TP2: Iterative Closest Points algorithm for point cloud registration

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Exercise A: CloudCompare ICP

Question 1:

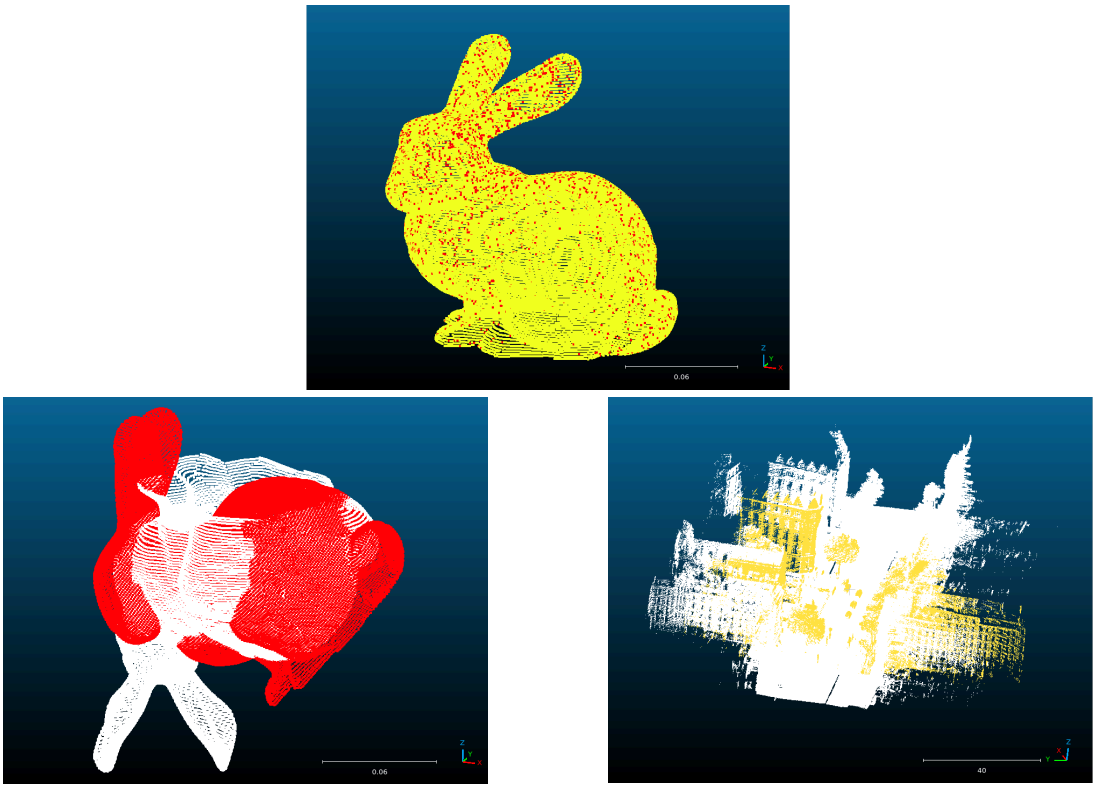

Figure 1: **Point clouds after running ICP.** For Notre Dame des Champs (bottom-right) and perturbed bunny (top), ICP works well. However ICP fails aligning returned bunny (bottom left). For the bunny models, the difference between the aligned and reference clouds boils down to a simple transformation (rotation + translation). A direct consequence is that both clouds have the exact same number of points. Conversely, clouds at stake for Notre Dame des Champs don't cover the same geographic area and don't have the same number of points. For this last example, the reference cloud must be the one having the biggest number of points. ICP involves computing the nearest neighbor for each point. This can be performed in $O(N_1 \log N_2)$ with a KD-tree, where N_2 denotes the number of points in the reference cloud.

Exercise B: Rigid transformation between matched set of points

Question 2:

After registration, we get a RMSE of 0.0. The heuristic of ICP requires the nearest neighbors to be relatively close to each other. With returned bunny (Figure 1) we see that matching point are at the opposite. In contrast, the method used here to determine the rigid transformation doesn't rely on such hypothesis. However, it requires the reference and aligned point clouds to have the same number of point (for the computation of H in the algorithm). We therefore can't use it on the scans of Notre Dame des Champs. What's more, we need a point wise matching. But even though we had the same

number of points on both scans, we couldn't have used this method since some points of scan don't match any point in the other scan.

Exercise C: Point to point ICP

Question 3:

