Extraction of cues for inside/outside scan registration

Research internship

Key Words : Registration, Lidar, Inside, Outside

1 Context

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 a 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.

The first challenge will be to accommodate for heterogeneous data as full building modeling calls for data acquisition inside and outside the building but also from an aerial point of view to model roof. The BIOM project will also aim at exploiting the complementarity of image and LiDAR data. Another challenge is coping with incomplete data due to occlusions by furniture inside and urban and mobile objects outside. Last but not least, BIOM aims at modeling a large variety of architectural styles, different interior scene layouts, and a high amount of different objects that may be contained within the scene.

State-of-the-art approaches treat outdoor and indoor worlds separately : most indoor reconstruction approaches focus on detailed modelling of single rooms whereas only very few have dealt with 3D modelling of complete floors (under Manhattan world assumptions). To the best of our knowledge, no works have been proposed, yet, that model buildings outdoor and indoor simultaneously within one single comprehensive framework. After separate analysis of indoor and outdoor data and their registration, we propose to formalize complex priors about the structure of buildings and included

Inside scan (left, from Stanford 2D-3D-S dataset) and outside scan (right, IGN dataset)

objects in a probabilistic fashion. A crucial unsolved problem in probabilistic modelling of dense, textured point clouds is how to take into account object-level context and topology of large, complex, cluttered 3D scenes. In this regard, our research shall investigate where the sweet spot lies between generative, procedural modelling and discriminative object labeling and generalisation or primitives based reconstruction. What is more, a good compromise of fast unsupervised and expressive, detailed supervised modelling and object recognition will be a major part of our research.

The BIOM project will investigate multi-scale application use cases and their specific modelling needs and develop operational methodologies for producing *Application/Domain Ready* BIM models in the standard CityGML/IFC formats. Use cases and proofs of concept covering different phases and aspects of the urban project will be experimented over two sites and industrialised through dedicated web services.

The development of new methodologies and services (such as simulations and optimizations) based on virtual clones of buildings can only address the very limited fragment of the stock for which a BIM model exists. The BIOM project will address this issue by providing a robust, comprehensive and reference methodology for data acquisition and reliable BIM modeling to address a broad range of applications : inventory and urban studies, life-cycle management, construction works, occupancy phase, consultancy and communication of urban information. We expect the BIOM project to have a significant potential of transmission of outcomes to industry products. IGN and CSTB will work with industrial partners, existing spin-offs, and public authorities on the increased valuation of the produced reference. An open call for initiatives stemming from such a reference will be released in direction of SME and start-ups in order to raise interest of new actors in the domain and generate innovating services.

2 Objectives

A crucial step of the BIOM project is achieving a registration of inside and outside scans whose accuracy is close to the scan accuracy (around 1cm). To achieve such accuracy, cues should be extracted from both inside and outside data, then matched. This is quite constraining because these cues should be visible from both inside and outside perspectives. The object of this internship is the extraction of these cues which could be :

1. 3D window frames as in [Cohen et. al. 2016]
2. 3D segments as in [Akinlar and Topal 2011, Bay et al. 2005, Koch et al 2016]
3. Planar polygons as in [Salaun et al. 2016]

Given the specificities of the Lidar data which beams traverses windows, we propose to extract planar polygons which offer a compact and localised representation. We propose the following steps to extract these polygons :

1. Detecting points inside buidings in the outside scan
   — Facade detection (planar vertical polygons with sufficient extent) based for instance on the modified RANSAC of [Demantke et. al. 2012]
   — Selecting Lidar rays which traverse this plane (sufficiently far)
2. Planar polygons extraction
   — Plane detection on the inside points from both inside and outside scans.
   — For each plane, clustering plane points
   — For each cluster, extraction and simplification of the boundary of the clustered points into a polygon.

Interestingly, the same planar polygons extraction method can be used both for facade detection and cues extraction. Most planar polygons detected inside will not be seen from outside. However they can be useful to add parallelity/orthogonality constraints with the façade detected from outside.

3 Profile

— Student in a Research oriented Masters degree
— Specialisation in Computer Vision, image processing, machine learning or optimization.
— Good skills in C++
— Autonomy, rigor, pragmatism
— Strong taste for scientific research

4 Environment

The contacts and coadvisers for this internship are :

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Bruno VALLET is full time researcher at the MATIS Team [1] and coordinator of the BIOM project. Pascal MONASSE is with the IMAGINE Team [2] and participates to the BIOM work package on registration.

The internship will take place in the MATIS Team from the LaSTIG Lab of IGN (Institut National de l'Information Géographique et Forestière), located at Saint-Mandé (close to Paris, metro line 1, Saint-Mandé station). It will last 4 to 5 months starting february to april 2018.

The MATIS team is located at Saint-Mandé, bordering Paris in France. It depends on the Research Unit in Geo-Information Science of the French Mapping Agency (IGN), which itself belongs to the Research and Teaching Department of IGN. The MATIS team leads research activities in the fields of mathematics and computer science applied to photogrammetry, computer vision and remote sensing dedicated to ground-based, aerial and satellite multi-sensor imagery (optical, LiDAR, radar, etc.)

IMAGINE is a research group in computer vision, machine learning and optimization of the École des Ponts ParisTech (a.k.a. ENPC). It is affiliated to the Gaspard Monge Computer Science Lab (LIGM) of the University Paris-Est (UPE).

5 Bibliography

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1. Web page : http ://recherche.ign.fr/labos/matis/accueilMATIS.php
2. Web page : http ://imagine.enpc.fr/