AsTeRICS: Assistive Technology for All

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Abstract: Millions of people all over the world have problems with their upper limbs and often depend on Assistive Technologies for accomplishing their daily life activities. From the wide spectrum of Assistive devices found in the market only few of them are flexible enough to adapt according to the changing needs of the patient. The AsTeRICS EC-funded project aims to provide a flexible and affordable construction set for building assistive functionalities which can be highly adapted to individual user's needs. The modular system architecture of the runtime system allows pluggable software components to dynamically form applications which run on the AsTeRICS embedded platform. Moreover, a configuration suite enables the graphical design and customization of assistive applications. This paper presents an overview of the AsTeRICS project, our objectives, the work done so far and plans for the future.

1. Introduction

Assistive Technologies (AT) support a great number of people with disabilities in Europe and worldwide [1]. AT devices are continuously increasing and extending their capabilities. To date several devices are available, providing a wide spectrum of assistive applications that can improve the quality of life. However, since the potential of each individual user is very specific and their situation may change radically since the day of purchase, adaptive solutions are needed to enable these people participate in modern society. Such systems are rarely available on today's market.

AT devices often require adaptation of software and/or hardware before they can be used for the specific needs of each user. Devices that have been specifically designed for particular applications cannot be used in slightly different environments without serious customizations. Therefore, the daily life activities of disabled people are restricted, either because AT devices cannot be adapted to meet their needs, or due to the unaffordable costs for the device per se or for the necessary adaptations.

The AsTeRICS (Assistive Technology Rapid Integration & Construction Set) project will provide a flexible and affordable construction set for building assistive functionalities which can be highly adapted to the changing needs of each individual. The scalable and extensible system allows integration of new functions without major changes. AsTeRICS opens access for people with severe motor disabilities to a standard desktop computer but also to embedded devices and mobile services, which have not offered highly specialised user interfaces before.

AsTeRICS is not the first project in the area of AT. Taking into consideration the plethora of relevant European Projects we aim to minimize overlapping and reuse common knowledge and technology, if and whenever possible. For example, the TOBI project [2] focuses mainly on the design of non-invasive BNCI prototypes that combine existing assistive technologies and rehabilitation protocols. Much like AsTeRICS, the goal in this area is to improve people's communication potential and opportunities by providing access to a variety of devices such as virtual keyboards, internet, email, telephony, fax, SMS and environmental control. We believe that AsTeRICS and TOBI share similar goals, especially on the BNCI part of our project. We enable brain computer interaction through the Enobio [3] biosignal unit, supplied by our partner STARLAB.

The BRAIN [4] project aims to enhance intercommunication and interaction skills of disabled people through the development and integration of Brain-Computer Interfaces into practical assistive tools. The goal is to improve user interaction with other people, home appliances, assistive devices, personal computers, internet technologies, etc. BRAIN is specialised on BNCI based user interaction and aims to augment its reliability, flexibility, usability and accessibility by improving the main components of BNCI systems: signal acquisition, operating protocol, signal translation and application. Although BRAIN is mainly focused on BNCI technologies we aim to a close collaboration between the two projects to share knowledge in BNCI and other relevant aspects.

BrainAble [5] is a European collaborative project started in January, 2010. Its main objective is to improve the quality of life of people with disabilities by overcoming exclusion from home and social activities. They aim to provide an ICT-based human computer interface (HCI) composed of BNCI sensors combined with affective computing and virtual environments. Much like AsTeRICS, BrainAble aims to produce a set of technologies suitable for assisting people with physical disabilities regardless of cause. Being specialized on human-machine interfaces for the disabled, BrainAble can provide valuable information on interfacing with ambient devices in living environments as well as outer virtual environments, such as social network services. We aim to investigate the possibility of reusing HCI knowledge developed during the BrainAble project, whenever possible.

