Assignment4 - Model Fitting

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Jan 2023

Contents

1 RANSAC Algorithm

Random sample consensus, or RANSAC, is an iterative method for estimating a mathematical model from a data set that contains outliers. It mainly has five steps:

1. Randomly select a minimal subset of points required to solve the model.
2. Solve the model.
3. Compute error function for each point $p_i = (x_i, y_i)$.
4. Count the points consistent with the model, i.e., $d_i < \tau$.
5. Repeat step $1 - 4$ for N iterations, choose the model with most inlier points.

Since we want to use RANSAC to find the ground plane of a point cloud, a minimal subset of points required to solve the model should contain three non-colinear points. This is because the minimal number of points for determining a plane is three, as illustrated in Figure 1.

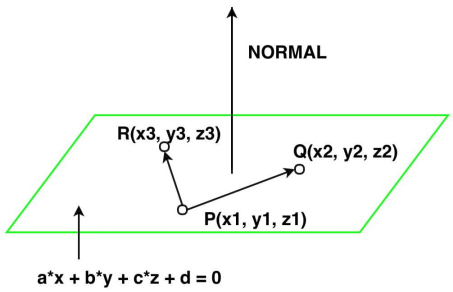


Figure 1: A plane determined by three points.

The model, i.e., the plane equation, is $a \cdot x + b \cdot y + c \cdot z + d = 0$. Given three non-colinear points, we can solve the model according to Equation 1.

$$\begin{aligned} a &= (y_2 - y_1) \cdot (z_3 - z_1) - (z_2 - z_1) \cdot (y_3 - y_1) \\ b &= (z_2 - z_1) \cdot (x_3 - x_1) - (x_2 - x_1) \cdot (z_3 - z_1) \\ c &= (x_2 - x_1) \cdot (y_3 - y_1) - (y_2 - y_1) \cdot (x_3 - x_1) \\ d &= -(a \cdot x_1 + b \cdot y_1 + c \cdot z_1) \end{aligned} \tag{1}$$

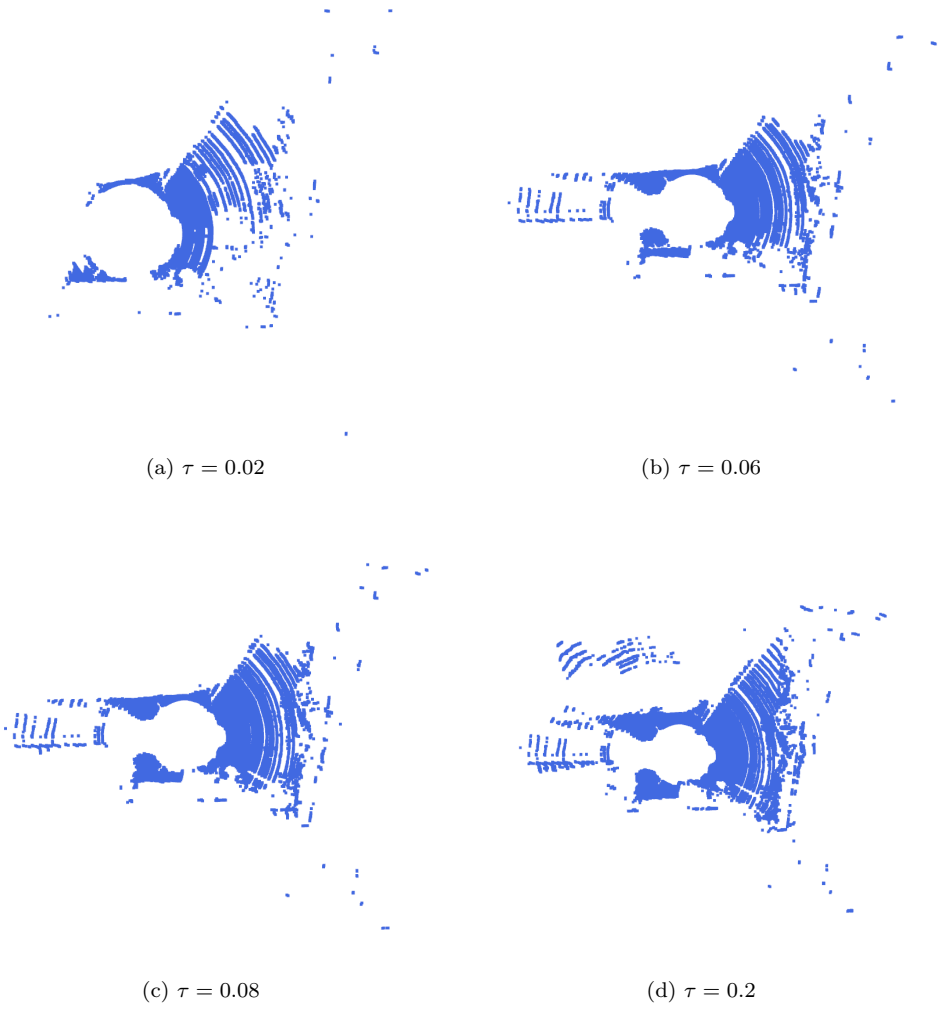
Given the model, we need to calculate the distance from each of the remaining points to the plane. Take a point (x_i, y_i, z_i) as an example, its distance to the plane is calculated as Equation 2. If $d_i < \tau$, the point will be counted as an inlier of the model.

$$d_i = \frac{|a \cdot x_i + b \cdot y_i + c \cdot z_i + d|}{\sqrt{a^2 + b^2 + c^2}} \tag{2}$$

2 Ground Detection

RANSAC has two hyperparameters that are τ and N. N represents the number of iterations, i.e., the number of model candidates. In the experiments, N is set to 50. Section 2.1 describes how to select the value for τ, Section 2.2 shows the detected grounds of three point clouds, and Section 2.3 shows the clusterings of the corresponding foregrounds.

