MTRN4010 Project 1

z5257541 - Marcus Oates

Term 1 2023

Part E - Basic Calibration

In a real life situation the sensor data that is collected from the gyroscope will included some noise, which in the case of the project has been modelled by some bias being added to the readings, which means at each time step the sensor will give an inaccurate reading. Ignoring this means that at each time step our prediction of the platforms pose will become increasingly incorrect, as the error in pose predictions will accumulate over time. Similarly, the LiDAR scanner may become misaligned at some point in the platforms journey, meaning that our understanding of where objects are in relation to the platform will not be representative of reality. Ignoring this factor means that objects detected by the LiDAR scanner will not be correctly identified by their position in the real world, which if their positions are used for deterministic localisation, means that our estimates of the platforms pose will be incorrect.

To find the bias in the gyroscope we first plot the ground truth for the position of the platform, and then the dynamically update the platforms predicted position on the same plot. Given that the bias is some constant b such that $-1 \leq b \leq 1$, we first note that the platform drifts to the left when $b = 0$ for data set "DataUsr_p020", so we set the bias to -1, and now the platform drifts to the right. By applying a binary search so that the platforms pose converges onto the ground truth, within the error margin of 3cm of displacement maximum from the ground truth, we find that $b = -0.3984375$ and $b = -5.703125$ for data sets "DataUsr_p020" and "DataUsr_p021" respectively.

We take a similar binary search approach and take into account the detected walls, making sure they are parallel to the ground truth, and also the landmarks, making sure that the scans line up with the exterior of the landmarks that are facing the scanner. Using this approach the LiDAR misalignment is found as $\theta = 5$ and $\theta = -7.265625$ for data sets "DataUsr_p020" and "DataUsr_p021" respectively.

Part F - Deterministic Localisation

To determine the pose of the platform we have the ranges from the LiDAR scanner to the detected landmarks, whose position has been verified by the Data Association in Part D. For localisation to occur, there must be two landmarks within view of the LiDAR scanner, and the LiDAR scanner must lie on the intersection between two circles that are centred on each of the landmarks, with radii defined by the previously computed range to these landmarks, like $(x_l - x)^2 + (y_l - y)^2 = r_l^2$, where (x_l, y_l) is the position of the landmark in the global coordinate frame (GCF), (x, y) is the unknown position of the LiDAR in the GCF, and r_l is the distance from the LiDAR to the landmark. Taking each pair of landmarks we can build an average estimated position for the LiDAR scanner in the GCF using the intersection of the two circles surrounding the landmark. To determine which of the two intersection points is the correct position for the LiDAR scanner, we compare them to the last known position of the LiDAR scanner, and choose the point that is closer to this last known point. Now we can determine the heading of the platform, which is given by the equation $\phi = \mathrm{atan2}(y_1 - y, x_1 - x) - \alpha_1$, where ϕ is the LiDAR heading in the GCF, (x_1, y_1) is the computed coordinate of the landmark in the GCF, (x, y) is the position of the LiDAR in the GCF and α_1 is the angle to the landmark as computed in Part B. Note that the heading of the LiDAR scanner is also the heading of the platform. As such, we can use the coordinate frame transform to find the position of a landmark in the platforms coordinate frame (PCF), and then use this point to find the position of the platform in the GCF. Therefore, $p^p = R_0 p^l + T_l$, where p^p is the landmark in the PCF, R_0 is the rotation matrix with a zero angle input, p^l is the landmark in the LiDAR coordinate frame and T_l is the displacement vector of the LiDAR from the platform origin in the PCF. We can then find $T_p = p^g - R_\phi p^p$, where T_p is the displacement vector of the platform in the GCF, p^g is the position of the landmark in the GCF and R_ϕ is the rotation matrix for the platforms heading. The position of the platform is estimated by T_p.