

# Extension of Electronical Nautical Charts for 3D interactive Visualization via CityGML

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## Abstract

The idea of Augmented Reality (AR) is the enhancement of captured images with external data. Used with a video capture device in real-time, interactive navigation and the understanding of foreign environments is possible. We use the Augmented Reality Binocular[4] to overlay Electronic Navigational Charts (ENC) onto the video signal to support nautical navigation. To realize this, the 2D ENC chart data has to be expanded into the third dimension which leads to a change of the viewers perspective. This might result in an overload of data in the visualization, which prevents a clear identification of objects. We present an approach to reduce the amount of data in the visualization by semantic clustering, which enables the interactive use of the 3D navigation scene.

## 1. Introduction

There is a high demand for expanding 2D chart data into the third dimension. Many applications in Augmented Reality (AR) are known which overlay given chart data into the view of the actual environment to provide additional data for navigation or knowledge enhancement[1][2]. Another usage for 3D chart data is to utilize real world chart data to build up virtual scenes for simulation purpose[3].

There is a wide variety of these applications varying mainly in the kind of ENC chart data they use to display. The Augmented Reality Binocular, which is under development [4], is used to overlay the chart data<sup>1</sup> onto the video signal to support nautical staff in challenging situations. The Figure 1 shows the principle of the data flow in the AR-Binocular.

### 1.1 3D ENC chart data problems and approach

A novel module of the ENC-software<sup>2</sup> is able to offer a 3D symbolization and a scenegraph structure of the data.

2D ENC data is designed for a top view onto the map. A change of the perspective into a head-on one, where the user is mainly in the height of the objects, leads to significant occlusions. The data is concentrated at the coastline and the scene is rendered with a radius of 10 km. Even displaying the safety information, which is defined as the minimum displayed data, may result in an overloaded view. It is therefore necessary to reduce the data in a way, that the user can operate in all situations properly.

In an interactive view, the user should decide which infor-

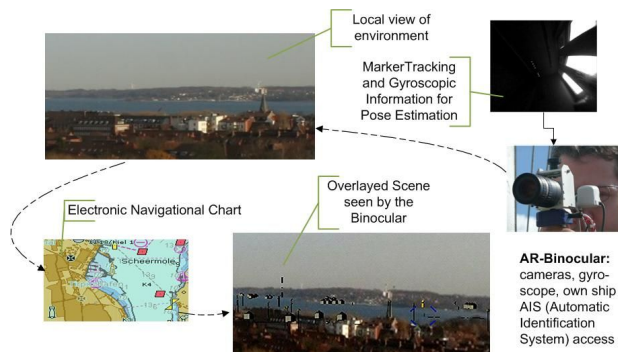


Figure 1: Augmentation Principle of the Augmented Reality Binocular; on the right there is a video capture and pose estimation device; it overlays the local environment (top left), with the correctly aligned chart data (bottom left).

mation is important at a time, e.g. the entrance of a harbour, but not any longer the landmarks of the city in the background. To decide which properties of objects are used to filter the scene, the individual use case of the user should be known, which is not always possible. The aim here is to give the user semantic and local information to support a user-guided selection.

In the 3D scene, the user can then select semantic groups like scale level and decide in this way which sublevels are shown and which not. This enables a context-driven scale scheme in interesting areas of the scene, where at the same time other areas stay in an overview status.

To generate the semantic information the ENC data has to be preprocessed, as there are no hierarchical relations between the objects.

We choose CityGML to store the generated information in an applicable format. In the next sections we explain the conversion to this scheme and the data export into a scenegraph system, which is used to render the 3D scene onto the video signal.

## 2. Approach to map ENC data into CityGML

To overcome the mass of data and information, we aim for a hierarchical data structuring, which allows the possibility of semantical object groupings. An existing method of filtering objects in ENC data is to select object classes, e.g. show all

<sup>1</sup> The chart data is based on the product specification ENC of the IHO-S-57 standard, Version 3.1 [5]

<sup>2</sup> The software is provided by the SevenCs GmbH, which is a market-leading software company for e.g. Electronic Chart Display and Information Systems (ECDIS). It is owned by the United Kingdom Hydrographic Office (UKHO)

buoys, which has no semantic reference.

We build up a hierarchical structure of all primitives, e.g. buoys, by exploring the relation schemes implemented within the geometry definition of the objects. It is defined in the S-57 Standard that geometries should share their segments. This allows the ECDIS system to provide a knowledge base if primitives e.g. „touch“ or „intersect“ each other.

