RESEARCH ARTICLE

Modern approach for intelligent database to support urban city accessibility tools for the pedestrian

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Abstract: Travelling through cities is one of the things which people with mobility impairment always have to deal with. A designed dynamic database of Maps for Easy Paths (MEP) project for storing and retrieving accessibility information about a particular path by using PostGIS may enable the public to enjoy the privilege of the technology that alleviates the problem of city accessibility through the Web, or more recently, through smartphones/tablet applications. An application of methods and techniques for designing a dynamic database to store and retrieve accessibility information by using a relational PostGIS is described. The conceptual data model is designed for a database (PostGIS) which provides an optimal description of the user requirements. Users will be able to actively participate in the process of taking pictures of obstacles, uploading them to the MEP server and giving some comments on the attributes of the picture of the barrier. The resulting data will help others to locate and evaluate paths. This paper presents the conceptual data model design as well as a review of features of the data of the existing systems. The paper demonstrates that our data-driven approach can be used to facilitate the planning, design, and implementation of an appropriate application to achieve the MEP goal. Therefore, the novelty of this approach lies in developing the dynamic database for the enrichment of geographical maps with information about the accessibility of urban pedestrian areas for people with mobility problems.

Keywords: city accessibility, dynamic database, path, PostGIS, smart city, users

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1 Introduction

In the recent years, there has been an exponential increase in the number of smartphones or tablets or PCs to the environment as well as for the applications. In today's life, using Information Technology, specifically smartphones or tablets or PCs, has become very important and thus will enable users to have the ability to view and access about the information on the accessibility of paths in a city. Therefore, parallel with the exponential increase in the number of the smartphone or tablet or PC to the environment, there has been a foreseen overgrowing availability of public data that enables a potential use of Geo-located content, low cost and infrastructure-less source of information for urban sensing in Smart Cities. Likewise, having the smartphone or tablet with the citizen sensors and citizen cyber may enable the public to enjoy the privilege of the information technology that alleviates the problem of city accessibility through the Web, or more recently, through smartphones/tablet applications. So people with motor impairments will constantly find the set of data that provides more up-to-dated information about the paths which a target user may choose. The work presented in this paper solves this problem by designing a conceptual data model of updated dynamic database (PostGIS) for Maps for Easy Paths, or simply MEP, on the popularity of the smartphones for navigation.

MEP is an ongoing project aiming at providing a set of tools and innovative solutions for the enrichment of geographic maps with information about the accessibility of urban areas for people with mobility challenges. Due to this factor, the conceptual data model is adopted in most of the database management systems used all over the world. The designed conceptual data model is focused on modeling the reality sidewalk of the point of interest (POI) using modeling constructs that are closer to the user and independent of the model adopted by DBMS. It allows users to access the information about the accessibility of paths for all sorts of points of interests (POIs) such as public toilets, metro, handicapped parking, etc, and helps them to navigate throughout a city while following the ideal route and avoiding all architectonic barriers and obstacles. Moreover, users are able to access the public transport system status through the visualization of the vehicle's position in a specific urban area.

The studies of and report that the independent mobility is an important dimension of quality of life for individuals with mobility impairments such as a user on a wheelchair, or with walking sticks and visually impaired persons [1,2]. These individuals may encounter an array of environmental barriers during their activities of daily living, some of which they may be able to overcome and others they may not be. A study conducted by interviewed 28 adult wheelchair users and found that the barriers frequently reported included narrow aisles, no ramps or steep ramps, bad weather, door handles or door pressure, no curb cuts or blocked cuts, travel surfaces, obstructed travel, etc [3]. On the one hand, showed that Americans with Disability Act (ADA) and Architecture Barriers Act developed specific accessibility guidelines for buildings and facilities that should be applied during the design, construction, and alteration of buildings and facilities [4]. On the other hand, environmental barriers remain to be a problem averting wheelchair users from participation and integration into the community [5]. The study of shows from the review of the prototypes/applications developed for the mapping of city accessibility, there is limited diffusion, lack of involvement of users in the whole design process, and complexity and richness of the requirements that should be faced by the application to satisfy all the users [6]. While such studies report a positive correlation between environmental barriers and people with mobility impairments, there is limited conclusive evidence to support a direct solution and the effects of the environmental barriers specifically to the quality and condition of the sidewalk for people with mobility impairments.

