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Collaborative planning of inner-city-railway-tracks: A generic description of the geographic context and its dynamic integration in a collaborative multi-scale geometry modelling environment

H. Steuer [a,*], M. Flurl [b], A. Donaubauer [a], R.-P. Mundani [b], T.H. Kolbe [a], E. Rank [b]

[a] Chair of Geoinformatics, Technische Universität München, Germany
[b] Chair for Computation in Engineering, Technische Universität München, Germany

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ABSTRACT

Planning sub terrestrial inner-city-railway-tracks is an interdisciplinary and highly complex task, which involves plenty of different stakeholders. Currently, the different planners work more or less separated in an asynchronous manner. To facilitate a collaborative planning process between these different stakeholders we developed a collaboration platform. Clearly, the integration of geographical information and geoprocessing results into the planning process and the different modelling tools will improve this process in a significant way. In this paper, we show how to describe the needed geographical information by so-called Geospatial Web Service Context Documents in a suitable way and how to integrate these pieces of information into the different planning tools via the collaboration platform in a unified, dynamic, and generic way.

1. Introduction

Naturally, the highly complex process of planning sub terrestrial inner-city-railway-tracks involves plenty of different stakeholders from various domains such as civil engineers, as well as subsoil, environment, and fire safety experts. These different adepts often use their own specific geometric modelling and planning tools thereby creating their own specific data in its own proprietary data structure. Thus, the different stakeholders work more or less separated in a not very contiguous manner. To combine, evaluate, and revise their specific work, the created data is exchanged between the different adepts in a file-based fashion or even on paper plans. Normally, the results of this evaluation and revision process are discussed in personal meetings or teleconferences resulting in an iterative process. This kind of collaboration obviously extends the duration of the planning process in a significant and undesired way.

Clearly, in the process of planning inner-city-carriageways the geographic context of the objects to be built is of major importance. For instance, to plan the specific track course one needs information concerning the soil conditions, the sub terrestrial buildings, the sewage water system, etc. The geographic context is especially of major importance at locations where the sub terrestrial track is connected to the terrain surface, for example at emergency-rescue-shafts. Thanks to spatial data infrastructure initiatives such as INSPIRE[1] these pieces of information are or at least will in future be provided by certain web services. Even though information on the geographic context of the planned track is available in principle, at the moment, the sheer integration of this information into the common modelling and planning tools is not facilitated in a convenient way. Additionally, there are at least three further problems concerning these web services. Specifically different services are hosted by different dispersed servers; different services provide the needed data, but they provide this data in diverging scales; and standardized web service interfaces have limitations compared to the requirements of a synchronous collaborative planning scenario [7].

In order to overcome the problems described above we developed a collaboration platform. This platform facilitates a synchronous modelling and planning process between modelling engineers and Geographic Information System (GIS) experts. The

* Corresponding author.
E-mail addresses: steuer@tum.de (H. Steuer), matthias.flurl@tum.de (M. Flurl), andreas.donaubauer@tum.de (A. Donaubauer), mundani@tum.de (R.-P. Mundani), thomas.kolbe@tum.de (T.H. Kolbe), rank@bv.tum.de (E. Rank).

[1] Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE).

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basis for the synchronous modelling process is a multi-scale procedural geometry model of the planned track, which describes the geometry by its several construction steps in contrary to an explicit representation. This procedural model supports the concept of different Levels of Detail (LoDs), which enable different planners to work in the abstraction level of their specific task, thereby using the geometry modelling tools they are accustomed to. Additionally, we designed a component structure, which allows the integration of different data sources into the different planning tools via the collaboration platform. In order to incorporate the geographic context into the planning process and the planning tools respectively, we investigated the description of collections of geospatial web services in so-called *Geospatial Web Service Context Documents* and used the developed component structure to do the integration.

In this paper, we describe the principle idea of *Geospatial Web Service Context Documents*. Then we will illustrate the integration of web services using these documents and a newly developed component structure. In doing so, we will show that this integration process is facilitated in a convenient way, (i.e., a unified, dynamic, and generic one). Finally, we will describe how this integration strategy of GIS-data can significantly improve the collaboration between different experts in the process of planning a subway tunnel by providing a use case, in which an emergency-rescue-shaft is located.

