The Honeycomb lidar is a revolutionary device. With its unprecedented 95º vertical field of vision (FOV) and its full 360º horizontal FOV, the Honeycomb lidar gives you an unmatched view of your world. In addition to its breadth of vision, the lidar also peers more deeply into the environment, returning four points of data instead of the usual two, resulting in more detail and dimensionality. Finally, with its minimum range of zero, the Honeycomb lidar can detect objects at very close range.

However, all these advances in technology, these new abilities and breakthroughs, require new ways of thinking and new processes to unlock the potential of the Honeycomb lidar. That's what these Tips and Tricks are about: providing users with the tools to fully realize the power and capacity of the lidar, and helping them to remove obstacles so that they understand its capabilities.

Calibration Parameters

The following calibration parameters may be of interest to Honeycomb users.

Intrinsic

Distance_offset: an offset added to the distance of all the points in the point cloud.

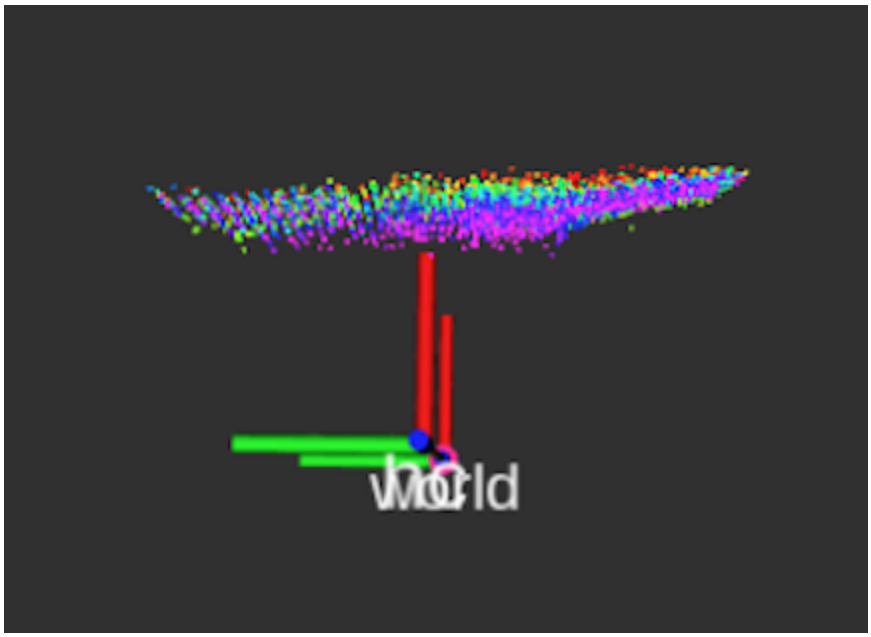

Fig. 1 Zero distance offset, target placed 30cm in front of lidar.

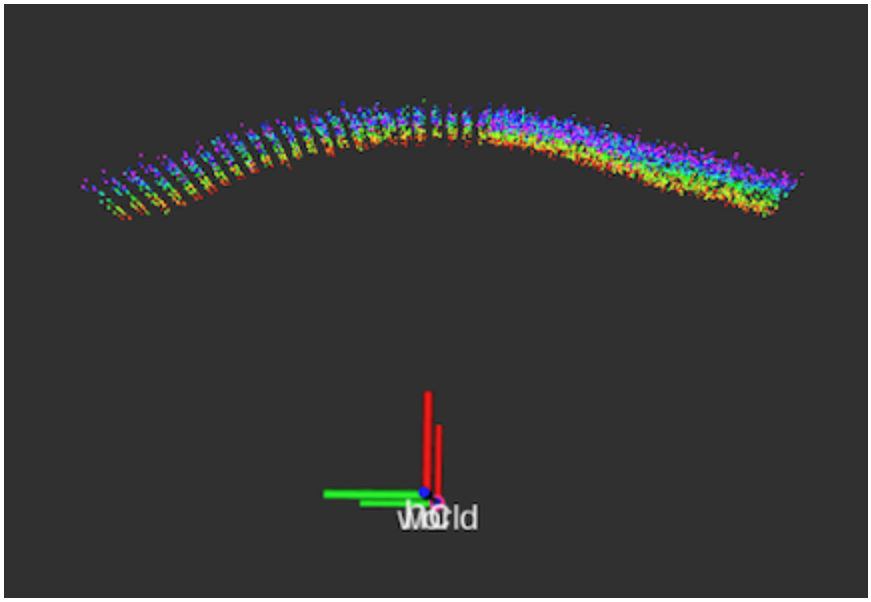

Fig. 2 Distance offset of 50cm, target placed 30cm in front of lidar.

