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Interactive web services for landslide and habitat monitoring

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Abstract

In this study we introduce a prototype of an interactive web service for semi-automatic landslide analysis using Earth Observation (EO) data. The web service consists of four subservices for (1) landslide mapping, (2) monitoring, (3) validation, and (4) infrastructure analysis to identify landslide-affected infrastructure. In addition, we adapt the concept of the existing solution for habitat mapping and monitoring. The presented examples show that the interactive web service has the potential to support the efficient management of the environment in protected areas.

Keywords

Landslides, Habitats, Monitoring, Interactive Web Services, Semi-automated Object Delineation, Earth Observation (EO)

Introduction

The currently ongoing biodiversity crisis is primary caused by the destruction, deterioration and fragmentation of habitats (GROOM et al. 2006). Therefore, monitoring and reporting on the state of nature gained increasing importance in the European Union, for example with the implementation of the Habitats Directive and the Natura 2000 network (VANDEN BORRE et al. 2011). An interactive web service for semi-automatic habitat mapping based on Earth Observation (EO) data could ease the process of habitat delineation and monitoring.

The prototype of such a web service with functionality for semi-automated object delineation and classification, web-processing and service provision of geo-information has been developed in the FFG ASAP project Land@Slide (2015-2017; http://landslide.sbg.ac.at; HÖLBLING et al. 2016a) which focuses on mapping and monitoring of landslides. One goal of the service is to effectively manage geographically distributed landslide datasets and to promote the interaction between various users and stakeholders. There exist several local/national databases and platforms which provide and publish data of different types of landslides as well as web-based risk maps and decision support systems. Also, the European Commission implemented the Copernicus Emergency Management Service (EMS; http://emergency.copernicus.eu) in 2015 that publishes information about natural and man-made disasters and risks. The Land@Slide project goes beyond the provision of information products and developed a web service for landslides that considers user needs and requirements (cf. ALBRECHT et al. 2016; WEINKE et al. 2016) and that enables the user to semi-automatically map and monitor landslides based on EO data.

The question is if the existing functions of the interactive landslide web service also allow the delineation and monitoring process of habitats. The presented research deals with adapting the concept of the existing landslide web service solution for habitat mapping and monitoring with the aim to support the efficient management of the environment in protected areas.

Methods

An incremental and iterative approach was used for the design and development of the WebGIS platform and the interactive landslide web service (see WEINKE et al. 2016). The requirements on the system and the service were derived from the project goals and the concrete user needs (see ALBRECHT et al. 2016). Four central main modules were designed and developed for the landslide service:

1. a mapping module (including image segmentation, classification and editing approaches),
2. a monitoring module to monitor changes over time,
3. a validation module to analyze landslide delineations from different sources and
4. an infrastructure module to identify landslide-affected infrastructure.

The two modules mapping and monitoring are tested for applicability for habitats. In the current version of the prototype, the multiresolution image segmentation approach available within the eCognition software (Trimble Geospatial) is used for creating image objects. For the classification of the segmentation-derived image objects selected statistical classification algorithms (e.g. Random Forest) from the Waikato Environment for Knowledge Analysis (Weka) machine learning software are included, whereby user-selected training samples serve as input. The monitoring and validation process is based on an area comparison approach between two or more mapping results.

Results

Fig. 1 shows the overview map of the first version of the web-based Land@Slide platform. Selected mapping examples are used to demonstrate the functionality of the service within four scopes: EO Data Selection, Classification, Validation and Infrastructure Analysis. For the test sites, optical satellite images from different sensors (e.g. Landsat, Sentinel-2, SPOT-5, WorldView-3), including time series, are currently integrated. Fig. 1 shows the semi-automated landslide mapping result of the test site Fürwag/Haunsberg (Salzburg, Austria) for the year 2002, which shows a good coincidence with the manual mapping result that is used as reference for validation. The semi-automated delineation is based on a Landsat 7 scene (30m spatial resolution), a digital elevation model (DEM; 10m) and the derived slope. For more details about the landsite delineation and validation see HÖLBLING et al. (2016b) and HÖLBLING et al. (2017).

Figure 1: Land@Slide service overview map – test site Fürwag/Haunsberg (Salzburg, Austria). Landslides are semi-automatically delineated using a Landsat 7 scene from June 2002 and compared to manual mapping results.

