4.13. Sensory Assistive Technologies for Impaired Persons

Project	Sensory Assistive Technologies for Impaired Persons
Organisation	Robotics, Brain and Cognitive Sciences department of the Fondazione Istituto Italiano di Tecnologia
Research location	Genova, Italy
Cooperation partners	Ten partners are involved from a variety of countries, see Organisational background section
Team	A senior researcher, three postdocs, four Ph.D students, three part-time technicians
Funding sources	Fondazione Istituto Italiano di Tecnologia (www.iit.it) European Commission (ec.europa.eu) Ligurian Region (www.regione.liguria.it) Fondazione Vodafone Italia (www.vodafone.it)
Website	https: //www.iit.it/people/luca-brayda

ORGANISATIONAL BACKGROUND

The project team is led by Dr. Luca Brayda from the Department of Robotics, Brain and Cognitive Sciences of the Fondazione Istituto Italiano di Tecnologia in Genoa, Italy. The team consists of a senior researcher, three postdocs, four Ph.D students, three part-time technicians (engineers, electronic and mechanical designers) all from the same department and a Master's student from Facoltà di Scienze della Mente, University of Turin, Italy.

The project involves collaboration with 10 partners:

1. Director of the Childhood unit at the Istituto David Chiossone onlus, Genoa, Italy
2. Professor, Head of the Microsystems for Space Technologies Lab, at the Ecole Polytechnique Fédérale de Lausanne, Neuchâtel, Switzerland
3. Director of the private company Geomobile GmbH, Dortmund, Germany (software design)
4. Operational Director at Ateknea solutions, Budapest, Hungary (Design and building of custom electronics to power tactile stimulators)
5. Director of Fundacja Instytut Rozwoju Regionalnego, Krakow, Poland (contact with end-users and their families, recruitment of blind and visually impaired persons, co-design of experimental protocols)
6. Former Director of Clinical Neurophysiology from Neuroscience, Rehabilitation, Ophthalmology, Genetics and Childhood Sciences dept. of the University of Genoa, Italy (Co-design of experimental protocols and methods to assess spatial abilities)
7. Researcher at Istituto di Bioimmagini e Fisiologia Molecolare, Consiglio Nazionale delle Ricerche, Genoa, Italy (Analysis of neurophysiological data, dissemination)

8. Researcher from Dipartimento di Ingegneria dell'Informazione, University of Padua, Italy (Co-design of experimental protocols for sonification of virtual objects)
9. Engineer at Linear Srl, Genoa, Italy (contact with hearing impaired persons, building and testing of hearing aids)
10. Professor from Department of Naval, Electrical, Electronic and Telecommunications Engineering of the University of Genoa, Italy (Design of sound-filtering algorithms for GLASSENSE)

FUNDING

The BlindPAD project was funded by the European Commission under the FP7 programme.

The TActile MOuse project was funded by Fondazione Istituto Italiano di Tecnologia and co-funded by Fondazione Vodafone Italia under the Digital For Social funding programme.

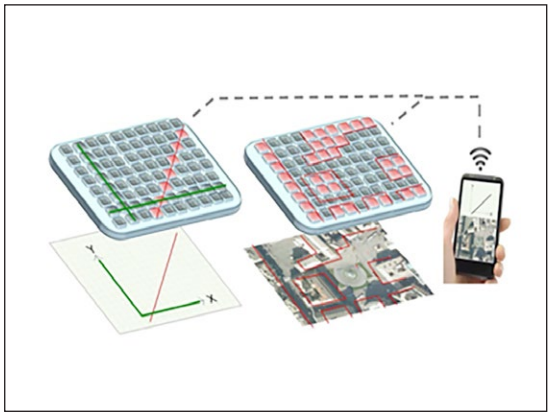
The Glassense project was funded by the Ligurian Region (Italy) under the five-year development funding programme.

