ARGUS: a Personalised Guidance System to Improve Autonomy of People with Visual Impairment in the City

Oihana Otaegui, Estíbaliz Loyo, Eduardo Carrasco, Claudia Fösleitner, John Spiller, Daniela Patti, Adela Marcoci, Rafael Olmedo, Markus Dubielzig

(Oihana Otaegui, Vicomtech-IK4, San Sebastian, Spain, ootaegui@vicomtech.org)
(Estibaliz Loyo, Vicomtech-IK4, San Sebastian, Spain, eloyo@vicomtech.org)
(Eduardo Carrasco, Vicomtech-IK4, San Sebastian, Spain, ecarrasco@vicomtech.org)
(Claudia Fösleitner, TeleConsult Austria, Schwarzbauerweg 3, 8043 Graz, Austria, claudia.foesleitner@tca.at)
(John Spiller, The 425 CompanyLtd, Hambledon, Hampshire, UK, john.spiller@the425company.co.uk)
(Daniela Patti, CEIT Alanova, Schwechat, Austria, d.patti@ceit.at)
(Adela Marcoci, CEIT Alanova, Schwechat, Austria, a.marcoci@ceit.at)
(Rafael Olmedo, OK-Systems, Madrid, Spain, rafael@ok-systems.com)
(Markus Dubielzig, Siemens AG, Parderborn, Germany, markus.dubielzig@siemens.com)

1 ABSTRACT

People with visual impairement have striking needs for trustfully navigation systems enabling for efficient mobility services, mainly considering safety and autonomy. Navigation technologies are being implemented in innovative personal navigation devices, but existing products fail because they lack accuracy and do not provide a suitable and efficient man-machine interface adjusted to this user segment, or rely on costly infrastructure.

The ARGUS project focuses on a satellite based navigation (GNSS/EDAS – EGNOS Data Access System) terminal for people with impaired visually capabilities, guiding them along pre-defined tracks using specifically designed HMI (Human Machine Interface) such as tactile, acoustic and haptic signals. It introduces the opportunity to develop an innovative guidance support system for visually impaired people based on the provision of a virtual-lead-line perception to the end user that can be perceived and followed. This will provide "track navigation" instead of the classical "waypoint or route navigation" which is used for car navigation or people with all visual capabilities.

This system will be also usable for professional, scientific and sport activities developed in reduced visibility scenarios that could require accurate guidance on normal or emergency situations, as well as for other people working in reduced visibility environments needing guidance and assistance.

This paper explains the features of the ARGUS device and expands on the Proof of Concepts that was carried out with the potential users.

2 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 specific results in areas of progress over the last 20 years including prevention, eye care servicies, 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 developmentet and implementation of technical assistance to the users. Despite the technology state of the art many questions remain open concerning autonomous navigation, acuracy, integrity.

3 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.

- Provide an intelligent navigation and 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

4 HOLOPHONIC SYSTEM

What is "binaural"?

Binaural sounds create the illusion that sounds produced by stereo headphones come from specific directions and distances, based on the interaural differences (arrival time and amplitude between the ears). This allows users perceiving 3D sound positioning, which can be used to guide visually impaired persons following a route (controlled via GNSS) giving a sense of 3D navigation.

To understand what binaural hearing is, we must know how we perceive the sound from those two "inputs", our ears.

The sound waves with their directionality and their amplitude make our ear/brain system locate sounds using our two ears. We use three different cues between our ears when locating a sound source: level, phase and spectrum (loudness). These differences are used in the ARGUS Project to generate virtual sounds creating another reality layer, corresponding to the direction that the user must follow. Although, none of these differences acts alone, the spatial location depends on many factors such as sight, location awareness, experience, environment, and even the state of mind are important for sound localization.
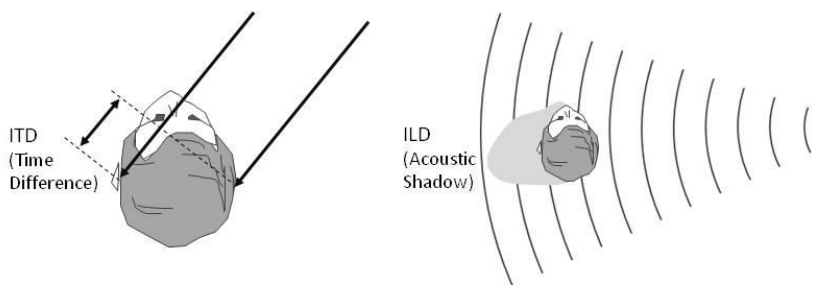

Image 1: Diagram explaining how sounds reach both ears in Holophonic system

The ARGUS User Terminal incorporates an Acoustic System, which receives the user's position from the Positioning Unit. The user perceives an additional reality layer of useful information, giving all the necessary stimuli to guide users naturally through a virtual pathway. Not just with a virtual 3D sound, but also with detailed audio descriptions of Points of Interest, services, and many environmental information.

