A voxel-based approach to automatically repair CityGML LOD2 buildings

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Abstract:

Many companies and local governments around the world have recently invested in constructing such 3D models. The Netherlands is one example, its government has financed the construction of a 3D model covering the whole country. These investments were made because 3D city models have, in theory, huge potential to improve the quality of life of citizens. For example, when used as input for 3D simulations, they can help us assess the impact that environmental factors, such as noise (Stoter et al., 2008), wind (Janssen et al., 2013), air pollution (Ujang et al., 2013), and temperature (Lee et al., 2013; Hsieh et al., 2011), have on the citizens.

However, 3D city models are in practice seldom used for advanced applications, the main reason being that they are geometrically and topologically invalid (Biljecki et al., 2016,?; Steuer et al., 2015; Alam et al., 2014; Stadler and Kolbe, 2007; P´edrinis et al., 2015). If a building contains cracks and/or is missing surfaces, then simply calculating its volume is often impossible. More complex software for simulation and spatial analysis often have the same requirement on the input (McKenney, 1998).

There exists different methods to repair generic 3D volumetric models, see Attene et al. (2013) for a survey. However, these methods are for a single 'smooth' 2-manifold, ie shapes with perpendicular angles are rarely handled (such as that of a building). For 3D buildings, Bogdahn and Coors (2010) and Alam et al. (2013), describe repair tools for a 2-manifold (free of self-intersection), but do not guarantee their results. Zhao et al. (2013) use the constrained Delaunay tetrahedralisation to extract the outer boundary of buildings, but do not handle well missing walls and intersecting surfaces.t is a 2-manifold.

We will discuss in the presentation how automatic repair methods based on voxels could be applied to 3D buildings. That is, we first fill an invalid object with voxels (which allows us to easily handle intersecting/degenerate/etc geometries), then we use morphological operators to close the surface, and finally we extract the boundary surface from the repair model. Unlike other methods, we can guarantee that our output 3D building is a valid boundary surface (a 2-manifold).

We have implemented our approach and tested it with real-world datasets. We have for instance tried to repair the first version of the open dataset of Rotterdam (in LOD2, from 2011, http://rotterdamopendata.nl/dataset/rotterdam-3d-bestanden), which contains around 90% of its 3D buildings as invalid geometries. Figure 1 shows a few example of buildings and the result with our method. It can be seen that several walls in the dataset were missing, and these were correctly added. Extra surfaces (eg in Figure 1a) were also correctly were also correctly removed. However, it should be said that the voxelisation also introduces artefacts in the output geometry; we will discuss these in further details in the presentation. With our method, we were able to repair most of the buildings in Rotterdam, ie only 7% of the buildings were invalid (originally 90%) for one neighbourhood.

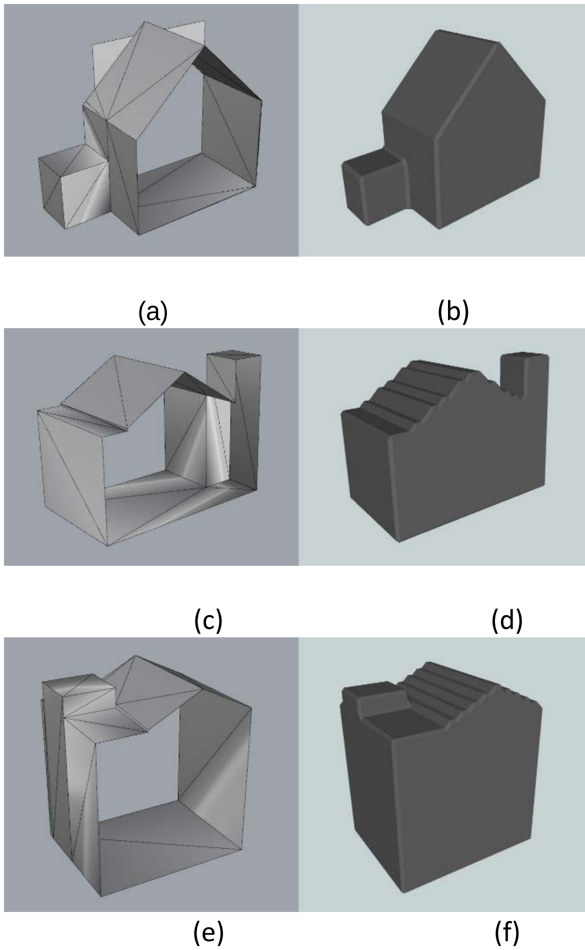

Figure 1: Left: 3D buildings from Rotterdam. Right: repaired building.

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