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 viewer's 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.

Keywords. ENC, S-57, 3D visualization, feature topology, CityGML, ADE Enc.

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]. Many of these applications vary mainly in the kind of chart data they use to display. The AR Binocular, which is under development [4], is used to overlay ENC chart data[1] 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[2] is able to offer a 3D symbolization and a scene-graph structure of the data. 2D ENC data is designed for a top view onto the map.

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

[2] 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).

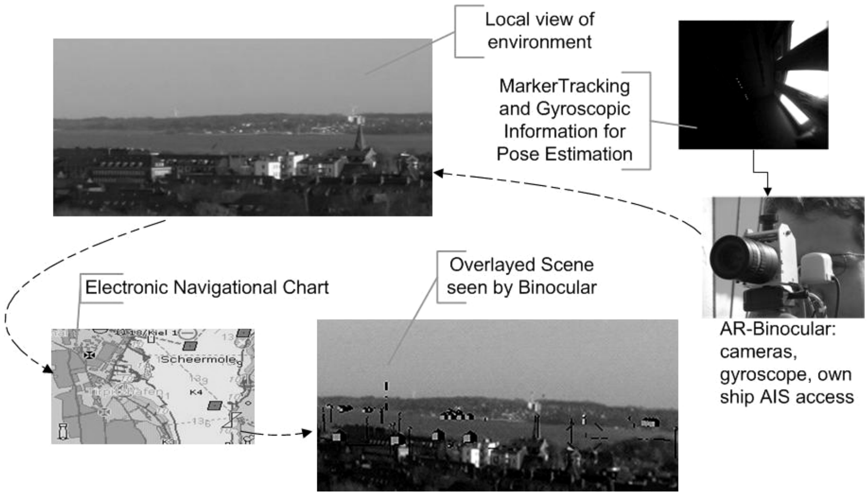

Figure 1. Augmentation Principle of the Augmented Reality Binocular; on the right there is a video capture and pose estimation device; it overlays the local environment (top left), with the correctly aligned chart data (bottom left).

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 information 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 scene-graph 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 object groupings by semantic. An existing method of filtering objects in ENC data is to select object classes, e.g. show 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.
At a higher level there exists a second relation scheme which relates the complete objects to each other. Using these relations which are modeled but not utilized (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 semantic 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 neighborhood relations between these groups, the topic of a cluster can be found. Topics are e.g. object names of land areas or sea regions.
As a result new requests are possible like getting all objects of an entrance of a habour or of a built up area. In combination with the given clusters, the filtering by the object categories is still possible. The approach here is not to map all ENC attributes in detail to the CityGML structure, but store the extension of the 3D ENC data format. These extensions are a hierarchy within the ENC objects and semantical groupings.

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 thematic modeling, semantic descriptions, appearance storage and 3D geometries [10].

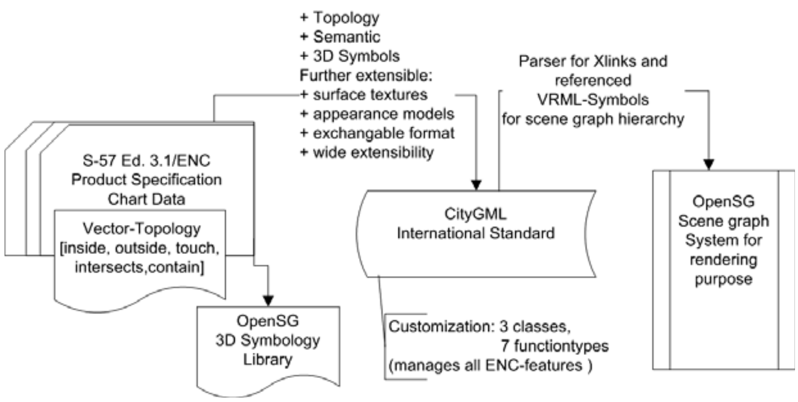

Figure 2. Data flow of the conversion from S-57 ENC data to CityGML and into a scene graph system.

This offers the infrastructure for a 3D ENC scene. It fits very well to the object types given by the ENC object catalogue since the complete scheme of CityGML only differs in 10 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 modeling and XML as exchange format, but a scene graph 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[3]. Figure 2 shows an overview of the data flow.

2*.2. CityGML ADE Enc Definition*

CityGML has 11 thematic models, from which we had to extend four. Main traffic structures like traffic directions, tracks and routes are mapped to the "transportation" module. 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
CURENT	Module: WaterBody, Class: Stream
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: Habour
LIGHTS	Module: CityFurniture, Class: Traffic, Type: Roadsign
T_NHMN	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. A full list can be downloaded with the ADE Enc

The Figure 4 shows the extensions of the schema for the objects which could not be mapped clearly. The extensions are additional definitions given by the "Generic Property"-attributes of the shown objects. The figure shows the kind of definition, the number and the mapped ENC object type. Additionally, we extended all of the shown classes and the "Building" module with an implicit geometry tag. Especially for "Buildings" it seems to be a good supplementary concept to use predefined models, because buildings often look similar and sights could be modeled once in detail. The semantic

[3] Available from: www.mip.informatik.uni-kiel.de/tiki-index.php?page=ARBinocular.

groupings are mapped by defining „CityObjectsGroups“, which are designed to group objects. Currently the 3D ENC module only supports one level of detail (LOD) which

