A conceptual model for submarine feature description and generalisation in nautical chart production

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Objective: This paper aims at defining an ontology of the nautical chart generalisation process that will be at the root of a model oriented generalisation process. This ontology includes both a top-level ontology of spatial relationships and a domain ontology of geographical objects of the submarine relief.

Background: Nautical chart is a kind of map used to describe the seafloor morphology and shoreline of adjacent land. The principle purpose of nautical chart is to provide necessary information to ensure safety and efficiency of navigation [1]. As a consequence, construction of a nautical chart follows very specific rules. On one hand, the depth indicated at a point of the map must never be deeper than the real depth and navigational hazards must be emphasised and on the other hand, passages marking navigation routes must be maintained. Such constraints, not required in other kinds of map, impose the development of specific methods for nautical chart construction: the objects appearing on the chart are not only selected and modified in order to provide a detailed but legible representation of the floor but are also selected and adapted based on the type of undersea features they model and their importance for navigation. This stage, called generalisation, has been largely automated for topological maps but is still performed manually for nautical charts. In order to move towards the automation of the generalisation process, our research is to develop a *model generalisation* strategy driven by the terrain features that are identified on the chart. This strategy is coupled with *cartographic generalisation* whose goal is to produce legible charts. Identification of terrain features implies the extraction and classification of knowledge from the terrain according to different concepts describing semantic and spatial information as well as relationships between the terrain features.

Data: On the one hand and to the best of our knowledge, no ontology has been defined to formalise the geographical and cartographical objects for nautical chart generalisation. Thus, we developed a bottom-up approach derived from the extraction and modelisation of knowledge from standards established by the International Hydrographic Organization (IHO) [2] and experts in the generalisation domain. On the other hand, we use general top-level ontologies such as those defined by the Ordnance Survey[1] formalising spatial and mereological relations.

Methodology: In order to be able to describe the seafloor and identify relevant features, an ontology of undersea features is first defined. Features are organised in a hierarchy of classes forming a domain ontology. Properties are characterised at super class level where features are defined at a low level of detail. Features defined in [2] appear at the highest level of description in the hierarchy. For example, a Trench Feature would inherit from the Channel Feature and the Bottom Line Feature. In a second part, we define a cartographic representation ontology of the submarine relief. This ontology deals with concerns related to how to conceptualise information present in a nautical chart and how to model them using depth points (or soundings) and level curves (or isobathymetric lines). Lastly, we define a nautical chart generalisation ontology which conceptualises the generalisation operators, constraints and rules. In order to structure the different ontologies, we use the multiple-ontology approach for GIS proposes by Fonseca [3] where ontologies for the geographic world are divided in two types: Phenomenological Domain Ontology (PDO) and Application Domain Ontology (ADO). In such a representation the ontologies of the undersea feature and of generalisation are part of the ADO whereas the cartographic representation ontology and the spatial relation ontology are parts of the PDO. The connection between PDO and ADO is made by semantic mediators which performs basic functions like selection and identification.

Result and Discussion: The different ontologies were developed in Protégé. All of 46 undersea features, which are defined in the IHO document [2], are classified and defined in the concepts of ontology [Figure 1]. The benefit of this hierarchical structure is that, depending on the density or quality of the input terrain data or the requirements of the application, the level of description can be adjusted to different precisions. The ontologies of the generalisation process and cartographic representation were realised in collaboration with cartographers from the SHOM[2] and integrate formal specifications as well as knowledge gained from experience.

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[1] http://www.ordnancesurvey.co.uk/oswebsite/ontology/

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Ontologies were integrated together and can provide enough concepts for the description of the model generalisation process.

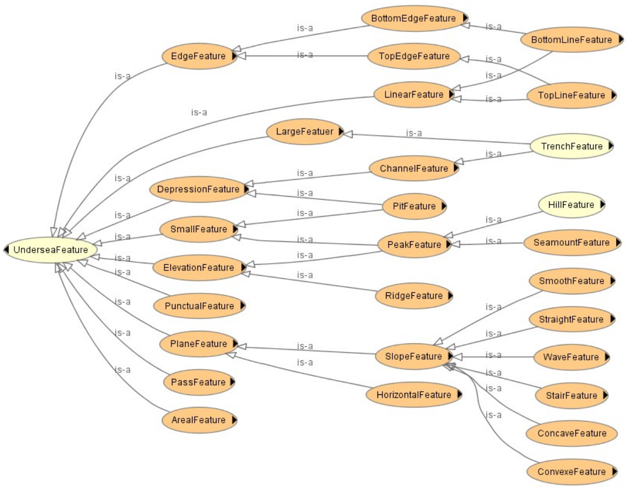

Figure 1. Ontology of undersea feature.

Conclusion and Future Work: This paper defines an ontology of the nautical chart generalisation process including the representation of submarine features. Future work will concern the development of an ontology-driven information system, which will be based on this model generalisation ontology in the specific case of nautical chart generalisation.

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