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3D Sensing and Sensor Fusion

Point Cloud Alignment using ICP and Tr-ICP

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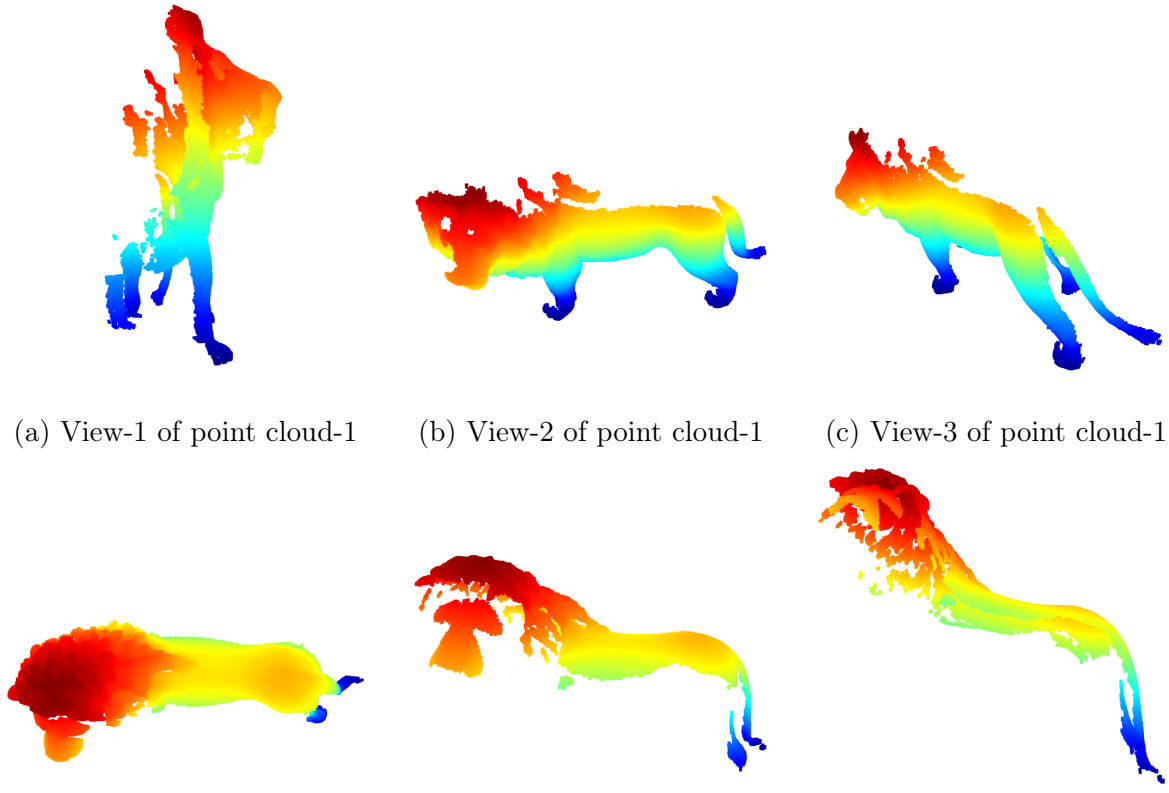
Contents

Chapter 1

Deliverable

The goal of this task is to implement and compare ICP and tr-ICP for partially overlapping point cloud alignment.

1.1 Subtask-1: ICP and Trimmed-ICP Implementation



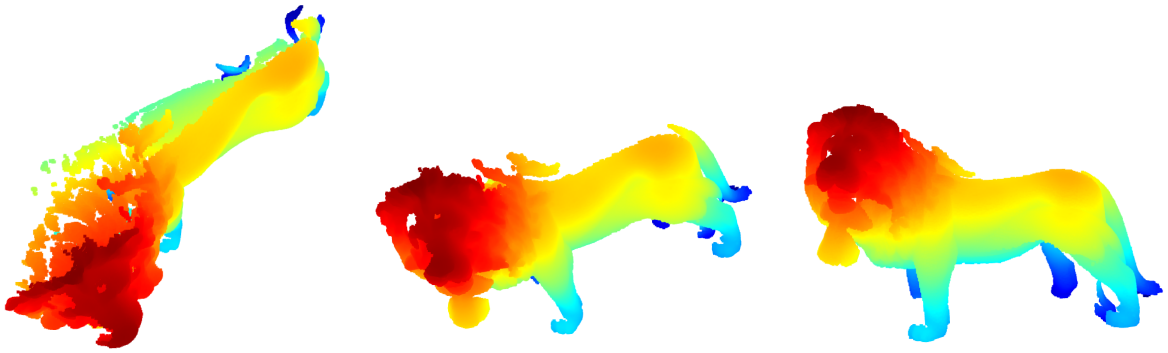
(a) View-1 of point cloud-1 (b) View-2 of point cloud-1 (c) View-3 of point cloud-1

(d) View-1 of point cloud-2 (e) View-2 of point cloud-2 (f) View-3 of point cloud-2

Figure 1.1: Different view of the two partially overlapping point cloud

In the subtask 1, I've implemented ICP and Tr-ICP. In the ICP, the first step was data association, where, I've used nearest neighbour approach and for the implementation nanoflann library is used. In the second step of transformation computation, I've used SVD to estimate rotation. On the other side, the only difference with trimmed ICP is minimum guaranteed rate of data points that can be paired is known.

