REMOTE SENSING EDUCATION THROUGH AERIAL PHOTOS AND SATELLITE IMAGES OF UNDERMINED AREAS PROCESSING

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Abstract: Remote Sensing is compulsory subject for some branches of study (e.g. geological engineering) at the Faculty of Mining and Geology of the VSB – Technical University of Ostrava (the Czech Republic). The students learn remote sensing principles through basic method of data processing. Evaluating temporal changes in the landscape is one of several topics in the teaching of Remote Sensing. It is the particularly topical problem to evaluate temporal changes in the landscape, where an intensive underground mining of coal is used. The issue will be explained using the example of Karviná District in which the part of the Ostrava-Karviná coal basin is situated. As a result of mining the depressions in the surface are being formed there and then flooded with water. These changes negatively influence the development of the Karviná District and together with other geofactors cause problems in foundation engineering. Early detection of such areas and monitoring of their parameters changes and prediction of their future development can be facilitated using the aerial photographs, data obtained by laser scanning and radar interferometry. Desired information is derived usually via the methods of digital data extraction (image interpretation and digital processing).

INTRODUCTION

VSB-Technical University of Ostrava was founded in 1849. The university was initially aimed at education in mining engineering but since its establishment it has grown into a modern institution of higher learning. Today 7 faculties of our University offer education in technical and economic branches of study.
History of the Faculty of Mining and Geology (FMG) dates back to the year 1716, so it is the oldest faculty of our University. FMG is a modern faculty which interconnects natural sciences with technical and economic fields of study in a completely unique manner. FMG provides following degree programmes:

- Geodesy and Cartography,
- Geological Engineering,
- Mineral Raw Materials,
- Mining.

Students of bachelor and master studies of geological engineering, geoinformatics, geodesy and cartography have a course of remote sensing. They learn the theoretical foundations of remote sensing method in this course, and also practise the basic techniques of remotely sensed data interpretation and some methods of digital image processing. Students of doctoral studies use remote sensing if this method is suitable as a tool for solving their research project. Education in bachelor, master and doctoral studies has relationship to many research projects. Some of these projects deal with issues post-mining landscape in the Ostrava and Karviná Districts.

The Ostrava-Karviná Mining District (OKMD) is an area in the Ostrava and Karviná Districts (the Moravian-Silesian Region) of the Czech Republic and the southern part of the Upper-Silesian coal basin as well. The OKMD is the only area in the Czech Republic where hard coal (bituminous coal) is mined. All hard coal mines in the OKMD are deep mines. Hard coal deep mining has a dramatic impact on the landscape in the OKMD. Very strong repercussion of deep mining manifests itself as anthropogenic landscape changes (waste rock banks, land subsidence). Besides deep-mining, coal handling and processing technologies need appropriate infrastructure on the ground (coal preparation plant, network rail structure, derrick towers, retention dams, tailings ponds, impoundments, etc.).
Land subsidence can produce many problems as a consequence of changes in elevation. It can lead to damage to roads, railroads, storm drains, canals, distribution networks, sanitary sewers, wells, levees and bridges. Subsidence can lead to property damage such as damage to public and private buildings. Subsidences negatively influence particular areas because of causing high probability of flooding. All these changes negatively influence the development of the Karviná District and together with other geofactors cause problems in foundation engineering.

Locate and quantify land subsidence hazards, timely prediction of land subsidence and its monitoring are very required services crucial for people activities in undermined areas. These are important and challenging tasks in engineering geology. To be able accomplish this tasks allow prevent or minimize subsidence damage.
The Karviná Mining District is currently only productive part of the Ostrava-Karviná Mining District (about 319 km^2). Professionals in various fields of human activity (engineering geologists, architects, civil engineers, specialist in land reclamation ...) need suitable data to deal with geospatial problems in the Karviná Mining District, they need spatial data (Kajzar, 2011). Geo-information technologies play a central role in spatial data acquisition and processing. Because of quite large area of the Karviná Mining District is necessary to use remote sensing for spatial data acquisition in the future.

MONITORING OF LAND SUBSIDENCE USING RADAR INTERFEROMETRY

There are modern methods for monitoring of land subsidence due to undermining. One of them is satellite radar interferometry (InSAR) method but it is usable depending on character of the studied area, velocity and the spatial extent of the land subsidence. Mr. Lazecký tried to verify InSAR method suitability for land subsidence monitoring and investigated its limitation. He proposed optimizing scenarios to increase the performance of InSAR techniques using C-band and L-band data to detect and estimate deformations due to land subsidence in the studied area. InSAR Processing was applied to images from satellites ERS-1, ERS-2, Envisat and Alos, in the total amount of 12 SAR images of ERS-1, 123 ERS-2 images, 45 Envisat images and 7 Alos images, all of these from at least two different orbit tracks (see Table 1).

