Sensor Data-driven Urban Site Analysis using Point Cloud from Urban Mapping System (UMS)

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***Abstract*— Understanding and analyzing urban environment have been of focus by many researchers [1]. While conventional approaches rely on survey and/or manual 3D modeling, this paper introduces a new approach that allows direct and fast urban analysis using sensor data from Urban Mapping System (UMS). We focus on a concept of 3D isovist as the urban analysis metric, and present a pipeline to calculate a 3D isovist using Light Detection and Ranging (LiDAR) data for large and complex urban sites. Each point has 3D global coordinates after applying localization algorithms and is merged to a voxel for efficiency representing the 3D isovist. Our method is capable of handling a a 3D isovist precisely while automatically generating its distribution following urban roads. The results produced by the proposed pipeline could be important evidence to study the utility of the notion of 3D isovists in real space.**

I. Introduction

Urban environment analysis has been widely studied since [1]. Among many concept and metrics used in urban site analysis, we focus on an isovist. An isovist [2] is defined as a polygon or a set composed of visible points from an observer in a given space. This is a core concept in urban design to analyze discriminative characters of a site.

Isovists have commonly been used in 2-dimensional planes, called 2D isovists because conventional maps are mostly planar. A 2D map has only rough shapes of city objects without containing any information about height or 3D shapes of buildings. However due to the limitation of 2D isovist within a complex urban area, a need for 3D isovists have arisen as in [3]. Unfortunately, aforementioned approaches are limited to a conceptual level and only locally applicable for a given restricted size of a space, not showing the distribution of 3D isovists in a large complex urban site. A consensus on whether the notion of 3D isovists is worth while does not exist yet.

We found that application to urban site analysis using a 3D dense map is rare, although organizing 3D dense maps using a point cloud is an usual task in robotics. To connect both fields and demonstrate the usefulness of 3D isovists in real space with complex externalities, we propose a pipeline to acquire realistic 3D isovists.

II. 3D Viewshed using Mobile Mapping System

The pipeline is conducted using LiDAR point cloud data acquired from a mobile UMS. The system is applicable for acquiring detailed data from large complex urban sites while

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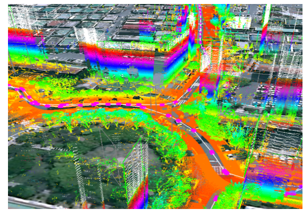
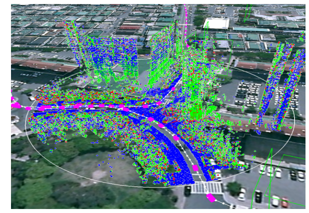
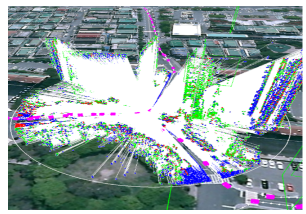


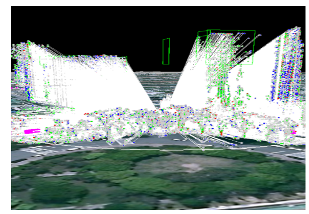
(a) Data Acquisition



(b) Voxelization



(c) 3D Viewshed Visualization



(d) Side View

Fig. 1. Visualization of a 3D isovist depicted as a viewshed from point cloud data in the visible region of the observer.

supporting substantially reduced process time. Finally we visualized the results of a realistic 3D isovist.

The overall pipeline is as can be seen in Fig. 1. The data obtained from the UMS presents a precise 3D map (Fig. 1(b)) with detailed shapes of city objects. Visible region ($50\ \mathrm{m}$ range) is considered in this analysis as in Fig. 1(b). The point cloud data may have many points at the same position because LiDAR rays along routes partially overlapped. Thus, we merged several points into a voxel if certain criteria were satisfied. These steps also provide efficiency when processing voxels into 3D isovists. Fig. 1(c) and Fig. 1(d) show the visualization of 3D isovists defined as a viewshed. Furthermore, more meaningful attributes (e.g., area, volume, skewness) can be derived from this basic geometric object. The values of those attributes represent features of a given site.

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