SMART ACCESSIBILITY 2017

The Second International Conference on Universal Accessibility in the Internet of Things and Smart Environments

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SMART ACCESSIBILITY 2017 Editors

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SMART ACCESSIBILITY 2017

Forward

The Second International Conference on Universal Accessibility in the Internet of Things and Smart Environments (SMART ACCESIBILITY 2017) was held in Nice, France, March 19 - 23, 2017.

There are several similar definitions for universal accessibility, such as design for all, universal design, inclusive design, accessible design, and barrier free design. These and similar approaches are relevant to this conference. The focus will be on methods, tools, techniques and applications for human diversity, social inclusion and equality, enabling all people to have equal opportunities and to participate in the information society.

The accepted papers covered topics such as accessibility by design, digital inclusion, accessibility devices and applications.We believe that the SMART ACCESIBILITY 2017 contributions offered a large panel of solutions to key problems in areas of accessibility.

We take here the opportunity to warmly thank all the members of the SMART ACCESIBILITY 2017 technical program committee as well as the numerous reviewers. The creation of such a broad and high quality conference program would not have been possible without their involvement. We also kindly thank all the authors that dedicated much of their time and efforts to contribute to the SMART ACCESIBILITY 2017. We truly believe that thanks to all these efforts, the final conference program consists of top quality contributions.

This event could also not have been a reality without the support of many individuals, organizations and sponsors. In addition, we also gratefully thank the members of the SMART ACCESIBILITY 2017 organizing committee for their help in handling the logistics and for their work that is making this professional meeting a success.

We hope the SMART ACCESIBILITY 2017 was a successful international forum for the exchange of ideas and results between academia and industry and to promote further progress in the universal acccesibility field.

We also hope that Nice provided a pleasant environment during the conference and everyone saved some time for exploring this beautiful city.

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OpenAPE

A framework for personalised interaction in smart environments

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Abstract—**In this contribution, we describe our preliminary work on openAPE - the open Accessibility and Personalization Extension framework. The main goal of the framework is to transfer platform independent context information from one device to another and infer personalized settings for user interface and device adaptation according to the user's needs. This shall contribute to improved usability and accessibility in smart environments. Two exemplary use cases are described, to illustrate in which contexts the framework can be used.**

Keywords-openAPE; Adaptive User Interfaces;Smart Environments; Eclipse Smart Home; Create@school

I. Introduction

During the last decades, information and communication technology (ICT) has found brought entrance in our everyday lives. This trend is expected to go on for the next years. Thereby, it is not only the amount of electronic devices and services that will increase but also their interdependencies and network capabilities. Overall, we can find more and more setups of smart environments in our surroundings. The field of Smart Environments and its subdomain of Ambient Assisted Living (AAL) have the high potential to support regular users as well as the elderly and people with disabilities in their everyday lives [1].

It is also expected that the way we interact with smart environments will differ from the way we interact with current ICT in the sense that interaction patterns will change from explicit to implicit and more natural ones [2][3].

Considering the huge amount of interconnected devices and new interaction patterns it must be assured that everyone, independent of age, computer skills, cultural background or disability is still able to profit from these developments. One major obstacle might however be inaccessible user interfaces (UI) [1]. Since almost everyone in the society will be affected from that, the users' requirements for accessible UIs might be very heterogeneous and sometimes even contradictory [4]. Therefore, it will be difficult to follow a one-size-fits-all approach and there will appear the need for personalized UIs in smart environments that take the individual user needs and preferences into account. Due to the huge amount of devices that users will face in future smart environments, it will be exhausting to adapt every device by hand to the user's needs. To transfer settings from one device to another is therefore a major step for enabling wide spread usable and accessible UIs. This is in line with the development goals of openAPE – the open Accessibility Personalization Extension [5].

The paper is structured as follows. In Section 2, we describe an illustrative use case and infer requirements for personalization in smart environment scenarios. The consecutive Section 3 will give a brief overview of related, existing systems. In Section 4, we will explain our approach. In Section 5, we will describe two research projects in which our framework is used.

II. Use case and Requirements for personalisation in smart environments

Let us think about a visually impaired businessperson from Germany. In Germany, he is living in his own apartment equipped with different devices like a smart TV, a lighting system and a smart heating system. He has configured his home in a way, that when he switches to TV mode the TV set is switched on and the light is dimmed down. He has also set a preferred room temperature. He can control the status of his home via his smart phone. The smart phone is configured with large font size and strong contrast.

Now, the businessperson has to travel to China. When he arrives in his hotel room, he immediately notices that the air-conditioning system has cooled the room too much. He approaches the control panel at the wall that is connected to the openAPE infrastructure. The businessperson authenticates himself via a RFID tag and the panel connects to the openAPE infrastructure to look up the users preferred settings. Among other information there is stored that the user has configured its smart phone with a larger font size and stronger contrast and that his preferred language is German. Therefore, the control panel reads aloud a short welcome message with some basic explanations. It also increases the font size and contrast and downloads all text labels for the UI in German language. Furthermore, it proposes the user's preferred room temperature.

Some weeks later, a deaf person stays in the same hotel. For him there are no adjustments made with regard to font size and contrast. However, since the person has problems

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with written language, for him the welcome message and all help texts are displayed as sign language videos. With regard to this use case, the following requirements for personalization in smart environments can be deduced:

When looking at different systems from the fields of smart homes, AAL, context aware computing and mobile computing, the following development goals can be identified:

- Interoperability: users will have to cope with different back-end technologies that must be integrated (e.g., in Smart Homes the integration of existing and new devices/systems).
- Device and service overarching use cases: in most cases, users do not want to make use of a single device or service only. Instead, several ones should be integrated to help the user perform a task.
- Adaptive UIs: to provide the best user experience, a UI should adjust to the context of use (user preferences, environmental conditions, technical conditions and the current task). It is also important, that in smart environments the possibilities of traditional GUIs are restricted and adaptivity must be considered from a generic interaction perspective <>.
- Adaptivity independent of controller device and place: in smart environments, users will move around and will interact with different devices. Hence, it is important that user preferences required for adaptation can be shared between devices.
- Openness for third party contributions: for the average UI developer it is difficult to develop user interfaces for people with disabilities, hence the system must enable the injection of expert knowledge [4].

III. RELATED WORK

The Eclipse Smart Home project [6] deals with interoperability problems and device abstraction in Smart Homes. The existing UIs and rule engine enable device overarching use cases and automatization. However, UI personalization can be achieved only to a very low degree by hand[7]. Other frameworks like AllJoyn [8] or OCF [9] provide abstract descriptions of device functions and states that can be accessed by a UI. The device models could be used to auto-generate UIs. However, currently there seem to be no adaptation engines available. Furthermore, the models mainly contain information about data types that shall be displayed in UI elements. Anyway, Mayer at al. [10] claims that this kind of information enables the generation of very simplistic UIs only. The authors argue that not only data types, but also the semantic of the interaction should be modeled. The authors present their own solution accordingly.

Projects like Supple [11] or MyUI [12] have tried to provide adaptive UIs, but relay on application models that do not abstract from devices and backend technologies and are consequently difficult to use in smart environments. The Universal Remote Console (URC) [13] and its runtime implementation the Universal Remote Hub [14] provide abstract device descriptions and a mechanism for exchanging personalized UIs to one or several devices. Furthermore, the URC framework leverages the concept of a resource server to provide specialized UI resources. This enables third party UI contributions like labels in different languages, icon sets, sign language videos, etc., (e.g., from accessibility experts) [15], even at runtime. However, an adaptation engine is missing.

MyUI provides a mechanism for third party contributions. Nevertheless, in the URC framework, specialized UI content can be provided, while in MyUI only a generic interaction pattern for a certain interaction situation can be contributed, but no content.

The Global Public Inclusive Infrastructure [16] provides a mechanism to transfer platform independent user preferences from one device to another, but lacks an adaptation engine.

IV. OPENAPE

When developing the openAPE framework [17][5] the focus was to address the following requirements:

- enable a platform independent mechanism to transfer context of use data from one device to another
- provide adaptation and UI settings information independent of place
- Enable third parties to contribute specialized content
- Provide specialized content independent of place.

Considering these developments, it is clear that there are overlapping with some other technologies, mainly GPII and URC. Nevertheless, there are some important differences. Similar to URC, openAPE implements the concept of a re-source server. However, OpenAPE ships with a context management infrastructure, something that is missing in URC.

GPII also provides a way to exchange context data (mainly user preferences regarding UI settings). OpenAPE differs in this case in the sense that it is not implemented as a monolithic system like GPII; instead, it is a very lightweight RESTFUL web service. It is also further in its API specification. OpenAPE is the reference implementation of ISO/IEC 24752-8 [18]that has already reached the status of a Committee Draft.

A. *Main components*

The openAPE infrastructure shown in Figure 1 is based on the specifications defined in ISO/IEC 24752-8 [18]. The main services are the following:

- Context services that can be used by any device to upload user preferences/settings, equipment, environment and task contexts (context of use) in order to make them globally available.

- Listing service that can be requested to get recommendations for UI settings and adaptations
- Resource service to make additional UI components available
- A feedback service to rate the proposed solution.

B. The related workflow is as follows:

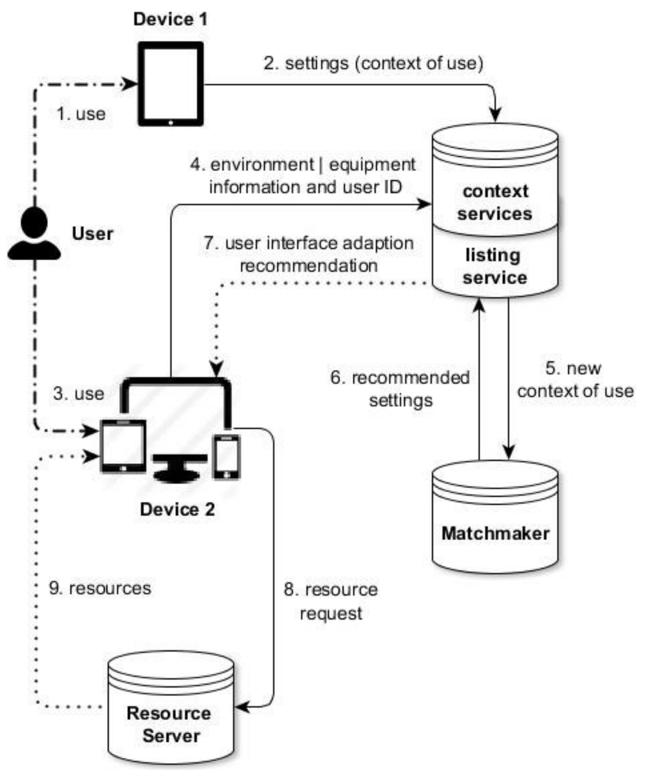

Figure 1: OpenAPE Architecture

1. A user personalizes a device according to his needs (e.g., font size, language etc.).
2. The device creates different context objects that contain the relevant user settings and for which context they were made. These contexts are uploaded to the corresponding context web services.
3. In a next step, the user can approach any other device connected to the openAPE infrastructure and can authenticate himself.
4. After the authentication, this second device uploads the current context conditions (equipment, environment and task context).
5. In a next step, it sends a request message to the listing service in order to obtain information about optimized UI settings and additional UI resources. Thereby it refers to the uploaded context information.
6. The listing service starts a matchmaking mechanism to infer the recommended UI settings and adaptations.
7. The listing service exposes the recommended settings to the client.
8. The client downloads the recommendations and adjusts its UI.
9. If mentioned in the recommendations, the device can download additional UI resources.
10. Optionally, the client gives feedback on the quality of the recommended settings to openAPE.