The preprocessing of the ENC data was done as follows:

- exploration of the implicit topology by searching for adjacent areas referring to a selected primitive and
- the use of given relations „inside“ and „contains“ to build up an area hierarchy within the adjacent ones in
- combination with comparisons of area sizes

At a higher level there exists a second relation scheme which relates the complete objects to each other. Using these relations which are modelled but not utilized in the ENC (e.g. „has\_a“), leads to a storage of the hierarchy within the data file without increasing the storage size.

That does not apply for additional information which is generated by the identification of semantical groupings. For this data we need an applicable storage format. Semantic information can be built by taking hierarchy levels and with the help of its children and by neighbourhood relations between these groups, the topic of a cluster can be found.

As a result new requests are possible like getting all objects of an entrance of a harbour or of a built up area. In combination with the given clusters, the filtering by the object categories is still possible.

### 2.1 Storing topology extensions in CityGML

The creation of information leads to a need for another storage format as knowledge representation.

CityGML provides the structure for thematical modelling, semantic descriptions, appearance storage and 3D geometries[10]. This offers the infrastructure for a 3D ENC scene. It fits very well to the 181 object types given by the ENC object catalogue since the complete scheme of CityGML only differs in 9 sub-definitions.

CityGML is an application scheme of GML3 (Geography Markup Language) and an international standard issued by the OGC (Open Geospatial Consortium)[6]. It was developed since 2002 and follows the ISO 19100 family like the S-57 standard in his next Version 4.0 (S-100) will also do[7]. Furthermore the new S-57 version will open the possibilities for 3D geometries, time-varying objects and introduces a new S-57/GML scheme for (2D) data exchange. The standard serves as a base for the product specification ENC, but will not be published before 2012. Beside this, there exists an XML scheme for 2D ENC-data, called MarineXML[8].

This shows that there is a development to 3D modelling and XML as exchange format, but a scenegraph structure needs in addition a hierarchy. CityGML provides an extension scheme called application domain extension (ADE). There are some ADE successfully implemented and available[3]. Therefore we created an ADE for the use of CityGML with standardized ENC data, called ADE Enc. Figure 2 shows an overview of the data flow.

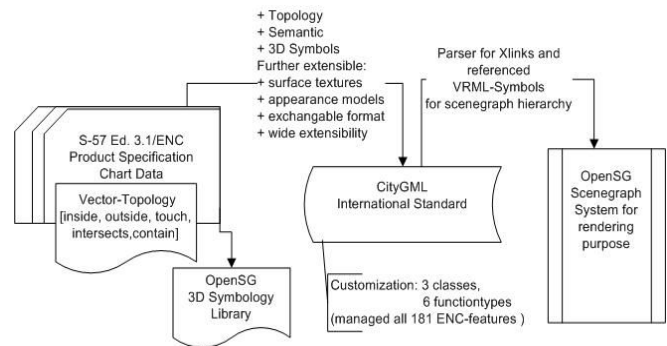


Figure 2: Data flow of the conversion from S-57 ENC data to CityGML and into a scenegraph system

### 2.2 CityGML ADE Enc definition

CityGML has 11 thematic models, from which we had to extend three. Main traffic structures like traffic directions, tracks and routes are mapped to the transportation scheme. Single features which have a local meaning and artificial sea signs are given to the CityFurnitures. Water elements, Vegetation and Buildings are given to their corresponding themes. Figure 3 shows a few examples of ENC objects and their conversion into CityGML.

Mapping ENC <> CityGML	
<<extract>>	
ENC object	corresponding CityGML object
BCNCAR	Module: CityFurniture, Class: Traffic, Type Roadsign
BOYLAT	Module: CityFurniture, Class: Traffic, Type Roadsign
CBLOHD	Module: BuildingInstallation, Class: Communicating
CURRENT	Module: WaterBody, Class: Stream, Function: Harbour, Usage: Public use
DEPARE	Module: LandUse, Class: Water, Function: Sea, Usage: Military
FERYRT	Module: Transportation, Class: Waterway, Function: Ferry,
FSHZNE	Module: WaterBody, Class: Sea, Function: Waterway, Usage: Fishing water
HRBFAC	Module: Transportation, Complexclass: Waterway, Complexfunction: Harbour
LIGHTS	Module: CityFurniture, Class: Traffic, Type: Roadsign
T_NHMM	Module: WaterBody, Class: Tidal water, e.g. Waterleveltype: Mean high tide
LOCMAG	Module: LandUse, Class: Water, Function: Special Function Area
OBSTRN	Module: Cityfurniture, Class:traffic, Function: others
CTNARE	Module: Transportation, ComplexClass:Waterway, ComplexFunction: Traffic marker

Figure 3: List of few examples which shows the mapping of ENC data into CityGML objects.

