EasyWheel - A Mobile Social Navigation and Support System for Wheelchair Users

Christian Menkens, Julian Sussmann, Miriam Al-Ali, Emanuel Breitsameter, Jelena Frtunik, Tobias Nendel, Tobias Schneiderbauer
Technische Universitaet Muenchen
Center for Digital Technology and Management
Munich, Bavaria 80290
menkens@cdtm.de

Abstract—Large cities are built and designed based on the needs of mobile people, architectural preferences and budgets. Unfortunately, this constitutes a big disadvantaged for those with mobility disabilities. Wheelchair users are regularly hindered by barriers from participating in daily life on their own. The research work presented in this paper solves this problem by providing EasyWheel, a mobile social navigation and support system for wheelchair users. EasyWheel allows them to access accessibility information for all sorts of points of interests (POI) such as public transport, shops, etc and helps them navigate throughout a city while following the ideal route and avoiding all barriers and obstacles. To connect EasyWheel with the whole community of wheelchair users and helpers, EasyWheel includes a social community system including reputation and reward features leveraging Facebook. This connection enables EasyWheel to gather currently not available but essential wheelchair accessibility for POIs as well as wheelchair routing information data from all community members using a mobile and/or browser/Facebook based EasyWheel application client.

Index Terms—Context, Android, Location, Community, Mobile, Health, Wheelchair, Navigation.

I. INTRODUCTION AND PROBLEM

In their daily lives wheelchair users are confronted with many obstacles once they leave the security of their homes. Large cities are built and designed based on the needs of mobile people, architectural preferences and budgets. As a consequence city centers are often paved with cobblestone, many subway entrances are only accessible by stairs or escalators and often shops, public facilities or even public toilets can only be reached by stairs. Unfortunately, this constitutes a big disadvantaged for people with mobility disabilities. Wheelchair users are regularly hindered by barriers from participating in daily life on their own. As people without disability are mostly unaware of the impact of these barriers and cities have hardly any recorded data on street and sidewalk pavements, curb boarder heights, sidewalk widths, street inclines, construction sites etc. there is an imperative need to address, locate and reduce barriers in cities.

In addition to that, popular modern navigation systems currently on the market (TomTom [1], Garmin [2], Nokia Maps [3], Google Maps Navigation [4]) do not support any features for wheelchair users and handicapped people. Some of these products just recently enhanced their feature portfolio with pedestrian navigation. Unfortunately non of these enhancements include or support data sets that are able to capture important street condition parameters such as incline, pavement etc. which would all be necessary for efficient and accurate wheelchair and handicapped navigation.

II. GOAL

This research work is aimed at generating a social value and it’s main priority is to support and enable wheelchair users to become more independent. The project increases the mobility of handicapped people so they can navigate throughout a city more independently and safely and thereby increasing their quality of life. To fulfill this, this project needs to define, conceptualize and implement an easy to use system that offers navigation and support features to wheelchair users as well as the wider group of their supporters. Especially to those that work or live with wheelchair users and help them to be better integrated in daily life activities such as accessible restaurant visits or shopping trips. The system needs to allow users to use it anytime and anyplace, thereby relieving them from long prior planning phases at home. By doing so, it needs to give them the feeling of security when traveling in prior unknown areas of the city.

There are still many errors in city planning that can be changed with awareness and public pressure, so the results of this project do not only manage and process accessibility, street condition, barrier etc information but also needs to provide public access to this information for organizations and institutions. So it can help to reduce barriers and obstacles, by giving city planners detailed information they can act upon.

III. CONTRIBUTION

This research work solves the problems and meets the goals mentioned above by conducting an extensive wheelchair user needs study and conceptualizing, designing and implementing a mobile wheelchair navigation and support system called EasyWheel. EasyWheel is specifically tailored for the needs, requirements and features of wheelchair users. It enables wheelchair users to obtain detailed and accurate information about barriers and obstacles in the public infrastructure (e.g. sidewalk pavements, street inclines, shop entrances, public transportation, toilets, parking, ...) and helps the wheelchair
users to avoid them and so to overcome their immobility problems to some extend.