Finally, Future BNCI [6] is a European project of the seventh framework, started in January, 2010 and aims to help BNCI research community to explore future directions in the emerging class of the so called BNCI systems. Through a series of dissemination activities, Future BNCI aims to provide information for the BNCI community and explore the best future research opportunities in different aspects of BNCI research. AsTeRICS aims to keep constant communication with Future BNCI and its activities.

With this paper we aim to give an overview of the AsTeRICS project, discuss our objectives and how we plan to achieve them. Also we present our methodology and technical approach and discuss how we plan to advance the state of the art in the area of Assistive Technologies. In particular, section 2 presents the project’s objectives and the basic principles followed in order to achieve them. Section 3 describes the project methodology and section 4 presents technical implementation details. Section 5 presents the current development achievements and our user-based evaluation approach. Finally, section

6 discusses the business advantages of the AsTeRICS project and Section 7 concludes the paper with a summary of the presented work and our plans for the future.

2. Objectives

Over the last decades a considerable number of information and communication technology based Assistive Technology (AT) devices have become available for people with disabilities. These AT devices often ask for adaptation of software and/or hardware to fit the user's abilities and needs before they can be used. Quite often, assistive technology that has been optimised for particular applications cannot be used in other situations out-of-the-box. Additionally some people cannot be supplied with AT devices at all, due to the limits of adaptability or unaffordable costs of the necessary adaptations.

The aim of the AsTeRICS project is to change this situation substantially. AsTeRICS provides a flexible and affordable construction set for user driven Assistive Technologies or assistive functionalities. Sensors and actuators are linked together via an embedded computing platform (or alternatively the desktop PC or laptop) and a configuration suite offers the interface to set up and configure them. Therefore the AT realised with AsTeRICS facilities can be tailored to the user's abilities and needs without high adaptation and configuration effort.

We plan to achieve our objectives by following some basic principles:

- The reuse and integration of standard sensors and actuators. No new devices or interfaces for the devices need to be developed and users do not have to buy new devices.
- The combination of all components on the AsTeRICS platform. All signals from all sensors, being attached to the AsTeRICS platform can be processed, filtered, merged, and combined before being sent to the actuators.
- The easy configuration and adaptation of the components using a configuration suite reduces the effort, tailoring the platform to the needs and requirements of the users.
- The openness of AsTeRICS allows the easy extension with new sensors and actuators. The openness will be reached by putting the main parts of the software under an open source license.
- Due to the integration of leading edge technologies like human-computer-interfaces (HCI) and eye tracking, new users can be reached, where other AT is not (fully) adequate to support them.

Overall our goal is to enable more people with disabilities to participate in the digital society and living a more independent life.

3. Methodology

The project follows a user-centric methodology which guarantees that the user interfaces will be well usable and accessible for a wide range of users with different capabilities. The system development and evaluation methodology is composed of the following, chronologically ordered phases:

- In-deep analysis of the users' requirements.
- Detailed analysis of the system architecture and the optimal hardware and software components to be used based on the analysis of user requirements and availability of products on the market.
- The hardware and software modules are developed in a 2-stage approach: A first prototype serves as a proof-of concept for functionality and interconnectivity of the system-components, the final prototype will include improvements and refinements of the modules. Between the two design stages, an intermediate user evaluation is planned for the first Prototype. The results of this user evaluation will be considered in the

redesign phase for the final prototype. Concurrently, a second technology analysis will be carried out and take into account recent developments and new products, to allow their integration into AsTeRICS.

This 2-stage approach allows the consideration of results gathered in the first user evaluation phase and possible optimizations of the architecture and the software algorithms. The second design stage will fully support industry compatible design processes and result in optimized hardware modules with lower power consumption, customized printed circuit boards (PCBs) and enclosures. The software will feature fully elaborated user interfaces so that the system is ready for the final user tests.

The system integration will evaluate interoperability and functionality of the system-as-a-whole. As essential part of both design stages, their corresponding integration steps will bring the system to live and prepare setups for the user tests.

The user tests and system evaluations are expected to reveal concrete impacts of the tailored AT-approach and comparisons of the achieved results against the conventional / prior solutions. These comparisons in terms of benchmarks, interaction / communication rates and achievable tasks will be an integral part of reports, publications and the scientific dissemination of the developed system.

