TP4 - Neighborhood Descriptors

NPM3D - M2 MVA

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1 CloudCompare Normals

Q1. Too small / too big radius leads to a bad estimation. The following figure shows four normal results calculated with radius in $\{0.1, 0.5, 1.0, 3.0\}$.

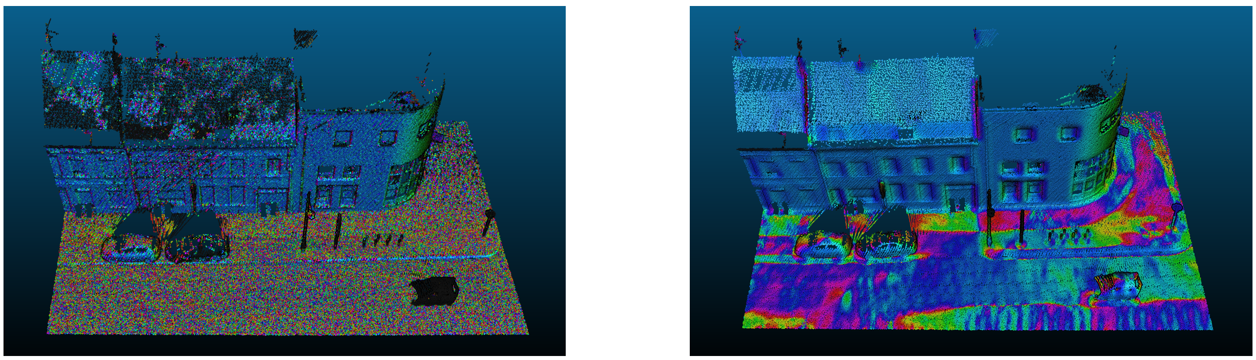

Figure 1: (a) $r = 0.1$ (b) $r = 0.5$

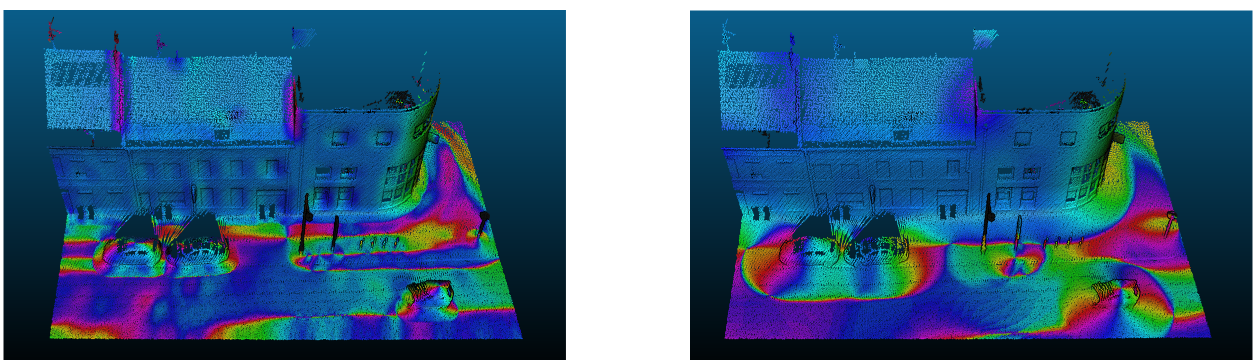

Figure 2: (c) $r = 1$ (d) $r = 3$

We observe that a too small radius makes the result noisy. Even two normals of close points might have a large angle. When the radius is large, the normal map is smooth but we loss some information especially on the borders. In our case, $r = 1$ should be a good tradeoff.

Q2. A density-independent way to choose a proper radius is to estimate the average spacing. For a query point x, we find its 6 nearest neighbors and calculate the average distance $\overline{d}$ from the point x to its neighbors. And then we can choose a radius propotional to $\overline{d}$ (for instance, $r = 3d$).

2 Local PCA

Q3. We use CloudCompare to visualize the computed normal map, and compare it to the one calculated by the software itself. The radius r is 1 for both calculations. Since the calculated normal map is unoriented, we use fast marching method to orient it.

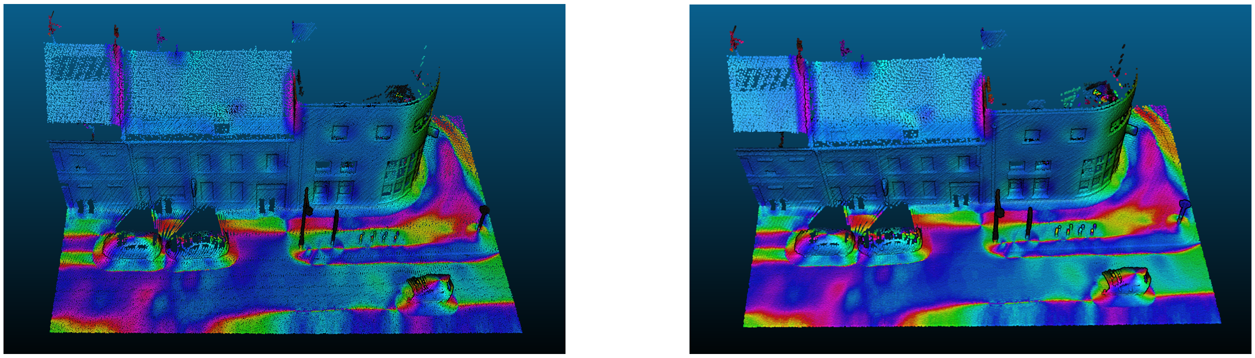

Figure 3: (a) CloudCompare (b) Neighbor PCA

We observe that the results are quite similar.

