3D Point Cloud and Modeling (NPM3D)
TP 2: Iterative Closest Points algorithm for point cloud registration

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Question 1

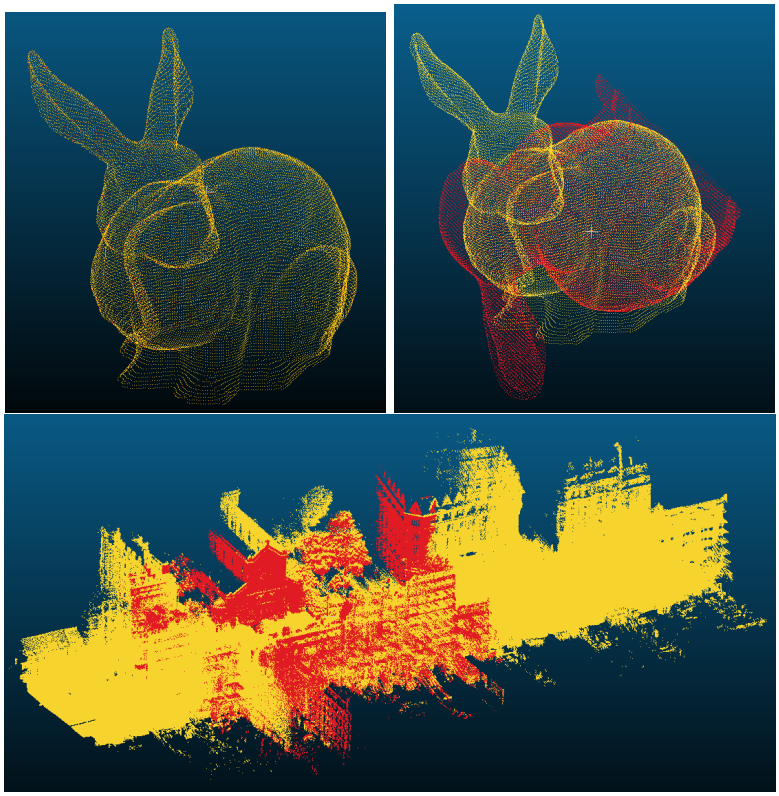

Figure 1: Results of CloudCompare ICP

In the first case with `bunny_original.ply` and `bunny_perturbed.ply`, the ICP performed very well, resulting a near-perfect alignment between the two point clouds, with a very small final RMS error (10^{-8}). In the second case with `bunny_original.ply` and `bunny_returned.ply` however, the algorithm failed to match the clouds as one of the bunnies remained upside down. In the third case with Notre-Dame des Champs, the algorithm performed well, providing a good alignment between the two point clouds.

The aligned cloud is the cloud whose points are to be matched with their respective point in the reference cloud.

In the last case of Notre-Dame des Champs, the larger cloud (`Notre_Dame_Des_Champs_1.ply`) should be the reference cloud because it covers more space than the other one, and it contains points that should not be matched with points in the other cloud.

Question 2

The RMS error decreased from 0.161 to 0 after applying the rigid transformation obtained from the `best_rigid_transform` function, which means that the transformation matched the two point clouds perfectly.

The reason that this alignment worked while CloudCompare ICP could not align the two clouds is that the matching between the points of the two clouds was known, i.e. the same order of the matching points. CloudCompare ICP did not consider this information and instead tried to find its own matching.

This function would not align the 3D scans of Notre-Dame des Champs, mainly because the two point clouds do not contain the same number of points.

