LIDAR BANDWIDTH AND RESOLUTION

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The Velodyne VLP-16 LiDAR sensor is widely used in applications such as autonomous vehicles, robotics, and mapping. Below are detailed calculations addressing the required bandwidth and the number of LiDAR points capturing a pedestrian at specified distances.

1. Bandwidth Requirement for Velodyne VLP-16 LiDAR

Specifications:

- **Data Points**: Up to 300,000 points per second in single return mode.
- **Data Packet Size**: Each data point consists of distance and reflectivity measurements, typically totaling 3 bytes (2 bytes for distance, 1 byte for reflectivity).

Calculation:

1. **Data per Second**:
   300,000 points/second×3 bytes/point=900,000 bytes/second300,000 \, \text{points/second} \times 3 \, \text{bytes/point} = 900,000 \, \text{bytes/second}300,000points/second×3bytes/point=900,000bytes/second
   This equates to approximately 900 KB/s.
2. **Additional Overhead**: Considering protocol overhead (e.g., UDP headers), the total bandwidth requirement is approximately 1 Mbps.

2. LiDAR Points Capturing a Pedestrian

Pedestrian Dimensions:

- **Width**: 0.4 meters
- **Height**: 1.8 meters

Distances:

- **Near**: 20 meters
- **Far**: 100 meters

LiDAR Specifications:

- **Vertical Field of View (FOV)**: ±15° (total 30°)
- **Vertical Angular Resolution**: 2°
- **Horizontal FOV**: 360°
- **Horizontal Angular Resolution**: 0.1° to 0.4°

- **Rotation Rates**: 5 Hz (maximum resolution) to 20 Hz (minimum resolution)

Calculations:

1. **Vertical Points**:
   - **Number of Channels**: 16 (each channel corresponds to a specific vertical angle)
   - **Vertical Coverage**:

     Vertical Angular Resolution=Vertical FOV / Number of Channels−1

     = 30 / 15=2°

   - **Pedestrian Height Coverage**:

     Number of Channels Covering Pedestrian

     = Pedestrian Height / Distance×tan(Vertical Angular Resolution)

     - At 20 meters: 1.8 m20 m×tan(2°)≈2.58 channels≈3 channels
     - At 100 meters: 1.8 m100 m×tan(2°)≈0.52 channels≈1 channel

2. **Horizontal Points**:
   - **Horizontal Angular Resolution**:

     Horizontal Angular Resolution=Rotation Rate / Points per Second

     - At 5 Hz (maximum resolution):

       5Hz / 300,000 points/second≈0.06°

     - At 20 Hz (minimum resolution):

       20 Hz / 300,000 points/second ≈0.24°

   - **Pedestrian Width Coverage**: Number of Points=Pedestrian WidthDistance×tan(Horizontal Angular Resolution)

     - At 20 meters:
       - 5 Hz: 0.4 m20 m×tan(0.06°)≈19 points
       - 20 Hz: 0.4 m20 m×tan(0.24°)≈5 points
     - At 100 meters:
       - 5 Hz: 0.4 m100 m×tan(0.06°)≈4 points
       - 20 Hz: 0.4 m100 m×tan(0.24°)≈1 point

Summary:

- **At 20 meters**:
  - **Vertical**: Approximately 3 channels
  - **Horizontal**:
    - 5 Hz rotation: ~19 points
    - 20 Hz rotation: ~5 points
- **At 100 meters**:
  - **Vertical**: Approximately 1 channel
  - **Horizontal**:
    - 5 Hz rotation: ~4 points
    - 20 Hz rotation: ~1 point

These calculations indicate that at greater distances and higher rotation speeds, the LiDAR captures fewer points on the pedestrian, potentially affecting detection accuracy.