V. APPLICATIONS

A. Eclipse Smart Home

Smart Homes and AAL yield the high potential to enable a longer independent life for the elderly and people with disabilities. However, as mentioned before, such environments must be adjusted to the users in order to let them exploit the full advantages of these technologies. The Eclipse Smart Home (ESH) is an open source framework addressing not only the field of smart homes but also of AAL. As pointed out in [7] personalization features are currently not very far developed yet. Nevertheless, the ESH framework provides enough connecting factors that enable the establishment of personalization features. Therefore, concepts from the URC framework and a connection between ESH and openAPE will be utilized.

Our goal is to develop a module that is deployed inside the ESH runtime and that connects to the openAPE infrastructure. The module can upload different context data such as devices being connected to the ESH server (equipment context) or environmental data (environment context). These data are than used to either download additional UIs or configuration data and automation rules. Downloading automatization rules goes far beyond personalization of UIs. They enable to personalize the behavior of the whole environment.

B. Creat@School

Playing games is a popular leisure activity for young people, it makes them focusing onto problem, accept challenges and push them further. Also creating games is a very motivating challenge, but creating a game seems to be a difficult task. Therefore, the Pocket Code app was created. It allows students to program small applications easily directly on their smartphone without the requirement for any additional hardware or learning a programming language. Within the context of the “No One Left Behind” (NOLB) project, mobile game-based learning should be integrated into school curricula.

Create@School is an enhanced version of Pocket Code which integrates the results of the pilot studies with teachers and students. One of these extensions is our integration of personalization features in Create@School to use the openAPE framework and to make the app more useable for various user groups. Software programs, mobile apps and websites have a default UI that tries to cater for many people, but that is often unsuitable for people with special needs. Many such programs are adaptable, but onside observations

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has shown that most people never adapt the settings of the software they use. This may be because they think the default settings are all there is, because they are afraid of breaking something or because it is too difficult. Another reason is that devices at schools are not used every lesson by the same student. For this reason, the students can choose a predefined profile in Create@School whenever they want. The chosen profile only influences the Create@School app and not the general device settings.

Therefore, we have provided the profile changing option direct within the Create@School settings menu and have made them selectable by the name of mythological characters to make them more distinctive and attractive for the user.

At the moment Create@School has five profiles (includign the standard profile) to personalize the UI. Individual settings are stored on the device and not in the openAPE framework. Therefore, if a pupil uses another device, his settings are not available on this one and everything must be customized manual again.

For this reason, the next step is to develop GPII enabled featured to provide individual profiles which are stored in the cloud and which are available on every device. All these further individual personalization features will be developed in the openAPE project, which will provide GPII enabled services to auto-adapt the Create@School UI to the user's needs and desires.

VI. CONCLUSION

At this stage, the matchmaking algorithm to infer the settings recommendations is a very simplistic one. In the future, we will work towards a more advanced one. Rule based solutions as well as such that utilize concepts from machine learning can be thought of. Furthermore, we will work on use cases in the field of smart homes and e-learning. Furthermore, the system must be evaluated with regard to different dimensions. First of all, there is the technical dimension. Is the REST infrastructure robust under high load, especially if there are frequent changes of context conditions? Next, it must be evaluated, wheater developers of adaptive applications see a benefit in using a REST API?

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Enhancing Accessibility Information in Google Maps

Adding new pieces of information to GTFS to improve accessibility

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***Abstract*—Google is the most important information provider on Internet. Within the Google ecosystem, Maps is a relevant tool, which is used to calculate routes and to find points of interest. As part of this effort, it has defined Google Transit Feed Specification (GTFS), a format to specify data of public transport. Now public transport agents can provide a "feed" complying with this specification and Google can use them and represent them on Maps. In spite of their relevance for accessibility in mobility, Google Maps does not offer detailed information about accessibility facilities to transit, and GTFS does not specify the necessary structure to provide that information about public transport. In this work, we propose an extension to GTFS to provide relevant data to represent accessibility elements on Google Maps and similar systems to offer different social accessibility services.**

Keywords-Public transport; accessibility; Google Maps; GTFS.

I. INTRODUCTION

Google says "Discover the world with Google Maps. Experience Street View, 3D Mapping, turn-by-turn directions, indoor maps and more across your devices". But, what about accessibility information? On December 2016, the Verge announced that "Google Maps now shows if a location is wheelchair accessible" [1]. The novelty is that Google Maps, an app favored by nearly 70 percent of iPhone users and installed by default in Android, will now list wheelchair accessibility alongside other information, such as traffic and store hours. The new addition makes easier for people with disabilities to use the app; this also applies to other groups, such as parents with strollers and the elderly.

With regard to the accessibility information provided by Maps, even with this addition, it is only including wheelchair accessibility, that is, it just takes into account mobility disabilities or mobility special needs. And what about other disabilities? Is it possible to provide accessibility information to ease the mobility for blind or deaf people? It would be interesting to offer new social accessibility services to help people with different needs. In this way, we feel that it is necessary to express the accessibility information of public transport in a more detailed way, taking into account that this information is even more important to impaired people. In this work, we propose a method to publish such accessibility data for the public transport. This method has been already validated against real data for the subway in the city of Madrid, Spain (METRO Madrid [2]).

Our proposal to specify the accessibility data of public transport is based on the Identification of Fixed Objects in Public Transport (IFOPT [3]) standard, which is an extension of the European Reference Data Model for Public Transport Information (Transmodel [4]) standard. IFOPT defines a model for the main fixed objects related to access to Public Transport, which also includes constructions to describe accessibility data.

The article is structured as follows: Section 2 describes the GTFS. Section 3 describes our proposal, specifying the context of this work, the modification proposal of GTFS and a case study. In Section 4, the conclusions and future work are presented.

II. ACCESSIBILITY IN GOOGLE TRANSIT FEED SPECIFICATION

GTFS [5] is a format for public transportation schedules and associated geographic information. A feed of GTFS is a collection of a maximum of six CSV files, with a .txt extension. Currently, only two of these files include some information about accessibility and special needs: *stops.txt* and *trips.txt*.

With regard to the *stops.txt* file, GTFS defines that "A stop is a location where vehicles stop to pick up or drop off passengers. Stops can be grouped together, such as when there are multiple stops within a single station. This is done by defining one stop for the station, and defining it as a parent for all the stops it contains. Stops may also have zone identifiers, to group them together into zones". The *stops.txt* file includes an optional column named `wheelchair_boarding` to indicate accessibility this kind of information about a stop. GTFS states that "It identifies whether wheelchair boardings are possible from the specified stop or station. The field can have the following values:

0 (or empty): Indicates that there is no accessibility information for the stop.

1: Indicates that at least some vehicles at this stop can be boarded by a rider in a wheelchair.

2: Wheelchair boarding is not possible at this stop".

GTFS also specifies that "When a stop is part of a larger station complex, as indicated by a stop with a `parent_station` value, the stop's `wheelchair_boarding` field has the following additional semantics:

0 (or empty): The stop will inherit its wheelchair_boarding value from the parent station, if specified in the parent.

1: There exists some accessible path from outside the station to the specific stop / platform.

2: There exists no accessible path from outside the station to the specific stop/platform".

With regard to the *trips.txt* file, GTFS defines that "A trip represents a journey taken by a vehicle through stops. So, a single trip represents one journey along a transit line or route". This file includes two columns, both optional, related to accessibility limitations or special needs: `wheelchair_accessible` and `bikes_allowed`. In this work, we only address accessibility aspects and therefore we will not discuss the `bikes_allowed` field. The `wheelchair_accessible` field has the following additional semantics:

0 (or empty): Indicates that there is no accessibility information for the trip.

1: Indicates that the vehicle being used on this particular trip can accommodate at least one rider in a wheelchair.

2: Indicates that no riders in wheelchairs can be accommodated on this trip.

In summary, Google Transit Feed Specification only specifies the accessibility information related to mobility needs, not taking into account other disabilities. For instance, we provide a subset of METRO Madrid real data following GTFS in Figure 1 and Figure 2. Figure 1 is a portion of *stops.txt* file, which contains data of Sol stop place. The first line of the file is the header, the second one shows data about the stop place in Sol (`stop_id = est_4_12`) and its wheelchair accessibility (`wheelchair_boarding = 1`), that is, "at least some vehicles at this stop can be boarded by a rider in a wheelchair". Moreover, as Sol stop place is located in a larger station complex, the file also specifies a `parent_station` value and additional information. For this reason, the following seven lines describe other stops associated to Sol (`parent_station = est_4_12`), and they inherit its `wheelchair_boarding` value from the parent station (`wheelchair_boarding = 0`).

Figure 2 is a portion of *trips.txt* file, which contains the services associated to trips of line 3 (Sol is a stop place in lines 1, 2 and 3). The first row of the file is the header, next rows represent, for each line, the associated service performing the trip. Each line has an associated value for `wheelchair_accessible` (in this case value number 1, that is, there exists some accessible path from outside to the specific stop / platform).

These data have been provided by the Regional Consortium for Public Transports of Madrid (CRTM) [6]. As you can see in previous figures, GTFS only makes possible to express that Sol stop place is not fully accessible. It just states that in Sol stop place "at least some vehicles at this stop can be boarded by a rider in a wheelchair" (motor disability). That is, it is impossible to describe the needs for people with audible or visual disabilities, which intend to travel starting or finishing the trip on Sol stop place.

III. Our Proposal

A. *The Context: CoMobility and Access@City Projects*

This work is being developed in the context of two related research projects: CoMobility and Access@City.

CoMobility [7] defines a multimodal architecture based on linked open data for a sustainable mobility. Its main goals are improving the citizen mobility, optimizing their trips combining public transport and the sharing of private transport (e.g., car sharing), and also providing a means for accessible trips.

