Large Scale Query Evaluation for Constructions and Built Infrastructure
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Abstract
Today, the need for digital information from built infrastructure is dominating many tasks within civil engineering such as planning and maintenance and it is still growing rapidly. In many cases the entirety of those information is not (cross-)linked over domains or scales, and, thus, prevents to gain a better insight and deeper understanding of the underlying data. To provide the advantage of hierarchical ordered information, it has to be dealt with data existing at different scales and models respecting the amount of data and their structure, which requires the application of appropriate hierarchy and usage of elaborate techniques.

In this work, we present an approach for the hierarchical organisation of varying information such as textured height maps for terrain visualisation or built infrastructure using Industry-Foundation-Classes (IFC) providing geometric and auxiliary information at fully detailed level. The objective is to enhance the gain of insight to the user by fusing and exploiting these diverse data. Such an aggregation is the basis for arbitrary queries, for example the embedding of graph theory to building information modelling, and enables the separation of certain information from unnecessary overhead.

In our approach, we apply a hierarchical data structure by using octrees in order to bridge the gap between different models and varying scales of information. This hierarchy, once established, provides an efficient tool for handling varieties of information and evaluating global specific values necessary for the orchestration of the models such as neighbouring relations between objects or calculating characteristics such as the total amount of floor space in a whole building. By doing so, we overcome the obstacle of (distributed) information being separated or only weakly associated and therefore receive meta-information which in that form is not available within the single data sources.

Outline of the Implemented Framework

The Data Source – Industry Foundation Classes (IFC)
- product model for constructions and built infrastructure
- industry standard ensures data exchange with other formats
- geometric representation
- fully detailed extraction
- auxiliary information
- mapping between geometry and function such as: door, window, etc
- association of attributes to objects (e.g. IP address of a network port)

The First-Layer Octree – Global Scale
- hierarchical data structure using spatial decomposition
- pre-computed and kept in main memory
- generated based on the bounding boxes of all IFC objects

used for decisions about
- location awareness
- which and when objects to load/disload

The Second-Layer Octree – Local Scale
- generation based on all elements of the construction
- temporary generated on the-fly
- one octree for each IFC object holding geometric and auxiliary information at fully detailed used for
- entity assembly
- visibility analysis
- parallelisation techniques

Level of Detail Dependent Analysis
- coarsening of fully detailed representations
- entity-wide: full scale of all objects
- construction-wide: approximation of building elements with their bounding boxes
- area-wide: simplified representation of constructions

Application to Planning Processes
- early examination of planning problems
- check for intersections of existing and planned constructions using octrees
- reduction to multiplexing linearised octrees
- one octree for the planned construction
- N octrees for existing constructions (1 per construction)

Global queries
- combination of global scope and local information depth
- interface for combined queries
- global: spatial relation
- local: detailed IFC information
- two step processing of queries
- identification of "spatial-candidates"
- processing of product models in candidate set following spatial order

Application of Indoor Thermal Comfort Assessment for Buildings
Definition of Thermal Comfort
ASHRAE Standard 55: Condition of mind that expresses satisfaction with the thermal environment
Benzinger (1979): The absence of driving impulses from cutaneous and hypothalamic receptors
- Related to the thermal state of the body as captured by thermoreceptors as
- / \ Tskin(t)

Varying influence of body parts (weighting required)
Significant:
- overall thermal state of the body
- moisture sensation from skin
- \( T_{hyp} \)
- mean skin temperature (setpoint deviation)
- \( \Delta T_{hyp} \)
- hypothalamus temperature (setpoint deviation)
- \( \Delta T_{hyp} \) / \( dt_{hyp} \)
- change of mean skin temperature over time
- efforts for regulating body temperature

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References