A study in reference shows that many wheelchair users hesitate to visit an unfamiliar place because they have no information about the new environment and the accessibility of its paths [7]. The study provides a basis for people with mobility impairments where they rely on repetitive and regular routes with least obstructions for their daily movement in a predefined area. Unfortunately, relying on repetitive and regular routes constitutes a big disadvantage to the people with mobility challenges who could find the city with the modification of infrastructure on a daily basis going on, and unpredictable weather, which dynamically changes the conditions of the viability of streets, sidewalks and water slides. In this do or die era, navigation software is available for many smartphone devices capable of using GPS sensors for positioning. Therefore, these problems can be anticipated and avoided by the people with mobility challenges by designing a dynamic database which will improve the accessibility of the cities. The MEP dynamic database has content that enables people with mobility challenges to move freely in the urban area without the limitations of barriers such as the roots of trees, potholes, and architectural barriers. The content enables the execution of two main activities. First, the registered user (person with mobility challenges and active citizen) is the main user who can access the information about the accessibility of the paths on their smartphones/tablets/PCs, as well as create, update and delete (CRUD) the comment concerning the path. Likewise, the registered user can also visualize all the provided information, such as the one inserted by another user; the data computed on the server (e.g., the path); and user profile data. The non-registered user can only visualize all information about the accessibility of the paths on their smartphones/tablets/PCs. So far, most of the navigation databases are static and cannot be created, updated and deleted. The designed dynamic database will allow creation, updating, and deletion of information about the accessibility of the paths. Therefore, the designed conceptual data model of a dynamic database provides an opportunity for the user to make an informed decision about the alternative paths. Accessibility maps are acknowledged as efficient tools for people with mobility difficulties when navigating in city areas, in particular, if they are first-time visitors. This report focuses on people with mobility challenges who are capable to move into the urban area.

2 Study Area

2.1 Problem Statement

Most drawbacks of currently available navigation systems are due to inadequate map information which is obtained mainly for car and pedestrian navigation. In their daily lives, people with motor impairments are confronted with many obstacles in the city such that it is almost impossible for them to move around while they are away from the security of their homes. An inalienable right, which also has deep roots in the law of the equality of all citizens, is the possibility to make a choice in freedom and be able to communicate discomfort. In this context, the following aspects are relevant: - the removal of barriers (e.g. in buildings in an urban context) which makes people with motor impairments independent and equal society, with capacity for choice and control over their lives; the ability to know the type of paths (not) eligible, given a specific level of mobility; and the ability to communicate discomfort, send a request, speak, and document a problem. In many contexts elimination of a barrier, when implemented, is permanent, or at least changes very slowly (e.g. access to a building or in a living environment); in others, it is a daily activity, a constant battle dictated by the unpredictability of events (an extreme weather conditions, temporary jobs), degradation and wear and tear, road works, although planned and temporary, make it impossible a course, a lack of attention to people with mobility challenges. These situations change the degree of urban accessibility constantly and unpredictably.

2.2 Objective of the Study

The main objective of the study was to identify the physical features that contribute to the accessibility for people with specific mobility problems in an urban setting.

2.3 User Involvement and User-Centred Design (UCD)

The study was conducted in order to obtain input data that would facilitate coming up with a design of an updated dynamic database. UCD optimizes the design of a dynamic database for MEP app on their experiences of the journey to use the MEP app, rather than forcing the users to change their behaviour to accommodate the tool. Thus, UCD stands between the two concentric circles: the inner circle and the outer circle. The inner circle includes the context of the MEP project, objectives of developing MEP app and the environment in which it would run. The study consisted of two phases, namely: awareness of the problem; and collection of suggestions from respondents.

2.4 Awareness of the Problem

The awareness of an interesting research problem may come from multiple sources including new developments in the industry or reference discipline[8]. It is worth devoting some attention to the activity that precedes the design process itself. The project was preceded by a compilation of the requirements through direct involvement of the project partners and beneficiaries in order to identify the possible scenarios of using the MEP apps. Instruments such as interviews, questionnaires and focused group discussions were used on beneficiaries. The data acquired during this process were found to be of fundamental importance in producing a conceptual data model for MEP project applications, to support the accessibility of paths for people with mobility challenges as well as in the output of designing of the updated dynamic database.