Access@City is a coordinated project, which defines a technological framework to process, manage and use open data about public transport with the goal to promote its accessibility. Multiply@City is a subproject within it, which is focused on processing and armonizing accessibility data of public transport in a semantic way, taking into account that data is provided by different sources and will have different formats. Therefore, it is necessary to integrate accessibility data from open data, together with web scraping, and accessible routes, obtained by crowsourcing from the users who use mobile technologies. Figure 3 provides a general depiction of this project.

```
stop_id,stop_code,stop_name,stop_desc,stop_lat,stop_lon,zone_id,stop_url,location_type,parent_station,stop_timezone,wheelchair_boarding
est_4_12,12,SOL,Plaza de la Puerta del Sol 6,40.4168864401114,-3.70316633485051,A,http://www.crtm.es,1,,Europe/Madrid,1
acc_4_12_1034,12,Alcalá,Plaza de la Puerta del Sol 13,40.4170832770092,-3.70286697000651,,http://www.crtm.es,2,est_4_12,,0
acc_4_12_1048,12,RENFE,Plaza de la Puerta del Sol 5,40.4168574567112,-3.70286733093632,,http://www.crtm.es,2,est_4_12,,0
acc_4_12_41,12,Carretas,Plaza de la Puerta del Sol 7,40.4166563378432,-3.70344111780431,,http://www.crtm.es,2,est_4_12,,0
acc_4_12_42,12,Carmen,Plaza de la Puerta del Sol 12,40.417145603815,-3.70320130556473,,http://www.crtm.es,2,est_4_12,,0
acc_4_12_43,12,Mayor,Plaza de la Puerta del Sol 9,40.4167162968701,-3.7044923366942,,http://www.crtm.es,2,est_4_12,,0
acc_4_12_776,12,Ascensor,Plaza de la Puerta del Sol 8,40.4166797644568,-3.70432248486764,,http://www.crtm.es,2,est_4_12,,0
acc_4_12_777,12,Preciados,Calle de Preciados 1,40.4172525245465,-3.70405646302912,,http://www.crtm.es,2,est_4_12,,0
```

Figure 1.GTFS stops.txt file about Sol stop place of METRO Madrid.

```
route_id,service_id,trip_id,trip_headsign,trip_short_name,direction_id,block_id,shape_id,wheelchair_accessible
4__3___,4_I12,4_I12-003_2015I12_1_1_4__3___,MONCLOA,VILLAVERDE ALTO-MONCLOA,0,,4__3____1__IT_1,1
4__3___,4_I12,4_I12-003_2015I12_2_1_4__3___,VILLAVERDE ALTO,MONCLOA-VILLAVERDE ALTO,1,,4__3____2__IT_1,1
4__3___,4_I13,4_I13-003_2015I13_1_1_4__3___,MONCLOA,VILLAVERDE ALTO-MONCLOA,0,,4__3____1__IT_1,1
4__3___,4_I13,4_I13-003_2015I13_2_1_4__3___,VILLAVERDE ALTO,MONCLOA-VILLAVERDE ALTO,1,,4__3____2__IT_1,1
4__3___,4_I14,4_I14-003_2015I14_1_1_4__3___,MONCLOA,VILLAVERDE ALTO-MONCLOA,0,,4__3____1__IT_1,1
4__3___,4_I14,4_I14-003_2015I14_2_1_4__3___,VILLAVERDE ALTO,MONCLOA-VILLAVERDE ALTO,1,,4__3____2__IT_1,1
4__3___,4_I15,4_I15-003_2015I15_1_1_4__3___,MONCLOA,VILLAVERDE ALTO-MONCLOA,0,,4__3____1__IT_1,1
4__3___,4_I15,4_I15-003_2015I15_2_1_4__3___,VILLAVERDE ALTO,MONCLOA-VILLAVERDE ALTO,1,,4__3____2__IT_1,1
```

Figure 2. GTFS trips.txt file: only line 3 (Sol stop place of METRO Madrid included).

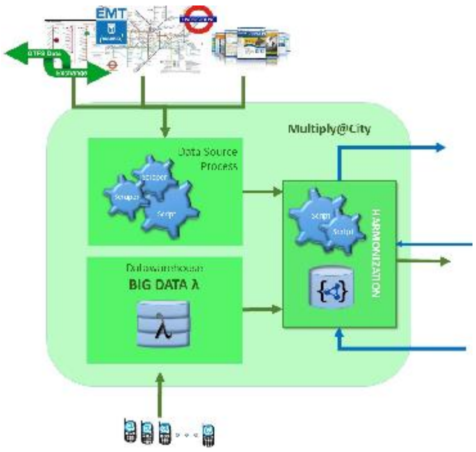

Figure 3. Multiply@City Project architecture.

The Regional Consortium for Public Transports of Madrid (CRTM) [6], the Madrid public bus company (EMT Madrid) [8], the Spanish National Society of Blind People (ONCE) [9], and the Chair of EcoTransport, Technology and Mobility of Rey Juan Carlos University [10] have expressed an interest in our CoMobility and Access@City projects' results.

B. *Proposal of the GTFS Modification*

The intent of our proposal is to improve accessibility information to support new social accessibility services. We have then integrated information relevant to blindness, hearing and mobility impairments and we have included the following pieces of information:

1) Stops.txt file*:* We have added two new colums, which are `blindness_accessing` and `deaf_accessing`. The values of these columns follow the same pattern as the GTFS specification for the mobility disability:

0 (or empty): There is no accessibility information for the stop.

1: Indicates that at least some vehicles at this stop can be boarded by blind (resp. deaf) people.

2: The access for blind or deaf people is not possible at this stop.

Moreover, GTFS specifies: "When a stop is part of a larger station complex, as indicated by a stop with a `parent_station` value, the values of the `blind_accessing` and `deaf_accessing` have the following additional semantics:

0 (or empty): The stop will inherit its value from the parent station `blind_accessing` and `deaf_accessing` fields, if specified in the parent.

1: There exists some accessible path for blind or deaf people from outside the station to the specific stop or platform.

2: There exists no accessible path for blind or deaf people from outside the station to the specific stop/platform.

2) Trips.txt file: We have also added two new colums, which are `blind_accessible` and `deaf_accessible`. The values of these columns follow the same pattern as the GTFS specifaction. The meanings of these values are:

0 (or empty): Indicates that there is no accessibility information for the trip

1: Indicates that the vehicle being used on this particular trip has elements to assist blind or deaf people.

2: Indicates that there are no elements to help blind or deaf people on this trip.

C. *Case Study: Proposed GTFS extension with data of METRO Madrid*

In this subsection we describe the process to represent the accessibility data of METRO Madrid on Google Maps, using our proposed extension.

To realize the case study, it was necessary to use real data of METRO Madrid, namely lines, stations in each line and their accessibility. METRO Madrid specifies the accessibility in two different ways. The first one is on the *stations* web page. There, the user can determine if a station is accessible or not by means of icons (e.g., a wheelchair icon is shown to identify if a station is absolutely accessible, i.e., it has universal accessibility). The second way is on the specific *accessible stations* web page. In that case, METRO Madrid only indicates the accessible stations for each line. There are three different types of accessibility:

- *Universal accessibility* (UA): A stop place with UA indicates that any person should be able to access to the stop place, regardless of potential disabilities.
- *Complementary accessibility measures* without lifts and/or ramps (CAM): A stop place with CAM indicates that there are facilities to simplify the access of blind or deaf people, but the access of mobility impaired people could present issues.
- *Lifts and/or ramps* without complementary accessibility measures (LAR): A stop place with LAR indicates that there are facilities to simplify the access of mobility impaired people, but there are not special resources for blind or deaf people.

As METRO Madrid does not provide the means for downloading these data, we used a scraper to determine which stations are accessible, and their kind of accessibility in every case. This information was stored as a CSV file.

To integrate this information with previous GTFS data in the new structure proposed for GTFS, we have defined the following correspondences (see 0):

TABLE I. CORRESPONDENCES BETWEEN NEW GTFS AND METRO MADRID

GTFS Extension		METRO Madrid Accessibility		
Files	Added fields	UA	CAM	LAR
Stops.txt	`wheelchair_boarding`	1	2	1
	`blind_accessing`	1	1	2
	`deaf_accessing`	1	1	2
Trips.txt	`wheelchair_accessible`	1	2	1
	`blind_accessible`	1	1	2
	`deaf_accessible`	1	1	2

```
stop_code,stop_name,stop_desc,…,parent_station,stop_timezone,wheelchair_boarding, blindness_accessing, deaf_accessing
est_4_12,12,SOL,Plaza de la Puerta del Sol 6,…,,Europe/Madrid,1,1,1
acc_4_12_1034,12,Alcalá,Plaza de la Puerta del Sol 13,…,est_4_12,,0,0,0
acc_4_12_1048,12,RENFE,Plaza de la Puerta del Sol 5,…,est_4_12,,0,0,0
acc_4_12_41,12,Carretas,Plaza de la Puerta del Sol 7,…,est_4_12,,0,0,0
acc_4_12_42,12,Carmen,Plaza de la Puerta del Sol 12,…,est_4_12,,0,0,0
acc_4_12_43,12,Mayor,Plaza de la Puerta del Sol 9,…,est_4_12,,0,0,0
acc_4_12_776,12,Ascensor,Plaza de la Puerta del Sol 8,…,est_4_12,,0,0,0
acc_4_12_777,12,Preciados,Calle de Preciados 1,…,est_4_12,,0,0,0
```

Figure 4. New GTFS stops.txt file, including improved accessibility information in the Sol stop place

Following these specifications, we added these new attribute values to GTFS *stops.txt* file and *trips.txt* files. Figure 4 shows the *stops.txt* file with the values concerning the accessibility in the Sol stop place. We have omitted some fields in the central part of every row with the purpose of highlighting the additional accessibility fields added, which are also emphasized. This new accessibility information could be represented in Google Maps. In Figure 5 we mark the accessibility by means of colours in the Sol area:

Figure 5. Adding detailed accessibility in Google Maps.

The key box points to the Sol stop place. It is annotated with three colours: this is done to highlight that universal accessibility also includes lifts or/and ramps (LAR) and complementary measures of accessibility (CAM). However, when a stop place is only marked with dark blue colour, it has only ramps or/and lifts to access. When a stop place is only marked with green colour, it has only complementary measures of accessibility.

IV. CONCLUSION AND FUTURE WORK

Google Maps is probably the most widely used service for mobility. But currently it does not show the accessibility elements available in public transport. To represent the public transport information on the map and to calculate routes, Google uses the "feeds" (specified in GTFS) provided by transport companies. Due to the relevance of accessibility in mobility, we think it is necessary to calculate accessible routes, and to represent accessibility on Maps. In this work, we have extended the GTFS specification to support new social accessibility services.

This extension consists of adding relevant fields in the *stops.txt* and *trips.txt* files. To prove the validity of this extension, we have used real data of METRO Madrid. After obtaining them, we have identified the accessibility correspondences between GTFS and METRO Madrid data, and we added these new values to the *stops.txt* and *trips.txt* files. Next, we have represented them on the map: if a station has universal accessibility, complementary measures (for blind and deaf people) or only lifts or/and ramps (for mobility impairments).

For future work, we intend to provide fully accessible routes (from a stop to other) using these accessibility data.

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The Clinical Potential of a Cognitive Training Program Embedded in an Adaptive Video Game

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***Abstract*—Cognitive training programs commonly involve single game features, but they are rarely embedded in a complete, adaptive video game where the player can experience *game-flow*. The aim of this paper is to present a video game designed to train users' cognition across five key domains and to describe its potential. The training program is calibrated based on the individual scores obtained in a self-administered, online assessment targeting attention, working memory, episodic memory, executive function, and processing speed, which is automatically linked to the video game software, adapting itself to the player's progress. Structural features in the game contribute to creating an engaging experience for the users. Successful examples of implementation of the program have been tested in diverse settings, including educational programs and clinical trials. Improvements in cognitive function and transfer effects in academic and everyday life skills and behavior have been demonstrated and show promise for further analyses. The adaptive mechanisms and the game-like structure of the presented training program make it a potentially valuable starting point for further research on innovative cognitive programs.**

Keywords-Cognitive assessment & training; gamification; adaptive video games; performance improvements.

