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# AccessBIM model of environmental characteristics for vision impaired indoor navigation and way finding

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***Abstract*— Most blind people require assistance to navigate within buildings as there is often insufficient information about the buildings available to them. To address this problem, this paper describes the "AccessBIM" model as an approach to facility management in which a digital representation of the indoor building features is used to facilitate the exchange and interoperability of real-time information in digital format which can assist blind people to independently access unfamiliar building indoor environments. This paper discusses conceptual communication model driven architecture that can be implemented for way finding and data synchronization, generating, in real-time, an AccessBIM for a remote user.**

***Keywords-component;indoor navigation; AccessBMI; Depthmap, IndoorOSM, IAI IFCXML, Building Information Model***

## I. INTRODUCTION

Blindness affects approximately 45 million people worldwide. Because of rapid population growth, this number is expected to double by the year 2020 [1]. As with the sighted population they want to be informed about persons and objects in their environment and object features may be of importance when navigating a path to a given destination. Blind and vision impaired people would wish to exact information about appropriate paths, dangers, distances and critical situations.

While navigation systems for outdoor environments are readily available, navigation within buildings still poses a challenge. The Global Positioning System (GPS), the dominant system offering location information outdoors, suffers a poor indoor performance due to low signal availability, as GPS signals are not designed to penetrate through most construction materials. Many indoor positioning techniques have been developed, most of which rely on fixed references to determine the location of tagged devices [2]. The built environment is a central factor in our daily life and a large proportion of human life is spent inside buildings. Traditionally the buildings are documented using building maps and plans stored in electronic form with tools such as computer-aided design (CAD) applications. Storing the maps in an electronic form is already pervasive but CAD drawings are not adequate for the requirements of effective building models aimed at indoor navigation systems. To reach a higher level of data integrity and utilization potential of building information models, the International Alliance for Interoperability (IAI)[2] has introduced the Industry Foundation Classes (IFC) [2]. OpenBIM [4] describes the database that contains information about IFC compatible applications for the whole range of design and construction disciplines, including architectural, structural, building services, facility management and model viewing. To manage and centralize the construction based on the open standard IFC this research propose to build an Accessible Building Information Model (AccessBIM) to centralise and manage the information of the built environment. Simultaneous localization and mapping (SLAM) [3] is a Bayesian process to concurrently construct a map of an environment and estimate users' current positions. SLAM was originally proposed for unmanned robot tracking in robotic research. It has four major components: a map, observation model, mobility model, and Bayesian model. Although SLAM is an attractive approach for the robotics, there are several shortcomings when applied to human way finding. This research proposes to utilise and extend SLAM to automatically construct and update built environment way finding maps in previously unexplored buildings. The proposed experimental platform utilises a smartphone equipped with basic compass, accelerometer and gyroscopic sensors.

## II. RELATED WORKS

The work is a part of a larger project that is developing an indoor navigation system for vision impaired people using mobile devices such as smart phones and tablets. The following sections describe the literature review and the conceptual model that authors proposed.

Over the past few decades significant research has been dedicated to navigation assistance for the blind or visual impaired persons. Many of these navigation assistances can be categorized into basic obstacle avoidance systems for example like the NavBelt from Shoval et al. [12] that produces a 120-degree wide view ahead from the users current location. This information is translated into a stereophonic acoustical sound that allows the user to notice if a certain direction is blocked. Similar to this approach the Haptica Corporation developed Guido© [7] a robotic walking frame equipped with a sonar sensor. Recent and very promising approaches rely on the usage of robotic assistances like the work from Kulyukin et al.

[17]. Although they work very well in new, unknown indoor environments they still rely on certain provided infrastructure for example RFID tags as well as they are anything else than inconspicuous.

For outdoor navigation several systems have been proposed [8, 9, 11, 14] or are commercially available [16]. Although they share common characteristics with indoor navigation systems, we will not go into further detail regarding these systems, as they often rely on technologies that are not available in indoor environments - for example by using GPS for tracking. The Noppa system [10] also briefly mentions the possibility for usage as indoor navigation system, but unfortunately these capabilities are not further detailed.

