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Task 7.1 Theoretical questions

a) Explain the concept of odometry in your own words (4 points)

Odometry is a concept used to calculate the position of a robot as it travels over a period of time. It keeps track of the robot's wheel rotations so we can calculate the distance the robot traveled and the direction (angle) of the motion. We then use this data to update and estimate the robot's position which is important for navigating and path planning.

b) Explain why a robot cannot rely on odometry alone for localization (3 points)

Odometry alone is not reliable for robot localization because of the possible errors which lead to a uncertain position calculation:

- Deterministic Errors: There are systematic errors that can be reduced through calibration like misalignment of wheels or unequal wheel diameters.
- Non-Deterministic Errors: These are random errors that cannot be eliminated and that arise from unpredictable factors such as changes in the floor's contact with the wheels, leading to slipping.
- Integration Errors: There are small errors in the measurement of distance and angle of turns which accumulate, leading to deviations from the wanted path. Especially for turn and drift errors, which can greatly change the robot's orientation and position over longer distances or time periods, much more so than range errors.

Due to these errors, odometry alone is insufficient for localization and should be combined with other concepts, sensors and models.

c) Explain how we can reduce the uncertainty of the final position of the robot (3 points)

To reduce the uncertainty of the final position of the robot we need to use several concepts and methods:

First, we want to ensure that the robot's sensors and odometry are accurately calibrated to minimize deterministic errors. Then we try to minimize and compensate for the non-deterministic errors that cannot be eliminated by using error models. We also could use control systems like Proportional (P) and Proportional Integral (PI) control to correct the robot's motion based on sensor feedback. And lastly, we would keep track of the covariance of the robot's pose to recursively define the uncertainty and update it as the robot moves.

By combining all these methods, the robot's position could be optimized, leading to a more accurate final position.