Prof. Dr.-Ing. Reiner Jäger

Satellite Geodesy, Mathematical Geodesy, Adjustment, Software-Development and Surveying

HOCHSCHULE KARLSRUHE TECHNIK UND WIRTSCHAFT (HSKA)
FAKULTÄT FÜR GEOMATIK
INSTITUT FÜR ANGEWANDTE FORSCHUNG (IAF)

Moltkestrasse 30, D-76133 Karlsruhe.
Tel.: 0721 925 2620
Email: reiner.jaeger@hs-karlsruhe.de
Research-URLs: www.goca.info, www.monika.ag, www.moldpos.eu, www.navka.de

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Seminar (Lectures and Exercises)

TPQ Geomatics Project

http://www.hochschulkontor.lv/en/projects/projects-2012/73

on

Geodetic Monitoring

Monday 11-June-2012 to 13-June 2012

Riga Technical University (RTU)
Faculty of Civil Engineering
16/20 – 238A Azenes Street, Riga, LV-1048, LATVIA

Seminar - Contents and Targets

In the lectures the attendants learn about the present profile, the geomonitoring chain (sensor control and data-acquisition, modelling, reporting and alarm-management) and intensively about the mathematical models and background of scaleable multi-sensor (GNSS, LPS, LS[2]) geodetic monitoring systems. The application domains are geodynamics, geology, geotechnics, mining, monitoring of constructions and buildings, GNSS-services reference-stations monitoring, disaster prevention and forecasting and early warning systems. The full spectrum of mathematical models for the estimation of different kind of deformation state vectors and of different kind estimation principles in geodetic deformation networks are treated. The observation and coordinate related adjustment approaches are unified, and the benefits and necessities of a separate use in different profiles are explained. Further quality control concept and statistically based concepts for forecasting and alert setting in real-time (e.g. displacement estimation, Kalman-Filtering) are treated in the lectures.

[1] **Geomatics in Cross-Section of Theory and Practice**
[2] Local Sensors, e.g. Geotechnical Sensors (Strain-meters, Inclinometers)

In the exercise presentations of the software MONIKA (GNSS Reference Station Monitoring in the Karlsruhe Approach) and GOCA (GNSS/LPS-based Online Control and Alarm) are presented. The focus of the applications are demonstrations and exercises of GOCA system It comprises a set up of both of simulation scenarios as well of real sensor-networks, real-time data acquisition and monitoring using the GOCA system, as well as deformation analysis and alarming in the local environment by using total-stations as sensors.

The lectures and exercises are addressed to geodesy and geosciences students in middle and higher semesters, PhD candidates and to professional attendants working as geodetic monitoring experts in engineering geodesy, geosciences, GNSS-services, to consultants, professionals and scientists in the fields of industrial and technological developments related to geodetic monitoring, to people working in system and software architecture and development, in administrations, as well as to post-graduate or doctoral scientists working at research institutions. The exercises show the complete theoretical spectrum in the practical application and enable directly to set up and work the attendants with a geodetic online monitoring system. The exercise are also appropriate for pupils interested in Geomatics.

Seminar - Methods

The lectures are given by slides, power-point-presentations, and they are accomplished by a classical black-board writing e.g. to deepen and further explain the mathematical models and algorithms. The attendants receive a script. In addition introductorily computations are part of the lectures, such e.g. computations with MONIKA.
The exercises block starts with a GOCA-software and system introduction. Then the exercises are continued by the setting up of a practical geodetic monitoring project and scenery. This is done by a GOCA system set up "from zero", using the GOCA software with total stations as sensors in the hall. This is followed by Individual computations and data-analysis with the GOCA system.

Key words

Geodetic and Geo-Monitoring Systems, Geo-Monitoring Chain, Real-time Deformation Analysis, Least Squares, M-Estimation and Covariance Matrix, Robust Estimation, Geodynamics, Plate Tectonics, Observation- and Coordinate related Deformation Analysis and Unification, Multi-Sensor Monitoring Systems, 1D/2D/3D Geodetic Network-Adjustment, GNSS-Services and Deformation Integrity Monitoring, GNSS and TPS combined Adjustment, Free 1D/2D/3D Networks and Datum-Defect, Displacement Estimation, Kalman-Filtering, Statistical Testing, Forecasting and Alarm Probability, Early-Warning Systems, Multi-Sensor Monitoring Systems.

Links: www.goca.info, www.monika.ag, www.hs-karlsruhe.de

Geodetic Monitoring - Lectures

1. Introduction

- General standards and profile of geodetic monitoring and early warning systems for applications in the geodetic monitoring fields of Geomatics, Geodynamics, Geotechnics, Geology, Civil engineering, GNSS-services and others .
- Standards and profile of the GNSS/LPS/LS Monitoring System (GOCA).
- Standards and profile of the GNSS-Reference-Stations Coordinate Monitoring Karlsruhe (MONIKA).