As most of the information about accessible POIs and data relevant for wheelchair routing is not available, data collection, accuracy and actuality is achieved by combining the easy to use mobile clients interface for entering and collecting this information with building an interactive community system leveraging Facebook. As this allows all community members such as wheelchair users, supporters, family, organizations etc. to continuously gather information using both, a mobile and a social community client, the system creates a strong feeling of community affiliation. To foster this further and incentivize users to gather accessibility data for POIs, streets and sidewalks, all users are listed in a reputation, reward and ranking system. As all users of EasyWheel are active producers of necessary information, new possibilities are created that other traditional navigation applications cannot offer.

To be able to test and evaluate our concepts and ideas and to receive more valuable feedback from real-world test with wheelchair users, a system prototype is implemented using the Android mobile phone platform in combination with several reusable online services.

IV. EASY WHEEL USER NEEDS STUDY

To ensure to conceptualize, design and implement the most important features and requirements wheelchair users have for such a mobile navigation and support system, a user need study was conducted prior to developing the concepts and designing / implementing the prototype. The study is divided into two parts; at first it is investigated what user groups exist for the EasyWheel application in order to then, in the second part, analyze the needs and requirements of these different groups. This is done by interviewing a focus group [6] of representatives and letting them interact with paper prototypes and mock-ups according to ISO13407 [7].

A. EasyWheel User Groups

In general, the user base for the EasyWheel application is split into two main groups: first, the disabled wheelchair users that use the mobile application to navigate and collect accessibility information and second, their helpers that can use EasyWheel to support the disabled through collecting valuable accessibility information on the mobile client or by participating in the EasyWheel community.

The group of wheelchair users can be estimated when considering that within the European Union there are estimated 9.3 million wheelchair users, whereof approximately 1.56 million live in Germany - equaling 1.9% of the total population. In Munich the number is considered to be around 25,600 from which are around 12,600 below the age of 65 and the main target group of EasyWheel and this user needs study [5].

This group of wheelchair users can be further divided into three sub groups:

- **Active** - Are very active and athletic wheelchair users that are for example able to do certain sports, are very independent, are able to travel long distances on their own and are able to overcome many obstacles and barriers that wheelchair users from the following two groups can’t. All of the active wheelchair users use manual wheelchairs.
- **Partly Help Dependent** - Are still active but not athletic and their disability does not allow them to do any sport or similar. Traveling through the city without any help is very exhausting for them, so they need help to complete certain daily tasks, to overcome obstacles and barriers and to travel longer distances. This group uses manual or electric wheelchairs.
- **Help Dependent** - Their disability does not allow them to be active or athletic and even short distances are very exhausting for them. They use electric wheelchairs which makes it very difficult to overcome any barriers or obstacles, so they are restricted most when traveling through the city. In general, even for small daily tasks like shopping they depend on help 24/7.

The group of helpers mentioned above can be divided into two sub groups:

- **Family, Voluntary Helpers, Friends** - This group has an intrinsic motivation to help their friends or family members in wheelchairs. They are looking for ways to contribute to ease the wheelchair users burden and to help them to get up to date information about barriers and obstacles as they can avoid them.
- **Organizations, Associations, Social Workers** - Professional organizations to support disabled people as well as facilities like assisted living homes or retirement homes are constantly looking for ways to support their disabled customers as well as their own employees better at regular tasks like for example organized guided wheelchair excursions through the city. These organizations need up to date data about obstacles and barriers to put more pressure on city planners. Only so, they can motivate them to renovate parts of the city, to remove barriers and to include these parameters and needs into future city plans.

In addition to the groups mentioned above, there is another potential group that was not further investigated in the user needs and requirements study; Mothers with buggies and bicyclist. Most features and concepts of EasyWheel could easily be transformed in a support application for them.

B. EasyWheel User Needs and Requirements

For each group mentioned in the previous section several representatives were invited to a focus group [6] interview session. A total group of around 40+ people was interviewed by using regular questionnaires asking about their problems and needs as well as by interacting with paper prototypes and mock-ups [7] of first EasyWheel concepts and ideas. The tables I and II on page 3 present a structured overview of all findings of the user needs study.