2.5 Collection of Suggestions

The suggestion phase started with a discussion about accessibility problems that people with motor impairments face while traversing the urban area. In addition to that, suggestions consisting of a tentative creative idea on how to solve the research problem were identified. Since it was raining during the week, the respondents talked about how the weather conditions could affect the accessibility of the city. Hence, the two current urban city accessibility tools which used the spatial data were shown to the focus group. Consequently, most of the adopted UCATs were found to be not user-friendly. A good example is two of the reviewed applications, i.e., comunepertutti and mapability (www.mapability.org). (Figure 1) shows the interface of the satellite view of Cremona with green, yellow and red lines that indicate the accessibility of the streets. The list of the description of the accessibility degree of the street displays on the left-hand side when the line is clicked. The green line means accessible, yellow line means partially accessible, and the red line means not accessible.

The Mapability provides the most detailed picture by locating suitable services, roads, car parks and restaurants. Therefore, the user finds the interface not user-friendly since it is very congested with the information. It is difficult to click precisely on a certain icon or line such as the green, yellow and red in Mapability. Disabled people prefer the interface to be user-friendly.

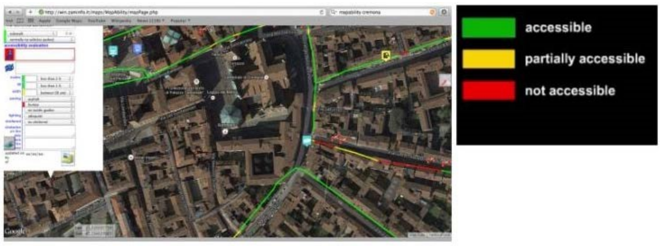

Figure 1. Cremona interface mapability
Source: www.mapability.org

Furthermore, during the focused group discussions, several visual tools were used. A series of images of barriers (holes, poles, trees, etc.), sidewalks (narrow, potholes, bumps, etc.) and pavements (surface neat, cobbles, ramp, etc.) were shown during the first discussion about architectonic obstacles. The results obtained from focused group discussions are qualitative in nature.(Figure 2) illustrates the results of the picture of the barriers taken from a real sidewalk. (Figure 3),(Table 1) and (Table 2) represent the assessing autonomy respondents based on the type of the elements.

Figure 2. Barriers

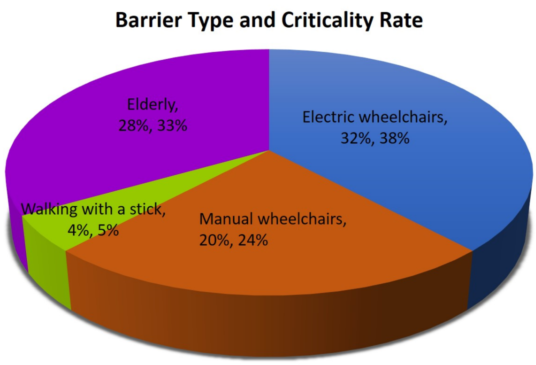

Figure 3. Percentage representation of respondents, barrier type, and criticality, and barrier category (low, medium, high)

Table 1. Sidewalk / Path

Types	Respondent (%)	Roots (3 out of 4, is accessible)	Potholes (2 out of 4, is accessible)	Poles (1 out of 4, is accessible)	UCATs usage is not useful (0 out of 4)
Manual wheelchairs	32	24	16	8	0
Electric wheelchairs	20	25	10	5	0
Walking with a stick	4	3	2	1	0
Elderly	28	21	14	7	0

Table 2. Pavement

Types	Respondent (%)	Surface neat (Accessible	Cobbles (2 out of 3, is	Gravel (1 out of 3, is accessible)	UCATs usage is not useful (0 out of 3)
Manual wheelchairs	32	32	16	8	0
Electric wheelchairs	20	20	10	5	0
Walking with a stick	4	4	2	1	0
Elderly	20	20	14	7	0

Firstly, the sampled users group agreed that UCATs is very useful, although it has to consider all types of users. To consider the effect of surface type and quality of mobility, various comments of experienced users were undertaken to design an updated dynamic database referring to the elements and comments given. From the sampled users group, this study concludes that the UCATs and the information technology or data around the urban area has a positive impact on the society, people with mobility challenges, as well as the entire world.