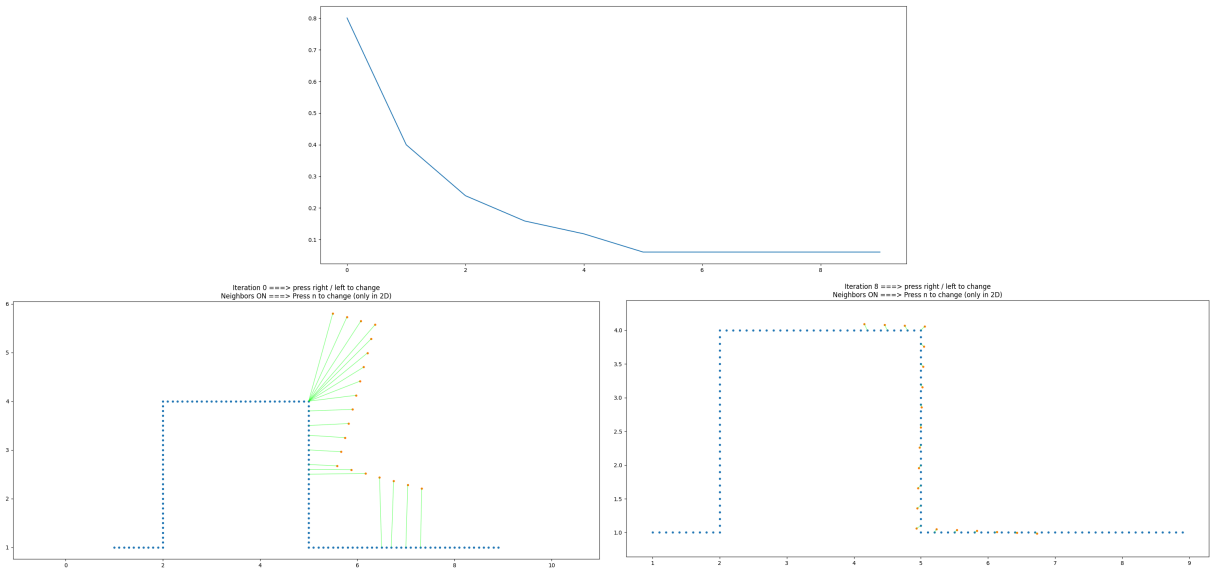

Figure 2: **ICP on 2D data.** The RMS curve (top) shows that ICP converges in 5 iterations. We also notice the nearest neighbors pairing at the first (bottom-left) and last (bottom-right) steps.

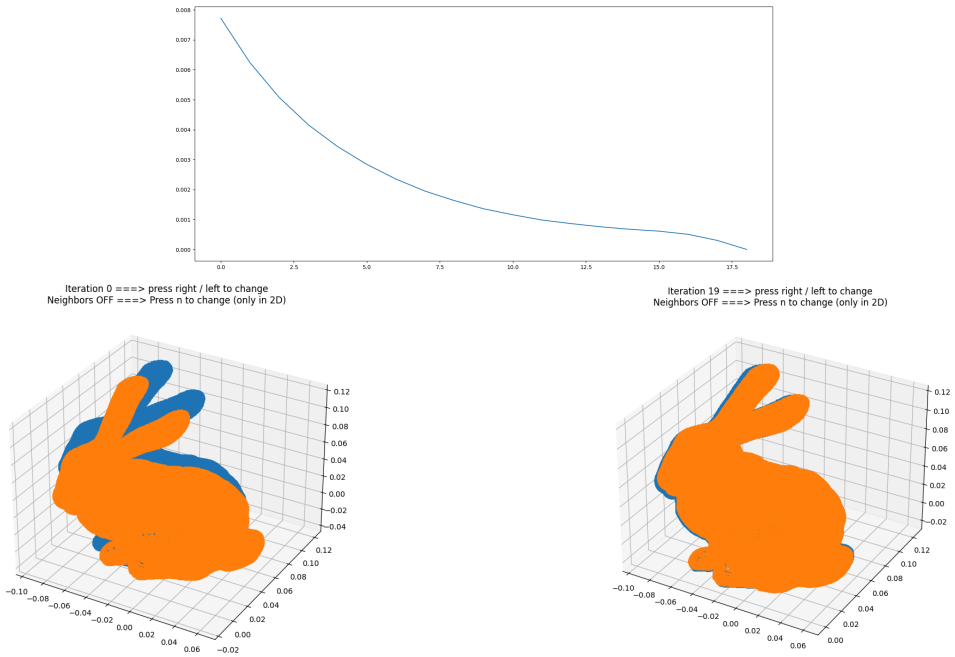

Figure 3: **ICP on 3D data.**

Question 4:

In contrast to the 2D case, the RMS converges here to nearly zero (around 0.1 for 2D data). It would actually be zero with a few more iterations, since both bunnies have the exact same number of points.

Bonus Question:

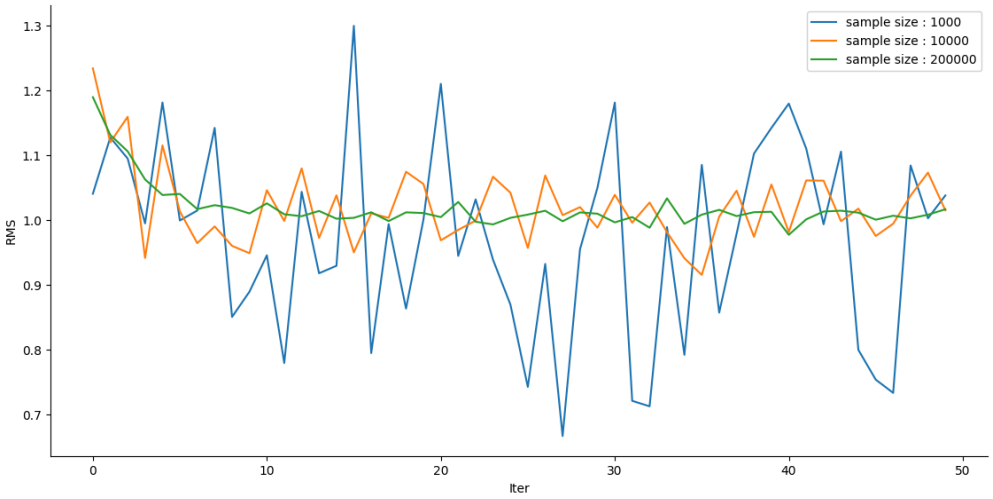

Figure 4: **Fast ICP on "Notre Dame Des Champs" with different sample size.** We can see that increasing the sample size leads to more consistent and stable convergence.