Technische Universität Berlin

Computer Vision &
Remote Sensing

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Examination

Digital Image Processing

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Name: ..... **Student ID:** .....

Duration: 90 minutes **Auxiliary material:** None

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1 Image function and histograms **14P**

a) Fig.1i) shows the relative gray-scale **histogram** of the image shown in Fig.1a). 10P
Fig.1b)-f) show the results of five different **image transformations** applied to the image in Fig.1a). **State** which image transformation was applied and which of the histograms depicted in Fig.1ii)-vi) corresponds to the given images. Please assign each histogram of Fig.1.ii)-vi) to exactly one image in Fig.b)-f).

b) Give a **detailed explanation** of „histogram equalization“ including its purpose. 4P

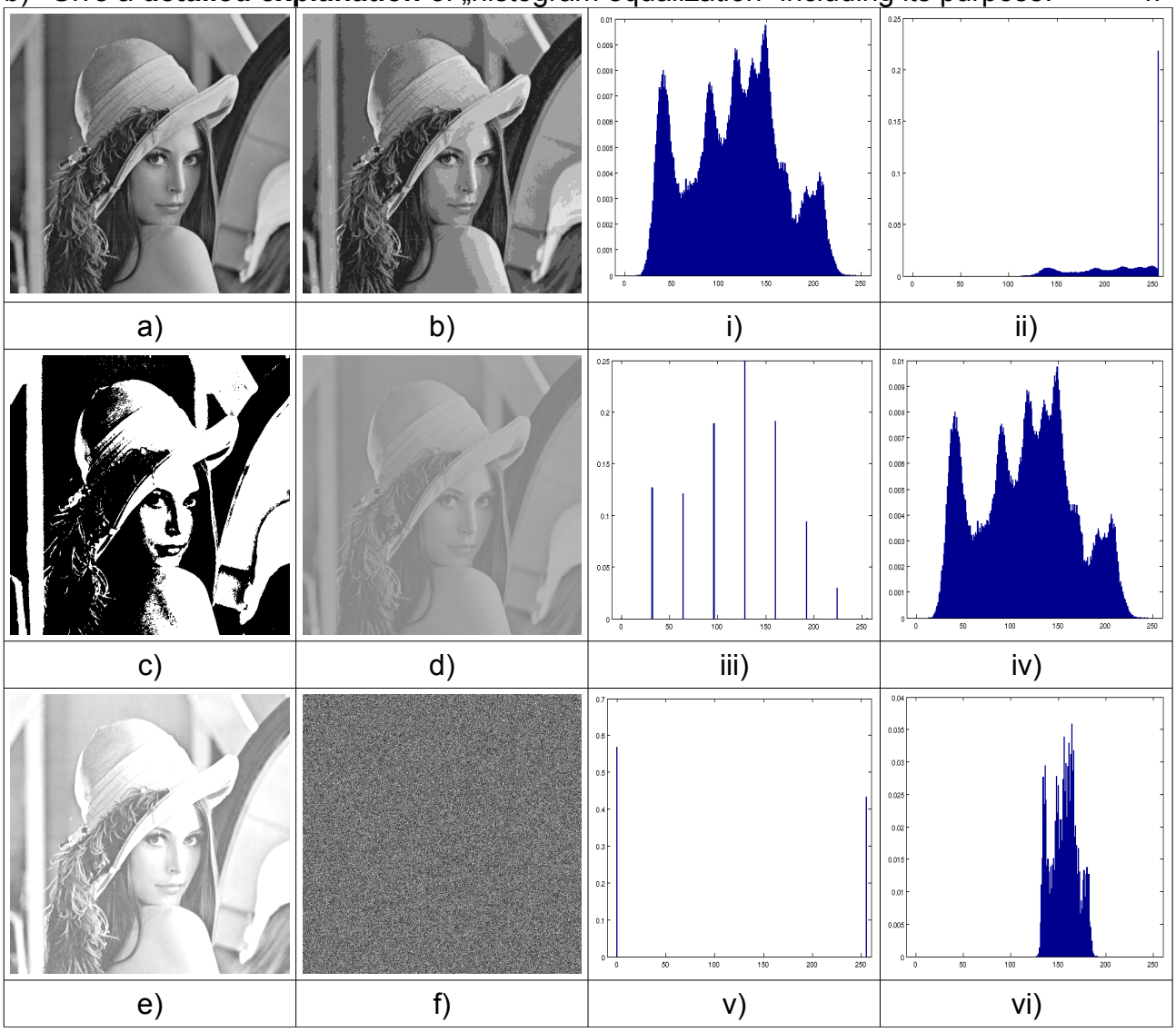

Figure 1

2 Image filtering 19P

a) State the filter kernel of the **Sobel** operator in x- and y-direction. 1P

b) How is the **structure tensor** of an image defined? 5P

Use the **Sobel** operator as defined in 2.a) to calculate the structure tensor of the center pixel in Fig.2.

