A Mobile Security Robot equipped with UWB-Radar for Super-Resolution Indoor Positioning and Localisation Applications

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ABSTRACT

In indoor scenarios where the environment is filled with dust, smoke or other particles the performance of classical sensors based on optics, infrared and ultrasound may massively be constrained or, in worst case, is suspended. Moreover, UWB-Radar benefits from the propagation of electromagnetic waves through walls and other dielectric media and can be used for in- and through-wall applications. In public buildings (e.g. airports, train stations) UWB-Radar can be used for security affairs without violating individual privacy as it would be the case with video surveillance. The large bandwidth of 4.5 GHZ in baseband and 9 GHz in passband mode which was used within these investigations results in a fine time resolution which enables resolution in sub-centimetre range. UWB-Radar with its superior advantages is an ideal candidate e.g. for security robots in indoor scenarios where it is too dangerous for rescue teams. Other application areas are given in the fields of security and military surveillance systems.

In this paper an autonomous mobile security robot is introduced which operates with UWB-Radar technology. Research investigations and results gained in the last years concerning UWB-Radar, UWB signal processing, object recognition, highly accurate wavefront extraction under multipath conditions and super-resolution imaging have been transferred and adapted to a new mobile platform. Many challenges in the area of robotics, localisation and robot motion resulted. In addition an optimal alignment of UWB antennas and robust UWB-Radar sensing conditions had to be taken into account.

The objective of this paper is the 2D inspection of an unknown or just roughly known area with unknown objects. The investigated objects consist of simple canonical and some polygonal complex objects. In a first scenario the robot makes chaotic motions in the room and avoids crashes by a UWB collision avoidance algorithm using a bi-static antenna configuration. Within this first part of an inspection tour the environment interacts with the transmitted UWB pulses and is characterized by diffraction, reflection, and backscattering. These effects are determined by the shape of the objects, their internal structure as well as material properties. The spatial and temporal signatures of the received pulses have subsequently to be analyzed to build a rough map of the scenario.

Subsequently in a second part of the scenario, objects are inspected by the UWB-Radar on a robot track around them. The motion algorithm around these objects are designed to be contour adaptive, exhibit collision avoidance features, and use the shortest tracks while maintaining optimal antenna alignments. The resulting radar images have super-resolution characteristics with an error in the sub centimetre range of the contour or, in case of a dielectric medium, of its interior structure.
These shapes can further or iteratively be used to improve the map accuracy and to resolve ambiguities. Due to the precise extraction of the object geometry a calibration-coordinate can act as a deterministic landmark or as an anchor node for further investigations

KEYWORDS: UWB-Radar, UWB imaging, Super-resolution, Anchor nodes, UWB based position determination