Elevation_adjustment: an offset that allows the elevation on the front and back point clouds to be matched. This parameter has been known to drift by up to 1.5º with a time scale of ~1 month.

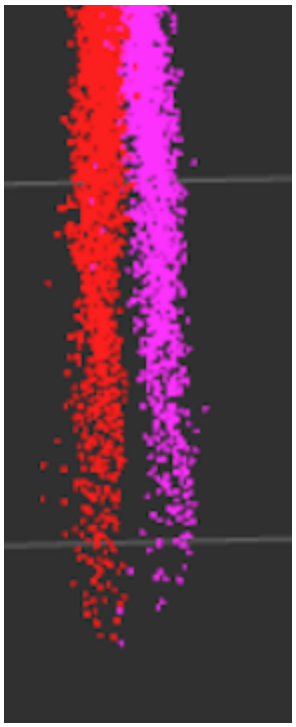

Fig. 3 Elevation offset.

Azimuth_adjustment: an offset that allows the azimuth of the front and back point clouds to be matched.

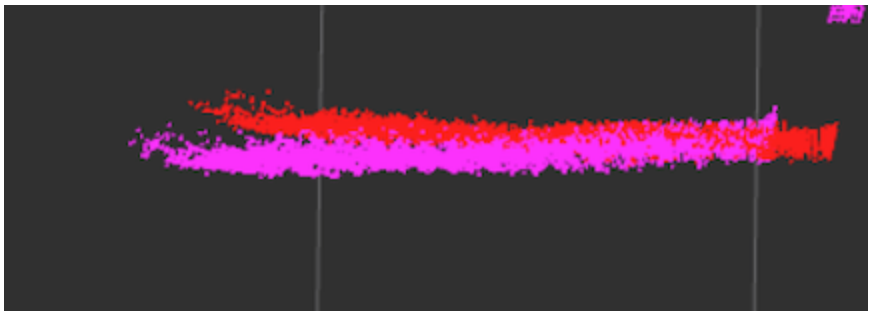

Fig. 4 Azimuth offset by two degrees.

The distance_offset and azimuth_adjustment parameters are expected to be calibrated during manufacturing in the future, but this is not yet the case.

Extrinsic

Roll/pitch/yaw: orientation of the lidar.

x/y/z: position of the lidar.

