A Technology Transfer Model Focused on Assistive Technology: Center of Assistive Technology – CETA, a Venezuelan Alternative

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***Abstract*— Assistive Technologies (AT) are technological solutions that provide a disabled person interaction and integration with the environment that surrounds them. The devices and solutions provided by AT are generally specific and personalized (ad-hoc) for each patient or group of patients and are seldom intended for massive distribution, making AT solutions expensive and of limited availability. In developing countries, AT are even more sparse and expensive either because of the low overall income and/or the lack of commercial interest of national producers. Therefore, the import of AT solutions is sometimes the only viable choice, insuring a high-cost low-availability scenario. However, technology transfer schemes (demand-pull and supply-push) with universities and technology park institutes can provide an alternative for the design and development of AT. These research centers count with highly qualified personnel and multilateral financial sources, thus being able to support and host AT centers. This is the case of the CETA-USB: Center of Assistive Technology of Simón Bolívar University, in Venezuela. For three years, CETA-USB has been researching, designing and developing AT, with the purpose of offering affordable alternatives to the Venezuelan handicapped community. Its mission is to perform research, development, education and service in order to increase knowledge, satisfy the needs and serve the handicapped community. Its vision is being an integral and multidisciplinary reference center of research, development and service provision of solutions for limited income handicapped people, adapted to the Venezuelan socio-cultural reality. This paper covers the research lines (at undergraduate and graduate level), accomplishments (the center's evolution, publications and projects) and products (communicational, robotic and therapeutic devices, interfaces, etc) obtained by the CETA-USB during the past 3 years. Such experience might be considered useful, as to be shared, promoted and discussed in order to benefit and help disabled and elder people in other places of the world.**

I. Introduction

THE unique characteristics of the various types of disabilities cause assistive solutions to become costly, of difficult access for low income individuals and not attractive for private investors. In the context of Venezuela, many Latin American countries and the developing world, there exist limited or immature (or nonexistent) governmental policies that pay attention to the disabled individuals. That is why the high cost of research and development in AT, especially considering infrastructure and personnel.

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II. Methodology-The CETA Project

A. Mission and Vision

This project has, for a long term goal, the formation of a macro-center of sustainable assistantship to the disabled. The mission and vision that guide the steps to follow for the attainment of the main goal are:

- *Mission:* Founded on October of 2003, the Center of Assistive Technologies of Simon Bolivar University (USB), CETA-USB, is located within the campus of USB, and has for a mission the research, development and education, in favor to increase the knowledge and satisfying necessities of individuals with disabilities and in process of rehabilitation; by means of assistive technologies (AT).
- *Vision:* To become a national and Latin American reference center for research and development of assistive technologies in favor of disabled patient and in process of rehabilitation, with special emphasis in developing low cost and high availability solutions. In order to achieve this objective it will be necessary the generation of processes, technologies and the implementation of a Venezuelan resource center for AT.

B. General Mission and Strategies

The center will function in four interconnected areas, in the form of projects:

1) *Research and Development of assistive devices & disabilities science.*
2) *Education and Human Resource formation.*
3) *Service Provision of AT.*
4) *Dissemination of Information regarding AT.*

The activities being developed are of a multidisciplinary nature, involving the collaboration of students, technicians and professors of engineering degrees (USB, Sartenejas campus) and technical degrees (USB, Litoral campus). Among the departments that could contribute directly (establish collaboration agreements) or indirectly (internships, thesis, or informal collaboration) are: Mechanics, Electronics and Circuits, Computing and

Information Technology, Industrial Technology, Biological Processes Technology and Biochemistry, even Architectural Design and Plastic Arts and Urban Planning. Additional resources include the clinical areas, departments and schools of Physical therapy, Occupational Therapy, Language Therapy, Medicine, Geriatrics and other clinical specialties located at the "Centro Medico Docente la Trinidad" (Teaching Medical Center of the Trinidad), the Orthopaedic Children's Hospital and the National Center of Rehabilitation, in Caracas, Venezuela (for now).

The CETA is expected to become a coordinating center of the four projects mentioned in the beginning of this section, which although interdisciplinary and interconnected will require of a certain level of autonomy. Each one of these projects will count with their own coordinating staff and strategic allies for research, development and financing. In this manner each project will be able to attend the particular needs specific to each project, contribute to the needs common among the projects and service the need of target consumers, such as patients, therapist, students, and so forth.

1) Research and Development of Assistive Devices & Disabilities Science

This project main objective will be to design assistive devices for rehabilitation, education, work, recreation and daily life. The research areas will be divided into: neuro-muscular disorders in children, early neuro-development and communication, inclusion and old age. This projects center will manage research and development based on two points of view from the technological transfer process, each one following a separate program:

- Program of "demand-pull": where the research and development is based on the need to serve the demand of those requiring assistive technology.
- Program of "supply-push": introduction to the surroundings of the patients that require assistive technologies, the novel and innovate contributions generated as product of research and development.

