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Abstract

Chapter 1

Related Work

In order to estimate normals of an object surface.

In 2012, Holzer et al. [1] presented a read-time method, which is able to run algorithm in a high frame speed. The drawbacks are, as mentioned in the paper, the normals error go up when point depths change severely.

In 2021, Zhou et al. [2]

Chapter 2

Formular

RGB image will be stored as gray value Scene using following equation:

$$gray : \frac{r + 2g + b}{4}$$

Capture Depth:

2.0.1 Normal from k neighbors

Given a point p locating on plane Π, calculate the normal n of plane Π.

First, find the nearest k neighbors $p_1, p_2, ..., p_k$ of point p using KNN-algorithms. The plane Π containing point p can be fitted using the neighbors of point p. Then the normal is available immediately.

Assume all the neighbors of point p are in plane $\Pi = ax + by + cz + d = 0$. Since we only need calculate the normal, thus with out loss of generation, we can set displacement $d = 0$. Then the normal $\mathbf{n} = (a, b, c)^T$.

Since all the neighbors of point p are located on plane Π, thus we have

$$P_{k\times 3} \cdot \mathbf{n}_{3\times 1} = \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix}$$

In order to avoid trivial solution, one more constraint should be added

$$\|\mathbf{n}_{3\times 1}\|_2^2 = 1$$

, which also let the normal to be a unit vector. In order to calculate a valid normal, 3 points are required at least. For the sake of robust, more points can be used to reduce the measuring error. In this case, the equation system is over-determined, which can be modeled as following optimization problem

$$\begin{aligned} \min \quad & \|P\mathbf{n}\|^2 \\ \text{s.t.} \quad & \|\mathbf{n}\|^2 = 1 \end{aligned} \tag{2.1}$$

Let the decomposition of $P = U\Sigma V^T$, The solution i.e. normal is the last column of V.

Bibliography

[1] S. Holzer, R. B. Rusu, M. Dixon, S. Gedikli, and N. Navab. Adaptive neighborhood selection for real-time surface normal estimation from organized point cloud data using integral images. In *2012 IEEE/RSJ International Conference on Intelligent Robots and Systems*, pages 2684–2689, 2012.

[2] Jun Zhou, Wei Jin, Mingjie Wang, Xiuping Liu, Zhiyang Li, and Zhaobin Liu. Fast and accurate normal estimation for point cloud via patch stitching, 2021.