The results of the study reflect that the wheelchair users main problems are unannounced road or sidewalk construction
<table>
<thead>
<tr>
<th>Manual vs. Electric</th>
<th>Major Barriers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manual: max incline: 3-8%</td>
<td>Construction Sites</td>
</tr>
<tr>
<td>Manual: max border: 3-5 cm</td>
<td>Narrow doors at Shops and Public Facilities</td>
</tr>
<tr>
<td>Manual: max trip length: 1-5h</td>
<td>No Elevators or No Ramps</td>
</tr>
<tr>
<td>Electric: max incline: 10%</td>
<td>No or Wrong Information about Accessibility of Public Facilities</td>
</tr>
<tr>
<td>Electric: max border: 1-2 cm</td>
<td>Curb Heights and Obstacles</td>
</tr>
<tr>
<td>Electric: max trip length: 2-3h</td>
<td>Street or Sidewalk Pavement and Condition</td>
</tr>
</tbody>
</table>

**TABLE I**

**USER NEEDS STUDY RESULTS - PARAMETERS AND BARRIERS**

<table>
<thead>
<tr>
<th>Paper Prototype and Concept Feedback</th>
<th>Required Environment Information</th>
<th>Required Points of Interests (POI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Interest in Mobile Navigation</td>
<td>Street and Walkway Width, Incline and Curb Heights</td>
<td>Restaurants, Shops, Leisure Facilities</td>
</tr>
<tr>
<td>Highly Usable in Daily Life</td>
<td>Accessibility Information of Public Facilities and all POIs</td>
<td>Disabled Toilets</td>
</tr>
<tr>
<td>Will Enhance Mobility Radius</td>
<td>Accurate Travel Distance and Time</td>
<td>Handicapped Parking</td>
</tr>
<tr>
<td>Large Set of Relevant POIs Needed</td>
<td>Up-to-date Construction Information</td>
<td>Public Transport Information</td>
</tr>
<tr>
<td>Usability is Good</td>
<td>Ramps, Elevators</td>
<td>ATMs</td>
</tr>
<tr>
<td>German Language Needed</td>
<td>Street and Walkway Pavement Details</td>
<td></td>
</tr>
<tr>
<td>Personal User Preferences Needed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Easy Tagging of Barriers and POIs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Good Integration of Facebook</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**TABLE II**

**USER NEEDS STUDY RESULTS - REQUIREMENTS**

sites, variations in street pavement surfaces and smoothness, steep road inclines, curb boarder heights, narrow street or sidewalk widths and holes or gaps in the streets or sidewalks. In addition to that, it has shown that a barrier free path for one wheelchair user is not necessarily useable for another user. While an active wheelchair user can easily overcome low curbs and steep inclines, a help dependent wheelchair user in an electrical wheelchair has no way to overcome them. This was supported by the apparent need for a clear differentiation between manual and electric wheelchairs and a strong personalization in terms of customizable user specific maximums for curb heights, street inclines, door widths and other parameters of the EasyWheel application.

**V. RELATED WORK**

Several wheelchair navigation and support system research projects from Universities and Institutions as well as initiatives from municipals, support organizations or volunteers already exist. They vary heavily in terms of realization and features and span from paper based high resolution and accessibility information enhanced maps to online or mobile route planning and navigation systems. This project evaluated the following projects and initiative and included the results and experiences from them into it’s concepts, design and implementation of EasyWheel.

- **Paper based City Guides** - there are around 160 city guides for disabled people in Germany in paper format, which give information on the accessibility of streets and public buildings, but are still inconvenient to use while moving in a wheelchair and quickly outdated [23].

- **Online Information about Barriers** - Existing online portals informing wheelchair users about barriers such as Sozialforum Tuebingen e.V. [25], Frankfurt Handicap [26], City of Berlin [22] and Database Mobidat [27] have overcome the problem with data actuality by showing online any updated data of barriers within a certain city. Yet they do not offer routing, a mobile function or the possibility to input data [24].

- **Interactive Online City Guides** - Interactive city guides such as "KOMM Muenster" [28] and "Freiburg Stadtplan" [29] do not offer routing, a mobile client or the possibility to input more accessibility data.

- **Research Project BAIM plus** - Barrier free passenger transportation in the Berlin-Brandenburg and Rhein-Main public transport cooperation system. It includes a large set of real time public transport and routing information as well as routing user grouping (e.g. wheelchair users) and an included community feature [30].

- **Trailblazers** - Was created by students from the University Hamburg and is a mobile routing application for disabled people including functions such as geo-tagging and a community. Yet there has been no news about the start-Up since 2007, and the software is not available [31].

- **University Maryland** - Is a routing service based on Openstreetmap [11] and can filter stairs, inclines and sloped curbs. Right now, there is no differentiation between the inclines and curb highs, there are no remark about the width and kind of surface of the street/sidewalk and it is only applicable on the campus of the University of Maryland [32].