2. Related work

2.1. Collaborative geometric modelling

Computer supportive cooperative work (CSCW) has been in the focus of scientific research for many decades. A broad overview about the needs and challenges in the development of CSCW and Groupware systems supporting collaboration of teams are given by Stefik et al. [26] and Ellis and Gibbs [12]. Many researchers focused on concurrency issues regarding CSCW, for example Munson and Dewan [21], Sun et al. [28], Sun [29], and Vogel et al. [30]. Strategies for conflict detection and management in collaborative systems were presented by Edwards [11]. Berlage and Genau [1] presented a framework for shared applications providing flexible merge- as well as undo/redo-strategies. Likewise, collaborative work in the field of geometric modelling has been researched for a long time. One key aspect of those research efforts concerned the exchange of geometry models between different CAD software tools. Standard exchange data formats such as IGES and STEP were devised in the beginning of the 1980th and 1990th. These formats were highly accepted by different vendors of CAD tools and resulted in the integration of import and export mechanisms using these formats into most of the common tools. Since they only support the description of the mere geometry data and the resulting BREP model respectively, the design intent is lost during the actual model exchange. This fact obviously hinders a collaborative modelling process so that researches started investigating possibilities to tackle this problem approximately one decade ago.

Choi et al. [9] suggested a macro-parametric approach to exchange CAD models between different CAD software tools. A sequence of history based modelling commands is recorded and can be imported by a different modelling tool. This approach may be a first basis for an asynchronous collaborative modelling process using different modelling system, i.e. one planner creates a model and exports it, and another planner imports this model and continues to work on this model. A synchronous modelling process using these macros is not supported or investigated at all.

Bidarra et al. [2] presented the Alibre Design 2D/3D CAD software. In a client–server architecture called webSPIFF a central server contains the geometry kernel and hosts the geometric model, while engineers using thin clients – the so-called webSPIFF clients – can work synchronously on this model. Though this approach facilitates synchronous work for engineers using the webSPIFF thin-clients, it does not support the usage of popular CAD software tools, such as Siemens NX or Autodesk Inventor.

Borrmann [3] developed the CoCoS platform, which allows a very simple synchronous geometric collaboration, but provides considerable possibilities to integrate simulation data into this modelling process.

Li et al. [20] developed a possibility for synchronous modelling using neutral modelling commands: Vendor specific modelling commands are translated into neutral commands, sent to a central collaboration server that forwards these neutral commands to the other clients. These clients then translate the neutral commands back into their own vendor specific commands. This approach is similar to ours but does not support the concept of different Levels of Detail, a major improvement in our concept. Also it does not support a collaborative workflow, in which more than one planner is allowed to do modification steps at the same time. Additionally, since the context of our approach is the planning process of inner-city carriage ways, we extend the normally used modelling functions by tunnel specific modelling commands.

Borrmann et al. [5] created a multi-scale geometry model, thereby providing possibilities to work in different Levels of Detail, while the system automatically preserves the consistency of the model. This multi-scale procedural model is the basis for our synchronous collaborative modelling approach.

2.2. Collaborative use of geospatial information

With the upcoming of OGC (Open Geospatial Consortium) web service standards, fine-grained access to geographic information has been introduced to GIS. Instead of retrieving files with possible large geographic extent and potentially containing many undesired features (in geoinformatics the term feature denotes an abstraction of real-world phenomena; see ISO 19109:2006) users can access exactly the desired features in a given geographic region by specifying spatial, logical, or temporal filters. In addition to accessing geospatial data, users may also access data processing functions through OGC web service interfaces. In this paper, we will address the following OGC web services: the Web Feature Service[2] (WFS), Web Map Service[3] (WMS), and Web Processing Service[4] (WPS).

WFS (ISO 19142:2010) enables access to GML (Geography Markup Language) data (ISO 19136:2007). If WFS allows the optional write-access to its features, it is called WFS-T (Transactional WFS). A WFS implementation may support the filter encoding language (ISO 19143:2010) which allows for expressing fine-grained query expressions, (e.g., for retrieving all the buildings in a certain geographic extent which are owned by a specific owner). The main geometry object types of GML are boundary representations (B-rep): points, lineStrings, surfaces, and solids. In GML, these geometry objects are used to describe the spatial properties of a feature, (e.g., the footprint of a building). In addition to the spatial properties, a GML feature may have an arbitrary number of non-spatial properties, (e.g., a building may have properties describing its usage and its owner). GML just defines a common modelling framework for modelling real-world phenomena. Actual real-world phenomena have to be modelled by so-called "GML application schemas". CityGML, an international

[2] OpenGIS Web Feature Service 2.0 Interface Standard, Version 2.0.0 OGC Document 09-025r1 and ISO/DIS 19142. http://www.opengeospatial.org/standards/wfs.

[3] OpenGIS Web Map Server Implementation Specification, Version 1.3.0 OGC Document 06-042. http://www.opengeospatial.org/standards/wms.

[4] OpenGIS Web Processing Service, Version 1.0.0 OGC Document 05-007r7. http://www.opengeospatial.org/standards/wps.