ELECTRICAL, ELECTRONICS AND COMMUNICATIONS ENGINEERING

CRT/DET - Multi-robot localization: Gaussian Belief Propagation on factor graph

Funded By	FONDAZIONE CRT CASSA DI RISPARMIO DI TORINO [P.iva/CF:06655250014] Dipartimento DET
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Context of the research activity	This project focuses on leveraging factor graphs and inference algorithms, like Gaussian Belief Propagation, to enhance autonomous robot localization and navigation. It aims to develop scalable, real-time solutions for handling uncertainty and fusing sensor data in dynamic environments. The research includes theoretical advancements, algorithm development, and validation on robotic platforms, targeting applications in urban navigation, exploration, and search-and-rescue.
Objectives	This PhD project explores the development and application of factor graphs and advanced inference algorithms, such as Gaussian Belief Propagation (GBP), to enhance the autonomous localization and navigation capabilities of robotic systems. Localization and navigation are cornerstone challenges in robotics, requiring precise and computationally efficient methods to handle uncertainty and fuse heterogeneous data in dynamic environments. By leveraging the mathematical framework of factor graphs, the project aims to establish robust, scalable, and real-time solutions for robots operating in complex settings. Localization and navigation are critical components of autonomous robotics, enabling robots to determine their position relative to the environment and plan safe, efficient trajectories. Traditional approaches, such as Extended Kalman Filters (EKFs) and Particle Filters (PFs), often struggle to scale or maintain performance in environments with high-dimensional state spaces, non-Gaussian noise, or significant data association ambiguities. Factor graphs offer a unifying framework to represent probabilistic relationships among variables (e.g., poses, landmarks, and sensor measurements) in localization and navigation tasks. Inference algorithms, such as GBP, allow for efficient message-passing and marginalization within

	these graphs, enabling accurate estimation of robot states and environmental models. This project seeks to push the boundaries of these methodologies to create next-generation algorithms for robotic applications. This research will contribute to advancing autonomous robotics by enhancing robustness, scalability, and real-time capabilities in localization and navigation. Beyond robotics, the outcomes may influence fields such as autonomous vehicles, augmented reality, and precision agriculture, where spatial awareness is critical.

Skills and competencies for the development of the activity	LM in Mechatronic Engineering Programming in C++ and Python Robotics Embedded systems and sensors AI/ML algorithms base elements ROS and ROS2