Real-time large-scale surface reconstruction

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Abstract

We present a large-scale surface reconstruction method based on lidar point cloud, which achieve both better surface reconstruction effect, and real-time effect. The method meets the needs of mobile robotic platform, and is very suitable for embedding to existing points cloud registration system. We use the pose information of each point cloud frame, update each frame points' sdf(signed distance function) value. By repeatedly updating the sdf of an object, so we get the implicit surface of the object, so we are able to draw the isosurface of the points with zero sdf value to get a surface triangulation model. Our method is good at denoising and accurately reconstructing a real surface. We also implement the parallel computation when we update each frame points' sdf value and achieve real-time effect. We compare our methods with other state-of-art reconstruction methods to show its advantage in terms of both quality and speed.

Introduction

Large scale 3D environment modeling reconstruction with precise and continuous surface in mobile robotic platform remains a very popular but challenging technology. This allows robots to plan precise path, and respond faster and more accurate to the surrounding environment.

Among 3D sensing devices, lidar (Lighting detection and ranging) has the following advantages (i) Higher measurement accuracy and higher angles, distances, and speeds resolution. (ii) Weather/Light independence. Data collection independent of sun inclination and at night and slightly bad weather. (iii) Larger effective distance. Useful in a large complex scene, over 100 m^2. (iv) Low cost and small size. Suitable for embedding in current robot platforms.

