ARGUS:
Assisting Personal Guidance System for People with Visual Impairment

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1 INTRODUCTION

Almost 300 million people in the world are visually impaired. About 90% of the world's visually impaired live in developing countries, and about 65 % are aged 50 and older, with an increasing elderly population in many countries, more people will be at risk of age-related visual impairment.

The global response to prevention of blindness have had specify results in areas of progress over the last 20 years including prevention, eye care services, development of policies and strategies, campaigns to raise awareness, and stronger international partnerships with engagement of the private sector and civil society.

But this global response has also had one of the main areas of progress on the development and implementation of technical assistance to the users. Despite the technology state of the art many questions remain open concerning autonomous navigation, accuracy, integrity.

2 MAIN OBJECTIVES OF THE PROJECT

The ARGUS project focuses onto the development of a service platform and a satellite based navigation terminal for people with impaired visually capabilities, to guide them along a pre-defined track, using acoustic and audio-haptic signals. In this sense, the ARGUS system

provides a virtual guidance rope for blind and partially sighted persons or people working in environments with low visibility (emergency and rescue services, etc.). Based on GNSS systems, ARGUS acts as a leading climber providing a safety rope to the persons following, leaving for them a secure path.

The main goal of the project is to develop a GNSS based mobility service for people with impaired visually capabilities, to guide them along a pre-defined track, using acoustic and audio haptic signals, which meets the level of accuracy, integrity and reliability they need in urban and outdoor environment for improving their day to day life autonomy.

ARGUS project primarily retrieves benefits from satellite navigation services and technologies to increase the level of positioning accuracy and reliability as well as the level of service availability. But the ARGUS project will also develop a whole set of services aimed at pragmatically support visually impaired people in their day-to-day life mobility. For this purpose, some specific objectives are considered:

- To build up a commercial navigation product for visually impaired people which guides them with acoustic and audio-haptic signals along a secure, pre-defined track. The positioning component uses satellite based positioning
- To develop tactile signals, acoustic and audio-haptic ones, for providing a non-visual track perception and mental map of the path, and supporting the guidance of visually impaired people along a pre-defined track.
- To develop an application for authorised third parties. With the application software, stored pre-defined tracks can be transmitted to the user terminal on demand. Furthermore, the application software uses the positioning information from the user terminal to compute protection levels and re-transmit alerts in case of emergency (e.g. degraded positioning accuracy, etc.).
- Provide an intelligent guiding portable device to support ageing population and visually impaired people.
- Provide updated data through a public Web services sharing information collected by ARGUS users with other ARGUS users or with general public

3 HOLOPHONIC BINAURAL SYSTEM

Throughout history, multiple solutions have been designed to help in guiding blind or visually impaired people, based on different technologies. Speech based techniques, as well as more sophisticated devices based on handheld haptic display using verbal and non-verbal communication technologies for visually impaired pedestrians have been developed and compared. However, the ARGUS project will focus on a specific audio-haptic signal, which is

binaural audio technology, providing spatial information through three dimensional sound perception.

The word binaural means “both or two ears”. Human audition is in most of the cases binaural and this term is used to refer anything concerning two ears. To understand what binaural hearing is, it is necessary to understand how sounds are differently perceived by our ears. The sound waves with their directionality and their amplitude make our ear/brain system locate sounds using our two ears.

As proposed by Lord Rayleigh [REF], Duplex theory describes sound reaching the two ears as Interaural Time Differences (ITD) and Interaural Level Differences (ILD). While ITD represents, in terms of time, the path difference from the sound source to each ear, the ILD is produced due to shadowing of the head.

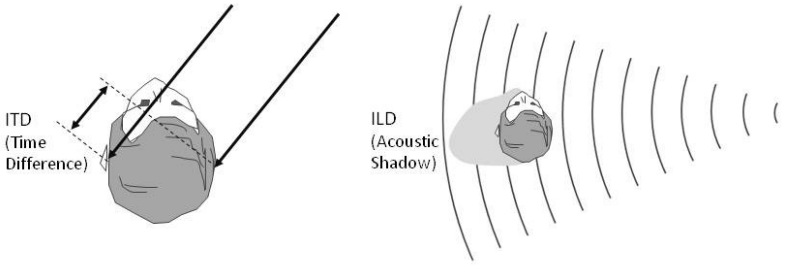

Figure 1: ITD and ILD. Interaural Time and Level differences

Therefore by using binaural sounds the user perceives 3D sound positioning. Based on this binaural sound perception, the main goal of this project is to guide the visually impaired person through a preselected route. This route can be selected over previously recorded tracks (natural routes: no multilayer cartography available) or selecting origin and destiny (city or urban scenarios, multilayer cartography available). This route is a series of continuous geolocated points in 2D, therefore this geographical map has to be translated into a sound map (binaural map) as it is shown in the next figure.

