

## A robust and precise 3D indoor positioning system for harsh environments

In recent years there has been a considerable research on the development of indoor positioning systems. Several kinds of technologies such as ultrasonic, UWB, WLAN, optical systems and hybrid based solutions were already utilized, which, however, encounter many difficulties in indoor environments due to none line of sight (NLoS) and multipath errors, signal obstruction as well as noises.

In this contribution an alternative positioning system even for harsh and NLoS environments is presented and its performance for 3D indoor localization is evaluated. The presented DC magnetic signal based positioning system shows no special multipath effects and has excellent characteristics for penetrating various obstacles. The system consists of multiple electric coils generating artificial magnetic fields. Capturing the coils' fields with a three-axis magnetic field sensor, which serves as mobile station, its position can be estimated precisely using the lateration principle. Basically, the localization procedure is divided into four successive steps: sensor inclination determination, elevation angle calculation, range computation and position estimation.

To eliminate other interference fields (e.g. earth's magnetic field, electrical disturbances) a differential measurement principle was developed. Digital signal processing techniques and adaptive noise suppression algorithms allow the magnetic field detection at distances up to 20 m with mid size coils. By using bigger coils and higher currents the range could be expanded to about 45 m. For short distances even smartphones (e.g. iPhone) embedded low quality sensors can be utilized. Setting up only three coils inside or around the building a real 3D position can be estimated with accuracy lower than 50 cm. In order to analyze existing systematic errors, a calibration procedure was developed. By carrying out calibration measurements a regression function could be found. In result the systematic errors could be reduced, which leads to an improvement of the system's positioning accuracy to less than 10 cm.