Secondly, (Figure 4) was intended for comparing the categories of barriers with different obstacles that respondents encounter during their travel around the city. There are four types of users who respond to (Figure 5). In short- there are registered users and non-registered users. In registered users, there are many different categories of users of the MEP tool. All respondents indicated that they found that neat surface was useful for all, i.e. the way was perfectly accessible. With regards to the cobbles and gravels, they indicated that the user had neither difficulties nor preferences related to the accessibility path type of this barrier are accessible of the path with some efforts the kind of that barrier on his/her way. In this case, an alternative path is preferred, but it is not necessary. The barriers are listed in three categories: low, medium and high. Hence the comparison of the differences of the accessibility path between this category as low, medium and high according to the respondents' responses to the questionnaires. Comparing the respondent groups which are the main targeted users of the MEP tool, the possible values for each user preference on how to rate the barrier while providing the information is:

(1)LOW: This value means that the user prefers this type of a path when available. The value is usually related to the barrier and not accessibility facilities. It indicates that the user has

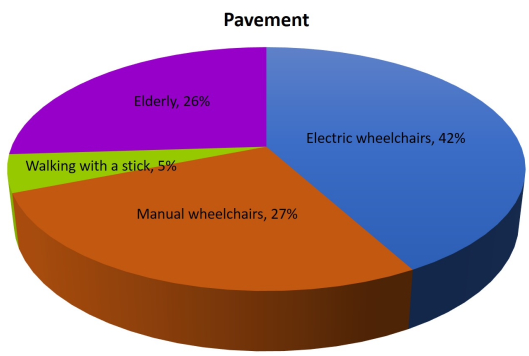

Figure 4. Percentage representation of respondents, pavement, criticality and the categories of barries (low, medium, high)

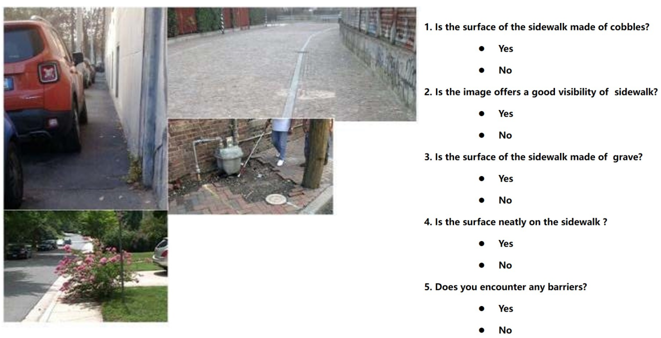

Figure 5. Pavement

neither difficulties nor preferences related to the accessibility and it is totally irrelevant to him/her to meet such a kind of barrier. This means that his/her way was completely accessible.

(2)MEDIUM: This value indicates that the user has neither difficulties nor preferences related to the accessibility of a path type. This barrier is accessible of the path with some efforts the kind of that barrier on his/her way. This value is used when a user faces an accessible path type, but with some efforts. In this case, an alternative path is preferred, but it is not necessary.

(3)HIGH: This value means that the barrier type represents an impossible path to the user.

2.6 User Centred Approach to Conceptual Data Model Design

The conceptual data model for MEP project is very simplified and connections are explained hereafter. The conceptual schema model is configured to interact with two different classes of users: registered and non-registered users. To explain this issue related to MEP dynamically updated the database (PostGIS) modeling and design, the methodology used and looked at the adoption starting from the requirements. The methodology adopted is waterfall model(Figure 6).

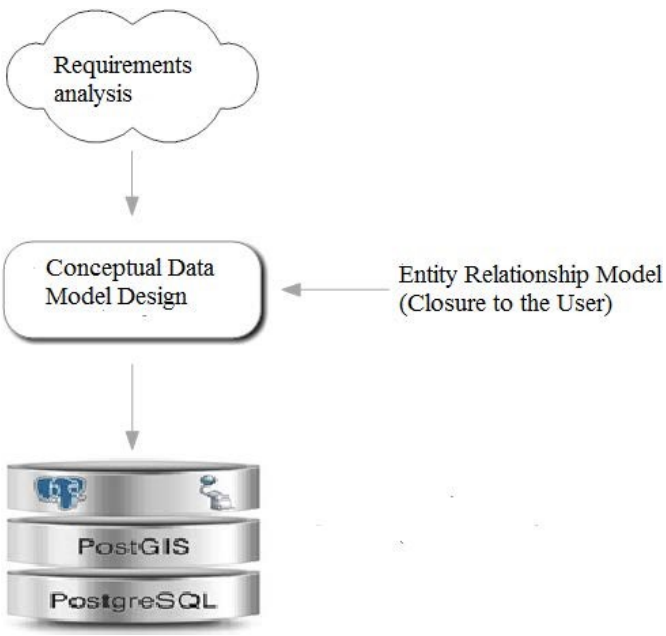

Figure 6. General schema as representation of conceptual data model design

2.7 Waterfall Model Strategy

The waterfall model is a sequential strategy approach to the updated dynamic database (PostGIS) design as the proceeding is seen as flowing steadily downwards (like a waterfall) from the attributes and entities which are found and then moving towards an acceptable conceptual data model through piecing together of associated attributes. In other words, the waterfall model is a sequential strategy approach which is a type of active acquisition of information from a primary source. In this database (PostGIS) design in which the end users were involved, the emphasis was on the active participation by all people with motor impairments, ranging from users with manual or electric wheelchairs, the elderly with or without mechanical support, to people in temporary situations of reduced mobility. Input into a waterfall model was a sequential strategy approach which could be views of data, such as screen shots or reports (printouts), or patterns of co-occurring attribute values identified within large data sets(Figure 7).