Figure 1.1 represents an example of the two overlapping point cloud that are used as input of ICP and Tr-ICP. Figure 1.2 presents the result after applying ICP on the two lion-scan point cloud of 1.1. 1.3 illustrates the result after applying Trimmed ICP on the same cloud pair. It can be clearly seen from the diagram that Tr-ICP gives better result than ICP.



(a) (b) (c)

Figure 1.2: Result of ICP from different view

(a) (b) (c)

Figure 1.3: Result of Trimmed ICP from different view

1.2 Subtask-2: Evaluation Studies

The table 1.1 explains the result of ICP and Tr-ICP algorithms on above Lion Dataset. It can be said that the algorithms works significantly fast with almost 2000 points in

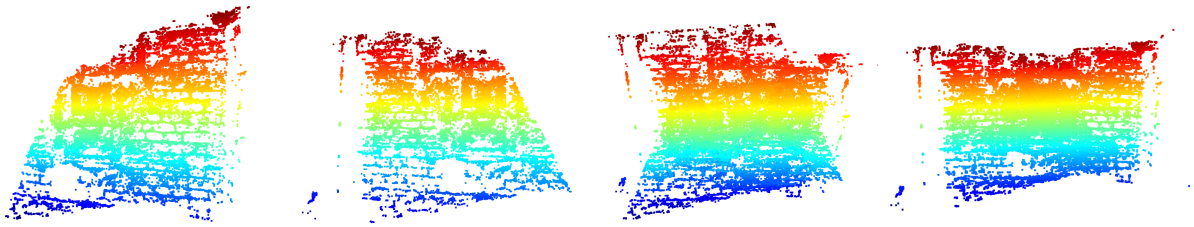
Table 1.1: Evaluation of Lion dataset for different initial rotation

Algorithm	**Rotation (Degree)**	**Angular Rotational Error**	**Euclidean Translation Error**	**MSE**	**Runtime (sec)**
ICP	0	45.4539	10.8206	5.14611	40.318
	5	45.146	10.6202	5.14656	30.6887
	10	44.7972	10.5947	5.14652	31.7574
	20	43.9173	11.3069	5.14655	31.8605
Tr-ICP	0	11.0868	3.84213	4.55632	23.7607
	5	11.0271	3.84353	4.55633	21.3978
	10	10.64	3.8624	4.55662	17.7061
	20	11.8551	3.90483	4.55652	29.1245

each cloud. Tr-ICP performs better than ICP in case of MSE, runtime, rotational and translation error. All of the trials or done with 100 iterations.

Table 1.2 represents the comparison matrices for different iterations. It can be seen that for increasing iterations the results remain almost same. But in each case Tr-ICP performs better.

Figure 1.4 shows the result of the both algorithms on fountain dataset where one of the point cloud was rotated 20 degree initially.



(a) point cloud 1 (b) Point cloud 2 (20 degree rotated) (c) After ICP (d) After Tr-ICP

Figure 1.4: Result of ICP and Trimmed ICP on fountain dataset

Similarly as table 1.1, table 1.3 represents the result from Fountain dataset, which has almost 60,000 data points but with very small overlap. So, for this initial 0 degree rotation gives very good result but with increasing rotation angle all the error and run-times keep increasing.

Table 1.2: Evaluation of Lion dataset for different no of iterations

Algorithm	**Iteration**	**Angular Rotational Error**	**Euclidean Translation Error**	**MSE**	**Runtime (sec)**
ICP	50	45.1459	10.7985	5.14881	23.237
	100	45.4539	10.8206	5.14611	32.8183
	200	45.4539	10.8206	5.14611	32.8275
Tr-ICP	50	10.8706	3.81953	4.55776	15.2793
	100	11.0868	3.84213	4.55632	18.0753
	200	11.0868	3.84213	4.55632	18.0146

Table 1.3: Evaluation of Fountain dataset for different initial rotation

Algorithm	**Rotation (degree)**	**Angular Rotational Error**	**Euclidean Translation Error**	**MSE**	**Runtime (sec)**
ICP	0	11.389	5.96327	0.270897	17.9678
	10	22.8273	6.87521	0.257669	16.35
	20	60.3471	15.7463	0.211858	36.758
Tr-ICP	0	3.40715	0.802396	0.00990501	5.64979
	10	23.9947	8.88617	0.0184334	12.2095
	20	53.7033	18.4336	0.062443	18.5817