Department of Aerospace and Geodesy
TUM School of Engineering and Design
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Master's Thesis Proposal

Application-Agnostic Extension of the CityGML Conceptual Model with Physical Material Properties

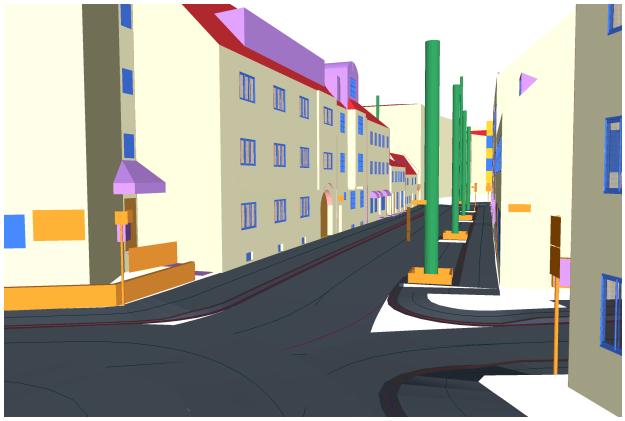

Figure 1: Semantic model at LOD 3 colored according to CityGML 3.0 class

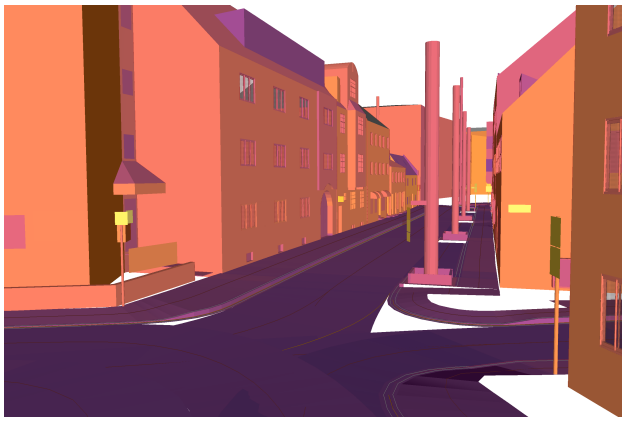

Figure 2: Object surfaces colored according to the material property reflectivity at 903 nm wavelength

Description While semantic 3D city models are already provided and updated for entire countries at Level of Detail 2 (LOD 2), methods for reconstructing higher-detail semantic models are steadily improving and the number of available LOD 3 models continues to grow. However, these models do not yet capture the individual materials of object surfaces and their physical properties.

The goal of this thesis is to develop a CityGML extension for representing physical material properties in an application-agnostic manner. To achieve this, a requirements analysis of relevant physical material parameters will first be conducted. This includes a comprehensive literature review and an examination of existing material property models and their applications, such as building energy estimation, microclimate simulation, and sensor simulation. Relevant extensions include OpenMATERIAL 3D, which was developed to support physics-based simulations of LiDAR, camera, and radar sensors [1], and the EnergyADE for CityGML, which integrates material information to enable energy simulations and assessments at both building and city scale [2]. To assess the applicability and general usability of the developed material property extension, it will be practically tested within a single application scenario. For this purpose, an OpenMATERIAL-compliant environment model will be derived in the glTF graphics format in order to carry out a physics-based LiDAR sensor simulation.

Requirements Proficiency in Python or C++ programming is essential. Experience with data modeling in Enterprise Architect and semantic model processing is an advantage. Familiarity with the CityGML standard and FME is considered beneficial.

References [1] ASAM (2025). *ASAM OpenMATERIAL 3D*. `https://www.asam.net/standards/detail/openmaterial/`. Accessed 7 Oct 2025.
[2] Agugiaro, G., Benner, J., Cipriano, P., & Nouvel, R. (2018). *The Energy Application Domain Extension for CityGML: Enhancing interoperability for urban energy simulations.* Open Geospatial Data, Software and Standards, 3(1), 2.

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