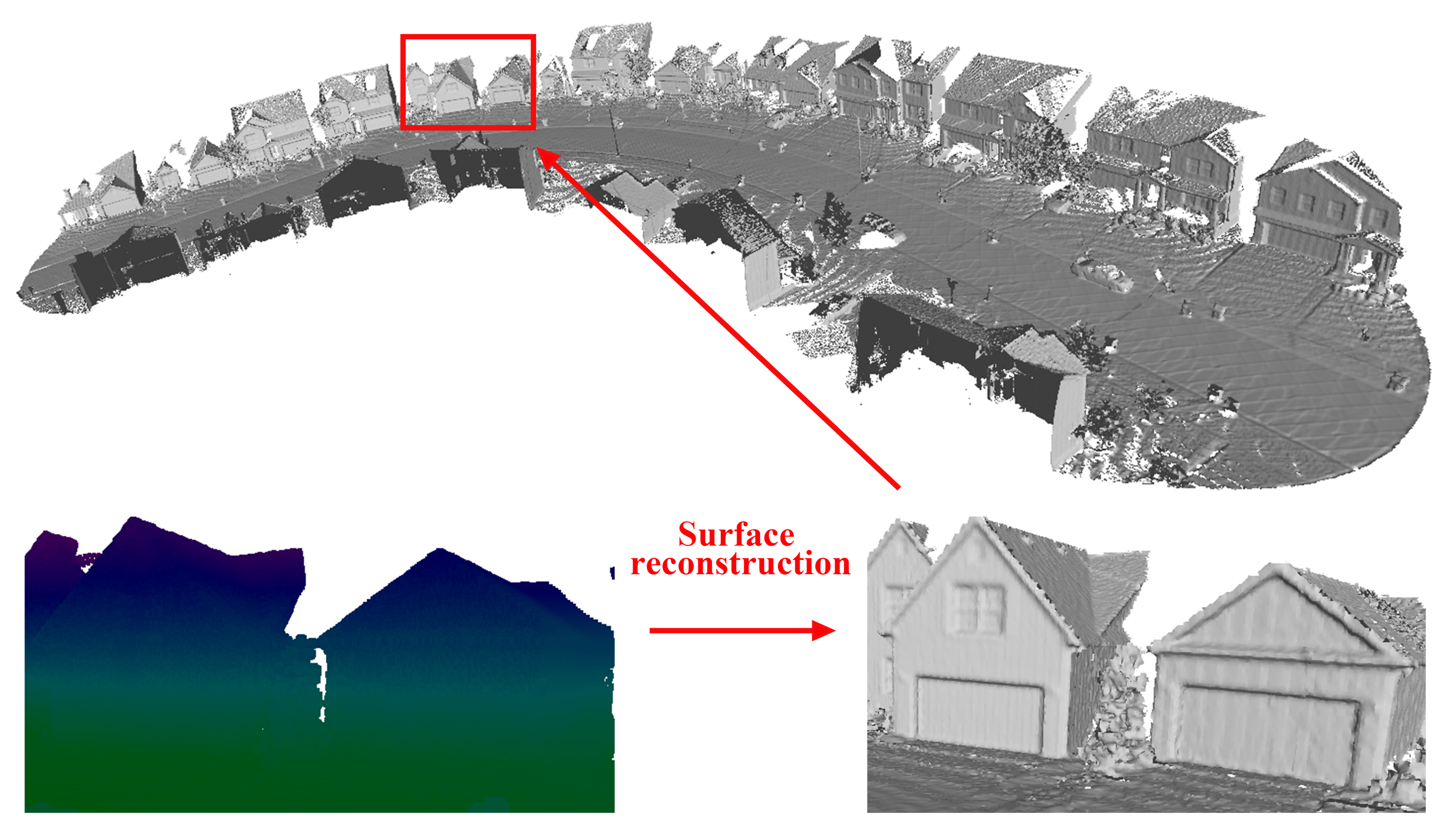

Figure 1: Our proposed real-time large-scale surface reconstruction method update each frame points' sdf value using each frame's pose information and draw isosurface among zero sdf value points

We reconstruct surface to get a more realistic model since points are just a discrete representation of our real world. What lidar get is unorganized point cloud. There are many ways to reconstruct the point cloud [2, 4]. Their reconstructions are confined to a small range and need a lot of computation, which are not allowed in the mobile robot platform. Due to inaccurate external parameters calculation, the sensor error, the noisy point cloud data with outliers, misaligned scans, missing data in the registration of the point cloud, the point cloud model stratifies after several scans for a real surface. What commonly used is to cluster point cloud and get a cluster centroid to represent these points. But these direct fusion methods are unable to accurately reconstruct the true surface of an object. Most of existing lidar point cloud reconstruction methods are not real-time and reconstruct surface after point cloud registration, which lose lots of useful information. Our real-time surface reconstruction ensures that we only reconstruct a reliable surface, which improves the surface reconstruction effect, because we used corresponding pose information that the sensor collected at each frame. The pose information reflects the real state at that time.

Our Methods

We update each frame points' sdf(signed distance function) value by taking the advantage of the pose information of each point cloud frame. Our method removes noise and accurately reconstructs a better surface, when compared to the direct drop-down or discarding excessive points in other systems. By repeatedly updating the sdf of an object, we get the implicit surface of the object. We draw the isosurface of the point with zero sdf value to get a surface triangulation model. We also implement the parallel computation when we update each frame points' sdf value and achieve real-time effect. The new method we propose is to update the SDF using line of sight to find voxels related to each point and update it, as shown in figure 2.