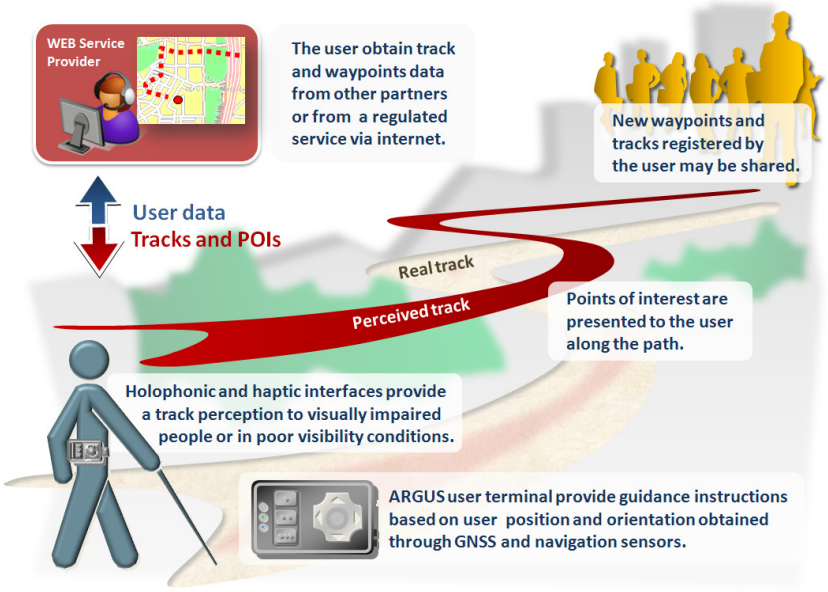

Figure 2: Navigation based on track perception

Binaural technology record the wave sounds, the way those are received at the tympanic membrane. For that purpose, Binaural technology use auditory system dummies, capturing even the slights differences perceived by the ears caused by direction of the coming sound. Then, binaural sound recorded may be reproduced by a stereo headphone creating the illusion that sounds come from specific directions and distances.

5 THE USER REQUIREMENTS

The main goal of the testing phase consisted on the selection and validation of headphones that meet the safety needs for the blind and partially sighted people in outdoor navigation conditions, and specifically, identifying the adequate headphones for non-disturbing the general hearing of ambient sounds. The binaural audio concept was also introduced over this testing phase to asses users' initial reactions. These points were addressed in different tests:

- Audio test 1: The objective was to test the non-disturbance of general hearing of the headphones by using a track in outdoor (street) conditions. Different headsets were tested, four models in total, two closed headsets (Sennheiser, Elecom) and two open ones (Vibe, Audiobone), through the input of a number of sounds consisting on a set of different sources, such as bells, music, voice instructions, etc. The validation itself was carried out by playing the sound track on a smartphone, while the user was listening to the candidate headphones. After the test, the user had to answer a questionnaire, that was gathered together with the other answers.

In addition, some instructions were provided to the testers: 1) They were asked to remain in a static position while listening to the sound tracks and 2) they had to listen the sounds with the candidate headphones in a indoor and quite environment first to get acquainted both with the sounds and headphones.

- Audio test 2: The purpose was to test the Argus binaural audio concept using different binaural audio tracks, ensuring the correct understanding of binaural sounds, trajectory identification, 3D sound perception and localization. For this test two different audio files were used: 1) a talking speaker in the native language of the user and 2) a virtual matchbox. The sounds were played on a smartphone likewise, but in an indoor quiet environment, and included too a questionnaire.