I. INTRODUCTION

Computer-based solutions for cognitive training are becoming progressively more popular in the commercial, clinical, educational, and business sectors. Most of these solutions have introduced elements of *gamification* [1], including feedback, an achievement level structure, competitions, and time pressure. However, only a few of these show a true involvement of the player, typically observed in the most sophisticated of video games, which can produce a *game-flow* experience. Flow may be defined as the complete absorption in an activity in which a person is involved [2]. In the case of gaming, the flow primarily depends on how much the game itself is adaptive, i.e., how much it can modify itself according to the user's progress to be sufficiently challenging. Other factors producing the flow experience may be a representation of the self inside within the game, a 3D environment, a narrative context, or a music background [3].

Traditional brain-training programs may be considered as a separate category compared to the video games, as they do not completely incorporate such game features, stopping at a puzzle level [4]. Most traditional cognitive games only introduce single game features, such as progress bars, level structure, and feedback, without producing an actual video game, even if some exceptions have been identified [5].

However, the cognitive programs following this type of approach do not embed an assessment tool to monitor the progress in cognition and to set in the game a level of play adapting to the user's cognitive level.

The aim of this paper is to present a novel approach which attempts to overcome these limitations by proposing an online, self-administered software tool, integrating both an assessment and a training program, where the training is embedded in an engaging video game, MyCognition AquaSnap.

In Section 2, the MyCognition software, integrating a cognitive assessment and a training video game is introduced and game elements are described. The structure of the training game will then be described more in more detail in Section 3. Some examples of successful adoption of the MyCognition programs are presented in Section 4, underlining the training conditions necessary to gain performance improvements. In Section 5 some considerations about future perspectives will be appraised and future directions will be outlined in Section 6.

II. THE MYCOGNITION PROGRAM

AquaSnap is a scientifically designed, cognitive training video game developed to improve cognitive function, targeting five key cognitive domains — attention, working memory, episodic memory, executive function, and processing speed [10].

To produce personalized training for every user, the amount of training for each cognitive domain is calibrated on the individual scores obtained in a cognitive assessment integrated into the system, the MyCognitive Quotient (MyCQ) assessment. MyCQ comprises a digital version of the most validated psychometric tests widely used over almost 200 years of neuropsychological research in their original, traditional, paper-and-pencil versions. In contrast, MyCQ is an online, self-administered assessment, whose final scores for each cognitive domain are automatically generated by the software system and feed the game engine. In this system, the lower a player's score in a particular cognitive domain, the more intense the training will be for that domain.

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The game has an aquatic theme in which players must venture into the ocean to undertake various activities. The activities include exploring rich underwater worlds populated with a range of fish and sea creatures, seeking out and photographing different types of fish, each with their own characteristics. The photos are placed for sale on the open market, to build wealth and reputation for the player. Finances must be mastered, as currency is spent to push further into the ocean to see the rarest and most elusive of fish.

The game is built from the player's self-perspective, which is represented in the ship moving across the ocean chart and in the camera's lens in the underwater environment. The ocean chart itself embeds a narrative aspect in the game, as it tracks the players' progress history and can be explored backward and forward. The evocative names of each oceanic area contribute to make the environment the scenario of a narration.

Moving from the 2D environment of the map to the underwater zone, the player can experience a 3D environment with the illusion of moving through the water and encountering different objects and animals as a part of each training task. The music in the background also contributes to creating a flow experience, facilitating the player's concentration during the training and ultimately advancing to produce a longer-term effect on behavior, as suggested in studies involving children with behavioral difficulties [7].

III. The Structure of AquaSnap

The training works by encouraging the player to undertake repetitive, and increasingly more challenging, tasks that are embedded in the video game. The tasks are designed to train a specific cognitive domain.

Each cognitive domain is mainly trained by a specific loop, with some domains trained using several tasks. The game develops on different structural levels. At the basic structural level, there are the loops which correspond to the five first tasks in Table 1. The loops are organized in dives, so that in each different dive the user can experience a set of loops.

The ocean map represents a meta-level of cognition. At the map level, users must organize their dive to both achieve the proposed mission and to discover new areas.

The progress of the players on the map, and consequently the growth of difficulty in the training game, depend on the coins the players can collect during their dives. In this way, the game adapts its difficulty to the level of improvement reached by the player.

The intensity of the training depends on the individual MyCQ scores, too, as mentioned above, as the number of loops for each type of task that the user experiences depends on the score obtained in each cognitive domain. In this way, more impaired domains will receive more intensive training.

TABLE I. INDIVIDUAL TASKS IN AQUASNAP AND TRAINED DOMAINS

Task	**Task Description**		
	Name	***Activity***	***Cognitive Domain***
1	Memory Shot	Remember the position of the glowing fish in the loop.	Working Memory
2	Quick Shot	Snap the fish as soon as you see it.	Processing Speed & Attention
3	Careful Quick Shot	Snap the fish as soon as you see it, but be careful not to snap the shocking fish.	Attention & Executive Function
4	Group Shot	Snap the group of fish when all together.	Attention & Processing Speed
5	Fish Tracker	Remember which fish are glowing after they change position.	Working Memory
6	Oceanic Survey	Remember which fish you have seen at the end of the dive.	Episodic Memory
7	Missions & Map Exploration	Achieve the goals proposed by the daily missions and try to discover new areas on the ocean map.	Executive Function

In the following section, further details about the amount of time the users play the training game and in-game adaptive mechanisms will be introduced, as these relate to real-world implementations of the program.

IV. MyCognition Program Implementation Studies

Considerable evidence has been produced in randomized controlled trials (RCT) in clinical and school settings and in individual and group case-studies in school and home settings, as described in the following paragraphs. These have shown the effectiveness of the described training video game in improving players' cognition and related performance for different categories of users. MyCognition generally recommends following the training program by playing the cognitive game at least 90 minutes per week, at least three times each week for eight/twelve weeks, and taking the MyCQ assessment at the baseline, in the middle, and after the conclusion of the program. The game itself keeps track of the diving time and displays it to the player. Also, the game proposes among the daily missions the task of playing at least 15 minutes in order to get 3 coins. As the coins are an essential tool to progress in exploring the oceanic map, players not complying with the recommended time adaptively have a slowed progress through training levels, which corresponds to their slowed cognitive improvement.

Users following the recommended program are usually able to get at least a 10 points increase in their MyCQ score on a scale going from 1 to 100, corresponding to a 20% increase for the average population, having a baseline score of 50 points.

The first clinical evidence came from two studies involving a psychiatric population affected by schizophrenia, schizoaffective disorder, obsessive-compulsive disorder, and major depressive disorder. Significant improvements in episodic memory were shown in the group of patients playing the cognitive game in addition to the usual treatment [15].

Outcomes are currently being measured across all the key cognitive domains in a Parkinson's disease population with mild cognitive impairment [18].

Several other clinical trials are ongoing, investigating the usefulness and usability of the cognitive video games in populations with neurodegenerative and psychiatric disorders and in other conditions, including cancer.

Evidence of the effectiveness of the training program and the attractiveness of the video game have been studied also in various education scenarios, involving mainstream and special educational needs students. In addition to improvement in cognition, students of different ages also showed advances in their learning skills, in academic achievements, and in class behavior [11][12][17].

Current studies are still investigating the usability of the programs in other contexts, such as social and health services and corporate wellbeing, showing preliminary promising outcomes [16].

V. Future Perspectives

Once the potential and the effectiveness of the training program presented has been shown in different settings, a further step in the development work would be to export the basic structure of the game and its different cognitive tasks t other analogous video games with different environments which can embed the training program itself.

Also, further research can be done in order to develop more sophisticated features to enhance players' engagement and the game's user-adaption, together with more sensitive assessment tasks and training loops.

Evaluations of similar and comparable studies can also be deepened, as well as analogous counterparts in the fields of serious games and exergames.

VI. Conclusion

Even if the work presented has limitations due to its "in progress" state, some innovative points have been identified and early evidence of the potential of the program has been shown. Future research can lead to the development of more sophisticated game features that are able to produce a more totally engaging game-flow experience in different categories of players, from the youngest children to the elderly population.

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Experimental Study on User Acceptance and Affordability of Intelligent Wheelchair

- Questionnaires on Human Machine Interface-

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Abstract—**We proposed the use of an intelligent wheelchair for new mobility for not only elderly people but also everyone. Our intelligent wheelchair has autonomous function and new gesture interface. For the introduction of the proposed intelligent wheelchair, there are several challenges associated with the use of the wheelchair. One of the most important points is the user acceptance, and it must be investigated with a plenty of subjects by experiments. In addition, the affordability is also important for the introduction. The two points were investigated by performing the several experiments with subjects. In the experiments, we did a questionnaire about the intelligent wheelchair. In this paper, we introduce experiments and the questionnaire results, and the results are compared and discussed in this paper. The questionnaire results proved that most subjects had the favorable opinions about autonomous function and new gesture interfaces. On the other hand, the challenging issues for improving the user acceptance of intelligent wheelchair were also found especially for the gesture interface. These results must be valuable for developers and researchers of new wheelchairs.**

Keywords- Intelligent Wheelchair; Elderly People; User Acceptance; Human Machine Interface; Pilito Study.

I. INTRODUCTION

The rapid increase in the proportion of elderly people in the population has caused several issues in Japan [1]. Thanks to the advancing science and inherent adaptability of humankind to though life conditions, there has been an increase not only in the average life expectancy, but also the population of aged and disabled people that in the need of mobility aid. The current figures report that nearly 15% of the population, corresponding to one billion in the world, are with some form of disability or impairment [2]. Besides that, according to the studies [3][4] the household rate of the people using wheelchair only in the USA, doubled from 1.5% to 3% from 1990 to 2010 and the majority of the wheelchair users are elderly. Useful, affordable and safe wheelchair is expected for elderly and disabled people [5-7].

We proposed an intelligent wheelchair to solve mobility issues [8-12]. The proposed wheelchair has two new features. One is an autonomous function, and the other is a new interface. With the autonomous function the rider in the wheelchair is not required to control the chair by a joystick, which is a conventional controller for a wheelchair. However, there are several challenges associated with the use of an autonomous system, the most difficult being cost. Several expensive sensors are necessary for a wheelchair to achieve complete autonomous functionality. These sensors increase the cost of an intelligent wheelchair, making it difficult for elderly people to purchase an intelligent wheelchair. With respect to new interface, as wheelchairs are smarter and more intelligent, a conventional joystick controller cannot be suitable. Also, people usually would like to use a new interface, and elderly people would like to use cool interface, because they want to look younger than they are. Seeing that the gestures as a one-way process from mind to body; how can gestures be used in creating user interfaces remains an open research question. A few numbers of studies discuss the usability and acceptance of gestural interfaces by the different age groups while touching the fact that design of intuitive gestures must be separately handled.

