Adjustment of Observations - BMEEOAFMF53

I. Subject Specification

1. Basic Data

1.1 Title

Adjustment of Observations

1.2 Code

BMEEOAFMF53

1.3 Type

Module with associated contact hours

1.4 Contact hours

Type	Hours/week / (days)
Lecture	2
Seminar	1

1.5 Evaluation

Exam

1.6 Credits

4

1.7 Coordinator

name	Dr. Gyula Tóth
academic rank	Associate professor
email	toth.gyula@emk.bme.hu

1.8 Department

Department of Geodesy and Surveying

1.9 Website

https://epito.bme.hu/BMEEOAFMF53
https://fiek2.mywire.org/course/view.php?id=3480

1.10 Language of instruction

hungarian and english

1.11 Curriculum requirements

Compulsory in the Specialization in Structural Engineering (BSc) programme

1.12 Prerequisites

Recommended prerequisites:

- Numerical Methods (BMEEOFTMK51)

1.13 Effective date

1 September 2021

2. Objectives and learning outcomes

2.1 Objectives

The aim of the course is to provide the student with knowledge of modern procedures for solving common measurement processing tasks in the field of surveying and GIS engineering. Students will be able to choose the appropriate methods for their own tasks and apply the computer tools learned in the subject in a creative way. The course also aims to introduce students to the specifics of each measurement processing procedure through some specific examples.

2.2 Learning outcomes

Upon successful completion of this subject, the student:

A. Knowledge

1. is familiar with the most important quantities used to describe the characteristic value and uncertainty of the measurement data (mean, mode, median, most frequent value, standard deviation, uncertainty, dihesion, interquartile and intersextile half-width),
2. understands the fundamental role of statistical efficiency in estimates in terms of the amount of data required to achieve a given accuracy,
3. understands the difference between the traditional and Bayesian statistical approaches,
4. is familiar with the possibilities of using Monte-Carlo methods for estimating the uncertainty of measurement data sets,
5. is aware of the relationship between the standard error in geodesy and the measurement uncertainty used in metrology and the principle and means of determining the measurement uncertainty according to the GUM (Guide to the Expression of Uncertainty in Measurement) specifications,
6. understands the essence of integer least squares estimation procedures and is aware of their application to the processing of GNSS measurements,
7. understands the basic idea of Kálmán filtering and is aware of its geodetic applications,
8. knows the concepts of robustness and resistance, understands the principle of maximum likelihood estimates,
9. is familiar with the most important methods of estimating PSD (power spectral density) of time series,
10. is aware of the basic idea of RANSAC (random sample consensus) estimation and the main steps of the procedure.

B. Skills

1. is able to determine the most characteristic value of a measurement data set and the most important quantities characterizing the uncertainty of the data set (mean, mode, median, most frequent value, standard deviation, uncertainty, dihesion, interquartile and intersextile half-width),
2. be able to examine the type of distribution of any data system and give correct interpretation of the result of the statistical test,
3. is able to determine the measurement uncertainty according to the GUM specifications in simpler cases with the help of software suitable for the task,
4. is able to process the measurements of a simple GNSS network compiled by others independently with the help of suitable software,
5. able to estimate the PSD of time series data, to interpret the PSD,

6. it is also able to perform Kálmán filtering in the case of a linear task on its own.

C. Attitudes

1. understands the fundamental importance of robustness, statistical efficiency in the field of measurement processing,
2. open to a Bayesian statistical approach to data processing,
3. receptive to the knowledge and application of modern, efficient data processing procedures,
4. seeks to evaluate the advantages and disadvantages of various measurement processing procedures for the given task.

D. Autonomy and Responsibility

1. independently analyzes simple tasks and problems arising in the field of processing geodetic and GIS measurements, solving them on the basis of the given sources and samples,
2. openly accept substantiated critical remarks.

2.3 Methods

Lectures and computer exercises. Use of computer presentations and interactive graphic web worksheets.