  Below images of the open headset are available:

  Audiobone: *Vibe:*

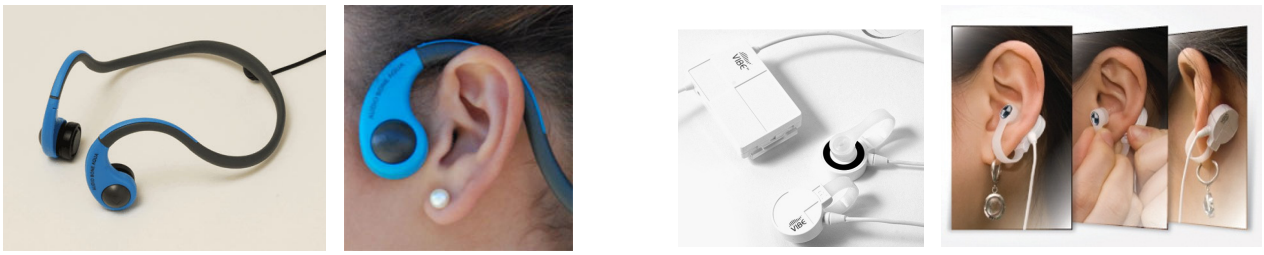

Figure 3: Audione and Vibe headphones

All tests were carried out following the privacy policy rules for users.

The consortium succesfully tested 28 users over the United Kingdom, Germany, Austria and Spain, targeting both, partially sighted and totally blind people.

When it comes to conclusions, results prove that 73% of the totally blind users (group 1) preferred open headphones against the closed ones; this relies on the fact that their guidance is mainly based on sound perception and closed headphones avoid any external sound source, which damages their guidance capabilities. However, 63% of people with partial visual impairment (group 2) preferred the use of closed headphones, which confirms that for group 2, guidance relies also on visual capabilities and thus, sound guidance provides a valuable plus to their navigation. Finally, around 96% of tested users could identify the approximated position of the sound source and over 75% of them reported that binaural sounds would be useful for people guidance; the remaining 25% were unsure rather than negative or against.

Persons that have lost their or have only limited vision heavily rely on their hearing. They are using the acoustic channel for orientation as well as for obstacle detection. A trained blind person can even hear how many doors are in a floor. Therefore the most important user requirement for the acceptance of the ARGUS technology is the non disturbance of the hearing sense of the users. The main question is how to use 3D audio technology without disturbing the hearing sense of the user with visual impairments.

In early evaluations some users claimed that even headphones which can be worn in front of the ear rather than on or in the ear (see Fig 2) had influence on their echo-localization. Therefore the ARGUS Project needed to spend huge efforts in finding a solution for non disturbance with regard to 3D audio capable headphones. Furthermore, currently user studies are undertaken in order to determine the hearing capabilities of people in different age groups and their ability to localise the exact direction from which a sound source is coming. Moreover different acoustic signals are tested with regard to frequency, volume, etc. By these user studies the perfect acoustic signals for each user group will be determined, proven under the influence of various ambient noise patterns e.g. flowing traffic, flowing traffic on a rainy day, etc. since these ambient noises will influence the necessary audio signal perception.

6 THE TESTING PHASE

The starting point for the determination of user requirements in the Argus is a personal interview user questionnaire and an online questionnaire, thus enabling Argus to reach a wider and more diverse set of respondents. These questionnaires follow a common pattern, thus enabling the results to be analysed and collated into a coherent and valid set of user requirements.

There were 65 usable replies to the Argus User Requirement questionnaire, the sighted respondents were discounted. Two thirds of respondents are partially sighted and a third totally blind. Just under a half of interviews were conducted face-to-face.

Respondents: Totally Blind & Partially Sighted

	Count of Impairment Severity	% of Impairment Severity
Partially Sighted	42	65%
Totally Blind	23	35%
Grand Total	65	100%

Table 1: Breakdown of Totally Blind vs. Partially sighted

Type of Interview		
	Count of Interview Type	% of Interview Type
Face-Face	30	46%
Web	35	54%
Grand Total	65	100%

Table 2: Breakdown of Type of Interview

Not all users would interface with ARGUS in the same way however, some general pointers have emerged on the environment in which ARGUS would be used; these are listed below.

- Almost all use a white cane both for identification and navigation
- Dogs are used by some but they have limitations
- Most use a sighted guide for new routes and some for all routes
- Under half had special training on getting around when blind
- Approximately 32%, the majority of which have some sight, already use GPS, but most of these have reservations on safety and accuracy
- Most ask passers-by for help when unsure
- Public transport was either not used much or used with sighted guide
- Most are computer literate, less than 5% are unfamiliar with computers
- All rely on hearing for navigation and safety
- All carry and use mobile phones
- The majority (92%) were keen to try new methods of guidance.
- About half currently undertake unknown routes.
- All were keen to have better technology

7 HOW ARGUS COULD BE COMPATIBLE WITH OTHER TECHNOLOGIES

Currently all pedestrian navigation systems designed for people with blindness and visual impairments are using haptics or speech output to guide users. A great number of different solutions is already available on the market, all with some sort of limitations. Most of them are propriety (vertical) solutions, which can therefore not be used in combination with ARGUS. A very promising approach was developed in the EU-Funded Project HAPTIMAP. They have developed a toolkit for easy creation of multimodal interfaces. To widen the group

of users including those who are not willing to rely only on 3D audio, ARGUS is planning to cooperate with HAPTIMAP and to use the toolkit for the creation of a multimodal 3D audio interface. Thus allowing users to either use 3D audio or haptics or both.