Preliminary experiments were performed with the proposed wheelchair, and we proved that there was a possibility to use the proposed wheelchair by performing experiments. It is important to evaluate user acceptance, and affordability with real subjects, and to get feedback from the real users

In this paper, the performed experiments with the proposed intelligent wheelchair and questionnaire results will be introduced, and user acceptance will be evaluated with questionnaire result.

Herein, in Section 2, the Tsukuba Designated Zone, where the real-world experiment was conducted, is described. In Section 3, we explain the proposed intelligent wheelchair. In Section 4, the experiments and the questionnaire result of real-world experiments with the proposed intelligent wheelchair used by several subjects are explained.

II. TSUKUBA DESIGNATED ZONE FOR EXPERIMENTS

This section describes the Tsukuba Designated Zone, where the experiment was performed. This institution was formed to improve robotics technology. It was officially approved as the Tsukuba Designated Zone by the Cabinet Office in Japan on January 29th, 2010 [13].

The Designated Zone has two areas for conducting experiments. One is the Tsukuba Center Station area, and the other is the Kenkyugakuen Station area, shown in Fig.1. The Tsukuba Center Station area consists mainly of a pedestrian road from the University of Tsukuba to Akatsuka Park, with a major focus on Tsukuba Central Station. The width of this road is greater than three meter and is sufficient to allow use by bicycles. For these reasons, this public area is appropriate for experimental research. Even within the Tsukuba Designated Zone, there are some regulations that apply to conducting experiments. The committee of Tsukuba Designated Zone is applying relaxations of regulations for the experiments. We performed experiments on automated function in Tsukuba Center Area and Kenkyugakuen Area, and experiments on gesture interface.

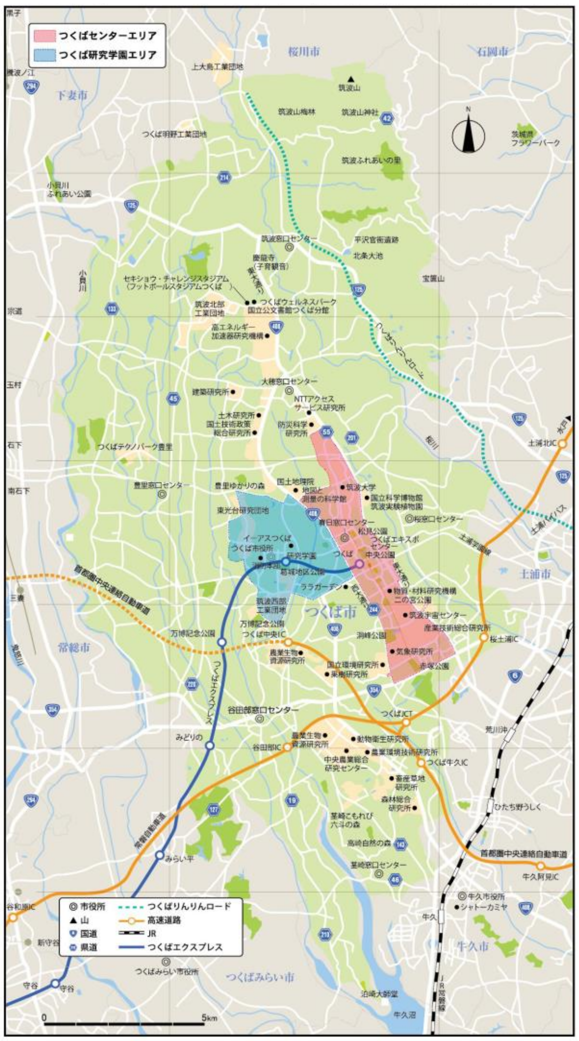

Figure 1. Tsukuba Designated Zone (Red: Tsukuba center area, Blue: Kenkyugakuen area) [13]

III. DEVELOPPED INTELLIGENT WHEELCHAIR

The intelligent wheelchair used in the experiment have been developed at the National Institute of Advanced Industrial Science and Technology (AIST). This wheelchair was modified from the wheelchair produced by AISIN SEIKI Corporation, shown in Fig.2. Figure 3 shows the system configuration of this wheelchair. It can be controlled by an on-board PC through an electrical signal. This wheelchair can move at 6 [km/h]; hence, the maximum velocity was set to 4 [km/h] during the experiments. This wheelchair can be used for traveling for about 2 hours without charging. The wheelchair has one Real Time Kinematic (RTK)-GPS sensor, one laser scanner sensor (LSS), one gyro sensor, two encoder sensors for counting left and right wheel speeds, a laptop PC, and an onboard PC. This wheelchair has two modes, one is autonomous mode and the other is a gesture interface mode.

In the autonomous mode, the system enables the intelligent wheelchair to travel autonomously with accurate positions estimated by the Kalman Filter and desired path[8][11][14]. In this mode, the rider doesn't need to do anything on controlling. This autonomous function was already developed and has enough level to do experiments outside and indoor environments.

Figure 2 Intelligent wheelchair

In the gesture interface mode, functions of obstacle avoidance and autonomous navigation were not used during the experiments. A gesture based interface is implemented by adding a Leap Motion camera to the wheelchair under the arm support, shown in Fig.4. Gesture interface needs the gesture recognition algorithm, which can estimate which rider's gesture is. This algorithm was already proposed [9][10] by referring to the presented theory[16-20]. There are four patterns of gestures, which were defined for the wheel chair control. These gestures are "Go Straight", "Turn Left", "Turn Right" and "Stop" hand gestures, shown in Fig.5. The gesture recognition algorithm recognizes both the hand gestures and postures with an overwhelming accuracy. Along with the gesture recognition system, a function of the Leap Motion development kit is used to recognize fingers touching and hand fist actions to add extra caution to the stop gesture. The system halts using three stop conditions as the experiments were conducted in a public area in Tsukuba. The wheelchair comes to stop in three conditions for either of finger touches, hand fist or hand is not seen in the sight volume of the camera. It was confirmed that the algorithm can correspond to everyone including elderly people [12]. Thus, it has enough robust and high accuracy to perform experiments in indoor and outdoor environments.

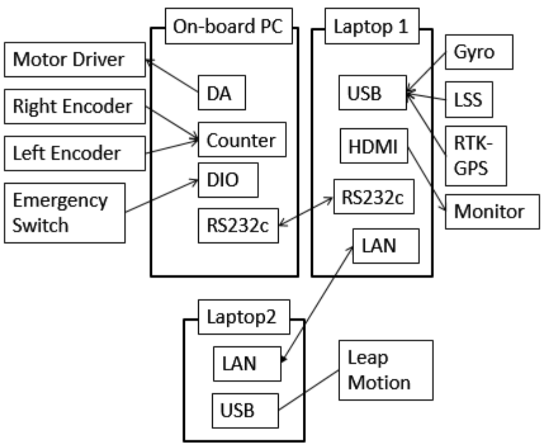

Figure 3 System Configuration

Figure 4 Gesture Sensor

Figure 5 Gesture Pattern

IV. Experiments with Intelligent Wheelchair

We conducted an operational evaluation through real-world experiments and introduced some of the experimental results the previous papers [10][11][14]. In this section, two conducted scenarios are described with the proposed intelligent wheelchair. The experimental conditions, the questionnaires provided, and the experimental results, as well as an overall discussion are explained. In addition to previous results, discussion based on experimental and questionnaire results, which were not presented in the previous papers, will be done in the next section. Experimental places used in this study were located in the Tsukuba Designated Zone in Japan, which is described in Section 2. Before conducting the experiments, we applied a risk assessment of riding the intelligent wheelchair for every route. Each of the two scenarios is described in the following sub-sections.

A. Experiments for autonomous wheelchair

59 subjects who are not disable people were employed for these experiments. We asked the subjects to ride the intelligent wheelchair with automated function. The experimental duration was set to 20 minutes for each subject. After the experiments, several questionnaires about the intelligent wheelchair were done.

1) Provided Questionnaire

Before participating in the experiment, the subjects answered same questionnaire about gender and age.

After experiments, the questionnaires, which all subjects answered are as follows:

- Q1. Did you feel any near miss events during the riding? (If yes, please explain in detail. If no, please imagine near miss event with the intelligent wheelchair)
- Q2. What distance do you think is appropriate between the wheelchair and surroundings?
- Q3. How much do you want to pay for this autonomous function?
- Q4. How do you feel about the stability on a scale of one to ten? (10 is best)
- Q5. How do you feel about the fun on a scale of one to ten? (10 is best)
- Q6. How do you feel about the comfortability on a scale of one to ten? (10 is best)
- Q7. When these intelligent wheelchairs are available in a supermarket or shopping center, do you think do they encourage you to go there?
- Q8. If you have any comments regarding these experiments, please let us know.

2) Questionnaire Result

In question1 (Q1), about 20 % subjects answered “yes”, and comments about the event are as follows:

- The wheelchair traveled very close to pedestrian
- The wheelchair suddenly stopped for the obstacle
- He unintentionally touched joystick controller

- The route, which the wheelchair chose, was different from the route he expected
- Suddenly, a pedestrian crossed in front of the wheelchair

Those who answered “no”, and comments they imagined are as follows:

- The wheelchair travels at high speed
- The rider forgets to turn off the switch
- The wheelchair travels in rainy, crowded, non-flat or slope conditions
- Software bugs exist
- High speed obstacles including bicycle cross in front of the wheelchair

With respect to Q2, average distance is about 1.29[m] and standard deviation is about 0.64[m]. This distance is about double person’s width, and the personal differences are large by considering the standard deviation. Thus, it is supposed that autonomous wheelchair needs to keep enough distance (more than 1.2[m]) between obstacles and the wheelchair, and the distance should be able to be changed by users.

With respect to Q3, average cost is about 137000 Japanese yen (1370 US dollar) and standard deviation is about 209000 Japanese yen (2090 US dollar). In Japan, an electric wheelchair costs from 200000 to 500000 Japanese Yen [21]. This autonomous function must be under this wheelchair costs, and the number of this standard deviation means that the value of autonomous function depends on users, thus, some users strongly want to use this function, and there is a strong possibility that they will pay for this function.

With respect to Q4, Q5 and Q6, Table 1 shows the questionnaire results. This result shows that comfortability and fun are enough high, but stability needs to be improved. This means that subjects didn’t trust the autonomous function yet, despite no accident in the experiments.

In Q7, the result shows that about 90 % subjects answered “yes”. This means that the intelligent wheelchair is very attractive for a supermarket or a shopping center.

Their comments in Q8 are given below.

- The design of the wheelchair should be changed
- Interface for a rider is important even when the wheelchair travels autonomously
- The wheelchair should move more smoothly
- A rider wants to confirm surroundings, as the wheelchair recognizes

We found that the subjects expressed favorable opinions regarding the intelligent wheelchairs, and many expressed a desire to use it again in the future.

TABLE. 1 QUESTIONNAIRE RESULT OF Q4, Q5 AND Q6 (Average and Standard Deviation of each score. 10 is best and 1 is worst.)

	Q4	Q5	Q6
Average	6.99	8.20	8.95
Standard Deviation	2.03	1.96	1.80

B. *Experiments for new interface*

The experiments for evaluating the intelligent wheelchair with the new gesture interface were performed. The subjects who are not disable people were instructed how to use these gestures to command the wheelchair before using the intelligent wheelchair. The experimental place was Tsukuba designated zone, which was explained in Section 2. The duration of the experiment for each subject was about 20 minutes. Figure 6 shows the experimental scene.