2.4 Course outline

Week	**Topics of lectures and/or exercise classes**
1.	Determination of most frequent value and measurement uncertainty
2.	Cramer-Rao bound, statistical efficiency, statistical tests
3.	Introduction to Bayesian statistics
4.	Monte-Carlo procedures, measurement uncertainty based on GUM
5.	Processing of GNSS measurements, integer LKN procedures
6.	Sequential adjustment and adjustment in groups, processing with Bernese
7.	Photogrammetric bundle and DLT adjustment
8.	Kalman filtering in the linear case
9.	Kalman filtering in the nonlinear case
10.	Characterization of time series in the frequency domain. PSD and its estimation
11.	Maximum likelihood estimates
12.	The concept and role of robustness and resistance
13.	Data processing with RANSAC
14.	Determination of functions, processing point cloud data

The above programme is tentative and subject to changes due to calendar variations and other reasons specific to

the actual semester. Consult the effective detailed course schedule of the course on the subject website.

2.5 Study materials

a) Downloadable materials:

- Manuals for applied programs, web help, forums ... etc.
- Interactive workbooks on the subject's github page (https://github.com/gyulat/adjustment_computations)

b) presentations, descriptions, tasks in the educational framework
c) other materials:

- Vanicek P., Krakiwsky E. J.: Geodesy: The Concepts, Part III: Methodology (North-Holland, 1986)
- Steiner F. (ed.): The most frequent value. Introduction to a modern concept of statistics. Akadémiai Kiadó, Budapest, 1991. ISBN-10: 9630556871
- Steiner F. (ed.): Optimum Methods in Statistics. Akadémiai Kiadó, Budapest, 1997. ISBN 10: 963057439X
- Szabó, N. P.: Geostatistics. Lecture slides. Univ. of Miskolc, online: https://www.uni-miskolc.hu/~geofiz/Geostatistics.pdf

2.6 Other information

During the teaching and learning of the subject we use almost exclusively freely available software.

2.7 Consultation

Consultation dates: as specified on the website of the department or in consultation with the lecturers of the subject by e-mail.

This Subject Datasheet is valid for:

2023/2024 semester I

II. Subject requirements

Assessment and evaluation of the learning outcomes

3.1 General rules

The assessment of the learning outcomes set out in 2.2 is based on a written exam, 2 homework assignments and 1 midterm test.

3.2 Assessment methods

Evaluation form	Abbreviation	Assessed learning outcomes
Written exam (summary performance evaluation)	E	A.1-A.10; B.1-B.4; C.1-C.4; D.1
Homework 1 (small homework, partial performance evaluation)	HW1	A.9; B.5; D.2
Homework 1 (small homework, partial performance evaluation)	HW2	A.7; B.6; C.3; D.2
Midterm test (partial performance evaluation)	MT	A.1-A.6; B.1-B.4; C.1; D.1

The dates of deadlines of assignments/homework can be found in the detailed course schedule on the subject's website.

3.3 Evaluation system

Abbreviation	Score
HW1	10%
HW2	10%
MT	30%
Total during the semester:	50%
E	50%
Sum	**100%**

3.4 Requirements and validity of signature

The requirement for obtaining the signature is that according to 3.3., the student must complete all the homeworks at a sufficient level (50%). We do not prescribe a condition for the success of the midterm test.

3.5 Grading system

Grade	Points (P)
excellent (5)	80<=P
good (4)	70<=P<80
satisfactory (3)	60<=P<70
passed (2)	50<=P<60
failed (1)	P<50

3.6 Retake and repeat

1) The midterm test is not compulsory, therefore no re-takes are possible.
2) Homework - in addition to paying the fee specified in the regulations - can be submitted late until 16:00 on the last day of the delayed submission week or sent electronically until 23:59.

3) The submitted and accepted homework can be corrected free of charge till the deadline and in the manner specified in point 2.

3.7 Estimated workload

Activity	**Hours/semester**
participation in contact classes	14×3=42
mid-term preparation for practice classes	14×1=14
preparation for tests	10
preparation of homeworks	5+5=10
preparation for the exam	40
Sum	**120**

3.8 Effective date

1 September 2021

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2023/2024 semester I