UWB Radar sensor characterization for obstacle detection with application to the smart white cane

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Abstract

Obstacle detection capability is of great interest in application domains such as navigation of Visually Impaired and Blind people. To perform free-space assessment over the whole person height, range sensors are usually placed on a white cane and their measurements are analyzed to provide feedback about potential harmful obstacles. Thanks to technology progress both at hardware and software levels, integration of such obstacle detection capabilities in a white cane seems conceivable.

It is well admitted that ultra-sonic range sensors have limited sensing range (typically < 3 m) and difficulties of operating on highly reflective surfaces [1]. Laser-based solutions can be highly sensitive to ambient natural light and identification of transparent or mirror-like surfaces is difficult. RF Radar range sensor performance is affected by the electromagnetic backscattering characteristics of the obstacle (Radar Cross Section). The electromagnetic response is in general very different from the mechanical response to ultrasound waves or optical response to LiDAR. [2] shows that Ultra-Wide-Band (UWB) radar can be used effectively to detect obstacles under rain, snow, fog and smoke, thus being complementary to LiDAR. Therefore, to overcome limitations of each range sensor technology, Ultra-Sound, UWB RF Radar and LiDAR will be co-integrated in the obstacle detection system the H2020 INSPEX project is targeting (Fig. 1) [3]. This work details the characterization and future enhancements of the UWB RF Radar developed in the course of the project.

The complete system should not exceed 200gr in weight and 100cm3 in volume. Ten hours of lifetime in continuous use are expected with an initial target for power consumption smaller than 500mW. The obstacles could move at an unpredictable speed and direction and the system should detect reliably objects moving at a speed of ~1.4 m/s worst case (relative speed between the user and the objects) and be able to detect obstacles up to a distance of 4m.

After a static characterization phase of the UWB Radar, measurements were performed in mobility conditions. The Radar is placed on a cart moving linearly towards the obstacle with a colliding trajectory. The relative radial speed is about -0.15m/s. The right drawing in Fig 1

shows the Radar response over time with three snapshots in the speed domain. The top left curve clearly shows the “approaching” obstacle wave-front while the three other curves show how the speed can be exploited in colliding trajectories detection.

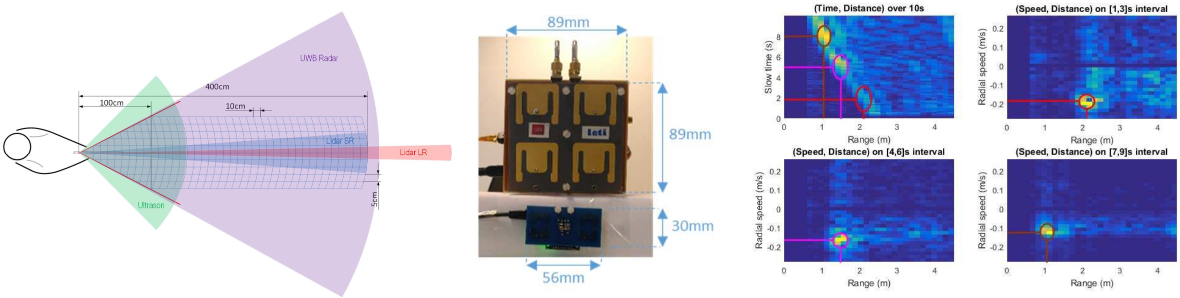

Fig. 1. Co-integration of several range sensors in INSPEX (left) UWB Radar and device [4] (middle), Obstacle echo over time and snapshots of (Speed, Distance) matrix estimation (right)

A first characterization of the initial UWB Radar sensor was performed according to the INSPEX system specification, focusing on low level metrics. The technology is well suited to provide wide field-of-view channel response and relative radial speed estimation up to at least 4m range. Typical obstacle measurements emphasize the obstacle echo versus nuisance clutter weights, showing the need for advanced signal processing and heterogeneous sensors fusion to re-inforce obstacle detection robustness in later stages of the INSPEX project.

Future work directions are many-fold. The first objective is the integration of the UWB Radar in a smaller form factor together with migration to 8GHz operating frequency. Notably, the expected antenna surface will be down-sized by 5.5 to 38*38mm² to reach the integration objectives. Second, the platform interface will be updated to get a refresh rate of 150Hz compliant with the system specification. Third, the sensor output will be interfaced with the integrated data fusion platform. Finally, a novel antenna structure and processing will be tested to bring angle-of-arrival and a richer 2D positioning information to the fusion platform.

References

[1] L. Scalise et al., “Experimental Investigation of Electromagnetic Obstacle Detection for Visually Impaired Users: A Comparison with Ultrasonic Sensing”, IEEE Trans. on Inst. and Meas., Vol. 61(11), 2012.

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[3] S. Lesecq et al., “INSPEX: Design and Integration of a Portable/Wearable Smart Spatial Exploration System”, DATE 2017.

[4] XeThru X4M03 development platform https://www.xethru.com/xethru-development-platform.html