Figure 6 Experimental Scene

1) *Provided Questionnaire*

Before participating in the experiment, the subjects answered their gender, age. We wanted to know the impressions of two kinds of controlling wheelchair (one is new gesture method, the other is conventional joystick method), thus we asked the following questions after we showed the movie about joystick and gesture interfaces.

Q1. How do you feel about the gesture interface on a scale of one to five? (5 is best)

Q2. How do you feel about the conventional joystick interface on a scale of one to five? (5 is best)

After the experiment, each subject filled out a questionnaire providing answers to the following questions.

Q3. How did you feel about the gesture interface on a scale of one to five after you used it? (5 is best)

Q4. How did you feel about the conventional joystick interface on a scale of one to five after you used it? (5 is best)

Q5. Can you tell me pros and cons of using the joystick for controlling the intelligent wheelchair?

Q6. Could you control the intelligent wheelchair by the gesture interface? If not, please let know about when and what condition you thought that you couldn’t control it.

Q7. Do you have any comments about the gesture for “go straight”?

Q8. Do you have any comments about the gesture for “turn right”?

Q9. Do you have any comments about the gesture for “turn left”?

Q10. Do you have any comments about the gesture for “stop”?

Q11. Where or which condition would you like to use the gesture interface?

Q12. If you have any comments regarding these experiments, please let us know.

2) Questionnaire Result and Discussion

Table 2 shows the results for Question 1, 2, 3 and 4 (Q1, Q2, Q3 and Q4). From this results, before using gesture, subjects thought the gesture interface was very interesting and useful more conventional joystick. On the other hand, after the experiments, unfortunately, the subjects thought the gesture interface wasn't satisfied yet. Thus, there are several challenging issue remaining in the gesture interface, and comments, which will be introduced in the result of Q6-Q12, are important.

Their comments in Q5 are as follows:

- Good reaction of turning and forward
- Easy to operate than gestures
- To get accustomed to the joystick interface more easily than the gesture interface
- Easy to use, without learning

With respect to Q6, 14.2% subjects answered "no". Those who answered "no" regarding Q6, their reasons are as follows:

- It was difficult to understand proper spacing of the hands and the sensor
- It was possible to smoothly steer in the beginning of the experiment. But, after practicing the gesture interface, it became easy.
- I wasn't able to successfully steer because the sensitivity of the sensor wasn't enough.
- Operation of the left hand, which was not dominant hand, was difficult
- I was able to operate "go straight" and "turn left", but to operate "turn right" was difficult.
- It was possible to operate "turn left", but to operate "turn right" was difficult.

From this result, it is confirmed that we need to improve the gesture interface, but this comments are valuable for improving the gesture interface. For example, the specification of the sensor should be improved, and explanation and trial are important to get accustomed to this new interface. The operation of "turn right" seems to be difficult for several users, and this problem can be fixed if this gesture pattern of "turn right" is changed.

With respect to Q7, Q8, Q9 and Q10, Table 3 shows the questionnaire results. As shown in the result of Q6, the operation of "turn right" should be changed and appropriate places of the arm and the hand must be easily fixed.

With respect to Q11, several interesting comments about condition are given and they are as follows:

- Operations using the center of gravity of the body
- Operation by using the leg or the neck.
- I want to operate in my dominant hand for the gesture interface.
- Not for me, but I think some people are interested in this gesture interface by considering the level of disability

In these experiments, we chose hand gesture but it will be interesting that other body gestures are employed for the new interface.

Their comments about the gesture interface in Q12 are as follows:

- The hand and arm should be fixed for keeping the appropriate place of the hand.
- We expect that the system should be more reliable and accurate
- It takes some time for this operation to get accustomed to.
- Gesture interface was funny
- I was impressed that the wheelchair moves with the gesture interface, and I want to use this sometime.
- It was fun to use, but it may be difficult for elderly to understand the operation for proper use

We found that the subjects expressed favorable opinions regarding the gesture interface, and many expressed a desire to use it again in the future. These comments indicate that we need to strongly improve the intelligent wheelchair.

TABLE.2 QUESTIONNAIRE RESULT OF Q1, Q2, Q3 AND Q4
(Average and Standard Deviation of each score. 10 is best and 1 is worst.)

	Q1	Q2	Q3	Q4
Average	4.14	3.71	2.71	4.00
Standard Deviation	0.35	0.88	1.16	0.76

TABLE.3 QUESTIONNAIRE RESULT OF Q7, Q8, Q9 AND Q10

Go Straight	Turn Right	Turn Left	Stop
Good	To keep appropriate distance between the hand and the sensor was difficult	Good	Good
Very easy	Difficult to operate	It was easier than "turn right"	Reaction of the wheelchair was good
It was easy to operate straight comparing to left and right	"Turn right" is more difficult than "turn left"	Turn left was simpler than "turn right"	Easy
It was difficult to fix the place of the hand	At first, it was not able to turn right. It was possible to operate after changing position of the arm	It was easy to operate. Distance between the sensor and the hand was important	It was easy because the system recognizes "stop" when the hand was released from the sensor
Hard to operate	On operationg "turn right", the left hand was too close to the sensor, and sensor couldn't recognize the hand	It was able to operate as intended	I didn't feel the anxiety because the wheelchair stopped in safety
I could not proceed straight without shifting a little to the left		Very easy	Very easy

V. Conclusion

We proposed the use of an intelligent wheelchair for new mobility not only for elderly people but also for everyone. Our intelligent wheelchair has autonomous function and new gesture interface. For the introduction of the proposed intelligent wheelchair, there are several challenges associated with the use of the wheelchair. One of the most important points is the user acceptance, and it must be investigated with a plenty of subjects by experiments. In addition, the affordability is also important for the introduction. The two points were investigated by performing the several experiments with subjects. In the experiments, we did a questionnaire about the intelligent wheelchair. In this paper, we introduce experiments and the questionnaire results, and the results are compared and discussed in this paper. The questionnaire results proved that most subjects had the favorable opinions about autonomous function and new gesture interfaces. On the other hand, the challenging issues for improving the user acceptance of intelligent wheelchair were also found especially for the gesture interface. One of the most important points is to choose easy operation especially for elderly people. These results must be valuable for developers and researchers of new wheelchairs.

For future work, we will perform the experiments under more situations and with more subjects including disable subjects. In addition, we will develop new intelligent wheelchairs by using feedback from this research.

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Inclusion of Down Syndrome in Architectural Design: Towards a Methodology

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***Abstract*—This paper develops an in-situ methodology to help architects insure better inclusion of people with Down syndrome all along preliminary phases of the architectural design process, and eventually to the designed space. This methodology first offers architects some design keys in regard of how people with Down syndrome interact with two types of spaces: their personal dwellings and some completely unknown spaces. The methodology then unfolds towards more pro-active inclusion of the participants thanks to playful expression of their feelings and perceptions. This paper discusses how this methodology relates to inclusive and universal principles, useful to design smart environments be they ICT-enabled or not. This paper closes on prevalent models of disability in architecture and how they articulate with the model of "architectural handicap".**

Keywords-disability; Down syndrome; inclusive design; universal design; methodological framework.

I. INTRODUCTION

This paper tackles the challenge of disability inclusion to architecture, disability considered here as a temporary or permanent condition likely to show up at any time of everyone's life. Statistically speaking, disability concerns 15% of the European population, i.e., more than 80 millions individuals [1]. Among them, only 20% are disabled from birth, while 80% will experience impairment later in life, as a result of an accident, an illness, ageing or a more temporary condition such as pregnancy [2]. We are therefore all concerned with disability, whatever our current situation.

Designers are yet struggling with the inclusion of disabled people, given the variety of disabilities and the variety of adaptations those disabilities require on both spatial and functional levels. In architectural design, and in Belgium more specifically, norms about persons with reduced mobility (PRM) constitute one of the few frameworks available to help designers integrate the needs of people who use a wheelchair or blind people. This regulation, yet, does not take into account cognitive impairments (nor hearing loss) that are thus generally neglected during the architectural design process. Likewise, in ICT related fields, cognitive impairments seem to be less often considered than visual or hearing loss impairments.

Consequently, this paper aims at offering concrete design tools to architects confronted to the needs of people with cognitive disabilities, and more specifically people with Down syndrome. The paper will first aim at studying the impact of architecture on the spatial perception of people with cognitive disabilities. In-situ observations of participants evolving through various spaces will provide some useful design keys in that regard. The methodology will then be expanded in order to include those users into a more active encounter with architecture, providing architects with fruitful information about how people with Down syndrome experience space on a more multisensory level.

In Section 2, literature review and the resulting research questions are presented. Section 3 details the methodology developed in order to conduct the observations. Section 4 describes the obtained results, presented in two subsections: design keys (Subsection A) and methodological keys (Subsection B) for inclusion of Down syndrome in architectural design. Section 5 closes on a theoretical discussion considering prevalent models of inclusion and disability in architecture and how these models should be revised in order to consider people with Down syndrome's sensitiveness as opportunity rather than threat to the architectural design process. Some insights built in this paper might be relevant for universal/inclusive design for ICT related fields.

II. STATE OF THE ART

We highlight here two main observations from architectural state of the art. First, as observed by several phenomenologists, architecture suffers some kind of uni-sensoriality hegemony. Architecture, according to these authors, has been reduced through the Modernist era to the sole consequence of visual expression and experience, neglecting the other perceptual senses and consequently deviating from the users' multisensorial realities [3], [4], [5]. This hegemony, authors argue, has impoverished the architectural experience and, as a result, the whole design process [6]. Second, theories of environmental psychology and healing environments suggest that the architectural environment influences the wellbeing, considering architecture either as a factor having a positive (curative architecture) or a negative (disabling architecture) impact on the emotional and physical experience [7], [8].

Building on these two main observations, some authors propose to interact with disabled people and to integrate their perceptions as soon as early stages of the design process [9], [10]. This early integration helps architects consider other users than the "*average, six-foot-tall, 20-years-old male, with perfect vision and a good grip* [11 (p. 60.7)]," encouraging them to question and reinstate users' multi-sensoriality and sensitivity into their work. In this case, disabled people are

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considered as experts and become a real source of creativity for designers [10]. The disability is then considered as an opportunity, both for architects who develop new ideas and for disabled people who take part in a process from which they are usually excluded.

This design approach fits the inclusive design theory and its two main principles, i.e., (i) considering the users' and designers' complementarity given their respective specific knowledge and expertise [12] and (ii) re-integrating the users' emotions and reactions in order to design sensitive architecture ensuring their wellbeing [13].

