Computers and Electrical Engineering 68 (2018) 557–569

Contents lists available at ScienceDirect

Computers and Electrical Engineering

journal homepage: www.elsevier.com/locate/compeleceng

Development of mobile platform for indoor positioning reference map using geomagnetic field data[☆]

He Huang[a], Dong Ha Lee[b,*], Kun Chang[c], Wei Li[a], Acharya Tri Dev[b]

[a] School of Geomatics and Urban Spatial Information, Beijing University of Civil Engineering and Architecture, Beijing, 100044 China
[b] Department of Civil Engineering, Kangwon National University, Chuncheon, Gangwon, 24341 South Korea
[c] School of Geodesy and Geomatics, Wuhan University, Wuhan, Hubei, 430079 China

ARTICLE INFO

Keywords:
Geomagnetic field
Indoor positioning
Mobile platform
Kriging
Map

ABSTRACT

In recent years, geomagnetic as an indoor positioning benchmark has become a popular research area. This paper presents a study on the geomagnetic indoor positioning technology involving various experiments to analyze the interior magnetic materials and electronic equipment of magnetic field interference to further explore interior magnetic properties, thus proving the feasibility of the use of the magnetic field to provide positioning information. In this study, Arduino Integrated Development Environment is used to develop the intelligent geomagnetic data collection platform. The platform is equipped with HMC5983 magnetic sensor to collect indoor geomagnetic data, and inertial navigation sensor for navigation including dead reckoning, wireless communication, obstacle avoidance, and main control modules. The platform can generate an indoor geomagnetic map with Kriging interpolation method and store it in the database. The platform as well as the map can be very useful for indoor mapping after its further improvement and experiments.

1. Introduction

Indoor positioning technology is a substantial expansion of Location-Based Services (LBS) that can effectively solve the bottleneck of "last mile" navigation problem [1,2]. The stable development of the mobile network and the rapid popularity of intelligent terminals for indoor positioning technology provide very broad application prospects; therefore, indoor positioning technology has become the focus of research, both in china and abroad. Currently, experts and scholars have proposed a variety of indoor positioning technology solutions, including primarily the use of Infrared, Ultrasonic, Bluetooth and Wi-Fi and Radio Frequency Identification Devices (RFID) and other short-range wireless positioning technology [3-6]; however, this type of technology is restricted to different degrees in the positioning accuracy, signal penetration and anti-interference and construction cost, etc., making it very difficult to achieve a wide range of applications [7]. In recent years, without any additional hardware investment in geomagnetic indoor positioning technology, researchers have achieved significant progress, thus enabling the low cost, low complexity, high precision indoor locating technology to become one of the most promising technical solutions [8].

Earth's magnetic field, which is one of the natural characteristics of the earth, is a type of vector field, exhibiting the characteristics of size, direction, spatial distribution, and temporal variation. Any point on the near-earth space has a unique magnetic field vector. Modern buildings of reinforced concrete structure and metal materials with the electric power system, electrical and

[☆] Reviews processed and recommended for publication to the Editor-in-Chief by Guest Editor Dr. J-S Sheu.
* Corresponding author.
E-mail address: geodesy@kangwon.ac.kr (D.H. Lee).

https://doi.org/10.1016/j.compeleceng.2018.05.001
Received 25 August 2017; Received in revised form 15 January 2018; Accepted 2 May 2018
0045-7906/

electronic equipment, industrial equipment have relatively constant magnetic field effects on the formation of a geomagnetic disturbance, such as the with elevator, escalator, or furniture etc. [9].

In the process of implementation of geomagnetic indoor positioning technology, the establishment of the geomagnetic reference map is very important [10]. Hence, in order to acquire geomagnetic information of an indoor space, this study develops a mobile platform composed of geomagnetic data acquisition module, dead reckoning module, wireless communication module, obstacle avoidance module, and main control module. First of all, the feasibility of this research based on the spatial distribution of the magnetic interference in the experiment area was done followed by the development of mobile platform and accuracy analysis of the module. At the end, a reference map has been described as an output of the device developed.

The paper is organized as follows. In Section 2, the feasibility study of magnetic field for indoor positioning is presented. Section 3 describes the development of mobile platform based on magnetic data and its modules. Accuracy analysis of dead reckoning module is presented in Section 4. The reference map based on geomagnetic field data is discussed in Section 5. Finally, conclusions and future work are given in Section 6.