Users can customize the system choosing among different sounds and adjusting parameters like volume, or speed of sound. Others will be automatically set up depending on the usage context and environment. The system will self-adjust its loudness to be heard but not disturbing in any area.

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In addition to the navigation system an online service will support in-situ routing assistance and a web-based collaborative environment including a social network will be used.

5 USER REQUIREMENTS GATHERING

The ARGUS project tackles a problem faced by many people with visual impairment in getting from one place to another. The project team wanted to check that the initial assumed user requirements were correct and if not to suggest alternatives. A survey was conducted using a questionnaire answered either in a face-to-face interview or online. There were 82 replies in total coming from Spain, UK, Germany, Italy and Austria.

Additionally to the user requirements, use cases were identified as well. The results of the questionnaires were analyzed and then discussed at a user workshop at UK.

The user survey of requirements showed that there was a need for a system, which would enhance the mobility and independence of blind and partially sighted people.

The main points of emerging from the survey were:

- The monetary value of such device and how it should be paid for.
- Users will not use ARGUS alone but as an aid to route finding.
- The security and safety of such a vulnerable group is important.
- Most beneficial when used in conjunction with public transport information.
- The helpfulness of a sound interface had to be validated by a Preliminary Proof of Concept test.

The survey confirmed the main requirements initially proposed for ARGUS.

6 WIZARD OF OZ PROTOTYPE

In parallel to the user requirements, the ARGUS team has developed a tool that allows testing the system setting up different parameters to configure the binaural sound and different User Interface options in an easy way. The Wizard of Oz tool helps to validate requirements, and can be also tested to train test subjects.
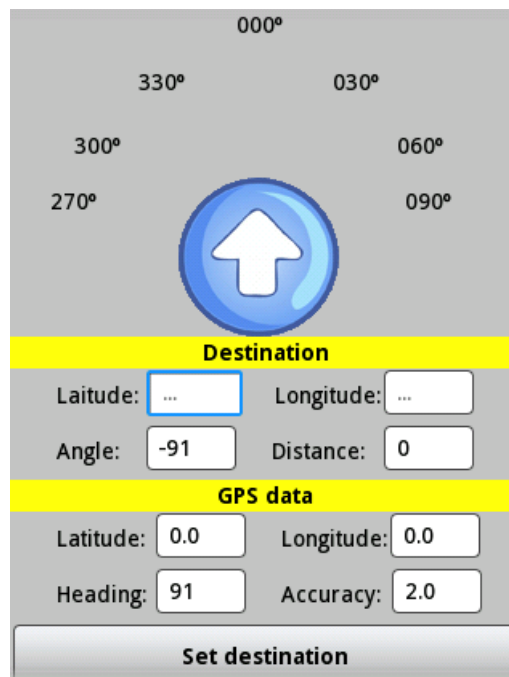

Image 2: Screen of the Wizard of Oz application

7 USER TERMINAL

Within ARGUS, the users play a major role. Based on interviewing sessions with them, the matter came up that they do not want another device but use their Smartphone.

Due to the fact that current Smartphones do not support the position accuracy and integrity required in ARGUS, the project decided to develop a separate localization and navigation module as a black box without

any visual user interface. The localization and navigation module is aimed at providing information like the high accuracy position, heading and velocity to the Smartphone supplying the precision needed by the ARGUS device.

The main user interface is realized in the ARGUS application on the Smartphone which is capable of guiding the user along pre-defined routes, using acoustic 3D sounds and haptic signals, and allowing Internet access for remote service supply and navigation position augmentation. Finally, it has to be stressed that the application for the Smartphone has been designed in order to be portable to current dominant mobile platforms such as Android, iOS and other mobile OS.

Key localization features:

- Position augmentation for precise positions.
- Quality check to indicate position accuracy.
- Safety-relevant integrity check.
- Additional measurements to bridge GNSS signal outages.

Image 3: User Terminal diagram: GNSS + Localization and navigation module + Binaural Guidance + Smartphone

8 ARGUS WEB SERVICES

The route calculation is one of the main ARGUS features. In order to generate the route from the origin to the destination, two options are available: pre-recorded tracks that can be used and a routing algorithm that calculates the best path to reach the destination from the origin point.

The optimal route is determined taking into account the restrictions or preferences of stored POIs. Pre-recorded tracks can be natural routes which are available in the multilayer cartography, or those previously generated by other users of the ARGUS system and published on the social network for other users to make use of them.

Furthermore, routes can be supplied with surrounding protection levels areas through the web-based application. The GEOCorridor® function enables additional route supervision by providing the possibility to define safety zones around given routes. An alarm is generated if the user leaves the safety zone marked by the GEOCorridor® function.

Additionally, by means of the dedicated social network, users can include their feedback and publish their experiences while using the ARGUS system. This personalized annotations become part of the multilayered data, thus the route calculation algorithm can consider it in further path generations.

