Thesis Topic: Evaluation of robot SLAM trustworthiness

Description of the work

In this work a student will investigate the combined use of several perception modalities with the aim of robot navigation in unstructured environments. The end goal is for a robot to use the most reliable method or a fusion of several methods to navigate in a cave-like environment using an archimedean screw-driven mobile robot (see references below). The robot is equipped with vision-based SLAM, lidar-based SLAM, whisker-based wall following and path planning, as well as kinematic and dynamic locomotion models for pose estimation. The student will develop an algorithm that evaluates the uncertainty of each SLAM method online as the robot is moving, determines which method should be trusted more at any given time, and switches to using whisker-based navigation if SLAM is not reliable.

What will you learn?

- State-of-the-art navigation concepts in simulated and "real-world" scenarios
- Developing tools for ROS2 and the gazebo simulator
- Designing and conducting experiments in real-world conditions
- Data processing

Why is this important:

Robot navigation in unstructured environments requires reliable knowledge of the robot's location and of its surroundings. Several methods exist that achieve this, but their effectiveness declines when sensor data is unavailable or untrustworthy. Online SLAM output evaluation and taking appropriate action to ensure the highest trustworthiness can have considerable impact for mobile robotics.

Requirements:

- C++ (preferred) or Python 3 skills for development for ROS
- Familiarity with ROS. ROS2 Humble is used, older ROS experience is also valued
- Familiarity with sensor fusion and probabilistic algorithms will be helpful

References:

- Robot's software: https://github.com/Centre-for-Biorobotics/rm3_ros_packages
- Robot's locomotion: https://ieeexplore.ieee.org/abstract/document/10591748
- Whisker-based navigation: https://ieeexplore.ieee.org/document/10610762
- Introducing noise into SLAM: https://github.com/Centre-for-Biorobotics/turtlebot4-slam-noise

Why is this important?
A robust, low-cost sensor that can provide data for SLAM, even at limited range, can be a great improvement for negotiating unstructured and sensory-deprived environments, and significantly increase robot safety.

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