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Characterization of the Indoor Magnetic Field for Applications in Localization and Mapping

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ABSTRACT

For millennia, humans have successfully employed the Earth's magnetic field for navigation. While a compass needle in combination with a map of magnetic declination is a simple and effective means to determine heading in outdoor locations, this field is generally believed to be of limited use in indoor environments due to strong perturbations caused by the abundance of ferromagnetic objects (e.g., pipes, ducts, rebar). In contrast, we believe the resulting omnipresent and information rich three-dimensional magnetic vector field can support not only heading estimates but also higher dimensional pose estimates in general.

To improve our understanding of the indoor properties of the perturbed Earth's magnetic field, we have developed a methodology to obtain dense and spatially referenced samples of the magnetic vector field on the ground's surface and in the free space above the surface. This methodology draws on the use of optical tracking to accurately determine the pose of the magnetic sensor, which can be positioned manually and by ground and aerial robots to acquire densely gridded sample datasets. We have found that the indoor magnetic field exhibits a surprisingly fine-grained and persistent micro-structure of perturbations in terms of its direction and intensity. We believe that, instead of being a hindrance to navigation, the variations of the three vector components are sufficiently expressive to form re-recognizable features based on which accurate localization is possible. We have ongoing experiments in which we simultaneously localize a robot within this environment while it maps the magnetic field. The resulting maps may serve to compensate the perturbations and subsequently determine the heading or pose of a robot or a person-carried device in pedestrian dead reckoning applications, based on a magnetometer and inertial measurements at very little computation cost.

KEYWORDS: indoor magnetic field, localization, pose estimation, simultaneous localization and mapping (SLAM), pedestrian dead reckoning (PDR).