Project 5 Report

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Naive vs Numpy Transforms

Record the time per loop for your naive implementation and the time per loop for your numpy implementation. How many times faster does the numpy implementation run compared to the naive implementation?

Time per loop for naive: 398 ms

Time per loop for numpy: 1.97 ms

202 times faster!

Map with Identity Transforms (pt. 1)

Uncomment the `get_identity_results()` method to replace the transforms with identity transforms, and observe the map. Does this make sense? Why is it necessary to perform a transform to all the point clouds in order to create a map?

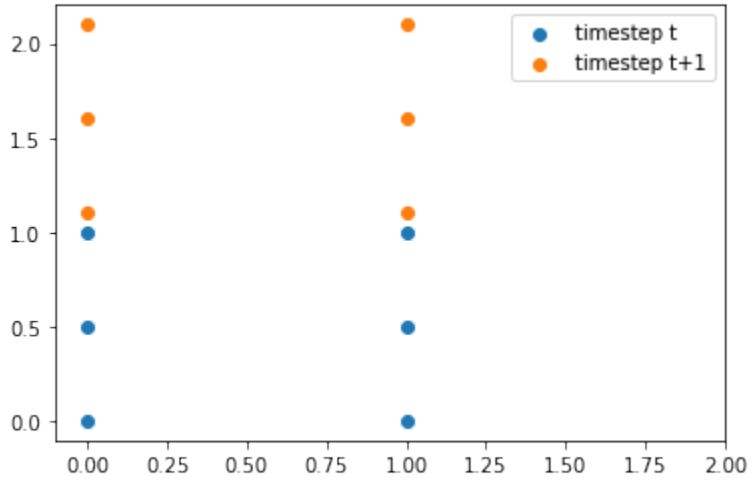
It does not make sense. Its showing all the point clouds within their own coordinate system. We need to transform all the point clouds to the world coordinate frame for it to make sense.

Aligning Closest Pairs Rearrangement

Why does `align_closest_pairs` return a "rearranged" cloud?

We are trying to represent the cloud in the shape of clouda but able to form closest pairs index-wise between points in clouda and points in the rearranged cloudb. This is only possible when the cloud is rearranged.

Scan Correspondences Issue



Observe the given example scans (2D clouds). What happens when you make correspondences based on shortest Euclidean distance like in `assign_closest_pairs`? Why might this be an issue?

ICP Transform Conventions

Why is the output of ICP denoted as `bTa` and not `aTb`? Refer to Section 6.1 in the textbook for transformation conventions.

Because clouda is being transformed to align with cloudb. This output estimates how cloudb transforms clouda.

Triangle Initial Estimate

Change the initial estimate for the ICP triangle example to be `gtsam.Pose3(gtsam.Rot3(), gtsam.Point3(1, 1, 1)`and evaluate the result. Play around with changing the initial estimate. What happens when your initial estimate is initialized far away from the ground truth? Why is it important to have a good initial estimate?

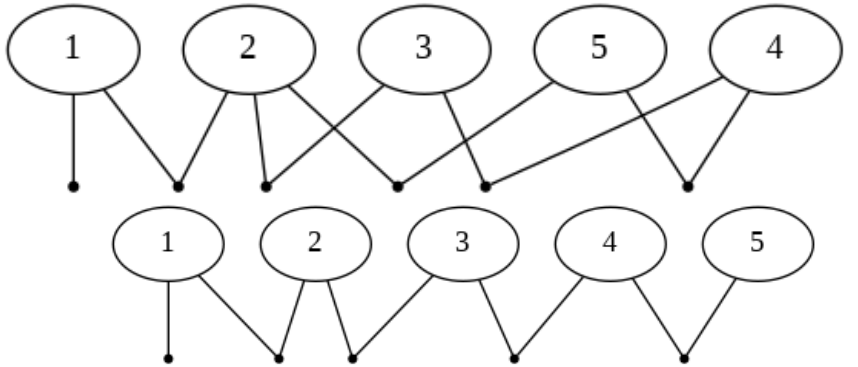
When it is initialized farther from the ground truth it takes more iterations to complete.
A good initial estimate helps lower the overall computational cost.

