Integration of image data for the refinement of planimetric and topological accuracy of existing roof models

Geometrically and topologically correct 3D building models are required to satisfy the increasing demand in, for instance map updating, virtual reality, robot navigation and urban planning. To this end, a new approach is developed to enhance the planimetric accuracy of roof outlines while rectifying some topological issues associated to already derived building models. To achieve this goal, straight line segments are first extracted from the aerial images with known orientation parameters. Burns line extractor is used for extracting the line segments automatically (Burns et al., 1986). Existing roof models derived from point clouds are projected on to the image space via collinearity equations which then use to restrict the search space of candidate line segments extracted by Burns extractor. From the potential candidates corresponding image lines are matched to construct object space line segments. In the construction of object space boundary line segments from the stereo (and multiple) images, we follow the intersection of viewing planes in projective geometry as proposed by (Heuel, 2004; Ok et al., 2011). In order to minimise ambiguities which could arise in matching process, as a new notion, we introduce *scene constraints* acquired from the already derived roof models. In general, 3D roof models derived from point clouds are representing explicit unambiguous geometries about the scene except few uncertain properties such as planimetric positional uncertainty of roof outlines. As such, the *gradient* of a desired roof edge determined from the initial model, the status of planimetric symmetry, and the *perpendicular distance to the roof plane* from the midpoint of the constructed 3D line segment are incorporated for optimizing the matching process.

Furthermore, defects and gaps pertaining to the boundary segments derived from the image based method are minimised by determining their correct behaviour based on the well-defined evidences. Herein, known *structural arrangements* of roof models and *convergence priors* which are specifically defined to hypothesis how outer boundary lines converge in 3D roof models are used. Weakly defined step edge lines and roof outlines are refined by fusing line segments derived from images. Ridge-lines, however, are not updated as we assume intersection of planes derived from point clouds is generated accurate ridge-lines which are sufficient for geometrically correct building models.

Topological defects of building models derived from point clouds, for instance defects caused by occlusion, are rectified by adding line segments derived from images. New topological relations which were missed or hidden between roof planes are recovered while inserting step edges where they are necessary. This enhances the completeness and correctness of refined building models. Experiments shows that image integration significantly improve the planimentric accuracy and also a solution to minimise topological errors available in building models.

Reference

Burns, J.B., Hanson, A.R., Riseman, E.M., 1986. Extracting straight lines. IEEE Transactions on Pattern Analysis and Machine Intelligence 8 (4), 425-455.

Heuel, S., 2004. Uncertain projective geometry: statistical reasoning from polyhedral object reconstruction. PhD, University of Bonn, Germany

Ok, A., Wegner, J., Heipke, C., Rottensteiner, F., Soergel, U., Toprak, V., 2011. Accurate matching and reconstruction of line features from ultra high resolution stereo aerial images. In: Proceedings of ISPRS Hannover Workshop, High Resolution Earth Imaging for Geospatial Information, Hannover, Germany.