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BA/FA/MA: Efficient target detection for low-cost radar-based indoor localization system.

Description: Indoor localization has seen an emerging interest over the last years. As Global Navigation Satellite System (GNSS) signals cannot be used indoors, dedicated systems have to be deployed for indoor localization.
Indoor positioning systems (IPS) based on millimeter (mm) waves offer high accuracy by using the ultra-wideband (UWB) approach, i.e. waveforms with large bandwidth. However, current UWB systems suffer from high system complexity and cost. We propose a millimeter wave indoor localization system based on active radar sensing of local passive reference points (LRPs) that promises highly accurate indoor localization at low system cost. This system shall be used to navigate autonomous mobile robots (AMRs) in indoor environments.

Localization of the AMR is achieved by processing the received radar signals and feeding the extracted radar target detections to a particle filter, a nonlinear realization of the Bayes filter.
As the cost of the system shall be kept low and fast and efficient radar signal processing is required for frequent position updates, novel ideas for the radar processing specifically applied to the proposed localization system shall be studied. The focus is on optimizing the target detection algorithm using prior information about the system and candidate robot locations (particles in the particle filter). The investigation further includes possible improvements over the baseline CA-CFAR (Cell-Averaging Constant False-Alarm Rate) and DBSCAN algorithms for target detection and clustering, e.g. other CFAR variants and clustering approaches, adaptive parameters, clutter maps, simpler detectors etc.

Work package:

- Literature of FCMW radar including range-Doppler processing and target detection algorithms.
- Collection of small radar dataset for a few test scenarios to be evaluated.
- Study of better suited CFAR variants or other detections algorithms for heavily cluttered indoor environments and comparison to the baseline CA-CFAR algorithm.
- Study better suited clustering algorithms to process the target clusters after CFAR processing than DBSCAN that are e.g. less prone to fuse clusters of different targets.
- Study how a feedback-loop from the target localization algorithm (particle filter) can be used to speed up the radar processing by pruning the regions to test for targets.
- (Optional – depending on thesis type and left time: Study of low-cost improvements, e.g. adaptive parameters for detection/clustering, clutter suppression via clutter maps, …)

Prerequisites:
- Interest in the topic and ability to work indepently
- Signal processing basics (Impulse response, FFT, …)
- Programming experience (ideally Python)
- Ideally SASP and DPR lecture
- Ideally radar signal processing, e.g. automotive radar for autonomous driving lecture