PROBLEM BEING ADDRESSED

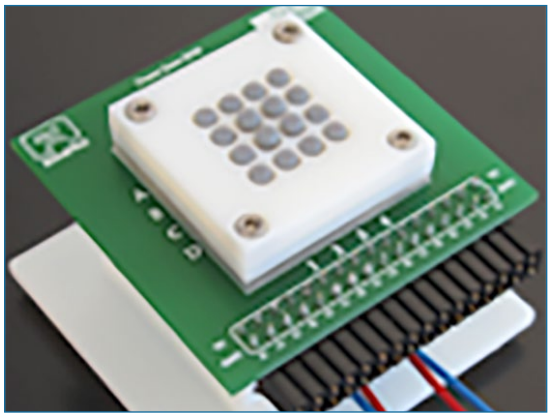
The goal of the research project is to narrow the gap between people with disabilities in society and access to environmental information. This goal is addressed in two steps: first the focus is on understanding the best ways to exploit the residual sensory abilities of impaired individuals; second, these abilities are enhanced by building and field-testing three novel sensory assistive aids. The specific targets are on visual and acoustic impairments. Digital content is being increasingly conveyed visually, which is a serious issue for people with vision loss. Therefore the study is about ways of translating visual information into tactile content through the phenomenon of sensory substitution. The team is developing multiple prototypes: the BLINDPAD, a tactile tablet, and the TAMO, a tactile mouse for blind people. These products are meant to support the acquisition of digital content, mathematics and maps. Another product is the GLASSENSE, a novel pair of intelligent glasses, which is an aid intended to complement hearing prostheses. The prototypes are being validated in a rehabilitation setup with target groups. These products will aid understanding of how the brains of sensory-impaired individuals can effectively acquire spatial information from residual sensory channels.

RESEARCH DESIGN AND SOLUTION

The research team is investigating how sensory-deprived people compensate for missing sensory channels by vicarious modalities. In the case of visual impairment, the research addresses new ways of exploiting the sense of touch to help blind and visually impaired persons to learn scientific content, access digital information and navigate in unknown environments. In the case of hearing impairment, the research approach is based on novel ways of presenting sound to hearing-impaired persons and increasing their spatial awareness. The ultimate goal is to build low-cost solutions to narrow the digital divide, therefore increasing social inclusion.



The GLASSENSE, the 'acoustic lens' for people with hearing impairment



Concept and prototype of BLINDPAD (Personal Assistive Device for BLIND and visually impaired people)

The TActile Mouse for blind people

GRAND CHALLENGE BEING ADDRESSED

By improving access to digital and environmental information, the research empowers disabled persons by offering them new possibilities. The main societal challenge is to reduce unemployment among individuals with visual and hearing impairments by improving their communication abilities, their mobility and their overall quality of life. European countries and their welfare and educational systems have divergent ways of rehabilitating visual loss, none of which are pushing towards technologies enabling independence and self-rehabilitation. This divergence is mainly due to the lack of accessible technologies, not to the lack of capacity among disabled people: the brain can adapt to new sensory conditions but this cannot occur when information is not accessible. For example, tactile maps and diagrams are bulky, expensive and not tailored to user needs. The use of the internet without sight is very difficult. For people with impairments, social exclusion results from the consequent lack of communication and mobility. Expensive hearing aids worsen the brain's ability to discriminate speech in noisy environments and there is still no solution to the further deterioration in the socialisation capabilities of both young and older people.

Although the present research helps to train the brain in alternative ways, the technologies are not prostheses, but non-invasive assistive tools. These are seen as useful tools or serious games, not as therapies. The research team is specifically targeting social communication based on the tactile tablet and a tactile mouse, which can be used with millions of web pages and social network profiles. For visually impaired persons, independent access to digital

information is crucial during childhood (when developing logical-mathematical knowledge), at developmental age (the internet is pervasive in communications between young people) and during adulthood (visual impairment correlates with high unemployment rates). When hearing impairment occurs, the products can help the brain to process speech in crowded environments, thereby preventing social isolation. Disabled persons who are more communicative, less isolated and more active will dramatically reduce welfare costs.