- **Navibil from Fraunhofer Institute** - Navibil was developed in cooperation with the Fraunhofer Institute Nuernberg. It allows routing and is applicable on mobile phones. Right now, it is restricted to the inner city of Koblenz with only very limited accessibility data and the software is not available for download [33].
VI. APPLICATION FEATURES

EasyWheel is conceptualized around the three main features Geo-Tagging POIs, Personalized Barrier-Free Routing and Social Community. Geo-Tagging enables users to use their mobile application to add or mark spots, whole streets, sidewalks or certain POIs with descriptive accessibility information and pictures of barriers. Personalized barrier-free routing enables a wheelchair user to navigate throughout a city on a route based on personalized mobility parameters that avoids barriers he/she can’t overcome. The social community connects wheelchair users and supporters worldwide, allows accessibility information gathering and updating and so

A. Geo-Tagging POIs

All stored and updated EasyWheel accessibility information data is based on inputs and experiences of wheelchair users and supporters contributing to the system worldwide.

All users can add/tag POIs (e.g. shops, public transport, toilets, elevators, spots, parts of streets, sidewalks, etc) they encounter or know from experience as well as enhance accessibility information data of existing ones while exploring a city. Geo-Tagging is done by inputting detailed descriptions of the POI including accessibility information and if applicable information and photos of encountered barriers. Data input on the mobile phone can be done either by tagging the POI at the moment of encounter based on geographical position data provided by the mobile device (e.g. GPS, Mobile Phone Network, ...) or by tagging the POI in advance or later by selecting the exact geographical location manually through pointing at a map on the mobile phone screen.

The user is guided through the tagging process step by step as illustrated in figure 1, beginning with the entry of the POI exact location, its category and its accessibility. In addition, optional the user can input more details including pictures or textual descriptions that are then presented as additional information. Once the entered data is uploaded to EasyWheel system, the map is updated and the information is available to all users. All tagged POIs are shown on the map as small icons, depending on their classification, such as stairways, construction sites, wheelchair accessible toilets etc. By selecting a POI on the map, all stored information including accessibility information details, photos etc is shown.

In addition to storing the POI and accessibility data in the EasyWheel system, in order to incentivize users to add and tag many new POIs and enter much accessibility information the Geo-Tagging component triggers actions in the EasyWheel social community component. At the time of tagging, a news feed entry as well as reputation, reward and ranking data is added to or computed in the EasyWheel social community component.

B. Personalized Routing

The personalized routing feature enables wheelchair users to navigate to any destination on a as barrier-free, personalized and optimized as possible route. This navigation is not limited to streets as in common navigation systems, it also includes sidewalks, bicycle lanes and pedestrian ways and is adapted and optimized to the wheelchair users previously defined personal mobility parameters as illustrated in figure 2. Examples are individual maximum curb height that can be overcome, minimal path width, maximum incline, etc.

In order to guarantee high rates of user acceptance personalized routing is designed as simple and user friendly as possible. Once the desired start and destination are defined, the system fully automatically displays the route without requiring any additional input.

While traveling on the calculated route, in case any data was incorrect or an undocumented barrier has been put up, the calculated route can be ranked and additional accessibility information or a new POI can be Geo-Tagged. This allows every users to actively participate to help and warn others. The updated data is immediately provided to all users and all following route calculations will take this information into account. In addition to that, a news feed entry is added to the EasyWheel social community to inform the whole community.

C. Social Community

The EasyWheel social community feature is conceptualized to build a worldwide community and foster a community spirit that enhances the system for everyone. The goal is that users can communicate, exchange ideas and thought but also constantly detect barriers in their environment and provide this information to the EasyWheel system. By doing so, a high data accuracy, quantity and quality can be achieved from which every EasyWheel user profits.

In the social community, all wheelchair users and supporters
VII. ARCHITECTURE CONCEPT

The architecture concept of EasyWheel applies a Model 2 web application architecture that defines a Model View Controller (MVC) [8] concept for web based applications. By applying the MVC architecture to a web and mobile based application, data model details are separated from the presentation, the application logic and processes that use this model. Such separation allows multiple views to share the same model, which makes supporting multiple clients easier to implement, test, and maintain [8]. This is essential for the EasyWheel system since both a mobile as well as a social community application client need to work on the same data model and the system has to be easily extendable with new features, applications and different types of clients in the future.