Table 1: Overview of selected SAR satellites (Lazecky et al, 2012).

Satellite SAR	Revisit time	Standard incidence angle	Standard ground resolution	Wavelength	Polarisation	Agency
ERS-1, ERS-21S	35 days	23 degrees (21° −26°)	26 m	5.57 cm	Only VV	ESA
Envisat ASAR	35 days	23 degrees (15° −45°)	25 m	5.56 cm	HH/VV, Dual	ESA
Alos Palsar	46 days	34.3 degrees (8° −60°)	10 m	23.6 cm	HH/VV, Quad	JAXA
TerraSAR	11 days	32 degrees (15° −60°)	3 m (up to 1 m)	3.11 cm	Single, Dual	DLR

Mr. Lazecký verified that whereas extent of subsidence troughs is often possible to delimit, the deformation velocities are usually underestimated. It was determined by comparing data observed by levelling. Using InSAR method is possible to resolve millimeter-scale for measurements of displacement so it certainly has strong potential for monitoring of slow deformations such as decay subsidence after coal mines closure. InSAR techniques were evaluated as appropriate for a systematic monitoring of subsidence in the Karviná Mining District as complementary to levelling measurements.

MONITORING OF DEPRESSIONS CAUSED BY LAND SUBSIDENCE FROM AERIAL PHOTOS

Land subsidence in the Karviná Mining District often can form depressions which are gradually flooded by groundwater. Flooded areas cannot be further used as agricultural land or areas for development of housing and infrastructure in municipalities. Ms. Burkotová has been observing the process of land subsidence depression flooding near the village of Doubrava in the Karviná Mining District. She interprets time changes of a flooded area from the aerial ortophotographs series.

RESULTS

The results of using interpretation and processing techniques of remote sensing in obtaining data of the Karviná Mining District correspond to current practice and the student experience. After the lecturer mentions the deficiency the student improves outcomes of the data processing so that they are usable for the framework project.
The results of the research project, solved by Mr. Lazecky, demonstrate the need for long-term monitoring of the situation in undermined areas using InSAR techniques.
Result of changes in interpretation of surface extent of depression, based on series of aerial photographs, the vector data representing a gradual increase of water surface resulting in a flooded area. The resulting data prepared by Ms. Burkotova document the dynamics of water area enlargement for the past 9 years. On the basis of such data it is currently possible to predict the process of deepening and enlarging surface depression scale. The results will thus become the important documents for the project solving the impact of chosen geofactors on the engineering object foundations in the undermined areas of the Karviná District.

DISCUSSION

Involvement of students in bachelor's, master's and doctoral programs in solving practical problems of larger projects, brings a number of effects. The most important of them include:

- the acquisition of professional experience for students,
- help students in solving university projects,
- improvement of students' teamwork skills,
- additional understanding of the theoretical fundamentals of the remote sensing, which were not initially understood.

CONCLUSIONS & RECOMMENDATIONS

The practical course of remote sensing, engaging students in particular real tasks solving, proves to be very effective. It is preferred if practical tasks for students are part of the solution of a larger project. Remote sensing is used as a tool to support other field of human activity, such as engineering geology. Naturally, the remote sensing course must be under the supervision of a teacher or researcher who is responsible for dealing with the parent project.

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REFERENCES:

References from Journals:

Guang L., Huangdong G., Jinghui F., Xiaofang G., Perski Z., Huanyin Y. 2009. Mining area subsidence monitoring using multi-band SAR data. In the 7th Joint Urban Remote Sensing Event 2009. Shanghai: IEEE, p. 1−6, ISBN: 978-1-4244-3461-9.

Lazecky, M., Jiránková, E., Rapant, P., Bláha P. 2012. Monitoring of Subsidence Karviná Mining Region. EGRSE – Exploration Geophysics, Remote Sensing and Environment, ISSN 1805-2266, 2012.

References from Books:

HANSSEN R. F., 2001. Radar interferometry: data interpretation and error analysis. Dordrecht: Kluwer Academic Publishers, pp. 328. ISBN: 0-7923-6945-9.

References from Other Literature:

Kajzar, V., 2011. Modelling the effects of mining of mineral deposits. VSB - Technical University of Ostrava, pp.50-55, Ph.D. Thesis,

Lazecky, M. 2011. Monitoring of Terrain Relief Changes using Synthetic Aperture Radar Interferometry: Application of SAR Interferometry Techniques in a Specific Undermined Ostrava-Karviná District. Ostrava, VŠB--Technical University of Ostrava, 2011, pp. 177, Ph.D. thesis