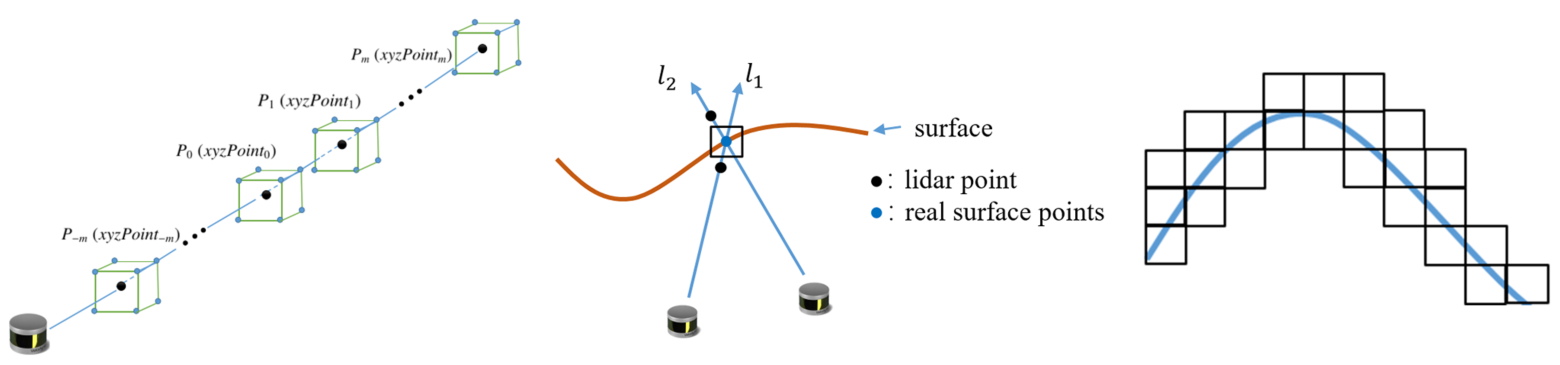

Figure 2: Reconstruction method

Results

We show ourlarge-scale reconstruction, as shown in figure 3. We do a good job on reconstructing residential houses composed of several gables and box structure at different scales and location and their detailed surrounding environment (such as trees, cars and lamps). We shows an overview of our large-scale reconstruction, as shown in figure 4.

