Chapter 20
GML-Based Data Management and Semantic World Modelling for a 4D Forest Simulation and Information System

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ABSTRACT

Various types of 3D simulation applications benefit from realistic forest models. They range from flight simulators for entertainment to harvester simulators for training and tree growth simulations for research and planning. This paper's 4D forest simulation and information system integrates the necessary methods for data extraction, modelling and management. Using modern methods of semantic world modelling, tree data can efficiently be extracted from remote sensing data. The derived forest models contain position, height, crown volume, type and diameter of each tree. This data is modelled using GML-based data models to assure compatibility and exchangeability. ForestGML is the name of a new schema family developed to provide a common basis for forestry data. A flexible approach for database synchronization is used to manage the data and provide caching, persistence, a central communication hub for change distribution, and a versioning mechanism. Combining various simulation techniques and data versioning, the 4D forest simulation and information system can provide applications with "both directions" of the fourth dimension. This paper outlines the current state, new developments, and integration of tree extraction, data modelling, and data management. It also shows several applications realized with the system.

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1. INTRODUCTION

At 3D GeoInfo 2012, we presented an innovative and efficient way to generate "Virtual Forests" from remote sensing data (Bücken & Roßmann, 2013). Individual trees are delineated from normalized digital surface models and annotated with height and species. This approach is the first step towards various forestall simulation applications based on real-world data like the simulation of forest machines (Figure 1), a flight simulator, or a tree growth simulation. To provide a basis for an efficient and modern data management of such vast datasets, a database-driven method for 3D simulation systems previously presented at 3D GeoInfo 2010 is used (Hoppen, Roßmann, Schluse, & Waspe, 2010). It provides a persistence layer and a common data schema for simulation systems. Now, it is enhanced by techniques for database-driven, distributed data management and simulation, and for data versioning.

In this new paper, we focus on the integration, enhancement, and on future trends regarding these two core technologies of a large-scale 4D forest simulation and information system. In particular, algorithms for the attribution of the individual tree, details on the GML-based (OGC, 2014) object-oriented schema family ForestGML for forestry data, and the concept of database-driven communication are presented. Overall, a shared world model is efficiently managed in a geo database and filled using modern techniques of semantic world modelling. The latter transform remote sensing data into a semantic object representation that can be used for the various simulation scenarios as mentioned above. Furthermore, data versioning can be used to analyse past scenarios like a windthrow, where the corresponding storm loss must be calculated. Furthermore, even simulated or predicted future values can be managed in a database for conservation, analysis, and comparison. These two concepts – simulation and versioning – add a fourth dimension yielding a 4D forest simulation and information system. Furthermore, given the performance of today's database systems, it even becomes feasible to use the presented system for a multi-client simulation. Here, different clients are simultaneously working with the shared world model, while their actions' effects are distributed over the very same active geo database system.

Figure 1. A driver training with the forest machine simulator