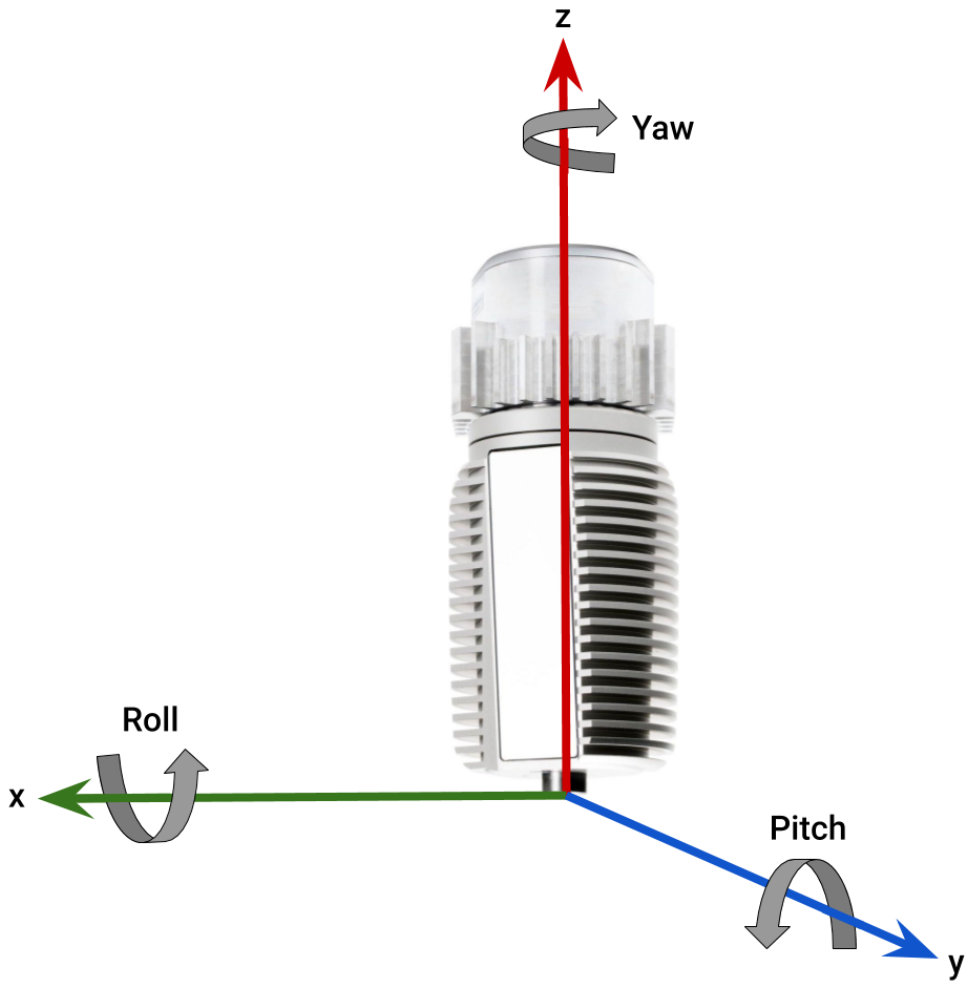

Fig. 5 Roll/pitch/yaw diagram.

Calibration Process

Waymo calibrates the Honeycomb lidar using the following two procedures:

Front-to-Back Matching

The elevation_adjustment and azimuth_adjustment parameters are adjusted to minimize the mismatch between the point cloud produced by the front and back side of the Honeycomb lidar. The mismatch is evaluated by looking at the distance from each point on one side to the closest point on the other side, and summing them using a Huber loss function.

Matching Point Cloud

The Honeycomb lidar also matches its point cloud to the cloud lidar on the roof of the car using ICP. This allows distance_offset (and roll/pitch/yaw) to be determined.

The x/y/z parameters are sufficiently consistent that they do not need to be calibrated.

During this calibration process, the scene being viewed by the Honeycomb lidar and the lidar on the roof of the car includes the ground as well as a vertical wedge (measuring 90º across) pointing towards the lidars.

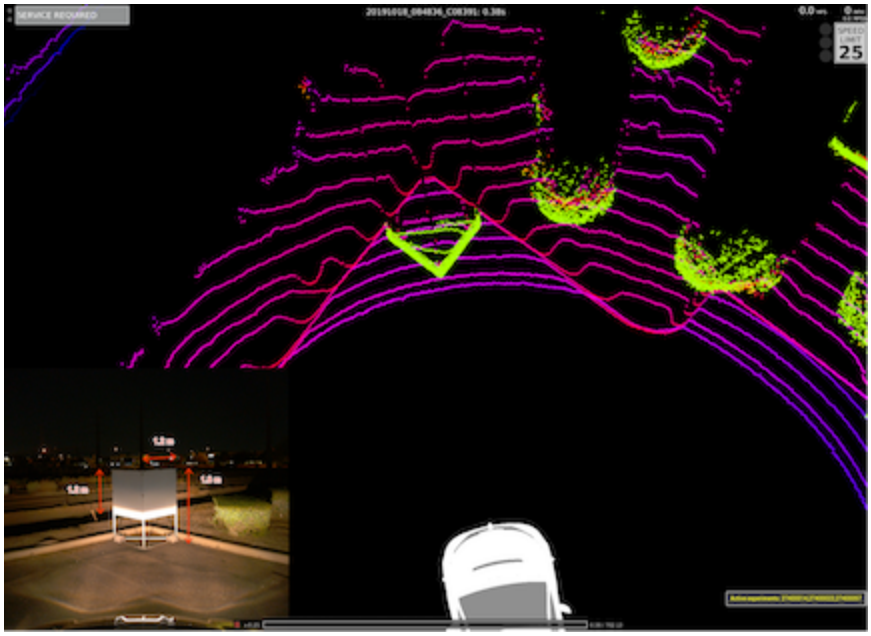

Fig. 6 Calibration target.

Determining Calibration Parameters

Waymo suggests the following procedure for determining the calibration parameters:

1. Elevation_adjustment and azimuth_adjustment can be configured by matching the front and back side point clouds, as described for Waymo's on-car process.
2. Roll/pitch/yaw are configured by matching the Honeycomb data to data from another sensor, or by presenting the Honeycomb lidar with a known scene.
3. We expect that for most customers, the position of the lidar (x/y/z) does not need to be calibrated. If it does need calibration, it can be included in the formulation for roll/pitch/yaw.
4. Distance_offset can be included with roll/pitch/yaw. It can also be determined by using a target that includes two features a known distance apart, and placing the Honeycomb between them.

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