Implementing GTSAM

What information does a `gtsam.NonlinearFactorGraph()` hold compared to a `gtsam.Values()` object? What method do you use to access Pose3 values from a `gtsam.Values` object?

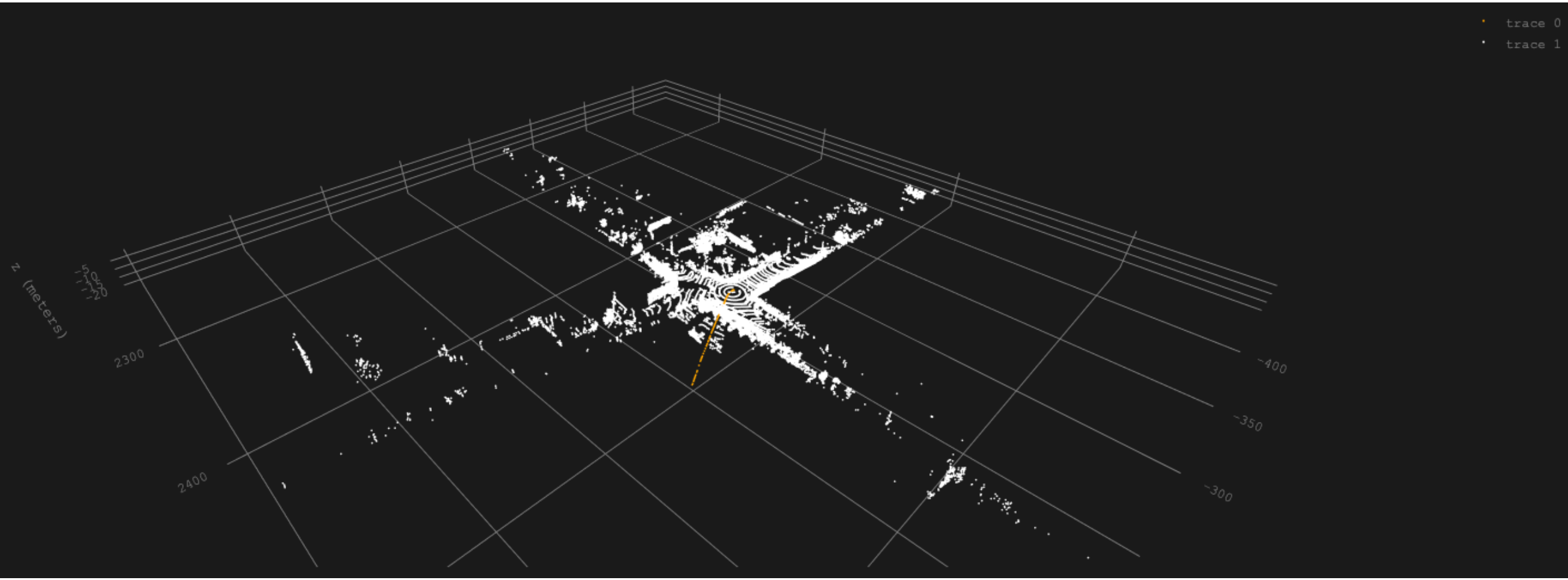
The values' structures of the graph are usually more general than just vectors such as Pose3 which are used in non-linear manifolds. Use the at() function.

Loop Closure



- Comment out the loop closure constraint and upload a screenshot of the covariance plot with and without loop closure. What does covariance represent? What happens to the covariance when loop closure is performed?
- With is on top and without is on bottom.
- Covariance represents the relation between the poses of the robot within each time step.
- When closure is performed the covariance increases and relations between non-neighboring poses are shown.

Final Vehicle Trajectory



Using gtsam.Pose3.inverse()

What is the purpose of using `gtsam.Pose3.inverse()`? What happens if we do not include this?

The purpose of the inverse function is to apply an inverse transformation with derivatives. Without the applied function, the code would fail since these matrices are not commutative.