2) Education and Human Resource formation

This Project seeks the formation of human resource through elective courses, undergraduate and graduate programs, at a professional and technical level, focused in the AT. The courses and programs should be adapted to the different disciplines offered to the student population. Outside of the formal academic structure dissemination can be achieved through workshops, seminars, open courses, outreach programs, and private courses for students, professionals and consumers outside the university campus. Another important undertaking is to channel the needs of the four projects and allocate resources in the form of thesis (undergraduate and graduate), internships, etc.

3) Service Provision of AT

This project has a more practical role with a dual nature. One side functions as a center for the design and manufacture of AT, taking advantage of the laboratories and workshops of the USB, serving the needs for prototypes elaboration, adaptation and small scale manufacture of assistive devices of the other projects and external clients (off campus demand). Another side will function as a service center for individuals with disabilities, promoting, commercializing and renting assistive devices produced by the CETA (or some outside partners), additionally serving as a orientation and training center for patients.

4) Dissemination of Information regarding AT

At an initial stage this project will be constituted by a web portal with up-to-date information regarding assistive technologies, including links, forums, email groups, for individuals interested in the subject. A special section will focus in the current research tracks of the CETA and its partners, promoting communication of the center with the global community.

III. RESULTS

Since the foundation of the CETA, three years ago, the project has been presented to numerous institutions in the search of alliances and financing, including the USB. In parallel a number of tangible developments in the form of prototypes and devices, research tracks, and academic developments in AT education. After these three years it is possible to highlight as results the following:

A. Infrastructure

Due to the current economic and political situation of Venezuela, the construction of proprietary buildings for the CETA is not a realistic short term goal. Nevertheless, laboratories spaces have been allocated to the CETA within the campus of the USB and within the city of Caracas where activities and projects are being developed meanwhile.

The space located within the USB campus is composed mainly of a 49 square meter laboratory, shared with another group, the Center of Integrated Circuits Design (CDCI). This shared laboratory offers undergraduate and graduate students with assigned well equipped workspaces. In the city of Caracas the CETA operates within shared spaces belonging to the Gait Laboratory and Prosthesis/Orthopedics workshop of the Orthopaedic Children's Hospital.

B. Research Tracks

Research efforts up to this moment have focused to two main tracks: Movement and Gait Analysis for Disability Characterization and Device Design.

1) Movement and Gait Analysis for Disability Characterization

Loss of movement and motor control is one of the main features of an important number of physical disabilities. A better comprehension of child developmental motor impairments, such as cerebral palsy, and then early intervention to them could reduce future movement and motor control limitations in such patients. The studies in this topics produced results in three areas:

a) Spastic Hemiplegia Characterization

- Applications of gait dynamic electromyography signal for pattern classification in cerebral palsy Spastic Hemiplegia (SH), in order to improve surgical and conservative treatments for gait enhancement [1, 2]
- Characterization of breathing signals in children with cerebral palsy in order to understand energy expenditure issues is pathological gait [3].
- Statistical learning methods of gait patterns for gait features extraction and characterization using support vector machines and contralateral limb analysis [4, 5] (see Fig. 1).

b) Gait Analysis in transtibial amputation patients and performance of prosthesis

- Study of the gait deviations and energetic consumption of transtibial amputation patients (M.Sc. thesis in progress).
- Effects of prosthesis alignment and different types of feet in the comfort of transtibial amputation patients (M.Sc. thesis in progress).

c) Lower limbs movement analysis applications

- Analysis of consistency of gait kinematics patterns, using the variability analysis between strides, in order to evaluate the quality of walk and the effects of treatments in the lower limbs (M.Sc. thesis in progress).
- The relation between oxygen consumption and gait kinematics as indicators of energy expenditure, for metabolic-mechanics relationship understanding in walking and characterization of gait records [6].

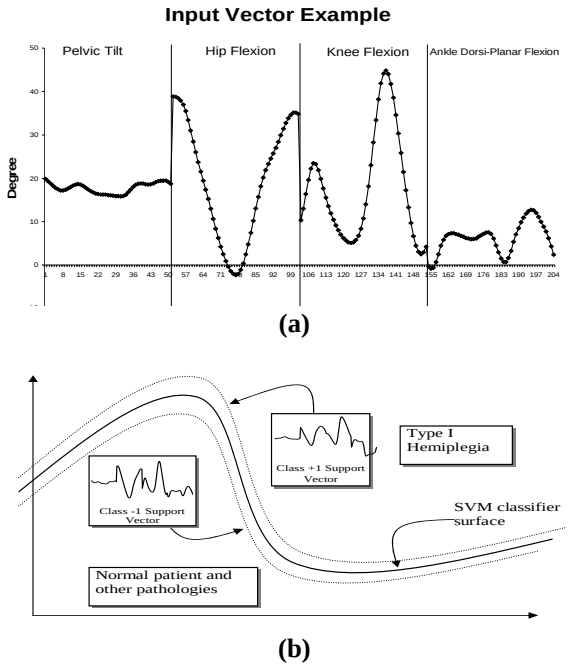

Figure 1. SVM in SH classification (a) A qualitative SH task Input Vector for SVM. (b) SVM classifier surface for Hemiplegia Classification.