8 SYSTEM ARCHITECTURE

The ARGUS system will be compound by the next elements:

- **User Terminal:** corresponds to a Smartphone and a portable GNSS based positioning terminal capable of guiding the user along a pre-defined track, using acoustic and audio-haptic signals, and allowing internet access for remote service supply and navigation augmentation.
- **Service Platform:** corresponds to the assistance and service platform based on a client-server architecture which will offer services all along the three travel stages i.e. before (planning), during (visiting destination) and after (remembering and sharing experiences).
- **Personal user software:** corresponds to the SW for personal usage to configure the User Terminal or load particular navigation information to the User Terminal.

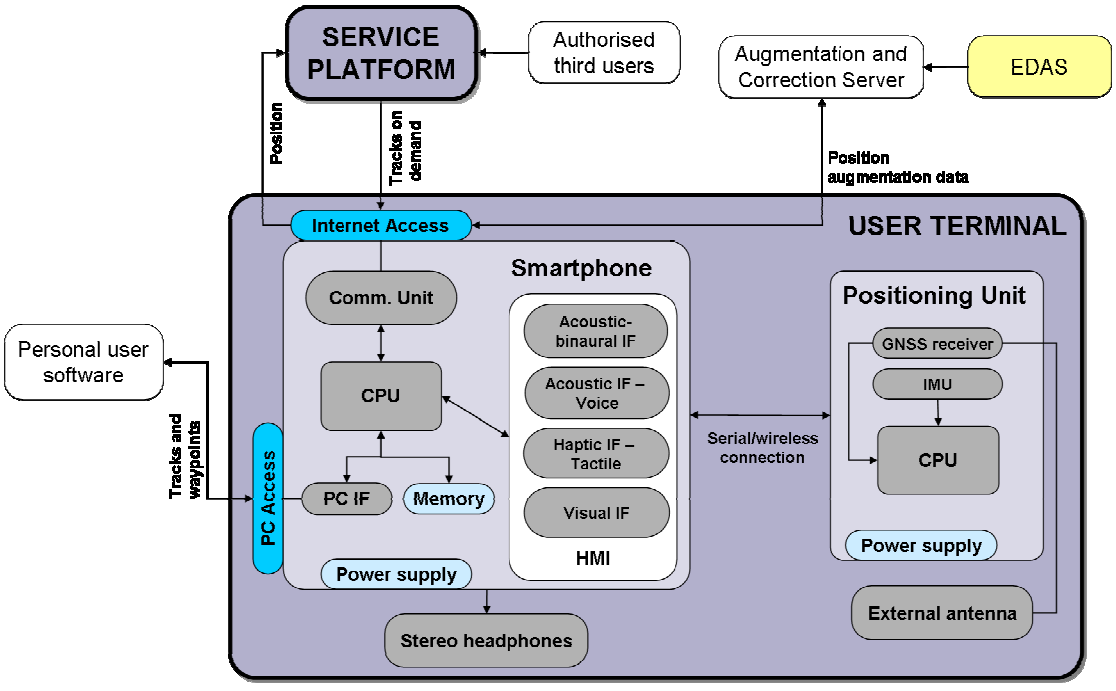

Figure 4: ARGUS system architecture

8.1 Service platform

Assistance and service platform will be based on a client-server architecture which will offer

services all along the three travel stages i.e. before (planning), during (visiting destination) and after (remembering and sharing experiences) in order to:

- Prepare their itinerary at home, taking into account specific scoring processes enabling the integration of route safety in the itinerary calculation.
- Manage their itinerary in real-time, with an accurate positioning.
- Share experiences with other users, improve the system and enrich the locations database with personal comments and points of interest (POI), trough the community website (social network).

8.2 Multilayer database structure

For routing calculation, GIS (Geoinformation system) information is required. The basic route calculation needs the topology of a network to generate a path, extracted from the different "way" type tags and attributes given by cartographic sources. OpenStreetMap is decided to be the basic geographic data source for the project as it is open data that has been created and is being maintained by its community. It is free to download, it contains a great variety of attributes and it is kept up-to-date in a satisfying way. The city GIS database clearly depends on the availability of specific geodatabase of the municipality one takes into account. Some public administrations are making big efforts in the generation of highly-detailed mapping and offering the information via open data initiatives.

