Technische Universität Berlin

Computer Vision
& Remote Sensing

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Examination

Optical Remote Sensing

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

Duration: 90 minutes   **Auxiliary Material: none**

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1. Data in Spectral Domain (5 points)

Suppose a given set of image data consists of just two bands, one centered on 0.65 μm and the other centered on 1.0 μm wavelength. Suppose the corresponding region on the earth's surface consists of water, vegetation and soil.

Construct a graph with two axes, one representing the brightness of a pixel in the 0.65 μm band and the other representing the brightness of the pixel in the 1.0 μm band. Show on this graph (we might call it the spectral domain) where you would expect to find vegetation pixels, soil pixels and water pixels. Indicate how straight lines could, in principle, be drawn between the three groups of pixels so that, if a computer had the equations of those lines stored in its memory, it could use them to identify every pixel in the image.

2. Histogram Equalization (6 points)

a) (3 points)

Derive mathematically the function that equalizes the histogram of an image having a histogram shaped like a Gaussian probability density function

$$N_{\mu=127.5,\sigma=42.5}(x)$$

centered at the center of the brightness value range [illegible], with the extreme values of the range being three standard deviations 3 σ=3 * 42.5 from the mean, i.e. covering the interval [0,255].

Hint: You do not need to write the complete Gaussian formula. Do only use $N_{\mu=127.5,\sigma=42.5}(x)$ as a symbol for the Gaussian in your formula.

b) (3 points)

What is the theoretical shape of the cumulative histogram H(X<x) of an image that has been histogram equalized? Draw a sketch of the cumulative histogram.

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3. Supervised Classification (6 points)

Suppose you have been given the training data in the table below for three spectral classes, in which each pixel is characterized by only two spectral bands λ_1 and λ_2. Imagine to use a maximum likelihood classifier to classify the pixels

$$\mathbf{x}_1 = \begin{bmatrix} 5 \\ 9 \end{bmatrix} \qquad \mathbf{x}_2 = \begin{bmatrix} 9 \\ 8 \end{bmatrix} \qquad \mathbf{x}_3 = \begin{bmatrix} 15 \\ 9 \end{bmatrix}$$

Explain the classification procedure step by step. Decide to which class each pixel belongs using your maximum likelihood classifier. Justify your decision why you prefer a class over the next (according to your decision somewhat less) probable class.

Class 1		Class 2		Class 3	
λ_1	λ_2	λ_1	λ_2	λ_1	λ_2
16	13	8	8	19	6
18	13	9	7	19	3
20	13	6	7	17	8
11	12	8	6	17	1
17	12	5	5	16	4
8	11	7	5	14	5
14	11	4	4	13	8
10	10	6	3	13	1
4	9	4	2	11	6
7	9	3	2	11	3

Hint: Plot the data!