2) Device Design

This research track focuses in more practical applications and each one of the devices being developed covers the needs of patients that were interviewed at the initial phase of the CETA. The main devices being developed can be divided in the following areas:

a) Third Age Independance

A portable and modular alert device for elderly individuals with hearing disability is being developed. An initial prototype of the device provides the user with a visual and motion based alert in the case of telephone rings, door bells, fire alarms, etc (B.Sc. thesis in progress). It can be adjusted to provide an alarm for any event caused by a loud noise. The loudness of the activation event and its duration can be calibrated in order to avoid false alarms. In the future this prototype will be expanded to include remote communication which can report emergency falls and user assistance contact.

b) Deaf-Blind Communication Device

A portable and modular communication device is being developed for deaf-blind individuals. The device currently counts with a Braille based interface and a Braille

adjusted keyboard [7] (see Fig. 2). Future editions of this device will include computer and cellular interface. Alliances with the Venezuelan Blind-Deaf Society and the National Rehabilitation Center "J.J. Arvelo" were consolidated with this project [7].

Figure 2. Testing of the Braille based communication system

c) Control Devices

The main device being developed is a multi-functional interface which seeks to provide a wide variety of disabled patients a mechanism for a programmable human-actuator interface. This design seeks to create a universal interface capable of adapting to the patient and reducing the training period by including smart adaptation algorithms. The actuators being considered at this initial stage are initially of an on-off nature [8], which although limited, provides the disabled community with a wide number of possible actions.

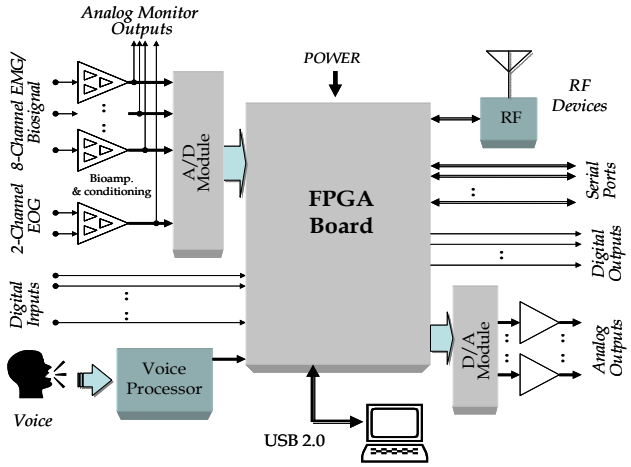

Figure 3. FPGA based version of universal interface

Two versions of this universal interface have been considered (and constructed at a prototype stage): one based on microcontrollers and one based on field programmable gate arrays (FPGA) [9, 10]. As part of the design and development of such interfaces (see Fig. 3), associated research tracks have been developed simultaneously seeking to study different bio-signals (EMG, EOG, to mention a few) and other variables [11], in order to better understand their behavior and their overall effect in the individual. Bio-signals such has EMG and EOG represent an alternative for input signal when considering patients with severe motor impairments [12].

d) Occupational and language therapy devices

Cause-effect training is a very important part of most occupational and language therapy rehabilitation programs. These exercise benefit from devices with visual and acoustic stimuli, for this reason the CETA has designed and developed several modules for such purposes [13] (see fig. 4(a) and 4(b)). The CETA has also developed communication panel prototypes for when augmentative communication strategies are required (i.e. when children need to interact and communicate with assistive equipment or personnel) [14] (see fig. 4(c)).

(a) **(b)**

(c)

Figure 4. (a) and (b) cause-effect devices for occupational therapy, and (c) augmentative

C. *Service Provision of AT*

The devices being developed are at a prototype stage and are currently being evaluated and tested. However, in parallel a census among disabled individuals has been collected as an initial stage for the provision of services. Currently dialogues have been establish with health centers and schools that have disabled children in order to establish an initial provision policy.

IV. CONCLUSION

This initiative, which materialized in the CETA project, is based on a technology transfer scheme and was embedded within a university environment. This approach drastically reduces costs and assures research, development and human resource in a sustainable form. In only three years several research tracks have been established in varied areas of AT, as well as the development products prototypes, some very close to their final versions. Not to mention the consolidation of an educational and institutional platform, advancing public awareness on the needs of disabled individuals. These achievements were possible with funds included in the budget for research and development of the USB, physical spaces within the campus, and alliances with already existing centers. These resources avoided large investments which would have been difficult to amass if attempted as a private initiative. This methodology could be replicated by other institutions within Venezuela and by other countries with similar characteristics and thus establishing a sustainable alternative and of manageable costs for the attention and integration of disabled individuals to the global context.

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