Figure 3 illustrates the dependencies between the EasyWheel MVC components:

- **Model** - The model represents EasyWheel application specific data and rules that govern access to and updates of this data. Often, the model serves as a software approximation of a real-world process, so simple real-world modeling techniques apply when defining the model. The EasyWheel model stores data and access rules for all EasyWheel specific POIs that are not pulled from the external map service including detailed accessibility information, photos, user comments, etc. The model stores all user related account data as well as wheelchair user personalization parameters and client configuration settings. Further more, it stores calculated routes including comments and ratings, contributors / city ranking information and social community news feed data. As a support function, the model stores all logging and event history information of the EasyWheel system, so every action, event, interaction and task can be tracked.

- **Views** - EasyWheel defines two different types of views, the social community application views and mobile client views. The views access the application specific data of the model, define and specify how this data needs to be presented and render this data on the clients graphical user interfaces (GUI). The views are responsible for maintaining consistency in their presentation when the model changes. This can be achieved by using a push model, where the view registers itself at the model for change notifications to query the model. Or a pull model, where the view is responsible for querying the model regularly to present the most current data. Due to the fact that EasyWheel aims at presenting highly accurate and up-to-date accessibility information, since it uses this information for routing and since accessibility data updates by users are not received periodically, a pull model is not suitable. Such a model would either query the model very often, not receive any data updates for most of the queries and so waste resources or query the model less frequent and miss important accessibility data updates that come in randomly but in a large quantity in short time. Only a push model is able to update the views right at the moment when updated accessibility data is available and so make sure that the system always presents and works with the most accurate and up-to-date data.

In addition to rendering model data, the views present the GUI of the application and initiate user interaction requests (embedding entered data) to the controller of the application.

- **Controller** - The controller translates interactions with the GUI into actions to be performed on the model. The actions performed on the model include activating application logic processes or changing the state / data of the model. Based on the user interactions and the outcome of the actions, the controller responds by updating the current or guiding to an appropriate view. Thus, the controller centralizes functions such as view selection, security, and templating, and applies them consistently across all views. Consequently, a major advantage of this architecture is, when the behavior of these actions needs to change, only a small part of the application needs to be changed: the controller and its helper components [9]. EasyWheel defines two completely different types of clients that require different corresponding actions, processes, permissions and configurations. So two controllers, one for social community clients and one for mobile clients have to be defined. Each of these controllers only implements the application logic and processes that are needed to fulfill all tasks for the client it serves.
VIII. EASY WHEEL COMPONENT ARCHITECTURE

EasyWheel provides two different types of end user clients; a mobile client based on the Android platform as well as a social community application client based on the Facebook platform. The system makes use of four independent web-based services as architecture components illustrated in figure 4.

IX. ARCHITECTURE COMPONENTS

- **OpenStreetMap** - The central component is the integration of the OpenStreetMap (OSM) service. Not only the usage of the existing collaborative freely editable database for geospatial information about POIs, roads and paths are valuable, but also the predefined application programming interface (API) for the manipulation of this data is used by the EasyWheel system. As the OSM database is freely editable EasyWheel can directly communicate with the OpenStreetMap Server and upload newly geo-tagged POIs. When users of EasyWheel contribute to the system by geo-tagging POIs or adding accessibility information about POIs (e.g. places, shops, ...) streets, walkways and paths they are thereby extending the OSM database.

- **Routing** - The Routing service provides the navigation component and utilizes a combination of OSM and EasyWheel model data to calculate and provide wheelchair users with barrier-free routes taking accessibility information into account. The route routing service understands and returns the RouteService XML Scheme defined by the Open Geospatial Consortium [10] and understands additional parameters that determine wheelchair accessibility.

- **Community** - The community service provides and manages the social community component of EasyWheel. It leverages the existing social community network platform Facebook which offers a strong API to hook into it’s community features such as social graph, friends, applications etc. Facebook already has strong base of active wheelchair users which can accelerating the growth and makes the utilization of this social community service seem ideal for EasyWheel.

- **Map** - The map service provides and manages the map based central user interface on the mobile client and displays all information about POIs, paths, streets sidewalks etc. with extended accessibility information. Due to its availability and API support on the targeted prototype platform Android Google Maps was selected as map service provider for the mobile client. On the community service client both Google Maps and OSM could have been used, but due to the use of OSM for geospatial information and accessibility data management OSM was selected.