2. Feasibility study of magnetic field for indoor positioning

Before deploying a sensor to produce a geomagnetic reference map of an interior space, it is very important to fully understand the spatial complexity of magnetic interference in the environment, including the fixed and mobile elements of the geomagnetic disturbance intensity, scope, etc. Therefore, interior-space analysis of the characteristics of the geomagnetic disturbance factors has important research significance.

2.1. Magnetic field does not change with time and intensity of light

The magnetic field terms from the interior of the earth, without the condition of interference from outer space, is very stable. To study the indoor magnetic field stability, we conducted an experiment with a HMC5983 magnetic sensor. It was placed in an indoor environment without external magnetic interference; the sampling interval is set for 30 min, and the magnetic field value data were collected for a month. With the passage of time, the intensity of light also changes in the room. As shown in Fig. 1, for the magnetic field value with time variation, the horizontal axis represents time, and the vertical axis represents the magnetic field value. The data exhibited abnormal increasing or decreasing phenomena many times with an average magnetic field value of 45.6961 μT. But, in those complete one month observation, the variation only account for standard deviation of 0.96. This suggests that the relative magnetic field fluctuations over time and light intensity are only by 0.96 of the average value of local magnetic field and that time and light are not one of the factors affecting the magnetic indoor positioning process.

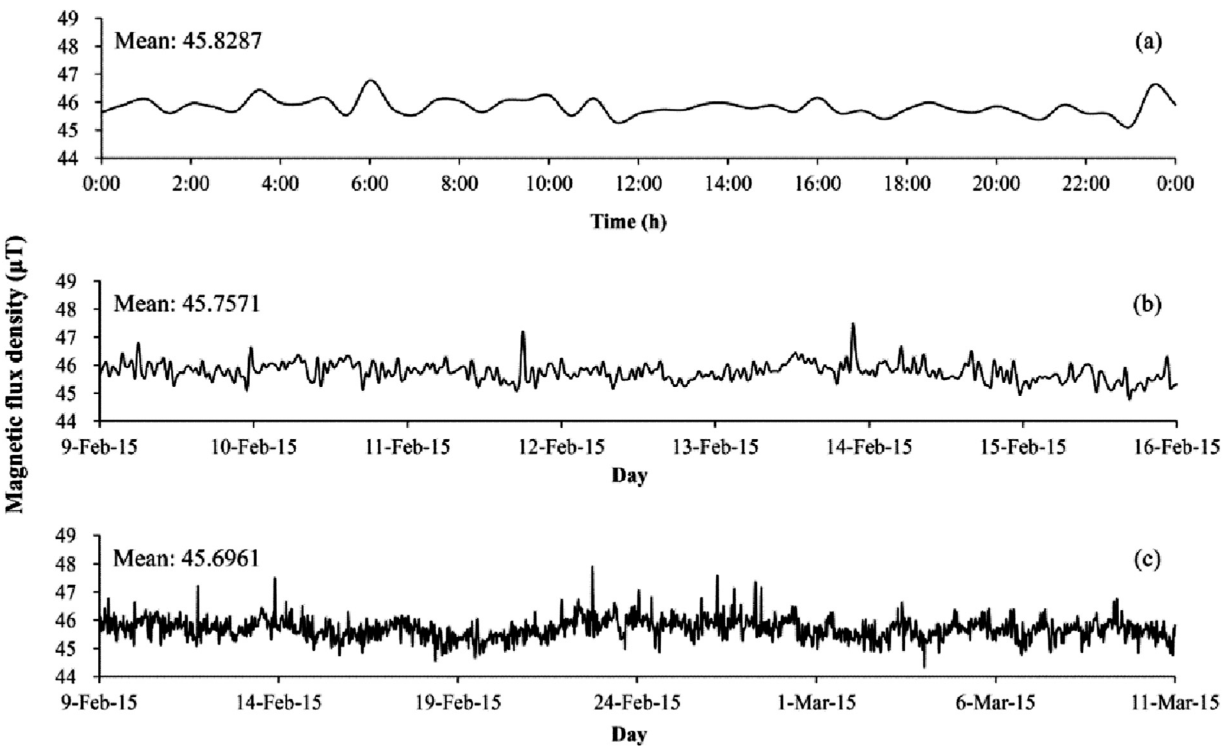

Fig. 1. Magnetic field values change over time: (a) changes over a day; (b) changes over a week; (c) changes over a month.