Infrastructure-free Indoor Positioning System using Smart Phone Sensors*

Extended Abstract†

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ABSTRACT

This paper discusses the technique used for indoor positioning using ubiquitous resources available at the target environment. Wi-Fi Received Signal Strength-based Fingerprinting is one of the promising technique to achieve indoor positioning up to a certain level of accuracy, whereas Pedestrian Dead Reckoning provides a little higher level of accuracy in tracking a moving resource using motion sensors provided the starting position. The technique proposed in this text is an infrastructure free technique which exploits the location and tracking information of Wi-Fi and PDR with sparse geo-magnetic tagging of the environment to achieve a higher level of localization information in the indoor environment.

KEYWORDS

Infrastructure-free Indoor Positioning System using Mobile Sensors

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1 INTRODUCTION

To provide precise indoor location information of a mobile target without any special infrastructure requirement is one of the most addressed problems in the field of geo-location technologies after the success of Global Navigation Satellite Systems (GNSSs) such as GPS in recent years. Several techniques have been proposed to solve this issue of the complex indoor canyon where RF signals go under high attenuation due to multipath, absorption and fading effects. Those techniques are commonly divided into infrastructure-based and infrastructure-free technologies. Infrastructure-free approaches are preferred due to adaptability point of view as the infrastructure-based approaches require costly pre-installation and configuration of specialized hardware prior in the environment. Techniques based on RFID, RF Sensors, Bluetooth, UWB are known as infrastructure-based techniques whereas techniques based on Wi-Fi, magnetic field, motion sensors, and vision are known as infrastructure-free technique. Infrastructure-free techniques are further categories into calibration-based and calibration-free techniques. Fingerprinting is one of the calibration-based technique which does not require any map information and location of access points(AP) deployed in the environment[3]. LOCALI is a calibration-free Path Loss Model technique using map and APs location information to avoid the laborious task of site survay[1].

2 PROPOSED SYSTEM

The lesson learned form IPIN2017 competition instead of relying on a single resource(Wi-Fi) this time we propose a system which incorporates multiple resources available in the environment for Indoor Position System(IPS). Our system is based on three kinds of commonly available resources: Wi-Fi infrastructure, Motion sensors, and Geo-Magnetism. Fingerprinting technique is used for Wi-Fi bases positioning which provides the initial location information for Pedestrian Dead Reckoning(PDR) approach of motion tracking using inertial sensors commonly available in handheld devices. To compensate the non-ideal situations we also employed geo-magnetic field positioning in case of inappropriate or no Wi-Fi facility.

Proposed IPS is a smart mobile-based system to estimate position locally, whereas for the fingerprinting survey of Wi-Fi and Geo-Magnetism are performed prior using a desktop system and mobile phone as a scanning device.

2.1 Wi-Fi Fingerprinting

Wi-Fi network is a commonly available resource in these days, therefore, we selected Wi-Fi fingerprinting as our primary technique for position estimation. Wi-Fi fingerprinting normally have two stages: offline fingerprint database generation survey of the environment and online fingerprint matching to estimate the location of the target node. In offline DB generation, a list of Wi-Fi RSSI values of access points(APs) at each reference point in the information is stored in the DB as raw wifi scans with location tags, which is a further process to generate fingerprinting database. Whereas in online location estimation stage the target nodes send the real-time list of mac addresses of visible APs at the particular

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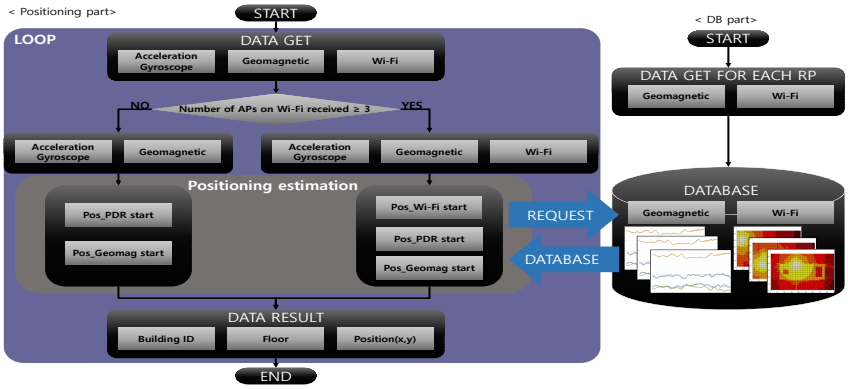

Figure 1: System diagram of proposed approach.

position with RSSI level to position estimation procedure, which finds a matching fingerprint in the DB generated in offline phase. Fingerprint matching algorithm uses kNN, SVM etc. technique to find the best match among multiple candidate location fingerprints with minimum error distance.

2.2 Pedestrian Dead Reckoning

Pedestrian Dead Reckoning (PDR) is a technique to estimate the distance traveled and heading angle of a user carrying a smart device bearing motion sensors or Inertial Measurement Unit(IMU) also know as Inertial Navigation System using Step and Heading System (INS-SHS)[2]. By applying the threshold on the measurement of the accelerometer and incorporating some correction using gyroscope values we estimate the step length and step count of a person carrying a smartphone with IMU sensor. Where are by fusing the Compass(Magnetometer) reading and angular velocity from gyroscope the heading angle estimation is performed. The system uses PDR information between successive location estimation from Wi-Fi fingerprinting technique to limit the estimation in a particular region.

2.3 Geo-Magnetism

Geo-Magnetism is another potential resource for indoor position estimation which available naturally. Positioning based on the magnetic field is also a two-stage process similar to Wi-Fi fingerprinting: model training stage and fingerprint localization stage. In the first stage, a localization model is built by fingerprints of magnetic field collected spatially with location tagging information of environment. In localization stage, the location of the target node is estimated by comparing the real-time magnetic signals collected at target node position with the localization model build in training stage[4]. A Sliding window technique is used to estimated to avoid the similarity between magnetic field at target location and fields of multiple candidate locations.

2.4 Algorithm

The proposed system required pre-survey of the environment to build fingerprinting database of Wi-Fi and geo-magnetism as described in Figure 1, <DB part>. After successful collection of survey data, fingerprinting Database for Wi-Fi and localization model for geo-magnetism is generated to be used for online positioning. The system utilizes all three resources discussed earlier for position estimation, whereas in case of inappropriate Wi-Fi resource region system switch to only utilize Geo-Magnetism and PDR resources, figure 1 <position part>.

3 CONCLUSIONS

Using single technique can provide location accuracy up to a certain level whereas by fusing multiple resource information in a hybrid solution helps in achieving a higher degree of accuracy by compensating the limits of one technique by other. The proposed system is a hybrid IPS which utilizes Wi-Fi fingerprinting, IMU based PDR and Geo-Magnetism and provide high-level accuracy for indoor localization.

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