As opposed to this inclusive vision, more traditional approaches characterize disability as a constraint for both designers and users. Architects indeed sometimes apprehend the norms regarding disabled people rather as obstacles to their creativity [14]. Those traditional approaches, along with their regulations, moreover only consider limited variety of disabilities, not taking into account variations within the same disability. The main studied disabilities are motor impairments and blindness, while cognitive impairments are more rarely addressed, except for autism that has been widely explored. Yet, just like people with autism spectrum disorders, Tufvesson and Tufvesson argue people with Down syndrome present a remarkable hypersensitivity and a particular spatial perception [15]. Even studies aiming at "*turning disability experience into expertise in assessing building accessibility* [16 (p. 144)]" or at designing multi-sensorial spaces [6] until now remained essentially focused on motor and visual impairments, neglecting the assessment of other peculiar ways to experience space.

The resulting recommendations and designs are thus never perfectly adapted to the users with cognitive disability who can then feel excluded and misunderstood [17]. We therefore formulate the following two research questions:

- How do people with Down syndrome perceive space at a multi-sensory level?
- How to set up a specific methodology to approach and leverage Down syndrome's specificities in architectural design?

III. METHODOLOGY

To answer those research questions, we build on a methodology of in-situ observation and interaction with disabled participants as suggested by Nijs and Heylighen [16]. Their methodology consists in considering disabled people as experts of their own peculiar way of experiencing spatiality and architecture. Through several cases studies, these researchers invited groups of disabled people (mainly persons with reduced mobility and visually impaired people) to experience a building and to discuss their own experience verbally, thanks to different keywords suggested by the researchers. While this section will develop how we implemented this methodology, Section 4 will come back on how and why this methodology had to be adapted given the communication difficulties of people with Down syndrome.

Firstly, we proceeded to the selection of the participants affected by Down syndrome among the residents of a Belgian non-profit association welcoming adults with cognitive disabilities and specifically intended to develop residents' artistic skills. Six participants were eventually chosen on the basis of several criteria such as the sex (to ensure gender parity), the housing type (in order to compare the participants' experience in terms of living with family or living permanently in the residence) or the severity of their disability and the impact it could have on their capability to express their experiences and feelings (Tab. 1).

Secondly, we conducted two phases of in-situ observations: first the visit of the residents' own dwellings and later the discovery of a public building, a local town hall unknown by the participants. The goal here was to compare the spatial perceptions of people with Down syndrome when confronted to familiar vs. unknown spaces. Those two observation sequences were video-recorded for practical reasons.

At the beginning of the visit of each dwelling, we set up a discussion table in order to collect some basic information such as, for instance, the resident's age or favorite room(s). This stage also helped us create a climate of confidence with the participant and his or her referee (family member or close relative). We then organized a playful activity that consisted in visiting the resident's three preferred rooms and interviewing him or her about his or her felt experience thanks to illustrated cards.

This combination of observation and interview methods, close to the "shadowing" technique, enables the researcher to follow a person in his or her daily activities while asking him or her some questions to complete the observed information [18]. Within this framework, the researcher takes over the role of observer-as-participant, i.e., he or she spends more time observing than participating. This role has several benefits: it is especially adapted for short interviews, it enables real-time filling of observation grids and it ensures transparency of the research goals towards the observed subjects [19]. However, given the brevity of each session (40 minutes in average), a mutual misunderstanding can occur between the observer and the observed person. Hence there is the need to quickly build confidence [19]. This could be achieved with the help of the participant's relatives that were present.

The methodology implemented during the visit of the town hall was rather similar: a few days later, we invited the same six participants to visit three rooms of the town hall,

TABLE I. DEMOGRAPHIC PROFILE OF THE PARTICIPANTS HIGHLIGHTING SOME ADDITIONAL SPECIFICITIES

#	Table Column Head				
	Gender	***Age***	***Housing type***	***Cognitive specificity***	***Mobility specificity***
1	female	25	family house	/	artificial hip
2	female	48	residence	/	slower motion
3	male	27	family house	verbalizes through onomatopoeias	/
4	male	36	family house	/	/
5	male	27	residence	/	/
6	male	49	residence	/	/

hall, this time chosen by the researcher in order to compare each participant's reactions. The visit of those three selected rooms was made individually. In the meantime the five other participants were guided by a social worker for a photo recreational activity. The pictures taken by the residents, as well as drawings produced later, are an additional means of expression completing or confirming the information collected during the individual visits.

IV. Results

The two next sections will present the results of the in-situ observations, starting with design tools in regard of space perception and following with some methodological recommendations.

A. Design Keys in Regard of Space Perception

During the two observation phases, four main phenomena have been observed.

Firstly, the people with Down syndrome who took part to this study all experienced some difficulties in identifying the limits between spaces that were not clearly delineated by a physical boundary. In the town hall, the reception and entrance halls were separated by a simple inner bay frame (Fig. 1), but the participants designated those two spaces as one single room. When asked to walk around the reception hall, they indeed systematically travelled both halls, obviously confused by the proximity of two sub-spaces whose functions were insufficiently distinct. Similarly in the case of private dwelling, one participant walked around the living room when asked to delineate the kitchen.

Secondly, and in contrast with the previous point, people with Down syndrome who took part to this study paid particular attention to the privacy of a space and how this sense of privacy could make distinct one space from another.

During the visits of their dwellings, the participants have always chosen their own bedroom as their favorite room, which underlines their need to have a personal space available. This characteristic could also be observed while experiencing the public building, especially when some residents felt the need to be alone and left in search of some smaller, more comfortable and/or less traveled space to retreat to for some time. In the case of their private spaces (their rooms), privacy did, in spite of its intangible nature, build some boundary between two subspaces. This phenomenon was specifically observed in a bedroom shared by two residents who never crossed the invisible line dividing the room into two individual and appropriated zones.

Thirdly, the participants demonstrated a particular attraction for light, bay windows, illuminated objects and surfaces. This characteristic was observed several times, particularly when participants were asked to point to their favorite object within a room. One of them, for instance, showed us his stereo, occupying a special spot on the windowsill of his bedroom, which was particularly well lit.

Fourthly, our observations revealed the great importance of material landmarks in the everyday-life of the participants, especially in regard of their day-to-day rituals and habits. Those well-known elements, which could be objects, pieces of furniture or even a specific material (e.g., local brown stone), were reassuring to them especially because they reminded them of aspects of their daily life and environments. In one of the residences, we visited a living room that had just been rearranged and refurnished. Inside this living room, social workers had left a small wooden table (Fig. 2) greatly appreciated by the participants because it had been crafted by one of the residents. This small table, placed there as a landmark of the previous space configuration, greatly facilitated the occupants' appropriation of this new way of organizing the room. The presence of this recognizable piece of furniture helped the acceptance of a new situation otherwise potentially disturbing.

Besides those four design keys of perceiving space, we have observed two additional mechanisms engaged in different settings: the visuo-spatial memory participants developed in regard of everyday spaces, and the multi-sensoriality participants deployed especially in unknown spaces.

Figure 1. Reception and entrance halls separated by an inner bay frame.

Figure 2. Wooden table in the living room of one residence: the reassuring landmark easing the space re-organisation and appropriation.

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When interviewed inside their dwellings, the residents generally looked beyond the current situation and appealed to their memory to describe the space as they generally experience it, rather than describing it in regard of its specificities at the time of observation. For instance, one participant stated that the living room was a place where "*it was dark*" while it was a bright middle of the afternoon at the time. The participant described the room as he usually perceives it in situation of most frequent use, i.e., when he watches TV in the evening, appealing to his visuo-spatial memory instead of his instant capacities of observation.

In the town hall, moreover, participants largely mobilized their five senses to experience space. For example, they relied on their hearing to determine the level of activity of the rooms: one participant said that the entrance hall was "*here, quiet, everything is quiet*" because we were alone in the room, while another one later found the space *"animated*" because several employees were present at the time. We observed that multi-sensoriality was generally only engaged during the discovery phases of a new space or a potentially disturbing environment.

B. Methodological Recommendations

In this section, we summarize adaptations made to Nijs and Heylighen's methodology [16] in order to make it more suitable to the specificities of people with cognitive disability (for which oral expression, for instance, can be difficult).

The importance of the referee (family member, close relative or educator) was made clear during the first phases of "discussion tables" we added to the methodology: this person, acting as mediator between the observer and the observed person, played a crucial role in decoding both stakeholders' words, intentions and behaviors and in ensuring their mutual understanding. In one particular case, the presence of the participants' parents turned out to be essential to "translate" his personal vocabulary mainly composed of onomatopoeias.

Expression of feelings and perceptual spatial experiences were moreover greatly facilitated by the use of four cards illustrated with cartoony human faces, each featuring one of the most widespread human primary emotions (happiness, sadness, nervousness and fear). These cards, chosen with the help of a psychologist specialized in assisting people with Down syndrome, were voluntary simple (free of superfluous details) and limited in their number in order to help participants express their feelings as accurately as possible. Participants were nevertheless free to combine several pictures to enrich their answers if necessary. Those cards, as suggested by Chase, adequately complement the content usually collected through narrative inquiry [20]. One important preliminary step, when presenting these cards for the first time, was to proceed to the emotions' recognition, i.e., to align our understanding to what the cards meant in the eyes of the participants. For instance, one resident had identified the card of the scared figure as a person "*who winced*", and this definition was therefore used for the rest of those observations. Those cards proved really useful to interact with the participants once on the field, and could efficiently replace the keywords used by Nijs and Heylighen [16] when interacting with people experiencing difficulties with verbal expression.

From an organizational perspective, we visited each room in two phases: first, we started interviewing the participant, and then we let him or her walk around the room. During the visit of one dwelling, one of the residents at first refused to sit and to answer our questions. We had to wait until he stopped moving before obtaining a single answer. Organizing the intervention in several, distinct and repeatable phases thus allowed us to progressively channel the resident's attention on our questions. We moreover observed that interviewing each participant separately proved particularly important to avoid participants influencing each other: at one point of the town hall visit, all six participants started to interact about the space and the influence of one of them was clearly at the disadvantage of self-expression.

Eventually, considering additional means of expression, such as photography or drawing for instance, proved very useful to complete some participants' comments.

V. DISCUSSION

Our in-situ observations contribute to an adapted methodology and to design keys useful for architects willing to include people with Down syndrome (their specific needs, their specific ways of experiencing spaces) into preliminary phases of their design processes. Since the results presented here are issued from six participants only, the findings should not be generalized to a larger group. As Kinnaer, Baumers and Heylighen underline in their research about autism, individual preferences play an important role for the perception and appreciation of certain spaces and should not be dismissed [21]. This has proven also true for people with Down syndrome, as one of the participants distinguished from the five others by his particular appeal for dark spaces. In this case, the participant considered his own bedroom, indeed rather dark, as his personal shelter of privacy, a space where he could freely unleash his emotions. He therefore associated dark spaces to this personal space, a protective cocoon where he could express himself untroubled. Designers willing to replicate the suggested adapted methodology might apply the saturation criterion [22] as a way to capture both specific and shared spatial perceptions.

Down syndrome, as any other cognitive disability, consequently ought to be considered as a complex condition, characterized by a variety of realities confined to a global medical model [17]. Yet, current theoretical and practical disability frameworks hardly take into account this variability. On the one hand, norms and regulations have the tendency to reduce the user to a single, « representative » profile: even the architectural norms applied to the inclusion of persons with reduced mobility (PRM) tend to dismiss personal specificities one wheelchair user can develop in regard of another. Theories such as Universal design, on the other hand, intend to transform architecture into some universal product including the diversity of needs of all potential users [23]. Such Universal architecture, by doing so, might even reduce the model of the user and his/her uses, as each Universal user potentially accumulates the incapacities of a larger diversity of users, the design object being consequently reduced to its lowest common possible use [24].

