SVM solver provides the Lagrange multipliers α_i for all training examples that are listed in the fourth column of the table below.

(a) Calculate the margin ρ of the trained SVM

(b) Caluclate the bias weight b of the trained SVM

pattern No.	class label $d^{(i)}$	pattern $x^{(i)}$	Lagrange multiplier α_i
1	$+1$	2	$\frac{2}{11}$
2	-1	1	$\frac{2}{11}$
3	-1	0	0

Question 9 (6 points)

Implement a MATLAB function that takes a gray level image and adds jitter (stochastically independent random noise). The jitter should be generated from a Gaussian distribution with zero mean and given standard deviation. The signature of the function should be:

```
function [ J ] = add_jitter ( I, sigma )
```

where `I` is the input image, `sigma` is the standard deviation of the Gaussian distribution, and `J` is the resulting image.

Remark: You might find the following MATLAB functions useful for this task:
`M = normrnd(mu,sigma,m,n)` generates an $m \times n$ matrix of random numbers independently generated from a Gaussian distribution with expectation value `mu` and standard deviation `sigma`. The third and fourth argument `m` and `n` are optional. If they are not provided to the function, it returns a single random number.