RESPONSIBLE RESEARCH AND INNOVATION

The researchers have developed strong links with societal actors, i.e. rehabilitation practitioners, teachers and families of end users. The assessment of the Tactile Mouse and the prototypes of BlindPAD have been monitored by stakeholders and policymakers (e.g. Institute Chiossone Onlus and Fundacja Instytut Rozwoju Regionalnego for blind subjects). The prototypes were tested using serious games that were co-designed and validated by school educators and rehabilitation practitioners. Based on the interaction with these stakeholders, the team was able to develop experimental protocols and share these between partners through a cloud-based platform. The results were disseminated to citizens throughout society in exhibitions centred on disability and the technologies were shared and developed with industrial partners that can exploit them in their product portfolios. There were contacts with these user groups and stakeholders throughout the project and during testing of the products.

The team involved three groups: children aged 6-12 years, young people aged 13-18 and adults aged over 18. The three groups were addressed with specific serious games, each designed and targeted to suit their age, spatial abilities and previous training. People with mild or no disabilities were recruited as control groups. The whole sample is replicated in two European countries: the research is multi-centric, with multiple European rehabilitation institutes contributing their different practices. This leads to considerable mutual enrichment, which is unique in the research context and very rarely done in clinical settings. The team shares research goals, experimental setups and findings with rehabilitation institutes for visually impaired people, experts in hearing impairment and centres building hearing aids. Rehabilitation practitioners co-create inclusion criteria, are constantly present during experiments and offer clinical perspectives. Based on the findings, the team has developed assistive aids with hardware and software companies which will help to make the products marketable in future.

Alongside scientific partners, the team included four main stakeholders: target groups, their families, rehabilitation centres and schools. Dissemination at exhibitions dedicated to sensory impairment ensures continuous feedback from potential future customers, thereby reducing risks.

The novel ways of stimulating the senses of touch and hearing of disabled people, as well as the three novel products, were unknown to traditional practitioners. Regular communication and meetings convinced practitioners to go beyond daily procedures and not only to try out the new techniques, but to actively participate in evaluating them. Although scientists and rehabilitation practitioners seem to speak different languages, what motivated the joint effort is the common goal shared by the research team and stakeholders which is to improve the quality of life of people with sensory losses.

The project methodology is to offer tools that do not replace but complement rehabilitation practices, which are not altered. The research is therefore synergistic with rehabilitation and represents a bottom-up process: experimental data and feedback from target groups are used to improve the type and amount of stimulation provided by the devices. The devices are turning out to be easily accepted: this is crucial, since assistive aids frequently fail to elicit interest among

those actually using them. Results are shared with the target groups: the parents of disabled children are invited to give comments; schools regularly visit the team's research site; practitioners are participating in interpreting experimental findings; flyers, news on digital social media and on websites are all distributed and updated regularly.

The user studies show that a graphical tablet for blind persons such as BLINDPAD is a highly desired solution for displaying scientific content. The findings also show that speech sources covered by "cocktail party" noise can be identified better when wearing the GLASSENSE device.

The mid-term impact is a wider assessment of the products with the stakeholders. This research part is ongoing. The motivation stems from the need to personalise the accessible information that is displayed. The research team has shown that individuals with different etiologies and disability onsets have to be treated differently. Case-by-case personalisation of sensory stimulation is changing our way of doing research, which traditionally uses the same protocol for all subjects in an experiment. The long-term impact of this is industrialisation. Stakeholders, such as rehabilitation centres, are a key factor. If they are the first buyers of the products and training aids then the impact is very likely to be high and well understood by the target groups.

EVALUATION AND DISSEMINATION

The research is coordinated by a small group of mainly young researchers and involves collaboration with a number of other research groups and practitioner organisations. The project team disseminated its findings well to civil society and policymakers. Contacts with industry seem to be at an early stage. Upscaling of the products is included in the design and contacts are currently being made with three European countries and one developing country. In total 22 publications were provided dating since 2012. Seven publications have been published in scientific journals and fifteen in conference proceedings of which three were based on conference workshops. The journals included *International Journal of Human-Computer Studies, IEEE Transaction on Haptics* and *International Journal of Social Robotics.*