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Evaluation Doctoral Thesis of Kamila Pawłuszek

Mrs. Kamila Pawłuszek submitted her Doctoral Thesis entitled „Application of Airborne Laser Scanning Data for the Identification of Landslide Areas". It is a cumulative thesis including seven articles, and separate chapters introducing the topic, giving an overview on landslides, explaining different approaches to landslide studies, explaining error metrics in classification, and summarizing related literature in landslide studies using different remote sensing techniques. In addition to these motivation and state of the art chapters, two chapters concentrate on the publications, a short summary of each publications which includes the main findings summarized over all articles and a chapter with concluding remarks.

Without the seven articles the thesis has more than fifty pages of text and appropriate, well-prepared figures, showing the effort Mrs. Pawłuszek invested in understanding landslides, the study of landslides, and the possibilities to monitor them by remote sensing. These corresponding chapters are, from a geodetic and Earth observation point of view very well written and present an excellent introduction to the topic.

The chapter on classification mainly introduces the error measures. It also includes a short overview on classification methods used in landslide studies. While the concentration on landslides is at first sight obvious, it could have also been used to present a more thorough introduction to classification. Division into pixel- and object-based classification methods is one possibility, others would have been on supervised vs. not-supervised or based on a model of the feature distribution vs. concentrated on the boundaries between classes.

Concerning the data source, airborne laser scanning, the thesis concentrates on terrain models derived from it. Therefore, point cloud processing, orientation of point clouds, filtering (also a classification task), are not treated in the thesis. Most of the methods applied are well-established: principle component analysis, decision trees, segmentation (in eCognition software), support vector machines (in ENVI software), maximum likelihood classification, and neural networks. Additionally, methods less well established in photogrammetry, but apparently often used in landslide studies, are employed (e.g. article 7).

Summarizing, the dissertation does not establish new methods, but really concentrates on the contribution of laser scanning derived terrain models for identifying and characterizing landslides. It gives a comprehensive review on the capabilities and usability of laser scanning in this context.

As written above, the thesis is written in cumulative manner. Article 4 to 7 are published in international peer-reviewed journals, namely Landslides, ISPRS International Journal of Geoinformation, and Naturaz Hazards (two articles). These are well established journals with different, but in all cases high standards in the review process. Two articles were published in the ISPRS Archives and one articles in the Proceedings of the World Landslide Forum. These contributions were reviewed rather on abstract basis. All together this is a notable output within four years of duration (first article published in 2016).

The first article shows a straight-forward study of using different terrain indices, or features in the terminology of classification, to detect landslides. In a first step, using principle component analysis, the number of features is reduced. Then reference data is used to learn the classification rules using the method of support vector machines. The accuracy, different measures are used, is around 70%. The second article is similar, but also concentrates on computation time, a very relevant topic. The third article has a similar setup, using other classification algorithms and additionally asking and answering the question of the appropriate DTM resolution. It also covers another area.

Article four can be considered as a comprehensive investigation based on the previous articles, covering multiple classification algorithms, DTM resolutions, terrain features, PCA and studies their impact on the automatic landslide identification. As can be expected, higher accuracy was achieved, but the results did not improve dramatically. This conclusion is taken up in the fifth article, switching from pixel-based to object-based classification. A complex workflow is developed, using multi-resolution segmentation, support vector machine classification and post-processing. Accuracy improves, but an additional, very interesting finding is, that the sensitivity to DTM resolution is lower for the object-based approach in comparison to the pixel-based approach.

The last two article put the previous work in a wider context. First, in article six, the features of landslides (here features in the sense of characteristic landslide elements like the scarp) are investigated. In comparison to previous work, not an all-automatic workflow is targeted, but the visual presentation of the landslide is enhanced in order to highlight the features. Also a critical point of view is taken towards the own work, because limitations (e.g. not applicable for historic landslides where forms have be changed due to anthropogenic or natural processes) and the relation of field vs. "office" work is discussed. Finally, article seven, concentrates on landslide susceptibility mapping. It uses the methods developed before (terrain indices, PCA), additionally considers other input channels, and also applies three strategies to generate the susceptibility maps from given landslide inventories. Interestingly, with only DTM information, a close-to-best accuracy can be achieved, which has practical relevance (e.g. no other layers of information required in advance).

Considering all articles at once, there is a logical sequence in the articles, showing the progress and first a deepening of the experiments and then an widening, an extension to follow-on questions. This is not only very well presented, but also demonstrates the understanding of the scientific process of Mrs. Pawłuszek. She has used a diverse set of methods, worked extensively and in depth with data, and came to sound conclusions.

The thesis submitted by Mrs. Pawłuszek clearly demonstrates that she can work scientifically. The requirements on a Ph.D. thesis are entirely fulfilled. I recommend to continue the procedure and admit Mrs. Kamila Pawłuszek to the defensio of her thesis.

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