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A Remote Sensing Biodiversity Monitoring Ontology

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Abstract

In the European Union, the adoption of the Habitats Directive in 1992 gave the basis for biodiversity data harmonization. Although habitat nomenclature and the interpretation manuals are standardized, there is a high variability of mapping methodologies and strategies between member states and biogeographical regions. This work describes the development of a biodiversity monitoring ontology with special regard to the Habitats directive and remote sensing classification techniques. It will be a basis for the evaluation of transnational biodiversity mapping comparability.
Keywords: biodiversity, remote sensing, ontology, semantic modelling, method harmonization

1 Introduction

Spaceborne imagery has made significant contribution to biodiversity monitoring and modelling over the last decade. Analysis based on fine resolution satellite data has a considerable potential for the mapping and evaluation of habitats, plant communities and selected plant species. Especially with a view to the challenging demands of the Natura 2000 initiative, remote sensing can be a consistent methodology, which is able to derive and update biodiversity information of large areas. Even though highly accurate ground surveys cannot be fully replaced by remote sensing techniques, it is possible to make the work of biodiversity experts more efficient and help them to overlook lager areas with less effort. There is a high number of different sensors, parameters and methodologies which are used for environmental data acquisition in different biographical regions and scales. [3] Therefore the collection and systematization of existing methods in a semantic graph is a first step towards harmonization and transferability of methods with regard to variable scales and class descriptions. Thus, this poster aims to

- develop a base ontology which integrates semantic relations between remote sensing sensors and parameters of Natura 2000 habitat description and status evaluation. Hence, it provides a prior knowledge base for automated interpretation of remote sensing imagery.
- eliminate ambiguities and inconsistencies in the knowledge base by logical reasoning.
- provide a basis for the evaluation of uncertainty and comparability of remote sensing techniques regarding biodiversity monitoring.
- be a first step to transfer existing remote sensing methodologies to other biogeographical regions and scales.

2 Habitat class descriptions and remote sensing monitoring

This section gives a short overview on parameters and sensors used in the remote sensing monitoring process regarding the Natura 2000 nomenclature. Moreover it describes habitat class descriptions and evaluation approaches used by ecologists in field surveys.

2.1 Natura 2000 habitat class descriptions

Crucial components for habitat identification and status evaluation are characteristic physiognomy, abiotic conditions, community composition, plant dominance, succession stage and, occasionally, animal community composition. [5] The monitoring often requires additional information such as habitat quality (e.g. naturalness, degradation, pollution, etc.), environmental parameters (soil type, weather) and potential drivers and pressures (land use, human impact). [6] For this study the classification hierarchy described in the Habitats Directive (92/43/EEC) has been taken into account.

2.2 Remote sensing habitat classification

There are a number of remote sensing based habitat classification approaches using a wide variety of sensors with variable spectral, temporal and spatial resolution. Therefore, spaceborne imagery has not only a proven potential in assessing spatial indicators (fragmentation, connectivity, patch size) and the coverage of invasive or unwanted species, it can also provide methods to monitor biophysical or biochemical indicators which describe the habitat structure (LAI, NDVI, penology, chlorophyll content, vegetation height, cutting events etc. [1, 2, 4, 7]). [8]

3 Remote sensing biodiversity monitoring domain ontology

This section describes the system requirements and gives a summary on accessible data sources and how to integrate their knowledge into the ontology.

3.1 Ontology requirements

The Ontology consists of hierarchically structured thematic and spatial attributes, describing biophysical/biochemical (e.g. vegetation, sand or water cover) and spatial properties (e.g. area, size, shape), that can be derived from remote sensing sensors with variable resolution. Hence, different levels of the hierarchical habitat class description can be characterized by primitives derived from the images. Semantic, spatial and temporal relations describe relationships between objects such as e.g. inheritance, class membership, topology or phenology. As seen in Figure 1 the main components of the ontology are scale dependent remote sensing and GIS data, spatial and thematic attributes of the habitat classes and the Natura 2000 class hierarchy. All components are connected with semantic, spatial and/or temporal relations.

Moreover the system should be open and easily extendable with new technologies and developments. It should correspond to the existing W3C specifications to ensure the possibility to publish its knowledge as linked Data on the web and interlink its content to existing nature conservation top level ontologies.

3.2 Implementation and data sources

Main input resources for remote sensing biodiversity indicators are knowledge bases and classification algorithms developed in the European Commission 7th framework project MS.MONINA. Since the development phase is not completed more and more methodologies will be added to the system. Semantic relations of classification components can be extracted from remote sensing knowledge bases or rule sets and directly imported into the domain ontology.

Detailed habitat class descriptions on European Union level can be found in the Natura 2000 Database of the European Environment Agency (EEA). Information on biogeographical regions, sites, designation status, species and impacts could be extracted and imported into the ontology by developing a ODBC database interface. Regional and local class descriptions have been collected from state authorities. All implementations are realized in Java (OWL API/ Jena ontology API).

