Technische Universität Berlin

Computer Vision
& Remote Sensing

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**Examination**

# Optical Remote Sensing

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

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

Berlin, 19 February 2018

Write your **name** and **student ID** in the corresponding places at the top of this page **now**.

Books, notes, dictionaries, own empty sheets of paper, and pocket calculators are **not allowed**.
**Use only a pen.** Everything written with a pencil will not be taken into account.

If you do not understand a question, please **ask**.
It will be to your advantage to read the entire examination before beginning to work.

## 1. Radiation (8 points)

a) How is a black body defined? (1 point)

b) Which natural object approximates a black body reasonably well? (1 point)

c) Roughly sketch the solar spectrum (spectral irradiance) at sea level as a function of wave length. (2 points)
Numerically indicate in your sketch at which wavelength interval human beings are seeing.

d) Which components of the atmosphere cause absorption bands in the solar spectrum at sea level? (1 point)

e) Draw roughly the spectral signature (reflectance as a function of wave length) of: (3 points)
1) healthy green vegetation,
2) bare soil, and
3) water.
For each case, indicate the lowest and highest reflectance.

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## 2. Satellite Remote Sensing Sensors (12 points)

An opto-electronic sensor has 20000 CCD elements with a size of 5 μm each. The ground pixel size is approximately 5 m by 5 m. The sensor is mounted on a satellite, flying at an altitude of 500 km. Answer the following questions:

a) Describe an opto-electronic sensor.
Use a sketch, and indicate all necessary parameters. (3 points)

b) Calculate the size of the swath. A detailed answer is expected. (2 points)

c) Deduce from above the focal length of the system.
A detailed answer is expected. (2 points)

d) Give two orbit types remote sensing satellites typically have,
and describe them. (2 points)

e) With respect to remote sensing images, what is (3 points)
- spectral,
- spatial, and
- temporal resolution?

## 3. Remote Sensing Image Processing (5 points)

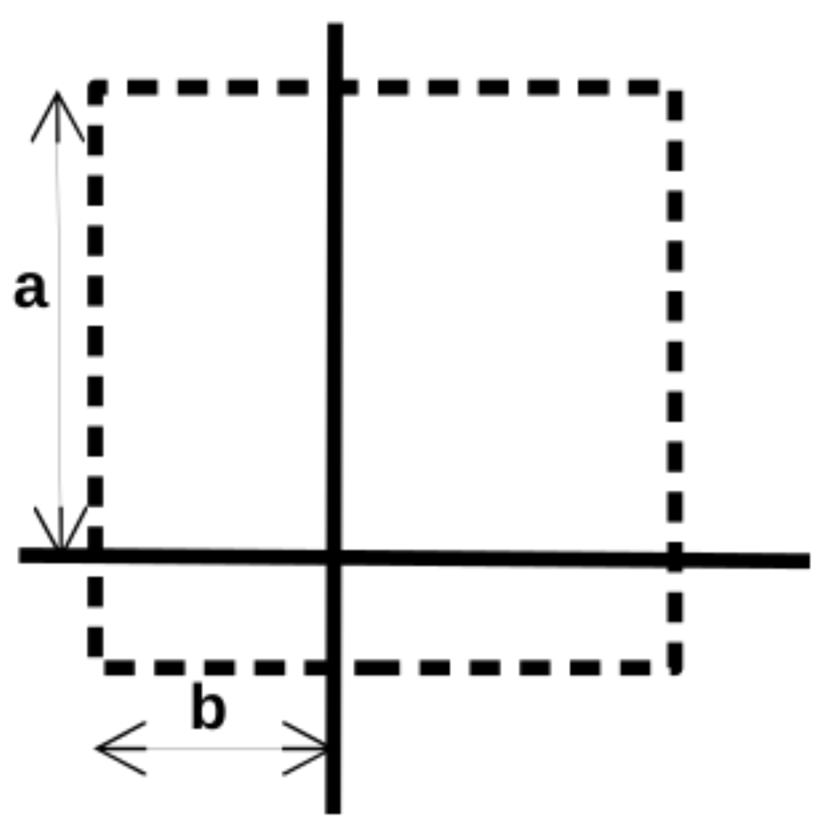
Remote sensing images frequently have to be resampled. Then the new image's pixel values are interpolated at non-integer positions in the given images pixel grid.

a) A frequently used interpolation method is bilinear interpolation.
Explain bilinear interpolation verbally. (2 points)

b) Derive a formula for bilinear interpolation. (3 points)
For your derivation use the sketch below.
In your derivation use the following variables:

$g_1, g_2, g_3, g_4$: grey values of the pixels located in the grid points of the dashed grid. I.e. the pixel centers are in the corner points of the dashed square.

a, b: Fractions of the pixel's size by which the new pixels location (cross drawn with continuous lines) is shifted against the input image's grid. E.g. a=0.8, b=0.4.



## 4. Supervised Land Use Classification (5 points)

a) List and describe the steps of supervised classification. (3 points)

The training data in the table below describe two spectral classes in two spectral bands $\lambda_1$ and $\lambda_2$. Assume a maximum likelihood classifier is used to classify the pixel

$$\mathbf{x} = \begin{bmatrix} 8 \\ 9 \end{bmatrix}$$

Make two decisions:

b) To which class does the pixel belong,
if a maximum likelihood classifier is used? Justify your decision. (1 point)

c) To which class does the pixel belong,
if a minimum distance classifier is used? Justify your decision. (1 point)

| Class 1 | | Class 2 | |
|---|---|---|---|
| $\lambda_1$ | $\lambda_2$ | $\lambda_1$ | $\lambda_2$ |
| 4 | 5 | 8 | 12 |
| 5 | 6 | 10 | 10 |
| 6 | 7 | 11 | 9 |
| 3 | 4 | 8 | 11 |
| 5 | 5 | 9 | 10 |
| 6 | 6 | 10 | 11 |
| 7 | 8 | 12 | 8 |

**Hint:** Plot the data!

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## 5. Hyperspectral Remote Sensing (5 points)

a) What is a hyperspectral remote sensing image - as opposed to a (much more frequently used) multi-spectral remote sensing image? (1 point)

Linear spectral unmixing is a method used in hyperspectral remote sensing in order to determine the how large the fraction of so-called "end members" for each pixel is (in percentage).

In order to keep the following calculations simple we assume the hyperspectral remote sensing image has only two channels. The reflectance values of the three end members "grass", "sand" and "rock" are given in the table below

| Grass | | Sand | | Rock | |
|---|---|---|---|---|---|
| $\lambda_1$ | $\lambda_2$ | $\lambda_1$ | $\lambda_2$ | $\lambda_1$ | $\lambda_2$ |
| 5 | 20 | 9 | 12 | 12 | 15 |

An observed pixel has reflectance values $\lambda_1$=10 and $\lambda_2$=15.

b) Compute the fraction each end member covers. (4 points)

**Hint:** Consider elimination method.

**Sum: 35 points**

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