Transformation Composition (pt. 1)

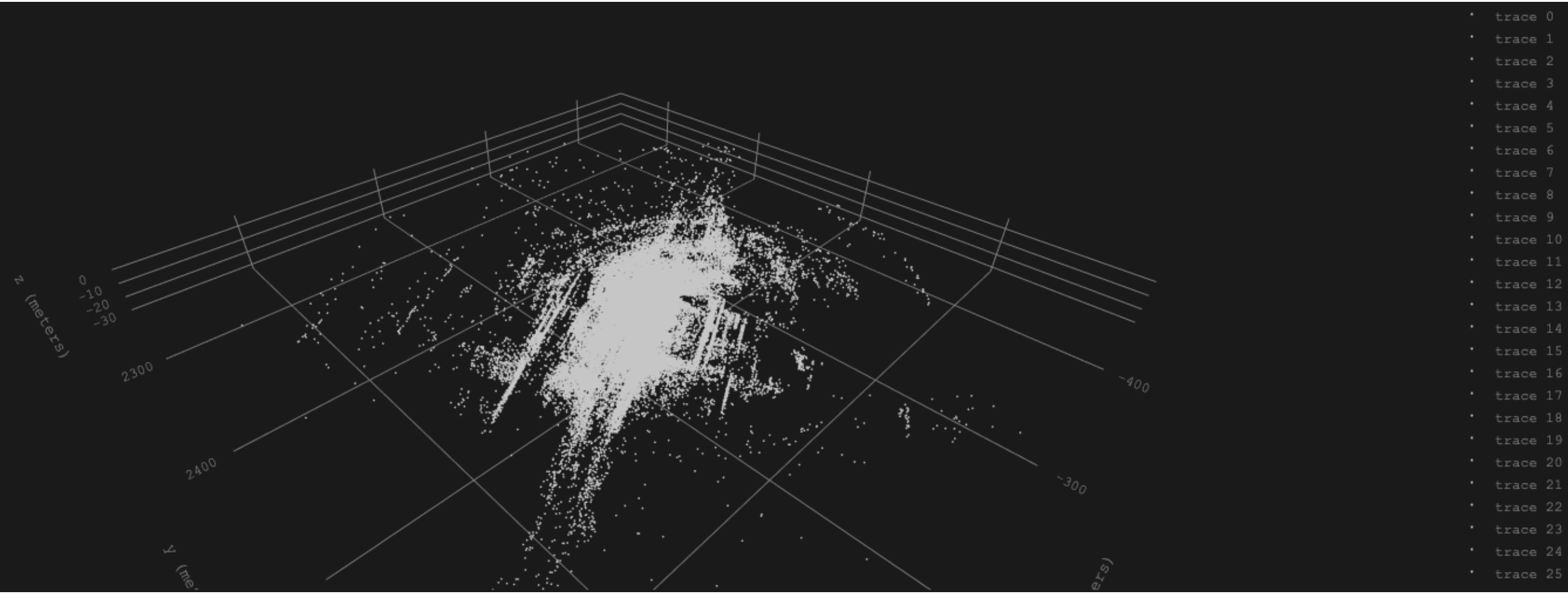
Suppose we have a robot that lives in 2D space and starts with an initial pose `gtsam.Pose2(0, 0, 0)`. The robot first performs the transform `gtsam.Pose2(1, 1, np.pi/2)` followed by a transform `gtsam.Pose2(-1, 1, np.pi/2)`.

- Draw the robot's initial pose, second pose, and final pose on a 2D coordinate grid.
- Calculate the robot's final pose using matrix multiplication. Show your work.
- Include a screenshot of calculating the robot's final pose using `gtsam.Pose2.compose()`. Does this make sense? What does this suggest about the relationship between transformation composition and matrix multiplication?

(Answer it on next slide)

Transformation Composition (pt. 2)

Final Map


z (meters)
0
-10
-20
-30
2300
2400
-400
-300
trace 0
trace 1
trace 2
trace 3
trace 4
trace 5
trace 6
trace 7
trace 8
trace 9
trace 10
trace 11
trace 12
trace 13
trace 14
trace 15
trace 16
trace 17
trace 18
trace 19
trace 20
trace 21
trace 22
trace 23
trace 24
trace 25

Factor Graph

Draw a factor graph between three point clouds, including skip connections.