Use a spatial neighborhood of **3x3 pixels** and provide numerical results of all necessary steps.

0	0	0	0	0
0	0	1	0	0
0	1	1	1	0
0	0	1	0	0
0	0	0	0	0

Figure 2

c) Based on the computed structure tensor calculated in 2.b) calculate the cornerness as defined by the **Plessey/Harris operator**. 2P

d) How is the convolution theorem defined and is it reasonable to be applied during application of the Sobel operator? 2P

e) **Explain** the idea, purpose, and application of **separable filters** with the Sobel operator as an example. 3P

f) Figures 3a)-c) show three different images, while Figures 3i)-vi) depict the **amplitude** of six different Fourier spectra. State which of the given spectra corresponds to which of the images. Note: A spectrum can be assigned multiple times and not all spectra have to be used. 3P

g) What is the **ringing effect** in the context of image filtering? 3P
How is it caused and how can it be avoided?

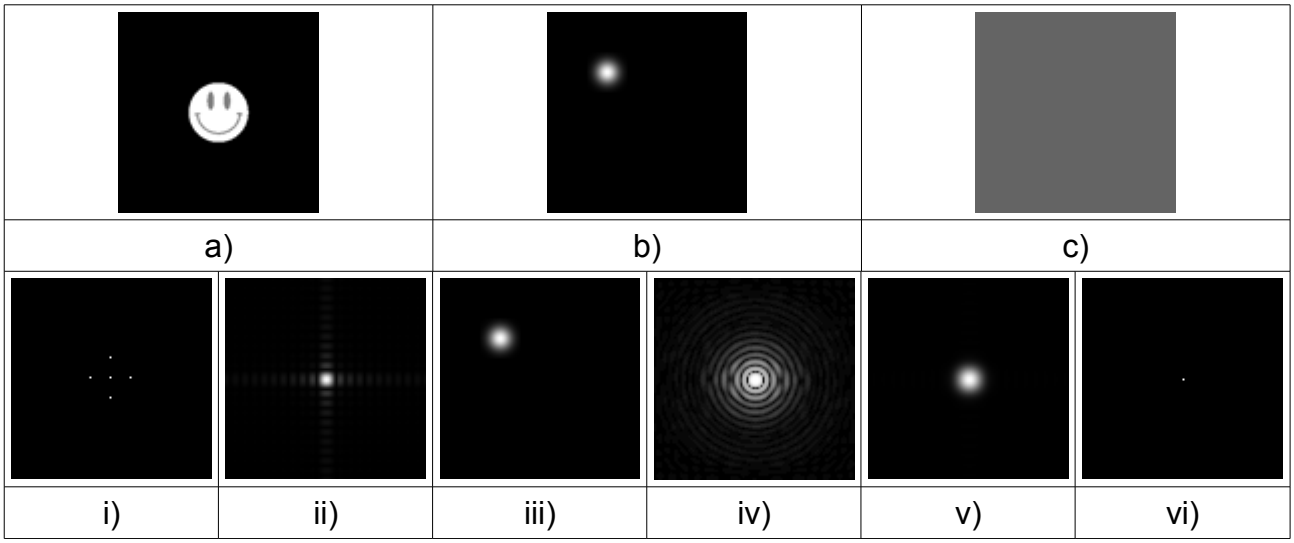

Figure 3

3 Image restoration 12P

a) Explain the **inverse filter** starting by the underlying **signal model** including inherent limitations and possible adaptions to cope with them. 5P

b) The signal model of an image $\boldsymbol{s}$ is known to be $\boldsymbol{s = h \otimes (o+n)}$, where $\otimes$ means convolution, $\boldsymbol{o}$ is the original image and $\boldsymbol{n}$ a random noise term. 2P
Will the inverse filter **improve the image quality**? Explain your answer.

c) Under which circumstances is the **Wiener filter** equivalent to the inverse filter? 3P
Give a mathematical proof of your answer.

d) The Wiener filter depends on the usually unknown **signal-to-noise ratio** as well as the **point spread function** of the degradation. Explain how these two quantities can be estimated. 2P

A total of **45 points** can be attained.

A short and accurate style as well as a clear handwriting should be intended.
Pay attention to a clear and comprehensible preparation of sketches.

Lot's of luck and do your best!