4 Results

The ontology provides an appropriate prior knowledge base for remote sensing based classification in the context of biodiversity monitoring. Since it contains various methodologies of different sources describing Natura 2000 habitat classes the possibility of logical reasoning helps to identify logical inconsistencies and eliminates ambiguity within the concepts.

5 Discussion and future work

One fundamental benefit of having a big amount of biodiversity observation methodologies is the opportunity to respond to the variable challenges of a diverse ecosystem with a high variety of different technical preconditions.[8] Having strict standards in remote sensing data collection would lead to less customization and less quality of output products. Since there is no superior mapping technique for one habitat type or one region, the possibility to have a methodological framework, which combines classification techniques will stimulate the harmonization progress in data collecting approaches.

The presented approach of collecting object primitives, that can be derived from satellite imagery, in an ontology gives the opportunity to combine methodologies from different sources and transfer existing classification techniques to different scales, regions and class descriptions.

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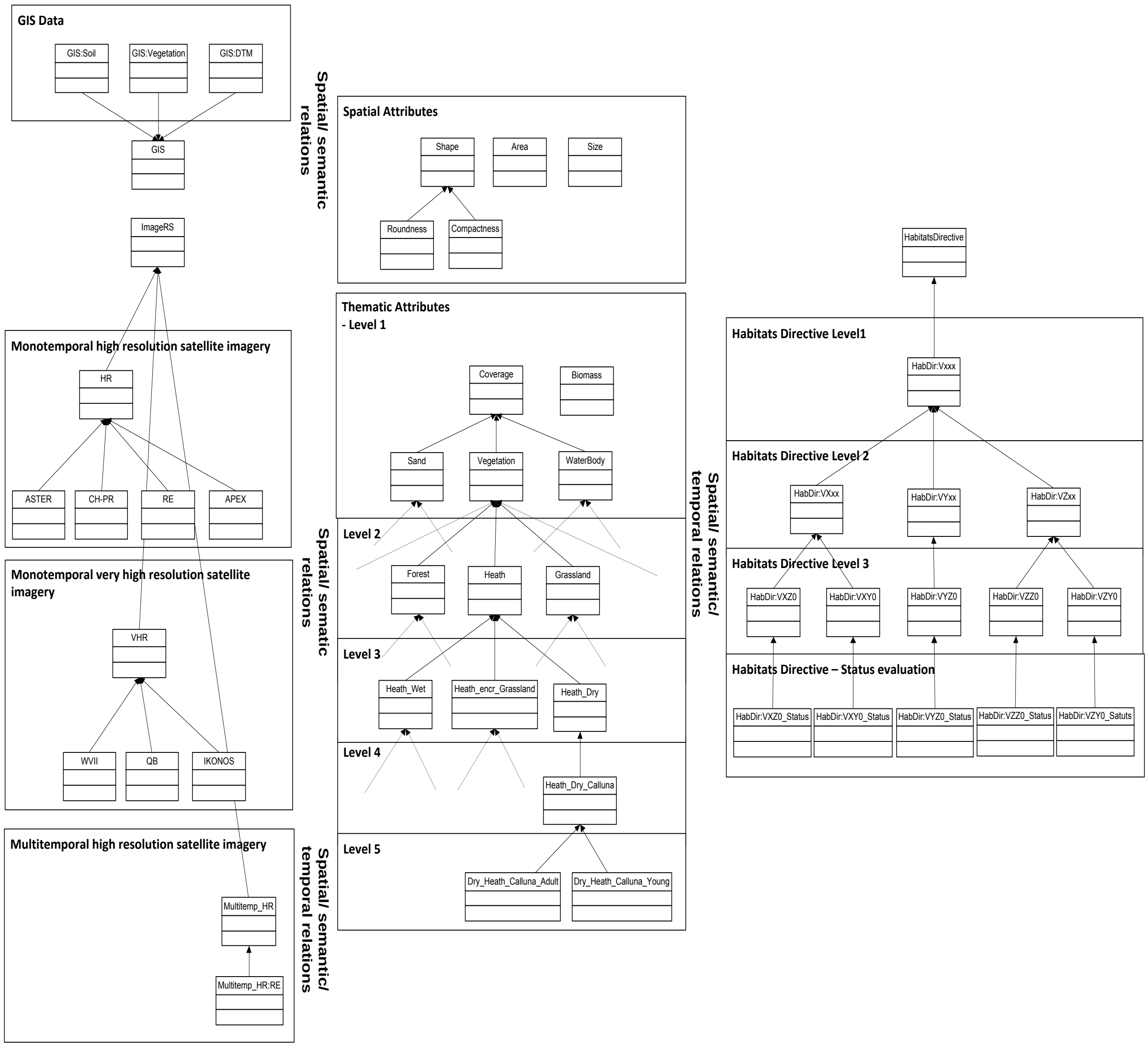
Figure 1: Schematic diagram of fundamental ontology content



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