The Figure 4 shows the extensions of the schema for the objects which could not mapped clearly. The extensions are additional definitions given by the „GenericProperty“-attributes of the shown objects. The figure shows the kind of definition, the number of it and the mapped ENC object type.

The semantic groupings are mapped by defining „CityObjectsGroups“, which are designed to group objects.

Currently the 3D ENC module only supports one level of detail which results in an unutilized Level of Detail concept of CityGML in this case. Furthermore, the ENC feature IDs were mapped as GML IDs.

To integrate the generated hierarchy into the GML structure, the CityGML „Xlinks“ scheme is used. The root object refers as a beginning and children are associated by the one-directional „Xlinks“. The geometry is set implicitly, as we use the VRML file format to represent the 3D symbols of the ENC data.

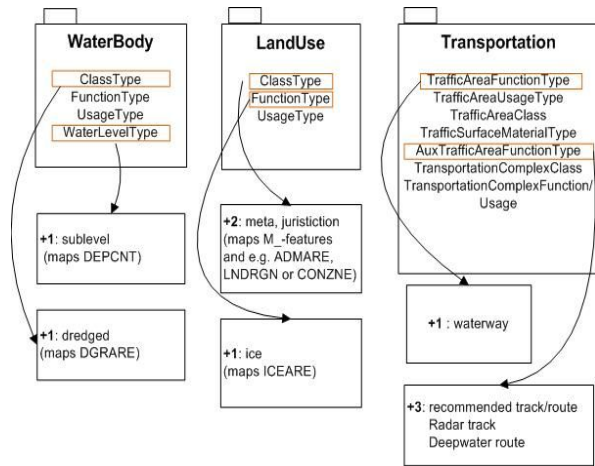


Figure 4: Extension principle for the ADE Enc. Only a few additional definitions have to be done

### 2.3 CityGML export to scenegraph framework

We have generated new information from the ENC data and stored it into the CityGML format. To render the scene, the structure of the data and the data itself has to be exported to a scenegraph, which is a standard data structure for rendering systems. Given a CityGML structure, which is enhanced with the described „Xlink“ hierarchy, a simple parser just begins at the root node of the CityGML objects and detects the transformation and the referenced VRML file. By relative transformation to the children, the tree-like scenegraph structure can be built. Figure 5 shows three scenegraphs with different display modes to show the display management. The semantic groups are modelled as nodes in the tree. If the user chooses a semantic group to be interesting, the according subtree is activated and can be shown, as requested. Each node in the subtree can then be used to set the new interest limit. These limits are used to decide, which nodes with the appending subtree are drawn. Safety information and objects like tracks are not given to this display management, as they are not locally bounded or should be displayed always.

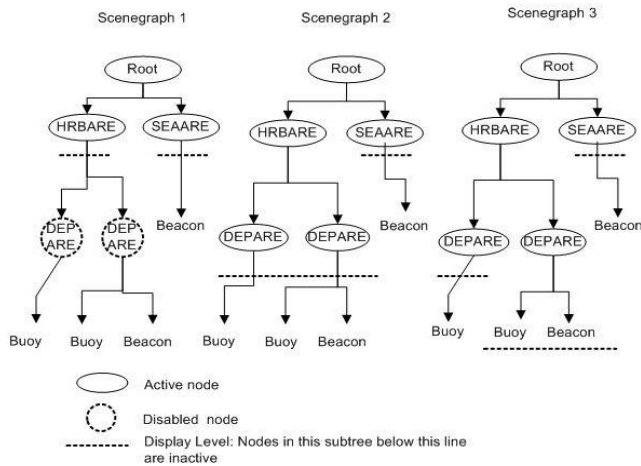


Figure 5: Principle of the display management; the scenegraph is shown with different display levels, which decide, which nodes are given to the renderer and which not

### 3. Conclusion and future work

We presented a scheme for the visualization of 3D nautical data, restructured for an interactive scene. We showed how we solved the display problems by generating an ENC-intern object topology and how the additional data can be stored in an exchange format like CityGML. Which regions are interesting can be decided by the user. The focus of the filtering then is choosable by a semantic and local clustering, based on the standardized ENC data.

A drawback of the 3D ENC module is the simple structure of the symbols, as there are only few surface textures. To improve this, computer vision techniques could supply more information and textures.[9,11]

Furthermore, we use implicit geometry handling. If textures are changed, the referenced geometry file has to be updated. A next step could be to rebuild the referenced models in CityGML by its GML3 geometry structure to have full access to all properties.

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