2. Deformation-Analysis based on geodetic network adjustment

- Coordinate systems and geo-referencing.
- Global geodynamics modelling (datum, datum-drift, plate tectonic).
- Simplified monitoring models compared to a strict network based geodetic monitoring concept.
- Observation and coordinate-related deformation analysis and unification.
- Free deformation absolute and relative deformation networks.
- Basic deformation state vectors and statistical testing.
- Virtual sensors modelling.
- Transition from geometric deformation analysis to system analysis.
- M-estimation in network adjustment and deformation analysis.
- Kalman filtering.

3. Geosensor-Networks and Geomonitoring Chanin

- Sensor-Control, Hardware- and Data-Communication design.
- Active and Passive Geosensor Networks
- Aspect of scalability of deformation approaches
- Geomonitoring-Chain

4. Mathematical model of geodetic monitoring in an observation related approach - Profile of the system GOCA as reference

- Characteristics of the observation based geodetic monitoring in absolute and relative deformation networks.
- Observation related three steps deformation network adjustment approach.
  - Functional models in 1D/2D/3D,
  - Initialisation of reference frame (GOCA step 1),
  - Geo-referencing of the object-points (GOCA step 2),
  - Modelling of object-point displacements (GOCA step 3),
- MVE - least squares and robust estimation.
- Online displacement estimation.
- L2/L1-Kalmanfiltering
- Prediction.
- Statistical testing of deformation state vectors.
- Statistical control of the reference frame.
- Alarming setting concepts.

5. Mathematical model of geodetic monitoring in a coordinate-related approach - Profile of the mathematical model MONIKA as reference

- Computation steps, aspects for a scaleable coordinate related geodetic monitoring approach and relation to the observation related approach (chap. 4).
- Relative and absolute deformation modelling (MONIKA step 1).
- Geodynamical models and reductions (MONIKA step 2-1).
- Datum-related transformations (MONIKA step 2-2).
- Multi-epochal and multivariate congruency testing and displacement estimation (MONIKA step 3).
- Displacement estimations type I and type II.
- GNSS-references stations as virtual geo-sensors.
- MONIKA software and applications. Demonstration with real data from IGS and GNSS reference station network of the state of Baden-Württemberg.

Geodetic Monitoring - Exercises with the GOCA System

1. Introduction to GOCA-Software and -Interfaces

- GOCA Geomonitoring Chain
- GOCA input data interface GKA (GNSS-Data, LPS-Data) and RINEX
- Sensor-Control and Data-Communication (GOCA-TPSControl, GOCA-GNSS-Control, VirtualGOCA)
- GOCA-Deformationanalysis software
  - Short repetition and feedback to the lecture part
  - Observation data and computation steps 1, 2 ,3
- GOCA output data interfaces (FIN, MVE, KAL, SHT, VHS)
- Reporting by GOCA-Earth software
- GOCA-Alarm software and data interface

2. Computation exercise of different projects with GOCA-software

- GOCA project set up by VirtualGOCA.
- GOCA deformation network definition and computation of the approximate coordinates.
- Set up and performance of GOCA computation step 1.
- Set up of GOCA step 2 (monitoring and georeferencing of object point series).
- Set up GOCA of step 3 (deformation-analysis for different deformation estimations and GOCA-alarm-settings).
- Computation of GOCA steps 2 and 3.
- Visualisation of deformation results by the GOCA-software and GOCA-Earth.

3. Set up of a real deformation network and exercises with GOCA

- Installation of local a GOCA deformation network using Leica-Geosystems Totalstations (TPS)
- GOCA project set up and geodetic monitoring using GOCA TPSControl, GOCA deformation analysis software, GOCA-Earth and GOCA-Alarm.
- Simulation of e.g. displacements and instable reference points, and interpretation of the results provided by the GOCA-software.

Lecturers

Prof. Dr.-Ing. Reiner Jäger - Lecturer
Head of the Geodetic Monitoring RaD projects GOCA (www.goca.info) and MONIKA (www.monika.ag) at the Institute of Applied Research (IAF) of Karlsruhe University of Applied Sciences**.** Head of the Institute of Geomatics at IAF. Head of Laboratory of GNSS and Navigation at HSKA.

Dipl.-Ing. (FH) Peter Spohn – Exercises with the GOCA-System
Scientific assistant in the RaD projects GOCA and MONIKA at the Institute of Applied Research (IAF) of Karlsruhe University of Applied Sciences

(Prof. Dr.-Ing. Reiner Jäger)