University of Cape Town

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APG4003Z Project Proposal

BSc Geomatics

Designing an automatic system that creates 3D wire-frame models of the interior of the rooms in a building

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Abstract

With laser scanning becoming more and more popular as a form of surveying, it has become increasingly important for us to be able to process and make the resulting point clouds usable. This paper works with laser scans of the interior of buildings and making those point clouds usable and helpful.

When a scan is taken of the inside of a room, it is useful to know what each point represents, be it the floor, ceiling or wall. This is done by segmenting and classifying the point cloud.

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1 Introduction

3D representations of buildings vary largely in terms of how rigorously the models are structured. There are two extremes to it, the first is highly structured models, made in CAD software, of the buildings before or after the building has been built. The other end of the scale is 3D points clouds created by laser scanners that are entirely unstructured because they are just points floating in a 3D space. There is no relation from one point to another.

For taking surveying related measurements having just a point cloud works just fine, you can pick out specific points and do measurements across the points. But when it point clouds are used for applications like as built surveys of factories with the intention of the factory being expanded and/or up graded, a point cloud just wont cut it.

So it becomes necessary to create structure in these 3D points clouds. This is usually done by turning the point cloud into 3D models that engineers can then work on and use. There is an added advantage that some methods used for point cloud segmentation work with by classifying the points which allows for the 3D model to have labels.

2 Previous Work

A paper was written in 2012 by the image Processing Lad at the University of California that present an automatic system for planar 3D modelling of building interiors from point cloud data generated by range scanners [2]. This paper is very relevant because it is more or less the same topic that this paper proposes. It however does not look at wire frames instead it looks at an automated 3D modelling process.

Their process looks at a 3 step system, the first step is a Principal Components Analysis that gives each point a normal. It then classifies and segments the points using the normals, for example a point with a normal pointing downwards is likely to belong to the celling. So they classify the point as ceiling and then create segments by grouping similarly classed points together. Once the points are classed and segmented the segments then have a model fitted tot them. the outline planar modelling and modelling of a staircase. In the results section they state that they used C++ and PCL (Point Cloud Library). Their future plan is to create a process that can model non planar systems and look at curved walls.

The Victor Sanchez and Avideh Zakhor paper mentioned above dealt with creating 3D planer models form point clouds, another option is to create wire-frame models of the point clouds. this is done in a 2010 paper by Karim Hammoudi and others[1] did just that. the paper titles Extracting wire-frame models of street faÃ§ades from 3D point clouds and the corresponding cadastral map. the main difference with this and the Victor Sanchez and Avideh Zakhor paper is that it is creating wire frame models as opposed to 3D models, and one is of the exterious of buildings the other of the inside.

After the raw 3D point cloud has been filtered, it is segmented into a cloud of only the faÃ§ade of the buildings on the street then estimates of the each individual facade are extracted using the cadastral map. A Progressive Probabilistic Hough Transform (PPHT) is used to determine relationships between points and creae the wire frame model.

3 Methodology

3.1 Objectives

The objective of this project is to be able to create wire frame models of the interior of buildings, through point cloud segmentation and line fitting.

Point clouds are notoriously difficult to navigate on computers, especially the interior of buildings. creating a wire frame model makes the buildings interior easier to navigate, measure and use in a practical way.

The goal of surface reconstruction can be said as follows: Given a set of sample points P assumed to lie on or near an unknown surface S, create a surface model S' approximating S A surface reconstruction procedure cannot guarantee the recovering of the surface exactly, since we have information about the surface only through a finite set of points.

Using C++ and Point Cloud Library (PCL) an algorithm to complete these tasks with as little intervention as possible will be written as an add on function onto existing software.

For this to take place all data structures and files will need to be in a standardised files.

3.2 Questions

- How do we go about segmenting the point cloud?
- How do we decide which point belongs to which room in the case of multiple rooms?
- generalising ad removing points? adding points if necessary?
- Triangulation, use all points? or minimize number of lines in the render?
- Hough transform to find breaklines?

3.3 Proposed methods

From points to surface:

1. Pre-Processing - Removing noise, cleaning up data to allow work to be done on it, or sampling to reduce computation time.
2. Determination of the global topology of the objects surface - look for segments and make sure features such as breadlines and such are preserved
3. generation of the polygonal surface - triangular meshes are created satisfying certain requirements e.g. size limits ect ...

4. post processing - when the model is created, editing operations are commonly applied to refine and perfect the polygonal surface

In some cases there may be an shortage of points or in the more likely case there are to many points. for example a wall, we don't need 100 000 points to approximate a wall, so we can generalize that segment to make computations easier and faster.

But equally we may get a terrible approximation if we are missing large portions of the wall due to scan shadows we may get a really bad approximation of the wall in places so adding points may become necessary.

4 Outcomes

The outcome of this paper will be to create an automatic system that creates 3D wire-frame models of the interior of a room/rooms in a building.

So if a large point cloud that represents the whole interior of a building is fed through the program it will return a 3D wire-frame model of the interior of that building.

The program will be created in C++ using Point Cloud Library (PCL) and then be used as an add on function for existing point cloud software.

References

[1] Bahman Soheilian Karim Hammoudi, Fadi Dornaika and Nicolas Paparoditis. Extracting wire-frame models of street facades from 3d point clouds and the corresponding cadastral map. preprint, 2010.

[2] Victor Sanchez and Avideh Zakhor. Planar 3d modeling of building interiors from point cloud data. preprint, 2012.