Magnetic-Field Feature Reduction for Indoor Location estimation applying Multivariate Models

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***Abstract*—In the context of a magnetic field-based indoor location system, this paper proposes a feature extraction process that uses magnetic-field temporal and spectral features in order to develop a classification model of indoor places, using only a magnetometer included in popular smartphones. We initially propose 46 features, 26 derived from the spectral evolution and 20 from the temporal one, chosen because of the statistical potential to summarize the behavior of the signal. Nevertheless, in order to simplify the classification model, a genetic algorithm approach, combined with forward selection and back elimination strategies was applied. Our results show that is possible to reduce the magnetic-field signal features from 46 to only 6 features, and estimating the user's location with even better precision.**

***Keywords*—Localization, Indoor Location, Magnetic-Field, Feature Extraction, Feature Reduction, Classification Model.**

I. Introduction

Several indoor location systems have used the irregularities of the earth's natural magnetic-field induced by buildings' structures and other common elements 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 standard smartphones [1], [2], [3]. 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 database for location purposes, finding the place most similar to the current one in the magnetic database, which is the system's estimation for the user's location. 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 accuracy is given by 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. We developed a method in which there is no need of constructing a detailed magnetic map, in the form of 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 a time evolution and a spectral evolution of the magnetic signal, the latter 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 assume that clever feature extraction from the magnetic field signal would reduce the amount of data required to estimate the location of an individual, without affecting in a negative way the estimation. We have the hypothesis that this feature extraction and a genetic algorithm (GA) approach, combined with forward selection (FS) and back elimination (BE) strategies, improves the accuracy and the robustness of the system, and reduces significantly the computational cost, enabling the system to be executed on a mobile device. In this paper we propose feature extraction and reduction of the magnetic-field signal using the approach of applying genetic algorithm (GA), combined with the forward selection (FS) and back elimination (BE) strategy. This simplification has the aim of locating the user in an indoor with less computational cost, since one of the objectives is to run the method on mobile devices.

This paper is organized as follows: after this introduction, a description of related works of feature reduction is presented in section II. In section III we describe our location estimation method and the extraction-reduction process. The results of the process are presented in section IV. Finally, our conclusions and future work are presented in section V.

II. Related Work

The feature extraction process has been employed for performing efficient data reduction while preserving the appropriate amount of information of the signal [4]. For instance, Arjmandi et al [5] the audio feature analysis is used to improve the identification of disorders in the voice through the comparison of feature reduction techniques like forward selection (FS), which generates nested models, adding the next best ranked feature, one at a time, and selecting the features that resulted in the maximum fitness [6], as well as the backward elimination (BE), which removes a model regressor one at a time, based on the least deterioration in model fit [7]. Other interesting approach for feature reduction is the use of genetic algorithms (GA). For instance, Lee et al [8] employed a GA to reduce the physical data of a patient which are used in a bio-medical set, whereas in some research works [9], [6] is used a genetic algorithms approach in combination with a FS and BE strategy, in order to to reduce a genetic code of a person useful for estimating the probabilities of developing an Alzheimer's disease. Consider that genetic algorithms have been used successfully in data optimization and analysis of microarray [10], [11]. We consider GA approach in this paper to extract and reducing the features of magnetic-field signal to estimate the user location. Additionally, we consider

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