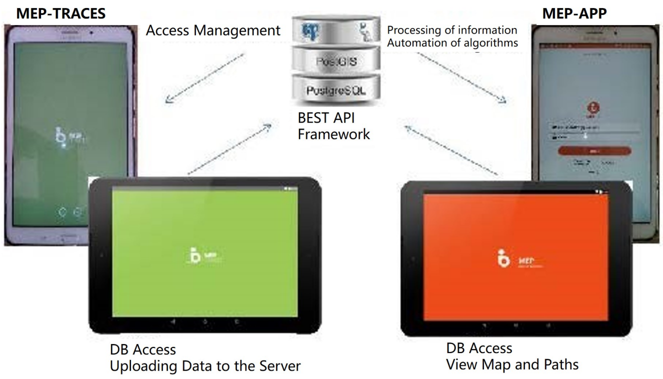

Figure 7. General schema as representation of conceptual data model design

2.8 Obstacle Annotation and Crowdsourcing

In this context, the term "Crowdsourcing" refers to the method and techniques of solving problems through contribution to the enrichment of geographical maps with information about the accessibility of urban pedestrian paths for people with mobility challenges[9]. The study provides a general knowledge of crowdsourcing with a smartphone for allowing users to transparently contribute to complex and novel problem-solving that happens every day. However, it is stated as methods and techniques to solve problems. Crowdsourcing can provide a platform for bi-directional communication and collaboration with diverse individuals and groups, it is registered users or non-registered users to the MEP app. Users actively participate in the process of taking pictures of barriers, uploading them to the dynamic database of the MEP server and adding some comments concerning the attributes of the pictures of the barrier. At the comments' table, there are two attributes, namely a text and criticality rate, based on the conceptual data model that was designed. There are so many advantages of using crowdsourcing, such as the ability to collect information quickly and efficiently, and ease of sharing information about the accessibility difficulties that they encounter in paths in the daily travels. Some disadvantages observed by the research shows that crowd-sourcing can favour the popular opinion, which in turn favours homogeneity. A study by[10] has reported that crowdsourcing can be expensive or unreliable, crowd-sourcing requires no or little expertise from participants and no supervision of participants[11]. Similarly, [12], [13], [14] and [15] report that crowd-sourcing is a powerful mechanism for outsourcing tasks which are traditionally performed by a specialist or small group of experts for a large group of community[12–15]. Furthermore, in the article by Jeff Howe defines crowdsourcing as “the new pool of cheap labor: everyday people using their spare cycles to create content, solve problems, even do corporate R and D”[16]. Later on the author in the article adds that “crowdsourcing is the mechanism by which talent and knowledge is matched to those in need of it”[17]. In addition to that, data about urban accessibility path, in terms of architectonic barriers and general infrastructure, which could be obtained by crowd-sourcing and sensing activities conducted by citizens equipped with mobile devices, could support users with mobility challenges. Whilst these other such studies report a positive correlation of crowd-sourcing for the general user, there is limited conclusive evidence to support users with mobility challenges.

Finally, data can be (and have been) donated to MEP projects, mainly from authoritative data of the Milan city transport such as bus stops and metro stops, parallel to the one from raw GPS data as well as other motion-related sensors data.

3 Conclusions

This paper makes an important contribution to the MEP project by developing a sustainability of data-driven approaches based on crowd-sourcing for the enrichment of public maps with the information about the accessibility of paths.

The MEP dynamic database was developed by basing on the literature review and exploratory field research, signalizing the satisfaction with the current database which most is static also putting less effort in the collection of real users’ requirements, which in many cases is completely absent.

The research results demonstrate that it is possible to produce viable a conceptual data model and apply the database to other contexts. This has been achieved within the data collection by the focused group. The end users were involved in a user-centered approach throughout the project through focused group discussions to observe the behavior. The focused group discussions provided qualitative data that allowed to design the entire dynamic database (PostGIS).

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