4. Technology Description

The requirements for the technical implementation of the AsTeRICS architecture were deduced from the user requirement findings. At the core of the AsTeRICS platform there is an embedded computing system, executing the AsTeRICS Runtime Environment (ARE). The latter is based on the Java OSGi framework [7] which enables dynamic plugging and un-plugging of 3rd party components, and provides the basis for a scalable and modular system.

The pluggable components are either sensors which provide input to the system, processors which process incoming data or actuators which allow the system to interact with its environment.

As shown in Figure 1 sensors and actuators are connected to the embedded computing platform by wire (USB, Ethernet) or wirelessly (Bluetooth, ZigBee) via Communication Interface Modules. The system can be configured remotely using the AsTeRICS Configuration Suite (ACS), which provides a graphical user interface to set up and tailor the components to the specific needs of the primary user.

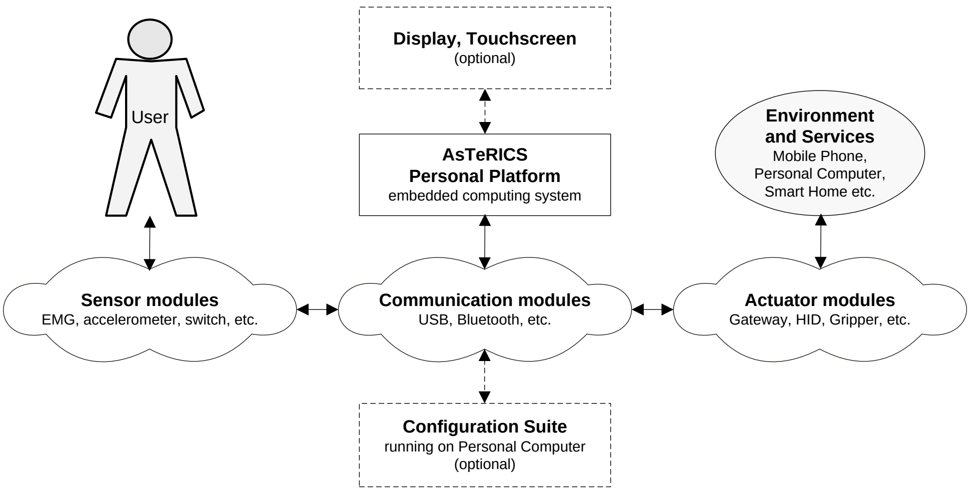

Figure 1: Schematic concept of AsTeRICS

Examples of sensors include classic AT-interfaces such as switches and special joysticks but also emerging sensor techniques like Computer Vision and Brain Computer Interfaces (BCI). Actuators include simple switches and digital-to-analogue conversion but also more complex modules like keyboard-, mouse- or joystick emulation, generic infrared remote control, KNX [8] interface to existing building automation systems or mobile phone access. If desired, an On-Screen Keyboard displayed on an optional LCD-touchscreen provides selection or adjustment of system parameters via scanning, voice-feedback and touchscreen interaction. The system can be configured remotely using the AsTeRICS configuration suite, which provides a graphical user interface to set up and tailor the components to the specific needs of the primary user.

5. Developments & Results

According to our methodology plan a user requirement collection involving 33 persons in three users' sites was composed of a different subset of primary (people with disabilities) and secondary users (professional care givers). Primary users sample was composed of males and females, aged between 18 and 91 from Spain, Austria and Poland. 54.5% suffered from tetraplegia, 21.5% paraplegia, 9.1% spastic tetraparesis, 6.1% hemiplegia, and 8.8% from other type of mixed motor disabilities.

For the evaluation of primary users in Spain, Austria and Poland, a common extensive questionnaire was used. All participants were informed about the project and signed a consent form for their participation in the study.