2.1 distance threshold (τ)



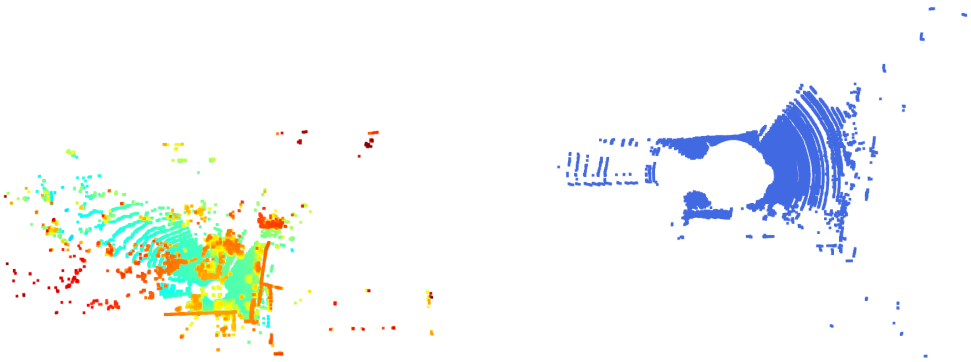
(a) $\tau = 0.02$ (b) $\tau = 0.06$

(c) $\tau = 0.08$ (d) $\tau = 0.2$

Figure 2: Four detected grounds of different values of τ.

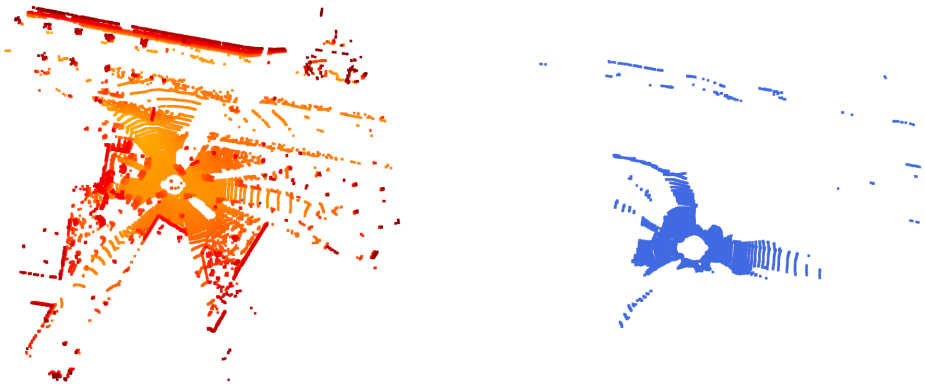
As shown in Figure 2, the subfigure (a) misses some information of the ground, and the subfigure (d) falsely detects many points as a part of the ground. By contrast, the subfigures (b) and (c) show better results. In the following experiments, τ is set to 0.06.

2.2 visualization of ground



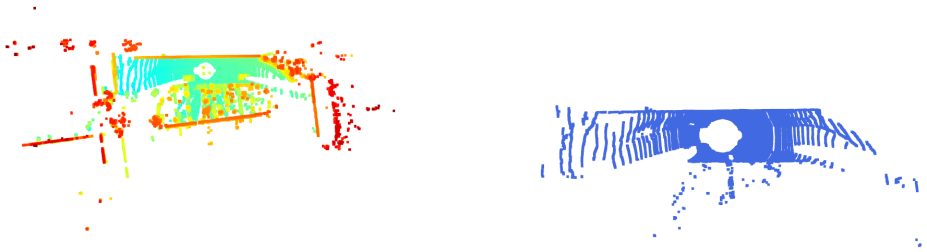
(a) origin point cloud (b) ground cloud

Figure 3: The detected ground of the point cloud of 000000.bin.



(a) origin point cloud (b) ground cloud

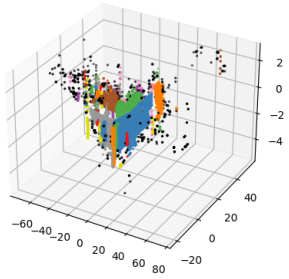
Figure 4: The detected ground of the point cloud of 000010.bin.



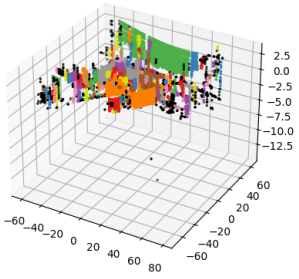
(a) origin point cloud (b) ground cloud

Figure 5: The detected ground of the point cloud of 000020.bin.

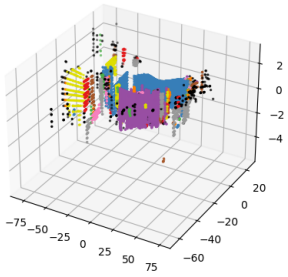
2.3 visualization of clusters



(a) foreground of Figure 3 (a)



(b) foreground of Figure 4 (a)



(c) foreground of Figure 5 (a)

Figure 6: Visualization of three foregrounds.