This research is therefore rather in favor of the inclusive model, taking into account the specificities of users and considering them, as much as possible, as creative input. We argue the methodology developed in this paper, favoring playfulness rather than simple consultation of the end-users, might potentially help architects in conducting in-situ research and in gaining knowledge about how specific groups of people with Down syndrome interact with architecture. Participants, considered as experts of their own disability and their own specific ways of experiencing space, might in this way contribute to architectural projects more prone to benefit the greatest number of users. As much as hypersensitivity [15], people with Down syndrome's specific ways to apprehend an architectural space, for instance through higher multisensoriality, could equip designers in their perception of end-users' needs. Whereas universal design aims at the lowest common denominator, inclusive design, we argue, provides more diversified avenues for design exploration.

Including participants with Down syndrome as soon as preliminary phases of the architectural design process, and specifically empowering them with a certain expertise, moreover suggests a possible evolution of current models of handicap in architecture. Disability has originally been considered the result of a medical condition, therefore building the "medical model" of disability in architecture. This model, focusing exclusively on disability as an illness together with its symptoms, nurtured a hygienist design of specialized institutions. Later, a social model of disability in architecture rather focused on the human being rather than on the mere "patient" and integrated notions such as "*origin, milieu, education, profession, economical position and social status* [25 (p. 11)], quoted by [26 (p. 19)]" to the design of adapted spaces. This social model, as a consequence, informed the design of healing environments outside the institutionalized boundaries of the hospitals and proposed living environments "*accommodating people with a social framework and, thus, supporting residents in developing their identity* [26 (p. 24)]."

Following our observations, we would advocate a third model of disability, i.e., architecture considered as a potentially disabling factor. This model, as an extension of the social model, would "*focus on individuality, difference (instead of commonality), experience and giving voice to people* [26 (p. 25)]," while redefining the role of architecture and the architects.

This concept, introduced by Goldsmith in the context of a research focusing on motor and visual impairments [27], states that architecture can constitute a proper physical barrier as much for disabled users than for people with temporary limited mobility (injured or pregnant person for instance). This "architectural handicap" therefore translates into an uncomfortable and constraining situation for the user, caused by the lack of consideration or anticipation from the designer that would not, or could not take into account the specificities of a larger group of potential users [8].

We argue this notion of architectural handicap extends to any type of disability, including cognitive ones, as well as any type of design field, including ICT-related ones. In the case of people with Down syndrome, our results suggest that architecture sometimes not only constitutes some physical barrier to one's mobility, but also a psychological barrier. Unclearly delineated spaces, for instance, can generate loss of reference points, misunderstanding of sub-functions and consequently loss of autonomy and social exclusion.

Architecture and architects therefore have a crucial role to play in terms of avoiding such handicapping situations: the design keys and methodology proposed in this paper offer support to architects who wish to deal with this new responsibility.

Conclusion and Future Work

This paper develops a methodology to approach Down syndrome in architectural design, in line with inclusive design theories. The originality of this methodology lies in its early integration of participants and its playfulness, enabling to go beyond simple consultation with users and to value the disability experience as an expertise.

The methodology and design keys suggested in this paper may be suitable to other user profiles, such as people bearers of another cognitive impairment, seniors or children who share some characteristics with people with Down syndrome.

Our research also highlights the limits of the current normative frameworks. Nonetheless, the actual lack of consideration for people with cognitive impairment compared with other disabilities, like motor impairment, demonstrates the benefits of such a norm. Since a strict regulatory framework would not be an adequate solution, this paper rather paves the way for a toolbox for designers, encouraging them to take into account people with cognitive disability and suggesting them some interaction techniques to reach this goal.

No longer considering disability as a threat or obstacle for architectural design, this work rather suggests that people with Down syndrome experience space with some specific sensitiveness. This sensitiveness could be leveraged as a source of creativity for the designer ("disability as opportunity"), while architecture could be considered as a potentially handicapping factor for the user ("architectural handicap").

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Development of a Sharing System for Virtual Graffiti of Tourism Information among Tourists using Image Recognition

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***Abstract*—We developed a sharing system for virtual graffiti of tourism information among tourists using image recognition. A tourist writes graffiti on a photo taken at a tourist spot using virtual graffiti interface and shares the graffiti among tourists who take similar photos on the system. Administrator of tourist destination need not to prepare for any information. Using our system, tourists can share tourism information with other tourists who visited the same place just by taking a photo. This paper describes the sharing system for virtual graffiti of tourism information among tourists using image recognition.**

Keywords–Virtual-graffiti; Tourism-information; Image-recognition

I. INTRODUCTION

The most important source of information for tourists is the reviews from other tourists [1]. Tourists can look at personal blogs and SNS to get reviews. However, when we focus on the information that tourists get during sightseeing, most of information is prepared by the tourist operator.

As the media to share reviews at tourists spot, there are communication notebooks (graffiti notebooks) which are put at shops and facilities, and graffiti on tourism resources. We can write whatever in our mind by handwriting, and notes by handwriting are more correct than typing [2]. It means that handwritten information is effective for sharing. However, it is insufficient that the tourists voluntarily share information without damaging the tourism resources in anywhere.

We developed the sharing system for tourist information that shares information at the tourist spots and encourages a casual input of information. Using the image recognition technology, this system realizes to attach the scenes at tourist spots to tourism information left by tourists by taking a photo at a touring spot which is the general behaviour during sightseeing. Besides, it does not limit the writing space for an individual, and many and unspecified tourist write something on an objective. The system provides virtual graffiti interface like real graffiti that people write on one object. This paper describes the development of a sharing system for virtual graffiti of tourism information among tourists using image recognition.

II. DEVELOPMENT

This section describes the development of our prototype system, which can share tourism information. The system shares comments (Graffiti), which were written on a photo by a tourist with other tourists using image-recognition. 2.1 explains the outline of the system. 2.2 describes the flow of system utilization during sightseeing.

A. System Overview

Figure 1 shows the outline of the sharing system for virtual graffiti of tourist information. The system consists of management server and virtual graffiti application.

We developed the Virtual graffiti application as Web application, and thus it can run on tourists' mobile devices access to the application without install special software. The application has four functions, upload function, display function, graffiti function and set up function. Upload function uploads a photo that was taken by tourist (taken photo) to the management server. Display function displays content which was created by creation function in management server. The content is the image which combines photos and some graffiti. Graffiti function adds graffiti to the content and tourists handwrite graffiti on the content. Set up function sets up the users' attribute which is given to graffiti.

The management server manages Graffiti Library. The management server has four functions, Registration function, Search function, Creation function and Save function, and has registered images and a library. Registration function registers a taken photo as a registered image. Search function searches registered images which are similar to a taken photo in Library. Search function uses Ricoh Visual Search (RVS) Technology [3] developed by Ricoh Innovations Corporation at Silicon Valley in U.S. It analyzes and quantifies the features of image, and can register the data and rapidly searches the database.Create function creates content which combines registered images with graffiti. Save function saves graffiti in library. In the graffiti library, there are taken photos and registered images in JPEG format and Graffiti in GIF format. Metadata include information of creating content and user type.

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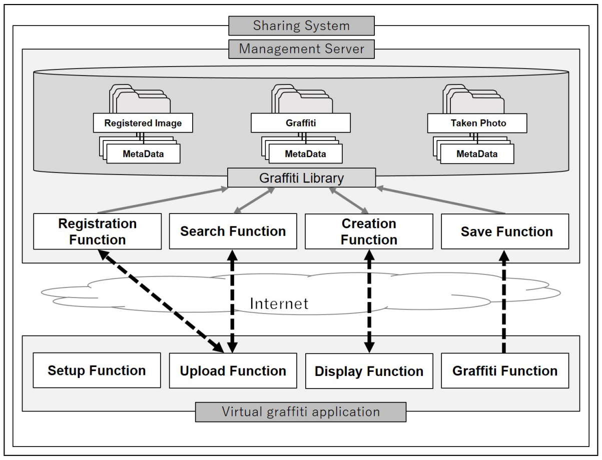

Figure 1. The Outline of the Sharing System for Virtual Graffiti of Tourist Information

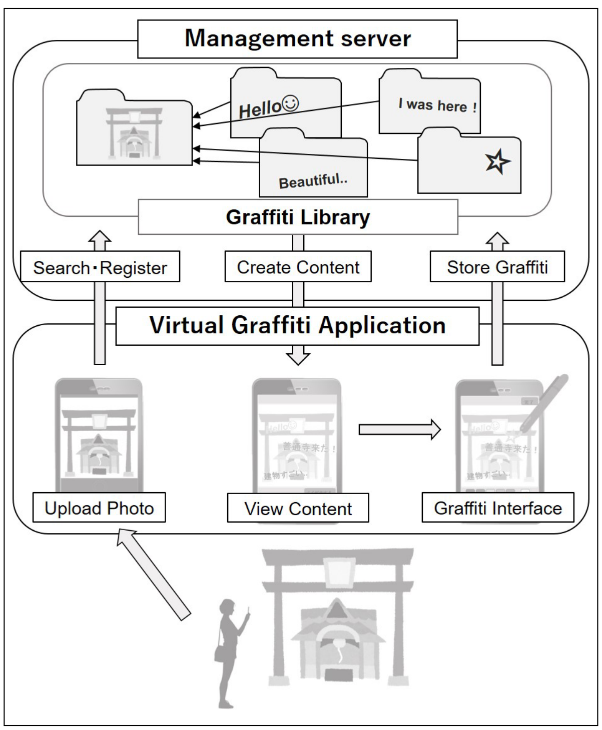

Figure 2. The Use Image of the Share System for Virtual Graffiti of Tourist Information.

B. Workflow of the System

Figure 2 shows the use image of the share system for virtual graffiti of tourist information. Users of the system are tourists who visit tourist spots. A tourist takes a photo in tourist spot. The taken photo is uploaded to management server and registered image is searched. If there is not registered image which is similar to the taken photo in the library, it will be registered in the library as a new registered image. If there is a similar image, content which is added to past graffiti will be created and sent to virtual graffiti application. Tourists look at the content and add graffiti on it.Figure 3 shows the screen of graffiti interface which a user wrote graffiti.

Figure 3. Screen of Graffiti Interfacen

III. Conclusion

This paper described the development of a sharing system for virtual graffiti of tourism information among tourists using image recognition. Using the image recognition technology, the system provides virtual graffiti interface, which is attached to a scene in tourist spot and add new graffiti. The system shares comments as graffiti which were described on a photo by tourist with other tourists using image-recognition. We have realized the system to provide the virtual graffiti interface to a scene by taking a photo at a touring spot which is the general behaviour during sightseeing. The sharing system of tourism information gives metadata to the registered image, graffiti, and taken photos. We can analyze graffiti and tourism behaviours using metadata. Now, we are planning to conduct a demonstration experiment from stored images and graffiti to confirm the effect of this system on the sharing of tourism information at tourist spots.

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