Lidar and Radar fusion Implementation Details

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1 Implementacion

1. Extract 2D virtual scans from 3D Lidar Clouds (Using technique from "2D mapping of cluttered indoor environments by means of 3D perception", Wulf)

2. Verify Plane geometries through horizontal line segmentation via RANSAC inside the LiDAR scans. If we find line segments inside the scans, we can assume that they do not come from aerosol detection.

3. Sensor fusion can only be performed in an overlapping scan field with the radius R_F. R_F is calculated in every fusion cycle.

$$R_F = R_{Radar,\varnothing} + \beta(R_{Radar,max} - R_{Radar,\varnothing}) \tag{1}$$

4. Fused scans S_{Fusion} containers 3 types of points, R_{Radar}, R_{Lidar} and R_{Fusion}:

$$R_{Fusion} = R_{Radar} + \frac{\sigma_R^2}{\sigma_R^2 + \sigma_L^2}(R_{LiDAR} - R_{Radar}) \tag{2}$$

   if correspoding radar and lidar points are closer to each other than a parameter d_F ($|R_{Radar} - R_{LiDAR}| < d_F$). They estimate the standard deviations σ_R and σ_L for a pair of points with two error functions:

$$\sigma_R \propto 1/P_e \tag{3}$$

$$\sigma_L \propto R_{LiDAR} \tag{4}$$

   with P_e the received power of the radar. If the corresponding lidar and radar points are inside the fusion range $R_F$having a distance larger than d_F, it means that the lidar beam hits an aerosol particle, if the lidar measurement is smaller than the radar one.

   Outside the fusion range R_F only the sensors with larger maximum scan range can contribute to the fused scan. If a lidar point is on a line, the its most likely not detecting an aerosol cloud and can be used for S_{Fusion}

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S_{\text{Fusion}} = \begin{cases} R_{\text{LiDAR}}, \text{if} & \bullet \ |R_{\text{LiDAR}} - R_{\text{Radar}}| > d_{\text{F}} \\ & \quad \cap R_{\text{LiDAR}} \in \text{Line} \\ & \bullet \ R_{\text{LiDAR}} > R_{\text{F}} \\ & \quad \cap R_{\text{LiDAR}} \neq \text{inf} \\ & \bullet \ R_{\text{LiDAR}} - R_{\text{Radar}} > d_{\text{F}} \\ & \quad \cap R_{\text{LiDAR}} < R_{\text{F}} \\ R_{\text{Radar}}, \text{if} & \bullet \ R_{\text{LiDAR}} - R_{\text{Radar}} < -d_{\text{F}} \\ & \quad \cap R_{\text{LiDAR}} < R_{\text{F}} \quad \text{(Type I)} \\ & \bullet \ R_{\text{LiDAR}} = \text{inf} \\ & \quad \cap R_{\text{Radar}} \neq \text{inf} \quad \text{(Type II)} \\ R_{\text{Fusion}}, \text{if} & \bullet \ |R_{\text{LiDAR}} - R_{\text{Radar}}| < d_{\text{F}}. \end{cases} \tag{2}
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