Results from technology used from the user requirement collection involving these persons concluded that:

- 97% of the users are able to use a PC regardless of their disability (email exchange 72%, chatting 57.6%, reading and watching films 48.5%, general internet use 48.5%, videogames 36.4%, work 21.2%).
- 32.3% of the PC users could not use the standard mouse at all and 35.5% could use it with difficulties.
- 81.8% of the users could use a mobile phone, but only 21.2% of those could properly use the numeric pad. 57.6% could send SMS messages, but only 24.4% without any difficulty.
- 72.7% of the queried users had never used before Smart Home facilities (e.g. to open doors, control lights, blinds, temperature or home entertainment devices) and would like to do so.

Secondary users' sample comprised of 46 males and females, aged between 21 and 70 years old. Different general user profiles in each country have been considered. According to secondary users, primary users use different technology systems to cope with their daily live activities: electric wheelchair to move, different devices to interact with the chair, computer and environment, and different systems to speak if they also have communication problems. The main issue for them is dealing with activities of daily living and environmental control. Regarding the primary users' psychological needs, the main problem seems to be the dependence and the related lack of privacy, frustration and leisure limitation. Stigmatization issues and aesthetics have been also addressed as a crucial issue for technology acceptance. The main domestic barriers are doors, stairs, small rooms and the difficulties to reach control buttons. Outside, the most referred barriers are public transportation-related. In all of the cases the technology is evaluated as a relevant approach to cope with the disabilities.

From the results of our requirements elicitation process we can conclude that there is a great need for supporting these people in their everyday common activities via computer-based solutions. The most desired use-cases for the AsTeRICS platform include: studying and learning via internet/IT-based technologies, communication with friends and family, obtaining information about the local environment and leisure activities like playing videogames or e-shopping on the internet.

The main building blocks of the runtime environment have already been defined and the overall system software architecture is in a stable version for the first prototype. An initial set of pluggable components has been developed, which allows the design of functional AT-configurations. Benchmark tests with the hardware platform have been accomplished successfully. The AsTeRICS Configuration Suite can already be used to graphically create AT-setups. First functional setups include a camera mouse application and a joystick controller via movement detection (IMU sensor).

For the AsTeRICS personal platform an embedded system built on a Pico-ITX board [9] with an Atom Z530 processor has been used. The platform features a control panel with a graphical display and navigation keys, 6 USB ports which can be used to interface with other modules, 4 general purpose input channels, and 4 general purpose output channels which can be used to interface with sensors and actuators.

The following modules are also included in the first prototype:

- General Purpose Input / Output (GPIO): this module offers 8 general purpose inputs and 8 general purpose outputs which may be used to interface to various sensors and actuators.
- ADC/DCA: this module offers 8 Analogue-to-Digital Conversion (ADC) inputs and 4 Digital-to-Analogue Conversion (DAC) outputs.
- Accelerometer module: a triaxial acceleration sensor with which the user can control other devices.
- Universal HID-actuator: this can be connected to another PC and work as a computer mouse, keyboard or joystick.

All these hardware modules communicate with the AsTeRICs platform through the USB interface.

Also the main software components have been developed and are functional for the first prototype. ARE is built using the OSGi framework. It is designed to deploy on embedded systems such as the AsTeRICS platform. It provides the runtime environment in which the AsTeRICS models execute; it can run, stop, change and reconfigure the current model. The ARE incorporates a set of about 60 components which may be used in user models. Actions performed by the components can include:

- Signal processing
- Interface with hardware modules: AsTeRICS platform, GPIO, ADC/DCA, Accelerometer module, HID-actuator
- Control of mobile phones
- KNX home automation[8]
- Infrared Remote control
- Text to speech synthesis
- Face tracking (using web-camera)

ACS provides a graphical-interface editor for creating ARE models; the user can already build a model using graphical blocks. The ACS can also connect to the ARE using a TCP/IP network connection to upload, start and stop models.

The runtime environment can be also integrated with Enobio [3] and Oska [10].
Enobio is a BNCI sensor system which can be used to control AsTeRICS via EEG (electroencephalogram), EMG (electromyogram) and EOG (electrooculogram).