Other research also deals with indoor navigation for the blind that is more challenging with respect to orienting a user, because a generic solution for this problem does not yet exist. Sonnenblick [13] evaluated and implemented a large-scale indoor navigation system for blind individuals at the Jerusalem Center for Multi-Handicapped Blind Children. It relies on specially installed infrared beacons for orienting blind users and on a custom-built end-user device. In contrast, the “Chatty Environment” by Coroama [6] is focusing on technology that does not require special hardware, but rather equipment that is already generally available. This system uses standard 802.11 Wi-Fi for positioning and PDAs as end-user devices, which increases the chances for a widespread use. In a later work they even extend this system to special routing algorithms focused to the needs of the blind [15]. However, their system does not really address common problems with Wi-Fi positioning and its rather coarse precision.

## III. APPROCH OVERVIEW

The proposed novel approach aims to develop a real-time communication model driven architecture for way finding and data synchronization, generating, in real-time, an AccessBIM for a remote user. Additionally, this research will aim to propose and develop a real time model of the users environment to assist vision impaired individuals to navigate indoors (such as shopping malls, exhibitions and university environment or unknown environments) using their handheld devices (smart phone).

The proposed focus on the plan to build a model of the floor plan by combining selected aspects of SLAM with a modified or subset of openBIM The proposed AccessBIM model is comprised basic tasks such as Capturing the Building Information, Communicating the end user and building via sensing the environment using mobile devices such as smart phones and tablets and helps in a proper way to provide step by step instructions for impaired person to arrive at the destination. Authors will apply the system to known buildings and use the model to reverse engineer the floor plan, ie we start with the floor plan and use SLAM to confirm it and update the stored information within AccessBIM thus creating a verifiable experimental framework model for environmental characteristics for use in indoor navigation and way finding for vision impaired requires the examination of types of models mentioned below.

### *A. Conseptual model*

Figure 1 illustrates the proposed AccessBIM consisting of sensor input (gyro sensors, accelerometers, proximity sensors, digital compare, light sensors, acoustic sensors and cameras), Gait analysis is used to assess, plan, and treat individuals with conditions affecting their ability to walk. User Interface (easier to use for end users) and filter. In this instance the filter is defined to be a method to pass relevant information from the pre-processed sensor data, for example camera subsystem will pass obstruction information. This model will use a subset of the OpenBIM standard with extensions in XML to build a data structure describing the characteristics of the user environment. (e.g. obstruction, movable obstruction, path, navigation feature).or heads unless they are unavoidable. Different actions should appear differently to people according to their capabilities. For example a space descriptor can be presented visual and/or in voice format and the Intents are filtered according to user capabilities. In the proposed approach, the remote devices that assumed be a Smart phone or tablet. These mobile platforms consist of a software stack including an operating system, middleware and key applications. The mobile platform is especially interesting in the proposed model because the taxonomy of its architectural components can be correlated with navigation tasks and concepts.

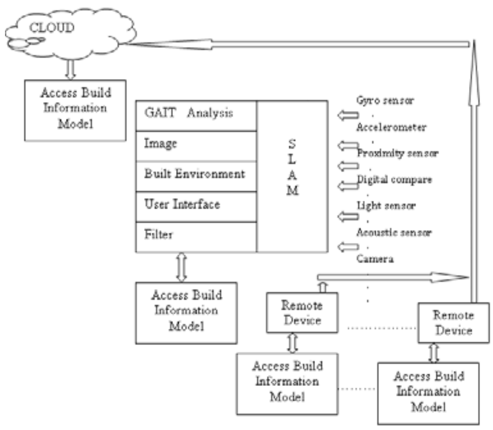


Figure 1. Conceptual Model

### *B. Synchronize the gathered information.*

One major issue is that of multiple users within the same building. Users will be independently constructing “maps” and it would be beneficial if these maps could be shared. However synchronization between multiple users and the “cloud” based storage is problematic. Therefore a robust method of data synchronization and storage needs to be developed. The “cloud” based storage will be available to other users to reduce construction time in building maps. To understand social process within the built environment authors proposed single software such as Depthmap[19] ,open source software such as IndoorOSM [18] for spatial network analysis design.