In Fig. 2 the scope New Analysis of the web platform is shown. This scope allows users to conduct their own analysis and contains the following main functions: Mapping (including segmentation, classification, editing landslides), Monitoring, Validation and Infrastructure Analysis. Fig. 2 shows a sample of a coniferous forest habitat on satellite images from 2005 and 2015. The habitat is situated in the Berchtesgaden National Park (Germany) and represents a mountainous area, characterized by high habitat diversity. The semi-automated habitat delineation for the year 2005 is based on a pan-sharpened QuickBird scene (spatial resolution: 0.61m panchromatic band; 2.4m multispectral band) acquired in August 2005 (see PREINER et al. 2006; WEINKE et al. 2006; WEINKE et al. 2008). For the semi-automated delineation for 2015, a Sentinel-2 scene (10m spatial resolution) was used.

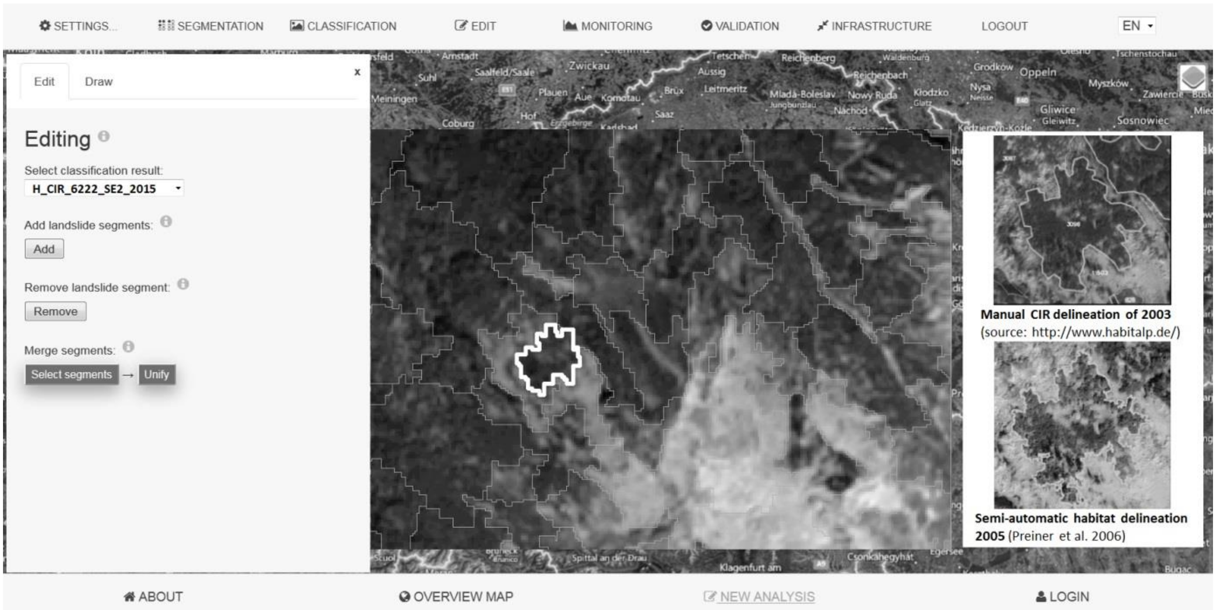

Figure 2: Land@Slide service New Analysis scope – delineation of a coniferous forest habitat on satellite images from 2005 and 2015 including a manual CIR (color-infrared) aerial photograph delineation of 2003 in the test site Berchtesgaden National Park (Germany).

Discussion and Conclusion

The examples presented above show that the tools of the interactive web service, which were developed for landslide mapping, are also able to support the delineation and monitoring process of habitats. This included the delineation of different habitats, their classification and the comparison to other datasets such as reference maps. The quality of the mapping results substantially depends on the spatial resolution of the used EO data. However, this is a general issue; the web service itself is capable to integrate EO datasets of various resolutions and from different sensors.

In a next step, experts (from national parks, etc.) could be included in a process to validate the service for specific scenarios of habitat mapping and monitoring. The feedback could be used to develop a customized interface for habitat analysis.

The Land@Slide platform is developed mainly based on a range of free and open source technologies and widely used open standards (e.g. from the Open Geospatial Consortium). Only for image segmentation the commercial software eCognition is used. It is planned that the service will be entirely developed using open source technologies to ensure interoperability among and between components and to reduce costs.

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