

Resilient Autonomous Navigation and Persistent Target Observation in Contested Indoor Environments (RAPTOR)

Autonomous robotic systems are increasingly being deployed in critical applications such as infrastructure inspection, disaster response, warehouse automation, surveillance, and search-and-rescue operations. These systems are expected to operate reliably in environments where localization, perception, and communication may degrade unexpectedly.

Indoor operation introduces a unique challenge since GNSS-based positioning is unavailable. Instead, robots must rely on alternative localization techniques such as Ultra-Wideband (UWB) ranging, inertial sensing, and visual perception. In realistic operational environments, localization measurements may become unreliable due to signal blockage, multipath propagation, temporary sensor failures, or communication degradation. Simultaneously, the robotic system may still be required to detect and track moving targets.

In this project, the objective is to **design, and implement an autonomous mobile ground robot** with localization, perception, navigation, and control capabilities that can navigate in an indoor area of minimum size of **10 m × 10 m**, e.g., basketball-court-sized indoor arena, detect a designated moving target, and continuously track it under degraded sensing conditions. The moving target may be a human, a mobile rover, or a remote-controlled vehicle.

The designed system should:

- Estimate the robot's position using raw UWB ranging measurements from four UWB anchors located at predefined positions together with IMU and camera information.
- Achieve a real-time localization error **less than 20 cm** under nominal conditions.
- Detect degraded or temporarily unavailable localization, perception, or communication information and maintain operation or recover from temporary localization and target-tracking failures caused by missing or biased UWB measurements, communication packet loss, occlusion, or illumination changes. The system should keep operating if any one of the four anchors fails or becomes biased.
- Navigate autonomously through at least 5 arbitrarily chosen different waypoints in the area.
- Search for a moving target entering the arena, detect it within 2 seconds after it **enters the camera's field of view**, and continuously track its position in the camera image while both the robot and the target are moving, maintaining the target within the camera's field of view.
- If the target is temporarily lost, the robot shall reacquire it within 3 seconds after it becomes visible again.
- Physically follow the moving target while maintaining a safe distance.
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- Avoid collisions with arena boundaries and obstacles.

- Return to a designated safe zone or stop safely when necessary (e.g., when localization uncertainty exceeds an acceptable limit).
- Provide a graphical user interface for monitoring the robot, sensor information, estimated positions, and target-tracking operation.

External localization aids such as LiDAR, GPS, or additional ranging devices shall not be used.

Extra Features

- Dynamic obstacle avoidance,
- Learning-based fault detection,
- Multi-target detection and prioritization,
- Target re-identification after occlusion,
- Predictive target trajectory estimation,
- Cooperative multi-robot operation,
- Adaptive mission replanning.