Magnetic-Field Feature Extraction for Indoor Location Estimation

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Abstract. User indoor positioning has been under constant improvement especially with the availability of new sensors integrated into the modern mobile devices. These sensory devices allow us to exploit not only infrastructures made for every day use, such as Wi-Fi, but also natural infrastructure, as is the case of natural magnetic fields. From our experience working with mobile devices and Magnetic-Field based location systems, we identify some issues that should be addressed to improve the performance of a Magnetic-Field based system, such as a reduction of the data to be analyzed to estimate an individual location. In this paper we propose a feature extraction process that uses magnetic-field temporal and spectral features to acquire a classification model using the capabilities of mobile phones. Finally, we present a comparison against well known spectral classification algorithms with the aim to ensure the reliability of the feature extraction process.

Keywords: Magnetic Field Measurements, Magnetometers, Location, Indoor Positioning, Location Estimation, Feature Extraction.

1 Introduction

User positioning has been the focus of many research groups around the globe. Several approaches have been proposed to estimate the location of an individual. For instance RFID, Wi-Fi and Bluetooth, which provide evidence of their ability to locate an individual indoors [1–3]. However, they require a dedicated infrastructure, and thus system scalability can be expensive, as it requires adding devices. Therefore new approaches have been proposed to avoid those issues; these new approaches are based on the reuse of the technologies that we use everyday (i.e. mobile devices) and using the signals already available in the indoor environment. An example of those approaches is indoor positioning systems based on Magnetic-fields [4].

The use of magnetic fields for indoor location systems has been explored in some pioneer works such as [5, 6]. Their idea is to use the irregularities of the earth's natural magnetic field induced by building's structures and other

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elements common in indoor environments, and detect these irregularities as clues for finding the user's location, with the help of a magnetometer such as those available in smartphones. Such approaches involve the previous mapping of a given indoor environment, measuring at each point the magnitude and direction of the magnetic field, and then, using this magnetic map for location purposes, finding the most similar place in the magnetic map to the one detected at a given point. ana

In our approach, the goal is to identify the "room" in which the user is at a certain moment, not to give exact coordinates, like some other methods do. In this setting, the precision is the percentage or times the system gives the correct room, not a measure in centimeters or other length measures. But in most practical situations, to know in which room the user is located, is exactly the type of information he/she needs, not to have a vector of coordinates.

Further, we developed an original method in which there is no need of constructing a detailed magnetic map, which is a grid of magnetic measures for each point in the building, as other approaches do, but just to store a kind of "signature" taken from a random walk inside a given room, which takes as an essential component the frequency spectrum of the magnetic signal, obtained from the Fourier transform of that signal. This method has been shown to be independent of the exact path used when picking the magnetic signal, thus giving it a very desirable robustness.

From our experience working with Magnetic-Field based location systems, we identify some issues that should be addressed to improve a Magnetic-Field based system. In particular, we guess that clever feature extraction from the magnetic field signal would reduce the amount of data required to estimate the location of an individual. We have the hypothesis that this feature extraction process improves the accuracy and the robustness of the system, and reduce the computational cost, enabling the system to be executed on a mobile device.

The aim of this work is to present a temporal and spectral feature extraction process, exploiting the statistical parameters to summarize the behavior of the signal. Further, we intend to obtain a classification model from temporal and spectral features of the magnetic field using a magnetic sensor included in a conventional mobile device.

This paper is organized as follows. A description of related works for location estimation that uses the magnetic-field is given in Section 2. A description of spectral and statistical features is presented in Section 3. Experimental procedures are described in Section 4. Section 5 shows the experimental results obtained after running the classification model. Finally conclusions and future work are presented in Section 6.

2 Related Work

Indoor positioning technologies can be classified into three categories: technologies based on signals-of opportunity (signals that are not intended for positioning