ANR BIOM PhD (36 months) proposed by TRIO (INSA)-IMAGINE (ENPC)

Location: ICUBE Laboratory at INSA STRASBOURG

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Joint Indoor/Outdoor Building Modeling from high cost LiDAR data
Modélisation conjointe intérieure/extérieure de bâtiments à partir de données LiDAR

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The Building Indoor & Outdoor Modelling (BIOM) project aims at automatic, simultaneous indoor and outdoor modelling of buildings from images and dense point clouds. We want to achieve a complete, geometrically accurate, semantically annotated but nonetheless lean 3D CAD representation of buildings and objects they contain in the form of Building Information Models (BIM) that will help manage buildings in all their life cycle (renovation, simulation, deconstruction). We view indoor and outdoor building modelling as a joint process where both worlds fruitfully cooperate and benefit one another both in terms of semantics and geometry. The hope is that this holistic scene understanding and reconstruction approach will lead to more complete, correct, and geometrically accurate building models: http://www.agence-nationale-recherche.fr/Projet-ANR-17-CE23-0003

The creation of as-built Building Information Models requires the acquisition of the as-is state of existing buildings. Laser scanners are widely used to achieve this goal since they permit to collect information about object geometry in form of point clouds and provide a large amount of accurate data in a very fast way and with a high level of details. In a former PhD, A. Boulch (2014) defined a framework for digital model production regarding both geometry and semantic, using point clouds as an entry. Nevertheless, the scan-to-BIM process remains largely a manual process which is time consuming and error-prone. The INSA ICUBE-TRIO group (Macher et al., 2017) developed a processing chain for the 3D semi-automatic reconstruction of indoors of existing buildings from point clouds for their integration in BIM software. The developed approach was composed of two parts. Based on indoor point clouds, the first part consists in several segmentations into spaces and planes and in the classification of points into several categories. The second part of the approach deals with the reconstruction of walls and slabs of buildings from the element point clouds extracted in the first part. At the end of the approach, a file in a BIM format is generated and reconstructed walls and slabs can be opened in BIM software. The approach was assessed based on different datasets which were not used for the development of the approach. The results obtained are promising from a geometric and a semantic point of view. Indeed, sub-spaces are almost all segmented and points are well classified into the different categories. Different evaluation items such as the degree of automation, the transferability of the approach and the geometric quality of results of the 3D reconstruction have been proposed. Quality indexes have been introduced to inspect the results in order to be able to detect potential errors of reconstruction.

In this PhD thesis, indoor and outdoor building modelling will be viewed as joint and intertwined processes. Indoor and outdoor modeling processes shall fruitfully cooperate such that missing elements on the outdoor are derived from the indoor and vice versa. This enables introducing strong constraints like co-planarity of walls, equal arrangement of floor levels and windows indoor and outdoor, etc. Apart from a geometric characterization point of view, the automatic identification of openings can be studied in different ways, e.g. radiometric information of point clouds namely colour and intensity will be considered and 3D object recognition algorithms will be tested in order to find automatically different types of openings in point clouds. In the BIOM project we thus advocate to treat indoor and outdoor worlds jointly to deliver one common “rich” geometrically accurate semantically annotated highly structured BIM 3D model. Quality criteria at each step of the process will be integrated in the approach in order to control the final accuracy of the complete 3D building model. The error budget of the whole processing chain, including the global indoor/outdoor registration step will be investigated. Reference buildings recorded with terrestrial and close-range LiDAR techniques in Strasbourg will be considered as test-fields for this project.

Boulch Alexandre (2014). Reconstruction automatique de maquettes numériques 3D, PhD thesis, LIGM, University Paris-Est(https://pastel.archives-ouvertes.fr/tel-01127912v2/document)

Macher, H.; Landes, T.; Grussenmeyer, P. (2017). From Point Clouds to Building Information Models: 3D Semi-Automatic Reconstruction of Indoors of Existing Buildings. Appl. Sci. 2017, 7, 1030. DOI: 10.3390/app7101030