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Integrated modeling of CityGML and IFC for city/neighborhood development for urban microclimates analysis

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Abstract

Planning of the built environment requires at least two different levels of planning process and modelling. They can be categorized as city/neighbourhood-scale and building-scale. The typical application for city/neighbourhood-scale is Geographic Information System (GIS) and CityGML for the open source 3D format. Meanwhile, for building-scale, Building Information Modelling (BIM) is used, and IFC format is the open source standard. In this paper, two case studies were presented, including visualization for a web application and input model of the urban microclimate modelling STEVE Tool. We used Autodesk Revit and Graphisoft Archicad in developing the building models as prototype for the transformation testing. The transformation system was developed using Feature Manipulation Engine (FME), by Safe Software. FME allowed us to restructure the data model (IFC) and transform it to the destination data format (CityGML).

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Keywords: CityGML, IFC, Interoperability, Sktechup, FME

1. Introduction

The approach for GIS (CityGML format) and BIM (IFC format) modeling integration has recently emerged as an important area of research. Extensive efforts are put on building models extensions, such as IFC4 and CityGML ADE,

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to realize meaningful integration. A unified model is under development for integrating the two standards; but the integration sacrifices its semantics and cannot be applied to existing models. The key of the integration is merely data conversion.

In this project, a practical approach for local Singapore context is being used to build a simple and straightforward transition framework. The research approach uses case study models and the research focuses on understanding and defining the rules of data semantics for seamless geometric transformation and semantic matching between the two formats.

2. Literature review

CityGML is an XML-based encoding for the representation, storage, and exchange of virtual 3D city and landscape models. CityGML is realized as an opened data model implemented as an application schema for the Geography Markup Language 3 (GML3), the extendible international standard for spatial data exchange issued by Open Geospatial Consortium (OGC) and ISO TC211. It provides a standard model and mechanism for describing 3D objects with respect to their geometry, topology, semantics and appearance. It also includes generalization hierarchies between thematic classes, aggregations, relations between objects, and spatial properties. [1,2,3].

IFC is defined as an object-based file format oriented specification for exchanging, sharing and re-using information throughout the building industry's life-cycle. It is an open file format developed and maintained by buildingSmart (formerly the International Alliance for Interoperability). The goal of IFC is to specify a common language for building industry technology that improves communication, productivity, delivery time, cost, and quality throughout the design, construction and maintenance life cycle of building. IFC is used to assemble computer readable models that contain data elements that represents parts of buildings and their relevant information. [1,3,4]

Despite the incompatibility between IFC and CityGML, various solutions have been tested to overcome this problem. The first approach is to achieve integration through application domain extensions (ADEs) as presented by Bahu and Nouvel [5] or T. Kolbe [6]. Other approaches to achieve integration are the unidirectional transformation of IFC building models into CityGML, as presented by van Berlo and de Laat with their GeoBim extension [7] or El mekway Östman and Hijazi with their Unified Building Model (UBM) [1,4,8,9].

Xun Xu, et al proposed the concept of City Information Modeling (CIM) as an information integrating framework for BIM and GIS, comparing and mapping the data schema behind each other [10]. Yu and Teo studied the generation of CityGML LOD models form BIM/IFC models by dividing geometric conversion into calculating node points' coordinates and editing geometric information, followed by attribute conversion [11]. Amirebrahimi, et al approached the integration of GIS and BIM through a data model to assess the damage of building due to flooding. They designed a conceptual data model illustrating the required concepts and their relationships. An UML class diagram was employed for developing and presenting the data model [12]. Geiger, et al integrated an IFC model in a CityGML through a method for semantical and geometrical generalization of IFC models. The method is implemented as an early prototype in the software platform IFCExplorer, developed at Karlsruhe Institute of Technology. [13]

Karan, et al used semantic web technology to ensure semantic interoperability between existing BIM and GIS tools [14]. Kang and Hong proposed a BIM/GIS-based information Extract, Transform and Load (BG-ETL) software architecture that separates geometrical information from that related to relevant properties [15]. Deng, et al used an instance-based method to generate the mapping rules between IFC and CityGML and design a reference ontology and CityGML ADE for schema mediation [16].

3. Research Objectives and Methodology

The objective of this research is to propose a spatial extract, transform and load (spatial ETL) workflow for the effective integration of IFC, CityGML and Sketchup that could be use as model visualization for web application and in a micro climate modelling perspective. Several effective ETL workflows are designed to define adequate transformations between IFC and CityGML at different Level of Detail (LOD) and between IFC and Sketchup.

Two case studies were developed, including visualization for a web application for urban energy planning and an input model of the urban microclimate modelling STEVE Tool.