### *C. Using existing technology and transform it to Accessible Information building model.*

It would be beneficial to develop formal methods to transform SLAM to AccessBIM (figure 2). The technique of SLAM is an important research topic in mobile robotics and it is therefore expected that this area will advance more rapidly than assistive technology will. SLAM addresses the constructing accurate maps in real-time despite imperfect information about the robot's strategy through the environment. Unlike other approaches that assume predetermined land marks. The authors describe a transformation method and the assistive technology applications that may benefit from the more rapid advances in robotics research.

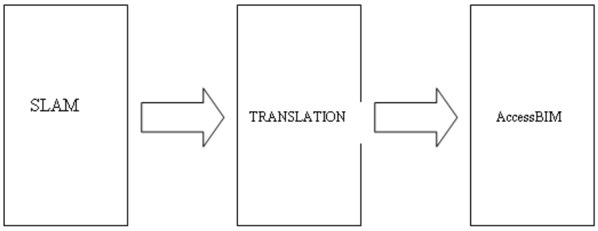


Figure 2. SLAM Transfer to AccessBIM Model

Early research on SLAM has focused on simplistic environment, in which the obstacles can be described by a small number of geometric parameters. Typical examples are trees in a park [20], corners and walls in office rooms [21]. However, mobile robots usually work in complex Environments, in which they do not know the geometric parameters of the obstacle in advance, or the obstacle's shapes, cannot be represented by parameters explicitly. This makes the SLAM algorithm working in complex environments a problem that may be solved through the proposed method. Proposed to use smart phones rather than using robots inside the building. The next problem that should be addressed is the proper way of transfer collected information to AccessBIM . BIM is often associated with Industry Foundation Classes (IFCs) and XML - data structures for representing information. IFCs have been developed by building SMART (the former International Alliance for Interoperability), as a neutral, non-proprietary or open standard for sharing BIM data among different software applications (some proprietary data structures have been developed by CAD vendors incorporating BIM into their software). One of the key enabler of IFC model, apart from its uniform information exchange between AEC applications is the information models that can be extracted from it. These primitive information models convey interesting information about building elements and their relationships. To create the IFC model of building, authors proposed to use the XML serialization of IFC model (IFCXML) and transformed it to the OWL format that conforms to IFC's Semantic Web schema. [2] The IFC schema itself is generated using the express distribution of the latest release of IFC2x3. At runtime the instances that are coming from the specific building information model will be combined with the semantic rules that are inferred from user and impairment knowledge as a set of concepts within a domain.By using above mention technology proposed to implement AccessBIM model to access to get indoor infrastructure details.

## IV. CONCLUTION

In conclusions authors propose possible solutions for blind and vision impaired people, however the discussed architecture can be generalized for other impairments and even for non-impaired people. The proposed solution aims to facilitate the building navigation for visual impaired in sensitive and extendable way that is easy to use by end-users and at the same time easy to maintain and manage by building administrators. In future work, the authors will focus on the implementation of models using the proposed architecture and test it in the real world environments. The proposed AccessBIM model is comprised basic tasks such as Capturing the Building Information, communicating the end user and building via sensing the environment using mobile devices such as smart phones and tablets and helps in a proper way to provide step by step instructions for impaired person to arrive at the destination. Future research will focus on applying the system to known buildings and use the model to reverse engineer the floor plan, ie starting with the floor plan and use SLAM to confirm it and update the stored information within AccessBIM thus creating a verifiable experimental framework and test it in the model in the real world environments.

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