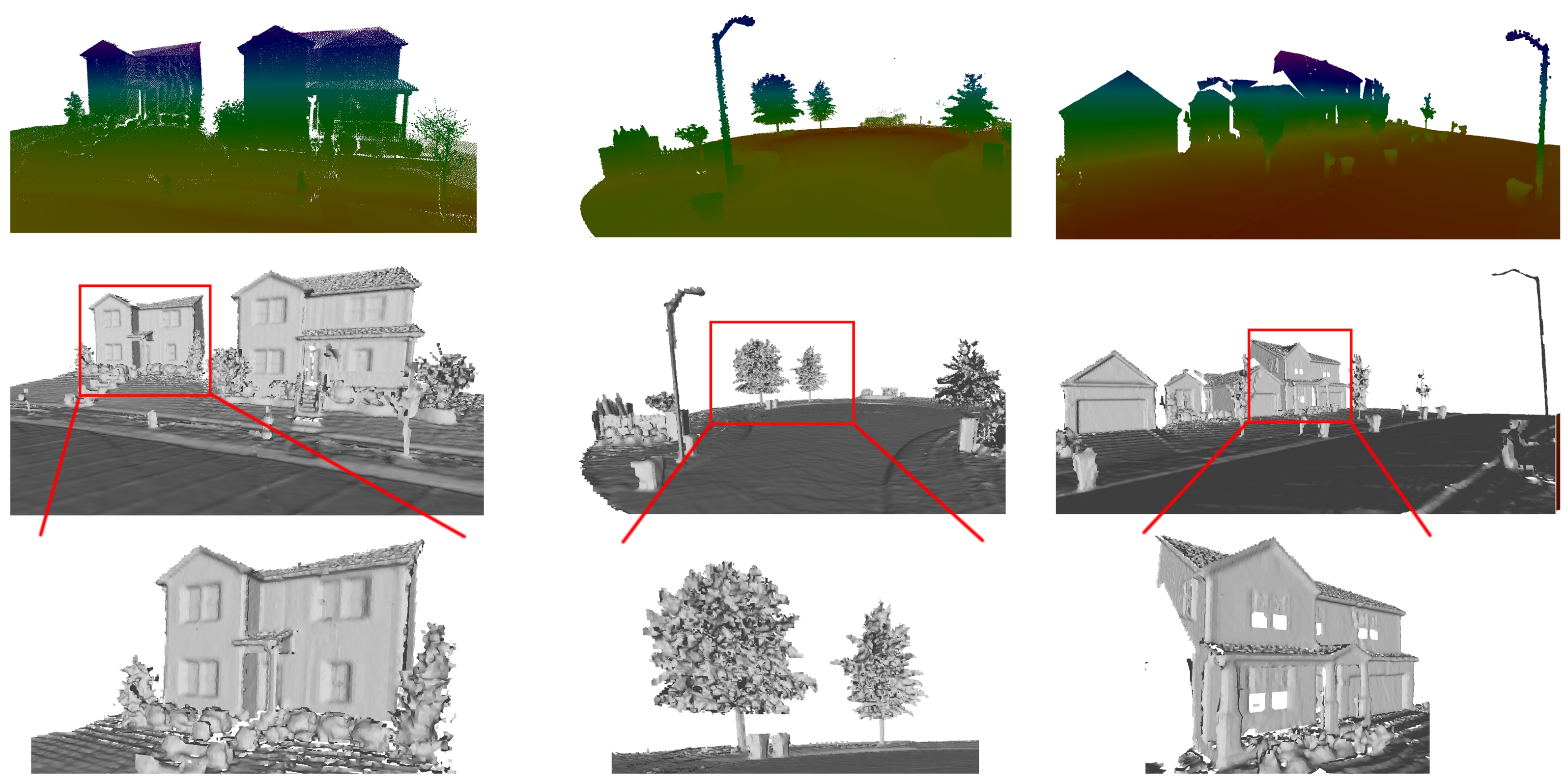

Figure 3: Outdoor large-scale reconstruction

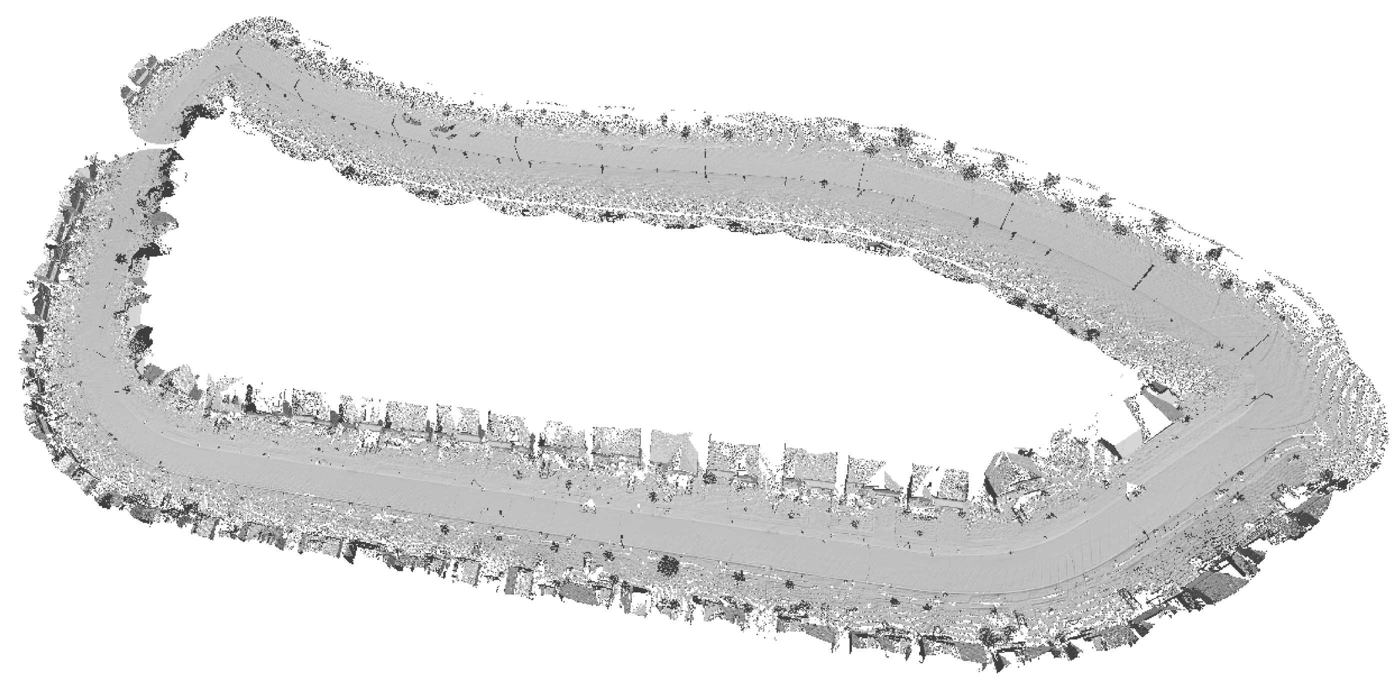

Figure 4: Large-scale reconstruction

We compared out approach with one most commonly used method, i.e. F. Bernardini et al's ball-pivoting algorithm for surface reconstruction [1] and a state-of-art method, i.e. Zoltan Csaba Marton et al's On Fast Surface Reconstruction Methods for Large and Noisy Point Clouds [3]. The ball-pivoting algorithm is able to reconstruct but creates holes when the roof scan is incomplete, and the second method has many holes since it used a triangulation method which depends on triangle setting.