Geodata strategy is based on interconnected information layers from different sources. The Multilayer Information Management System of the ARGUS Service Platform will be in charge of storing and managing the several available data layers in a coherent way. This data will be queried by the route calculation algorithms to get the required information so that the accurate itinerary can be defined.

- Base cartography from OpenStreetMap and city GIS Database
- General information layers
- User generated personal data layers

8.3 ARGUS Website Structure

The project includes setting up and maintaining a public website providing different services to the users of the ARGUS device, and a collaborative environment open to any persons and organizations that can participate in a social network to help improving the experience of the main users. The website will allow ARGUS users to register, in order to provide information about their profiles and needs and give them access to specific services like downloading data files (tracks, points of interest, warnings, etc.) or uploading the information collected during their journeys.

The main functionalities implemented in the website will be:

- POIs management: This block allows the users to manage personal Points of Interest and share them with other people. Different types of POIs are considered in the project execution. On the one hand, POIs of general interest – that are those included in commercial databases – are considered. However, these points of interest are of general interest, what means that perhaps they are not helpful for some situations or special needs. For example, people with visual impairment may need some additional information that is not considered in these POIs. Because of this, ARGUS is designed for considering some personal POIs, and POIs which are especially helpful or problematic for visually impaired people. ARGUS takes into account that POIs depend on variable circumstances. For instance, some dangers may depend on the season or weather conditions. In such cases, the weight of the POI is calculated to indicate the level of danger.
- Route Calculation: Route calculation will be performed by recalling previously uploaded tracks or calculating user specific routes from origin to destination. The algorithm calculates the optimal route taking into account the restrictions or preferences of stored POIs. For this purpose, city GIS data is required, so that optimal route can be calculated using effective and adapted routing algorithms. Existing navigation devices are designed for car usage and consequently, all input parameters are mostly vehicular in nature. While creating travelling and moving paths for pedestrians that are visually impaired, more sophisticated aspects have to be taken in to consideration including physical obstacles, particular characteristics of pathways (width and length), or the degree of how easily accessible is a specific route or portions of suggested paths. Finally, the route calculation algorithm gives back a file containing the indications to be followed by the user. This file can be stored in the computer and /or loaded into the User Terminal.
- Web 2.0: It is dedicated to share experiences of the user and acts as a social network for visually disable people. The user will be able to annotate any kind of incidents during the trip and share it via the web social platform. Any other person (not only visually impaired) could also register in the system so that they can collaborate with auxiliary tasks such as collecting data to feed the system, validate the quality of the data and ensure that there are no changes that could imply risks to the users, or communicate with the users of ARGUS to share experiences.

9 THE POTENTIAL FOR THE URBAN PLANNING COMMUNITY

The ARGUS project provides new insights for the planning community concerning various aspects: the end user involvement, the cartographic and semantic aspects, the definition of Points of Interest and the accessibility of the spaces in the city.

Therefore ARGUS will be useful to citizens in order to discover and use the city and for Municipalities and public administrations to have updated maps especially of points that might be dangerous or not accessible, offering an easy possibility to improvements.

What is also essential is to consider that this project is part of a greater movement of projects related to accessibility and mapping for blinds, and therefore can benefit and contribute to the ongoing exchange with these other initiatives.

10 CONCLUSION

The technical challenges comprise the overall development of a guidance system, which enables the users to follow a pre-defined path autonomously without seeing it by using tactile, acoustic or audio-haptic signals. One main challenge is the tailor-made development of a suitable Kalman Filter for the application under consideration in order to adapt it most suitable to the dynamic behaviour and thus the so-called dynamic movement model. Thus, extensive work will have to be spent onto this issue. Furthermore, the protection level algorithm has to be tailored carefully taking into account the target environments and ways of the potential users. The HMI which integrates multisensory actuators (acoustic, audio-haptic, and visual) is also a very challenging part of the development because of the necessity to integrate the different actuators in a most suitable strategy.

In order to accomplish the track guidance, it will be necessary to develop the holophonic sound map. It will allow accomplishing an innovative solution for the user perception of a non visible track path, and the development of the system that will allow visual impaired people to navigate the track in a safe way.

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12 REFERENCES

http://www.haptimap.org/
www.amauro.map.at/plus