Question 3

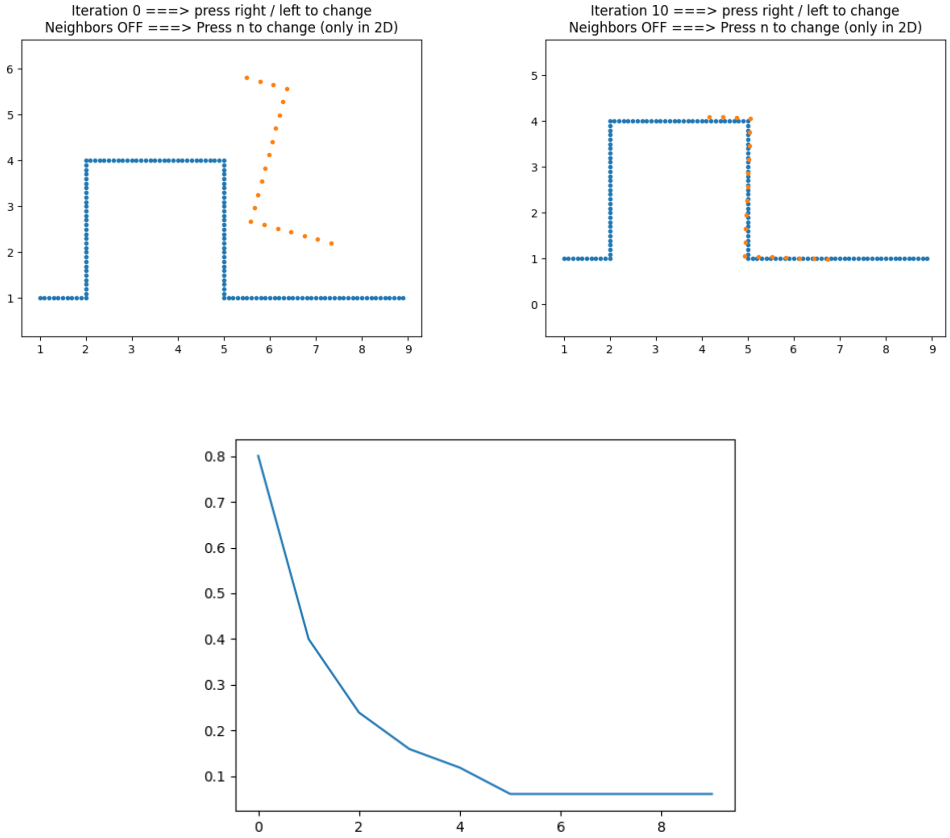

Figure 2: 2D case: initial point clouds (top left), clouds after applying ICP (top right), RMS error during ICP convergence (bottom)

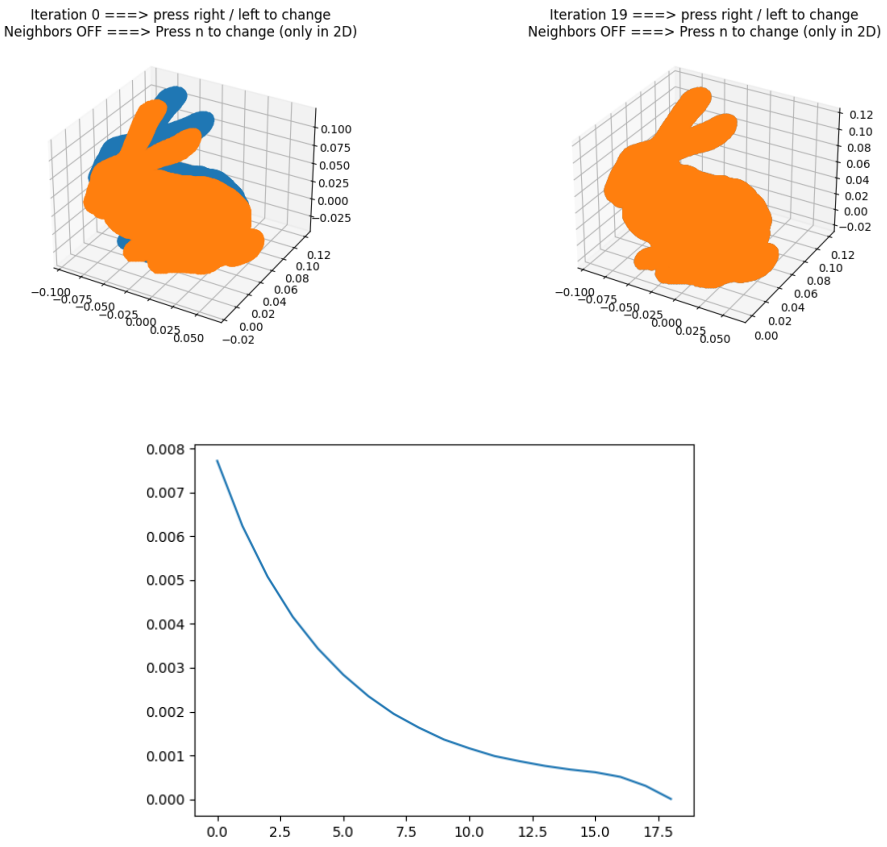

Figure 3: Bunny case: initial point clouds (top left), clouds after applying ICP (top right), RMS error during ICP convergence (bottom)

Question 4

In the case of the 2D point clouds, figure 2 shows that the RMS error decreased from the first iteration until the sixth iteration before stabilizing for the rest of the iterations. The optimal solution was reached at the sixth iteration with a RMS error larger than the set threshold (10^{-4}).

In the case of the bunny point clouds, figure 3 shows that the RMS error decreased from the first iteration until the 19th iteration, which is when the convergence was reached. The parameter of the maximum number of iterations was set to 25 and the algorithm stopped at the 19th iteration, showing that the RMS error got below the set threshold (10^{-4}).