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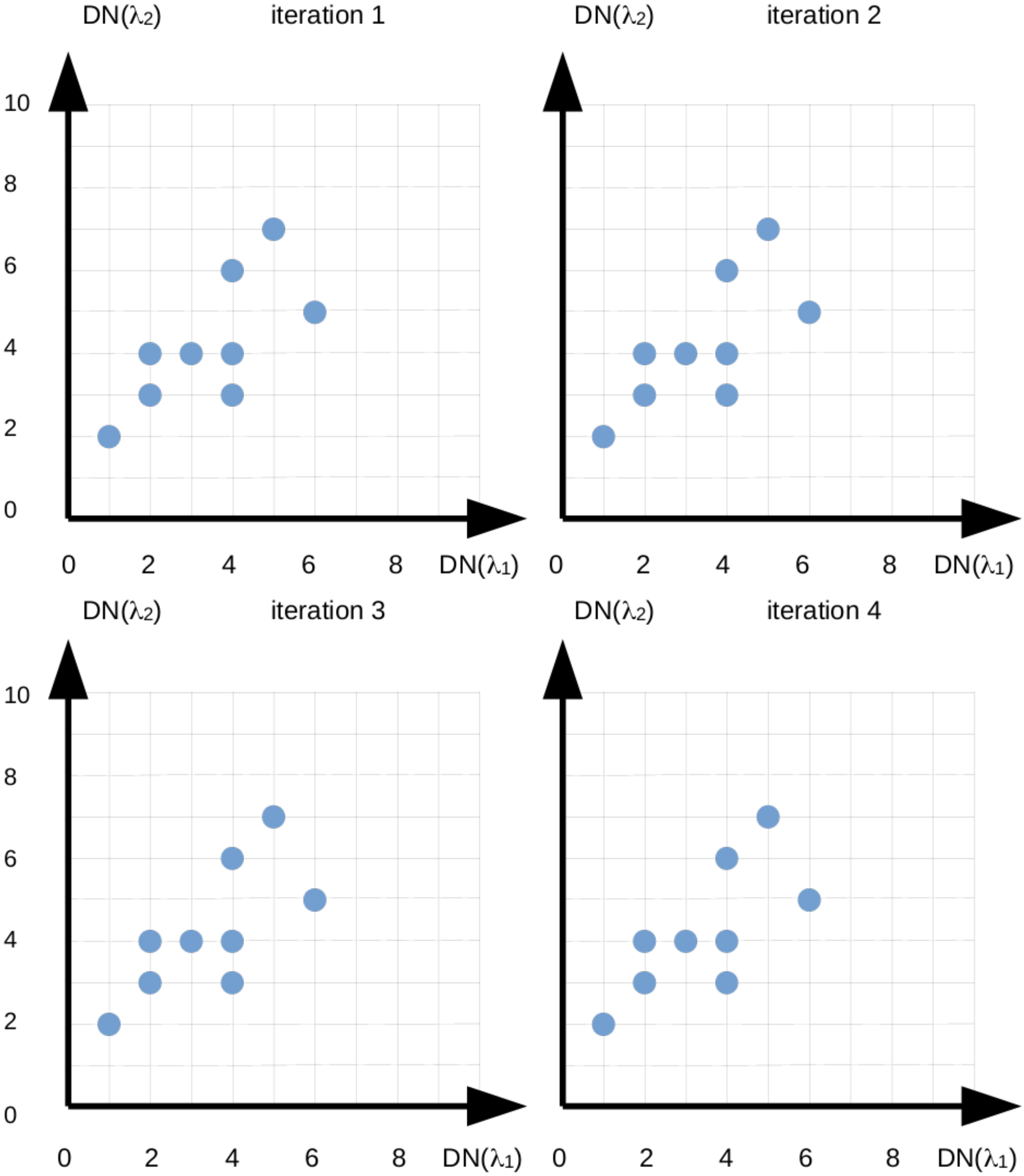
4. Clustering (8 points)

a) (6 points)

The locations of pixels in a two-band spectral domain are shown in the figure below. Set three initial cluster centers at

$$\mathbf{x}_4 = \begin{bmatrix} 1 \\ 1 \end{bmatrix}, \quad \mathbf{x}_5 = \begin{bmatrix} 3 \\ 3 \end{bmatrix} \quad \text{and} \quad \mathbf{x}_6 = \begin{bmatrix} 5 \\ 5 \end{bmatrix}$$

and apply the k-means clustering algorithm in at most 4 iterations graphically (use the figure below). Describe the algorithm step by step. (DN(..): digital number/gray value in band ..)



b) (2 points)

Did the algorithm converge? Justify your answer.

Give another commonly used name for the k-means algorithm as used by you.

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5. Image Classification in Practice (7 points)

Three analysts use different qualitative methodologies for interpreting spectral imagery. The methodologies are summarized below. Comment on the advantages and disadvantages of each approach and indicate which one do you think is most effective. Give reasons for your decision.

Analyst 1

1. Chooses training data from homogeneous regions of each cover type.
2. Computes statistics for a maximum likelihood classifier from the regions.
3. Classifies the image.

Analyst 2

1. Performs a clustering of the whole image and attaches labels to each cluster type afterwards.

Analyst 3

1. Chooses several regions within the image, each of which includes more than one cover type.
2. Clusters each region and identifies the cluster types.
3. Uses statistics from the clustering step to perform a maximum likelihood classification of the whole image.

Sum: 33 points

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