9 PRELIMINARY PROOF OF CONCEPT TESTS

Preliminary Proof of Concept [PPoC] user tests have been carried out in Paderborn (Germany) in September 2012.
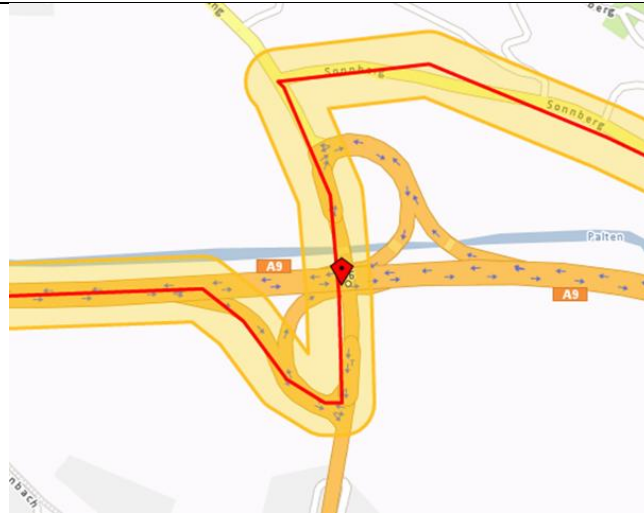
Image 4: map section with a route surrounded by a safety zone

A preliminary functional prototype with basic functionalities and using beta developments was tested by four expert users with different visual impairments who participated in these tests to technically assess the concept and to feed the project with the results obtained.

The outcomes of this PPoC have been very encouraging. All users successfully accomplished assigned navigation tasks, and low deviations from control points were achieved.

Only 5 minutes training on users was required to obtain good performance with the ARGUS system.

Key citation: "Before the test, I have to admit, I was very sceptic that this would work. I was very positively surprised after the first test with the Vibe. The headphones still allowed me to hear ambient sounds without missing the direction from where they were coming and the guidance sounds were not interfering with the ambient sounds. The navigation itself was very easy to follow and so precise that I hit two of the cones marking the track to follow. The GPS signal communicated via the binaural sounds was steady and kept me straight on the path to follow"
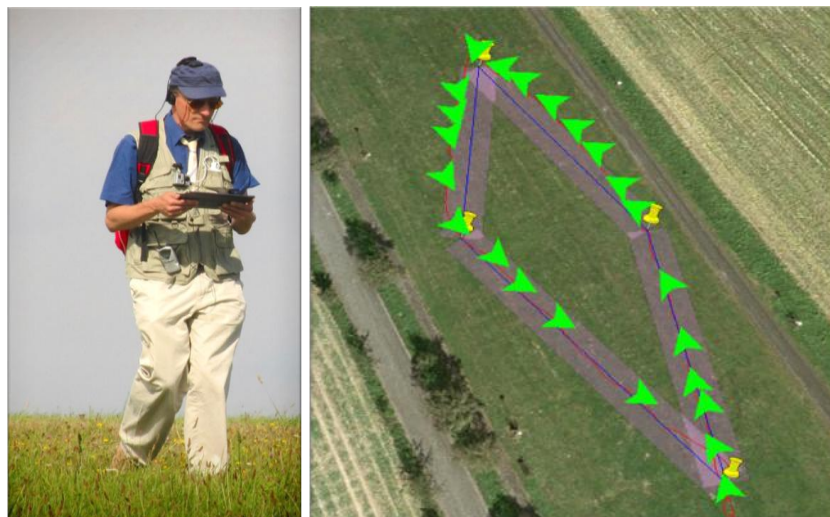

Image 5: User and route of proof of concept test

10 CONCLUSION

During testing and conversations with the potential users, most said that they would be interested in buying the ARGUS solution.

The interesting thing about the ARGUS product is that it will enable a larger accessibility of users to the city as it is useful to various sub-users groups.

ARGUS for most users will not be an alternative to the solutions already used, but an additional aid to support confidence and autonomy when moving around the streets.

It will not eliminate the use of some available solutions like the cane or the guide dogs. The cane will still be useful for detecting the closet obstacles but ARGUS will mean an additional aid to support confidence and autonomy when moving around the streets. Persons with guide dogs outlined that the system would allow them to choose additional ways to their destination instead of relying only on the trained route of the guide dog"

For example, ARGUS is of interest also for people with guide dogs. They outlined that the system would allow them to choose additional ways to their destination instead of relying only on the trained route of the guide dog. This does not imply that the ARGUS solution will be able to substitute a guide dog; it recognizes obstacles and guides them around road works while the ARGUS system would take over the guidance. Furthermore they outlined that they even would like to use ARGUS when walking accompanied by an assistant.

Even on familiar routes the system would make their lives easier, as it is a comfortable way to find the right directions without the need to count meters or crossings which is exhausting, especially after a long day at work.

The system significantly reduces the required mobility training of people with visual impairments since they can walk unfamiliar routes alone – even for the first time.

11 ACKNOWLEDGEMENTS

12 REFERENCES

http://www.projectargus.eu
http://www.haptimap.org