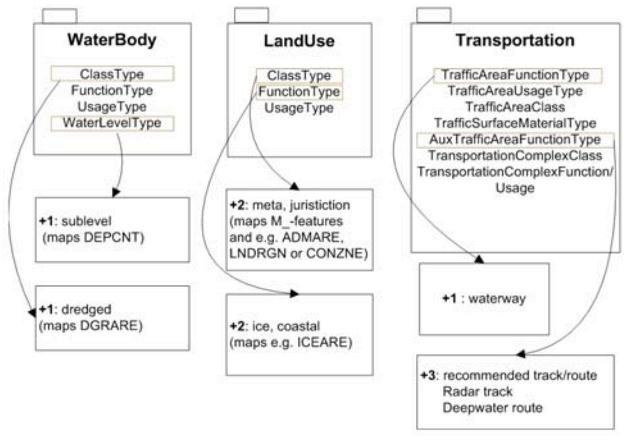

Figure 4. Extension principle for the ADE Enc. Only a few additional definitions have to be done.

results in an unutilized LOD concept of CityGML in this case. Furthermore, the ENC feature-IDs were mapped as object names. The object attributes of the ENC features are given in raw mode into the body of the defined objects. Important attributes which match the CityGML structure like position and color are processed independently. 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.

2*.3. Scene generation*

We have generated new information from the ENC data and stored it into the CityGML

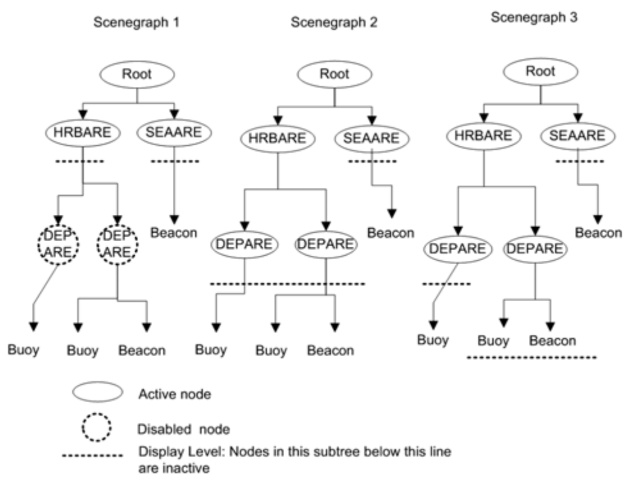

Figure 5. Principle of the display management; the scene graph is shown with different display levels, which decide, which nodes are given to the renderer and which not

format. To render the scene, the structure of the data and the data itself has to be exported to a scene graph, 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 transformations to the children, the tree-like scene graph structure can be built. Figure 5 shows three scene graphs with different display modes to show the display management. The semantic groups are modeled as special nodes in the tree. If the user chooses a semantic group to be interesting, the according sub tree is activated and can be shown, as requested. Each semantic 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 6 shows the raw view of the Binocular without any overlays and the overloaded situation by drawing all information at a time. In contrast to that, the Figure 7 shows the processed scene, where different LODs are shown. The left image shows that it is possible to decide e.g. if the sea or the land areas are important. The image on the right shows then the next LOD for a region on the land area. This mode is able to display only the information which is selected. In the application mode the scene starts in an overview mode and the user can pick regions of interest and increase the LOD while unselected regions stay in the overview status.

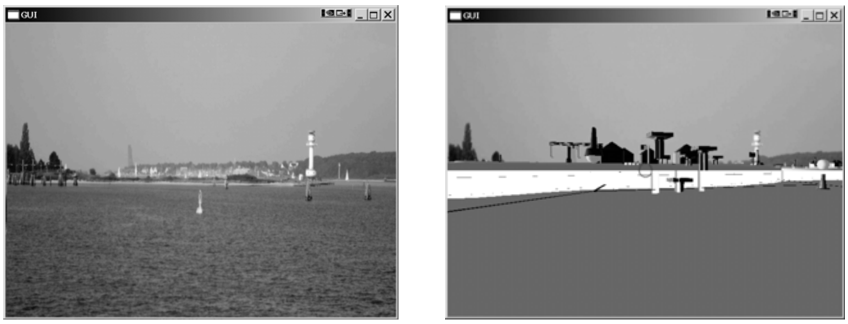

Figure 6. Left: Image of the environment without overlays; Right: all symbols are displayed in raw mode

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 the generation of 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 selectable 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 like colours 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.

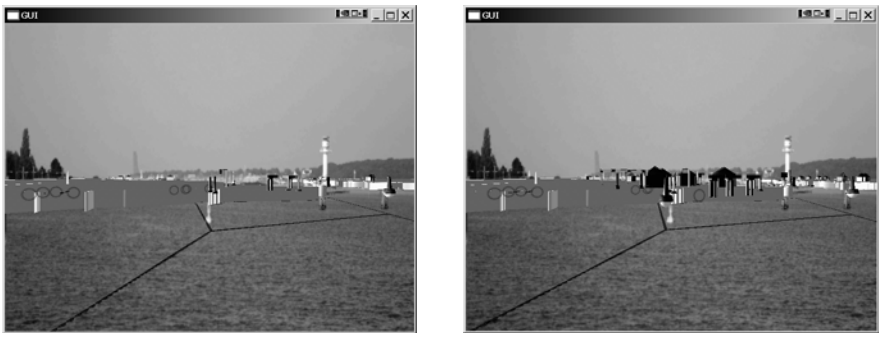

Figure 7: Left: First LOD for the selected region; Right: Next display level of the region.

Thanks. We thank the SevenCs GmbH, Hamburg for the ECDIS software and for the support during development. This work was funded by the Innovation Foundation of the State of Schleswig-Holstein (ISH).

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