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3D Scene Reconstruction and Change Detection using RGB-D Sensor

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Introduction

3D scene change detection is a challenging problem in recent years. Novel systems that provide both color and depth images became readily available. There are great expectations that this new technology will lead to a boost of new applications in the field of 3D reconstruction and scene change detection in unstructured environments and under real-world conditions.

Methodology

- RGB image
- Point cloud model
- Depth image
- Noise suppression
- Point cloud registration
- Change detection
- Staggered model
- 3D voxel resolution

Experimental Results

(a) Input Raw Point Cloud  (b) Filtered Point Cloud

Figure 2. Preprocessing by Noise Reduction

(a) Staggered Model  (b) Location Histogram  (c) Change Points

Figure 5. Change Detection in Staggered Model

Fig 5(a) is two staggered models at different times. In Figs 5(b) and 5(d), Histogram of staggered model's location and Hue value by 10 bins are implemented. Combing of location Fig 5(c) and color Fig 5(e), change points are detected as shown in Fig 5(f).

(a) Voxel Model  (b) Voxel Point Model  (c) Combination

Figure 4. 3D Voxel Models

In order to get the high resolution 3D model, we need more voxels in the 3D model, like high resolution 2D pictures need more pixels. Each color cube represents a voxel in the 3D world as shown in Fig 4(a).

(a) T1 Point Clouds  (b) T2 Point Clouds  (c) Scene Change  (d) Objects

Figure 6. Test on Different Real World Situations

The input to the point cloud change detection system consists of a voxels model of the environment at time t1, the RGB-D images observed at time t1 and time t2 as well as the reconstruction point cloud at time t1 and time t2. The depth and color images are denoted by D1, D2 and C1, C2 respectively as shown in Fig 1(b), (e) and Fig 1(a), (d).

Noise Suppression

A bilateral filter makes the raw 3D point cloud shown in Fig 2(a) represent more visually appealing as well as more effective for change detection. After filtering the depth, we get the new smooth point cloud model as shown in Fig 2(b).

Input Data

(a) Color Image at t1  (b) Depth Image at t1  (c) Point Cloud at t1

(d) Color Image at t2  (e) Depth Image at t2  (f) Point Cloud at t2

Figure 1. Input Data

In Fig 4(b), the cube include points that represent the voxel for the object surface, and others are the free space voxel. The first voxel model is called the voxel edge model. Another model is voxel center model, which has the same voxel size as the edge model but the voxel center moves a half size of the voxel for each directions. In Fig 4(c), blue cube is the center voxel, its 8 edge voxel model's neighbors are the white cubes. Each white cube is a part of eight neighbor voxels. The staggered model consists of the center voxel and the eight neighbor voxels.

(1) T1 Point Clouds  (b) T2 Point Clouds  (c) Scene Change  (d) Objects

Figure 6. Test on Different Real World Situations

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