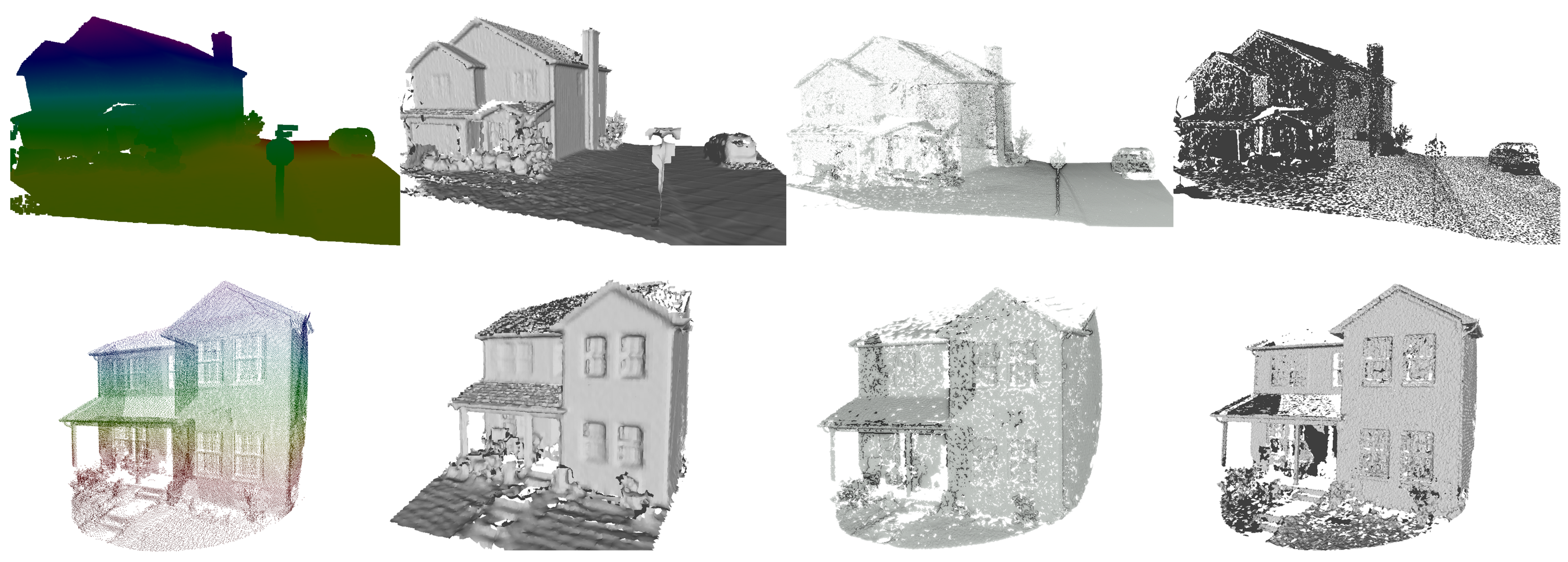

Figure 5: Comparing with other methods. The first column is point cloud, the second is our method, the third is Zoltan Csaba Marton et al's method, and the fourth is F. Bernardini et al' method

Conclusions

Here we propose a large-scale surface reconstruction method using lidar point cloud. We used our line of sight method to get and update each point's sdf value and then draw their implicit isosurface out. The experiment results demonstrate using implicit surface is the key to achieve better surface reconstruction effect. High speed and low computation meet the needs of mobile robotic platform, therefore it is very suitable for embedding to existing points cloud registration system.

Forthcoming Research

Our hope is to implement color and texture information to our reconstruction results using RGB cameras.

References

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[4] Jixian Zhang and Xiangguo Lin. Advances in fusion of optical imagery and lidar point cloud applied to photogrammetry and remote sensing. *International Journal of Image and Data Fusion*, 8(1):1–31, 2017.