Q4. Since eigenvectors are all normalized to have norm 1. One method to evaluate the normal estimation is to visualize the vector field $v_3\vec{n_3}$. The length of the vector represents its eighborhood's variance along this direction. If we consider a point on a plane, the length of its normal should be near 0.

Q5. The intuition of the four features are:

- Verticality: compare the local normal vector to the vertical vector.
- Linearity: is defined as $1 - \dfrac{\lambda_2}{\lambda_1}$. We can consider a point on a line, the eigenvalues should be $\{1, 0, 0\}$ ideally. So if λ_2 is much smaller than λ_1, its linearity will be close to 1.
- Planarity: is defined as $\dfrac{\lambda_2 - \lambda_3}{\lambda_1}$. We can consider a point on a plane, the eigenvalues should be $\{0.5, 0.5, 0\}$ ideally. Thus when λ_3 is tiny and λ_2 is close to λ_1, the planarity is close to 1.
- Sphericity: is defined as $\dfrac{\lambda_3}{\lambda_1}$. We can consider a point on a sphere, the eigenvalues should be $\{\frac{1}{3}, \frac{1}{3}, \frac{1}{3}\}$ ideally. When λ_3 is close to λ_1, the sphericity is close to 1.

In the following graph we show the four features of the point cloud: verticality, linearity, planarity and sphericity.

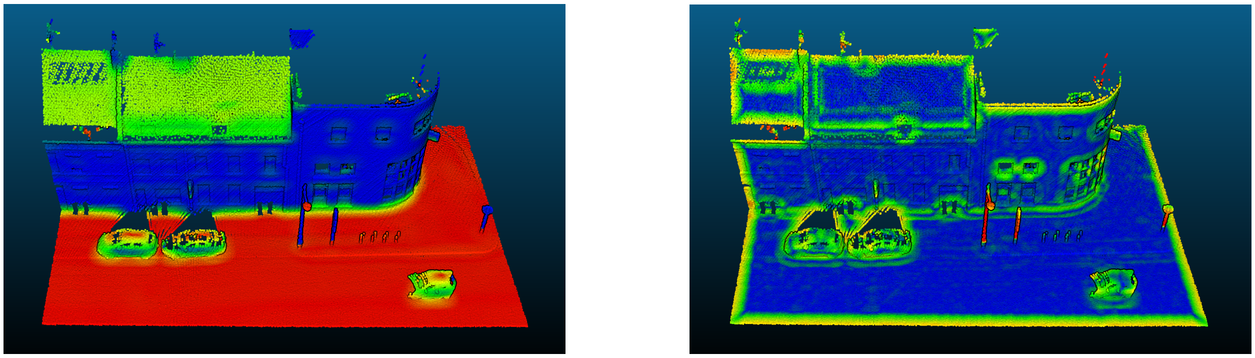

Figure 4: (a) Verticality (b) Linearity

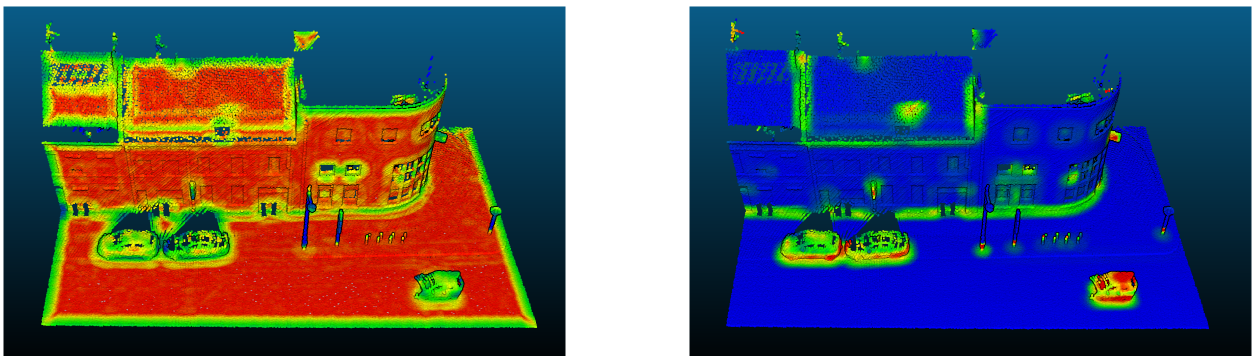

Figure 5: (c) Planarity (d) Sphericity