X. DESIGN

To define the interconnections of the distributed EasyWheel system architecture components the communication and interaction was designed using message sequence diagrams. Figure 5 shows the communication of the EasyWheel mobile client with the different architecture components and respective services behind them. Each interaction of the actor with the system represents one central EasyWheel feature and shows the message flow between the mobile client and the corresponding component / services.

At client startup and when the user drags the map interface, the map service is responsible for the correct delivery of the map tiles. The current concept supports both, Google Maps Service for Android [12] and OpenStreetMap using a free OpenStreetMap tool for the Android environment by the osmdroid project [13].

When the user enters start and destination in order to navigate, the routing service provided by the project Barrierefreie Wegplanung [15] of the Research Group Cartography at the Department of Geography of the University of Bonn [16] is called. The service is based on the A* Algorithm [17] and uses OpenStreetMap data as basis. Depending on accessibility tags and personalized wheelchair user parameters the service returns a route in valid GML based on the XML Scheme RouteService. To process the responses and convert the response in platform specific data structures, parts of the osmeditor for android project [14] are reused.

In order to show point of interests with specific criteria and within a certain view port of the EasyWheel application the OSM XAPI [19] provides the interface to query / request the required data by tags. The XAPI servers that are used for these queries are provided by members of the OpenStreetMap community and are mirrors of the actual OSM dataset. They are updated with a delay which normally does not exceed ten minutes.

When a user updates or adds new accessibility information, the OpenStreetMap REST API Version 0.612 [18] is used. It requires a valid OpenStreetMap account and covers adding and editing of nodes with parameters such as the “wheelchair tag” that can be set to “yes” indicating that the node is wheelchair accessible, as “no” indicating the opposite or as “not set”,

![EasyWheel Component Architecture](image)

Fig. 4. EasyWheel Component Architecture.
Fig. 5. Message Sequence diagram showing the interaction between the application and the services with their lifetime

which represents an unknown status of the wheelchair accessibility.

The EasyWheel mobile client publishes information about newly geo-tagged POIs updated accessibility information and adds comments to the social community using the Facebook community service wrapper library "FBConnectAndroid" [20].

As the existing APIs like Facebook and OpenStreetMap already store a large amount of data, it is important to connect those and to track them. This is done by the Tracking Service. It stores the users Facebook identification, the changes on the OpenStreetMap dataset and a timestamp. This data is used to calculate social community contributors rankings and to set up user statistics.

XI. IMPLEMENTATION

In order to proof all EasyWheel concepts of features, the architecture, the design and evaluate the benefit of the system with wheelchair users in real world situations, a system prototype including a mobile client based on Android and a social community client based on Facebook was implemented.

A. Mobile Application

The central user interface of the mobile phone client, illustrated in figure 6, is based on a map centered at the current geographical position of the users which is determined through the device’s GPS Receiver, the Mobile Phone Network or other means. An overlay of buttons provides access to the EasyWheel features Routing, POIs, Personalization and Geo-Tagging.

B. Social Community Application

For the social community client of EasyWheel four Facebook Markup Language (FBML) user interface pages are designed and implemented. The dynamic features are implemented in PHP and are supported by the official Facebook API PHP wrapper. The Index page and the Forum page are basic pages, enriched with Facebook widgets and some static text. The Ranking page that is illustrated in figure 7, displays the results of the Tracking Service. The Map page that is illustrated in figure 8 shows an OpenStreetMap visualization, implemented with the OpenLayers library [21]. It offers the option to display selected points of interest with a specific wheelchair color coding.

XII. CONCLUSION

This research work investigated the problems wheelchair user currently have when navigating through cities. It conducted structured user needs study and derived required features and concepts for a mobile social navigation and support
system called EasyWheel. The work presented details about feature that are required to solve wheelchair users problems, an architecture concept and design as well as a prototypical proof of concept implementation of the system.

XIII. FUTURE WORK

As follow up project to EasyWheel it is planned to include more personalization parameters and more types of accessibility information data into the prototype and to conduct an extended user needs study using the EasyWheel prototype. Then, from these results, an extended mobile social navigation and support system for wheelchair users including more types of support features will be conceptualized, designed, implemented and hopefully pushed to stable product ready for the German or even European market.

REFERENCES