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BSc Geomatics

Creating a 3D wire-frame model from a laser scan of the interior of a room

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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 you are left with a point cloud of the room. Point clouds are not very useful to most people so it is more useful to turn that scan into a 3D model. This paper deals with the process of taking a point cloud and generating a wire-frame model of that point cloud.

A wire-frame model is an edge or skeletal representation of a real-world 3D object using lines and curves. Wire-frame models consist only of points, lines, and curves that describe the edges of the object. Effectively removing all but the important pieces of information.

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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. These models are made by people using measurements.

The other end of the scale is 3D points clouds created by laser scanners that are entirely unstructured, this is 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 fine, you can pick out specific points and do measurements across the points. But when 3D models are used for more complex applications such as an as in engineering and architecture, just having a point cloud will not cut it. These applications need structure that a point cloud can produce.

So it becomes necessary to create structure in these 3D points clouds, or to create relationships between these point. This is usually done by turning the point cloud into 3D models that engineers and architects 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.

This paper goes through a method of creating wire-frame models from point clouds taken with laser scanners in enclosed spaces such as rooms and halls.

1.1 Previous Work

The most common method of turning point clouds into 3D models is by having a person digitize the whole cloud with CAD software. As a method of getting the work done this method works but in terms of efficiency its not great because you have somebody who sits all day and does nothing else. There are other methods like some software called PointFuse that is developed by Arithmetica. PointFuse works and does the job, but not nearly as accurately as a person would do it, making it not worth using until it becomes better.

There seem to be no previous examples of this project in previous papers, but there are two papers that are relevant in one way or another to this project.

The first is a paper that was written in 2012 by the image Processing Lab 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 (Sanchez 2012). 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 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 (Valero et al. 2012). The paper titled Extracting wire-frame models of street façades from 3D point clouds and the corresponding cadastral map. The main difference with this and the above paper is that it is creating wire frame models as opposed to 3D models, and is of the exteriors of buildings not the inside.

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

1.2 Methodology

1.2.1 Objectives

The objective of this project is to be able to create wire frame models of the interior of buildings.

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.

The programming will be done in C++ as this language is popular, has a large community and supports many large and popular libraries such as Point Cloud Library (PCL).

Using C++ and 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 outputted data must be in recognised file formats.

1.2.2 Questions

- How do we go about segmenting the point cloud?
- What is the best way to find breaklines, edges?
- How do we decide which point belongs to which room in the case of multiple rooms?
- Generalising, removing points? adding points if necessary?
- Triangulation, use all points? or minimize number of lines in the render?
- RANSAC?

1.2.3 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 surface - Triangular meshes or planes 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

1.2.4 Other Considerations

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.

1.3 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.qqq

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.

2 Literature Review

With how most of the world these days is online all the time, things such as Google Maps and Apple Maps are hugely popular as ways of navigating around. and because Internet connections are so fast the maps we can view with these applications are becoming more and more detailed. so with the outside world so well mapped and available to the public the next logical progression is to move indoors.

But with conventional methods of creating models of buildings being very slow or not accurate, the rate at which we are going to see navigate-able indoor models become popular will be slow.

So having the ability to create indoor models quickly and accurately will speed up the process of having everyone able to access indoor models.

Having easily attainable indoor models is not only something people want as a fun was of looking around buildings, it also has serious commercial uses in architecture and engineering.

3 Method

Method Here

4 Results

Results Here

5 Conclusions

Conclusions Here

References

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