

# Dolphin Indoor Localization System based on Hidden Markov Model

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## Abstract

Currently, most of indoor localization solutions rely on uncommonly technologies such as RF (Radio Frequency), laser, UWB (Ultra Wide Band) and ultrasonic wave, etc. In this work, we developed a low-cost, high-accuracy indoor localization system named dolphin, which relies on Wi-Fi, geomagnetic signals and PDR (Pedestrian dead-reckoning). Specifically, HMM (Hidden Markov Model) is built based on Wi-Fi and geomagnetic signals, search tree is constructed and variants of the Viterbi algorithm is designed to solve the matching of environment fingerprints, and it has some excellent characteristics such as using the existing infrastructure, no requirement of additional hardware components, no labeling of the initial location.

## Keywords

Indoor localization, fingerprint, Wi-Fi, Geomagnetic, PDR, HMM

## 1. INTRODUCTION

The outdoor localization systems such as GPS (Global Positioning System), GLONASS (Global Navigation Satellite System), BDS (BeiDou Navigation Satellite System) and GSNS (Galileo Satellite Navigation System), cannot be used indoor and in underground environments. Hence, a lot of attention is focused on indoor localization in recent years. As a result a number of technologies and solutions were developed such as RF, laser, UWB and ultrasonic wave, etc. which require deployment of special infrastructure and thus have little universality and commercial value to be promoted.

In this work, we propose a real-time indoor localization system based on HMM with commodity off-the-shelf (COTS) smartphones. The proposed system is named as dolphin which can be used to locate smartphones without any additional hardware.

## 2. SYSTEM DESIGN

The architecture of dolphin system consists of client and server, including smartphones as the client(s) and PC/laptop as the server, communicating with each other based on HTTP protocol, as shown in Figure 1.

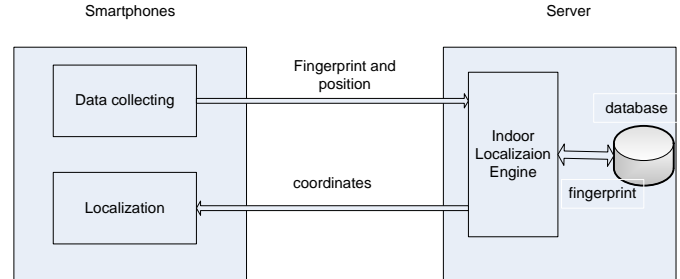


Figure 1 Dolphin system diagram

Dolphin is divided into two phases: offline data collecting phase and online localization phase.

### 2.1 Data collecting Phase

During this phase we constructed two kinds of fingerprint maps. Measurements of the geomagnetic field and Wi-Fi Received Signal Strength Indication (RSSI) are collected to generate the geomagnetic fingerprint and the Wi-Fi fingerprint respectively using the building map. Three elements were recorded in the geomagnetic fingerprint map including magnetism magnitude, orientation offset and corresponding map information.

### 2.2 Localization Phase

Localization phase contains three procedures:

#### a) Wi-Fi localization

Wi-Fi localization is to estimate target initial and coarse location.

#### b) Geomagnetic localization

Geomagnetic localization is to get a precise location. The geomagnetic signal is a time series, geomagnetic matching is a comparison of geomagnetic signal series and fingerprint, which is a line to surface matching problem. However, the geomagnetic fingerprints from different positions may be similar. We built a search tree for matching, and designed a variant of the Viterbi algorithm to speed up the search process.

#### c) PDR

PDR is used to do continuous locating. Geomagnetic localization requires a large amount of computation, compared with a much faster PDR. We used each geomagnetic location as the basis for PDR to calculate the location of the next few steps. This ensures fast continuous locating, as shown in Figure 2.

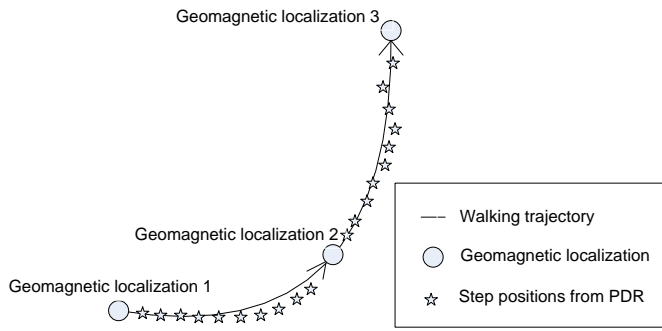


Figure 2 Dolphin localization phase

Dolphin runs on smartphones as an Android application, as shown in Figure 3. The proposed system is a low-cost scheme without requiring any additional hardware.

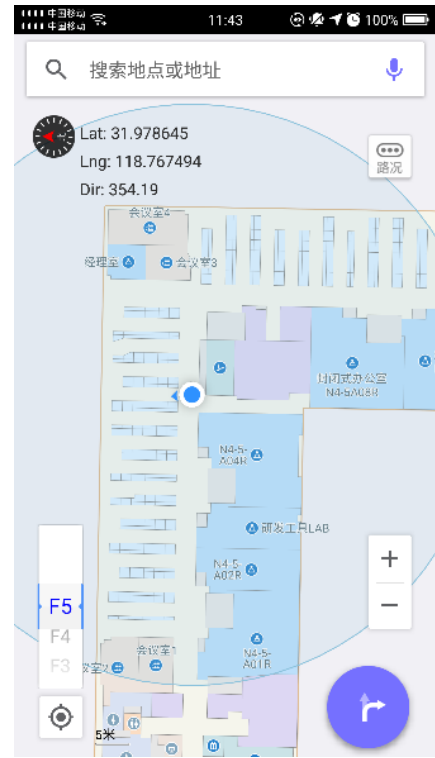


Figure 3: Dolphin indoor localization application

### 3. REQUIREMENTS

Dolphin location system requires no additional hardware, but need to keep holding the smartphone horizontally and walking forward.