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Open-Source Indoor Navigation System Adapted to Users with Motor Disabilities

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Abstract

This paper describes the development of a mobile indoor navigation system, supported by a GIS and built using only open source tools. For the sake of simplicity a single building was chosen for the tests converting the floors to digital information from paper plans. The rooms geometry was saved on a proper database with all the adjacent information associated, which can in turn be provided to the clients application by APIs and Web Services. The system is able to calculate the most adequate path between any of the rooms taking into account the user profile which is defined by it's degree of mobility (eg. wheelchair). By reading a QR code placed in key places inside the building the user can obtain, on a mobile phone, his current position and receive orientations to any room that he might want to go. The directions hints are complemented with the presentation of real pictures associated to key locations in the path to validate that the correct path is taken by the user.

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1. Introduction

Location awareness has always been a challenge for mankind. For outdoors and open spaces locations there are already various solutions available, and they are known to work in almost every corner of the world, but the same cannot be said about indoor environments. However, in recent years the interest in indoor location determination has grown with applications in fields like asset tracking, health care, location based services, logistics, shopping, security or tour guides [1][2]. When one thinks about people with some kind of mobility condition, indoor location

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awareness can be very important. They cannot follow paths that are not suited for their condition and sometimes finding an elevator or even a proper bathroom can be very difficult. While there are various systems to estimate a user's position inside a building, there is no standard for indoor localization [3][4]. Since it is application dependable, there is the need to select one that fits certain requirements better and develop the necessary components to achieve the best accuracy and precision possible [5].

The most common methods used in outdoor environments cannot be used within buildings because they use radio signals for the distance estimation which behave quite differently in indoor conditions. There is no line-of-sight between the sender and the receiver that makes the signal travel through reflections inside the building. Thus it is impossible to calculate the distance, and systems like the GPS will not work [6].

Indoor location and tracking systems can be devided in two groups: active and passive. The most common method in the first group is the Wi-Fi radio fingerprinting scheme [7] and systems that use the wireless local area network (WLAN) are the most common [5]. This kind of system requires the user to be in range of several Wi-Fi transmitters, which can be unavailable in some areas of a building and the signal can sometimes be blocked by elements of the infrastructure, like thick walls. It also requires a regular calibration, which can be time consuming and involves new measures when the physical conditions change or there are more people using the network [8]. The RFID technology is also suitable for dense environments but the building needs to have these tags at very frequent intervals, which interfere with the buildings architecture. There are other types of sensors, like Bluetooth, but they require a permanent electronic infrastructure and they are hard to deploy [9].

There are also passive methods, based on inertial sensors and dead reckoning. These methods consists on knowing a precise starting point, calculate travelled distance and measure the heading direction of the user. That can be used to estimate the approximated user position. They have the advantage of being independent from the infrastructure but they get more imprecise overtime [8]. Despite this imprecision there are some successful works that use the magnetometer and accelerometer [10], while others use the gyroscope and accelerometer [7] [11], in order to estimate and update the user position.

In order for the system to be capable of providing routing information a geographic information system (GIS) module is needed. It is a computer system designed to capture, manage, analyze, and display any type of geographically referenced information. This type of software has benefits to almost every kind of industry [12]. That information is derived from data such as floor plans properly organized according with the building infrastructure. These plans must contain data about its rooms, corridors, stairs and elevators, which are the elements used to obtain routing information.

In this paper it is proposed a method to build a mobile indoor navigation system. It was created using a dead reckoning approach that is supported by visual markers distributed along the building and a set of geo-referenced pictures representing key views located in the calculated path. The system is scalable and built using open-source software and can be implemented in any kind of building. A smartphone application to handle the navigation between the buildings rooms or specific point was developed.

The next section of the paper describes the proposed system which includes the indoor maps and paths creation, followed by the description of the Indoor GIS responsible for generating navigation routes. Then it will be described the purpose of the visual markers, the key views supporting the navigation and finally the capabilities of the client app. In the last section some considerations are made concerning the system's state of development and future work.

2. Proposed System

The system is divided in four main modules as the following diagram shows (Fig. 1). These modules will be described in detail next.