Oska is an On-Screen Keyboard Application for people which have difficulties using traditional computer input methods. It allows a user to generate keyboard input using techniques like scanning and alternative interfaces. Oska is included as an AsTeRICS main screen application.

The AsTeRICS prototype will be evaluated in three countries (Austria, Poland and Spain) with users with motor disabilities in upper limbs due to heterogeneous sources (multiple sclerosis, cerebral palsy, CVA, TBI, spinal cord injury) and with multiple motor capabilities as a consequence (hemiparesia, hemiplegia, paraplegia and tetraplegia). The project will also collect opinion about AsTeRICS from Assistive Technology Experts, Therapists and family members of people with disabilities. The results of the first prototype evaluation will be ready to be reported in September 2011.

6. Socio-economic Impact

The AsTeRICS platform, due to its flexibility, adaptability, configuration options and open core source code, has the potential to satisfy the needs of AT clients and become a significant product on the market. Furthermore, we believe that the low cost of the platform will make the product very competitive on the market. We aim to make the AsTeRICS platform the basic technology that people with motor disabilities will use for mobility and communication, and for operating computer and household equipment.

This will be an incentive for companies to invest in the AsTeRICS solution. AT companies may be able to produce the AsTeRICS system, extend the capabilities of their products by integrating AsTeRICS with their platforms, and may add value by developing sophisticate components, providing consultation, configuration of users' systems and end-user AsTeRICS training.

Furthermore, we expect to significantly reduce the amount of money that people with disabilities need to spend. Currently most of the devices in the market are specialized for very specific conditions. As the patient’s condition changes new devices are needed or devices already bought must be adjusted. With AsTeRICS we aim to provide a flexible solution that will enable the composition of applications adjustable to the patient’s changing condition. In order to make the AsTeRICS platform competitive in the market we follow an open source strategy where developers can provide their AsTeRICS plugins in order to integrate their products with the platform and other products also available in the market. The provided architecture is flexible enough to allow interconnection with any type of devices and we aim to provide documentation, wiki pages and ready-to-use code examples to motivate developers to implement AsTeRICS plugins. This will eventually lead to a competitive platform where plugins from several providers can participate to the composition of specialized assistive applications.

Apart from the economical impact, due to the raise in assistive devices development competition, we expect to have impact to sociological aspects as well. We aim to improve the quality of life of people with disabilities and enable more people with disabilities to participate in the digital society. Our overall goal is to allow end-users to live a more independent life.

7. Conclusions

AT today mostly focuses on specific applications. Due to the growing importance of the desktop computer, AT has been oriented towards standard Human- Computer or desktop interfaces. We believe that by providing an open architecture and integrating various sensors and actuators into a rich AT-infrastructure, AsTeRICS respects the strong need for flexible, adaptable AT functionalities accompanying people with disabilities away from their desktop, enabling them to interact with a diverse and fast changing set of deeply embedded devices in their ambient environment.

The first prototype of the AsTeRICS platform is already available and is going to be evaluated on July 2011. The results from our first user tests are very encouraging from both the primary and secondary users' perspective. In particular, end-users have provided very positive feedback due to the ease of use and flexibility of the platform. Based on the user evaluation we will extend and improve the framework for the next prototype. Our goal is to use the AsTeRICS prototypes for creating novel approaches to alternative user interfaces, and to evaluate and document the outcomes with the help of user tests and comparisons to traditional solutions.

Currently the first prototype of the AsTeRICS platform is already available and under user evaluation in three European countries. We aim to build on the user test results in order to provide a reliable platform that enables flexible and affordable composition of Assistive applications. Although the feedback from the first user tests is very encouraging, combining technologies from several providers of assistive technologies is not an easy task. The lack of standardize development approach as well as the commercial licenses of software to be integrated, as well as the competition between companies, often hinders our efforts. We encourage projects in the area of AT to follow an open source approach and consider the use of the AsTeRICS platform as the basic framework for their implementation.

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