A Graph Transformation based Approach to support Parametric Feature-Based Models

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In the scope of planning and realizing large infrastructural projects, it is reasonable to create product models as multi-scale models comprising multiple levels of detail (LoDs). This concept is already well established in the GIS field and applied in CityGML (Kolbe, 2009). To avoid inconsistencies among the different LoDs, however, it is necessary to apply parametric modeling techniques, which allow to automatically preserve the model consistency across the different LoDs in the case of modifications (Borrmann et al., 2014).

Previous research work in this area has revealed that the manual creation of consistency preserving parametric models is a very complex, time consuming and error-prone task. Therefore, research concerning the automation of the detailing processes is necessary.

The thesis will introduce a detailing automation approach which is based on graphs and graph transformations. It will further research how parametric geometric models can be represented by graphs and how refinement steps can be realized through graph transformation operations (Fig. 1). The theoretical basis of this research comprises the graph theory, graph transformation (Rozenberg, 1997) and parametric modeling (Shah, 1995).

The thesis will augment the general approach to represent two dimensional parametric sketches by the use of graphs as described in (Vilgertshofer, 2014). Thereby it will further elaborate how geometric elements and corresponding parametric constraints of a sketch can be depicted by the nodes and edges of a graph and their attributes. Also, the properties of this graph that are required for a non-ambiguous representation will be analyzed in-depth. In addition to the graph-based representation of pure two-dimensional sketches a second graph model will be introduced. It will comprise a procedural model depicting the
necessary geometrical operations (extrusions, sweeps, intersections, etc.) to create an evaluated three-dimensional geometric model (Borrmann et al., 2014).

To define the elements of the representing graphs, graph metamodels must be developed for both graphs. They describe the different types of nodes and edges as well as the attributes they possess. Based on this metamodel a set of graph rewrite rules will be defined. Those rewrite rules represent steps in the detailing process of a sketch. By applying a rewrite rule to a graph-based representation of a sketch, it is altered in a way that the resulting graph represents a refined version of the particular sketch. This thesis will discuss how the metamodel and the rewrite rules need to be assembled in order to create a graph that matches the requirements for an unambiguous representation.

The application of the graph transformation is performed by the graph transformation tool GrGen.NET at present. While other graph transformation tools have been considered, it was determined, that GrGen.NET is best suited in the context of this research. GrGen.NET allows automatic graph rewrite operations and can export the resulting graph data. In addition, the software application previously developed (Vilgertshofer, 2014), which interprets the graph data and creates the corresponding sketch or model in the parametric CAD design software Autodesk Inventor, will be extended.

To demonstrate the functional capability of the presented theories a prototypic implementation is being created. The developed functionalities are illustrated through the stepwise refinement of the model of a shield tunnel as well as other use cases.

References


