Technology and Disability. The Cost, Efficiency and Acceptability trade-off.

Josep Amat and Alícia Casals
Technical University of Catalonia

Abstract— Technology and robotics have proved to be effective tools for solving many human limitations at work or in daily tasks. In the field of disability the challenges of robotics are enormous but also the difficulties of developing equipment and devices that are well accepted by potential users. The engineering aspects here are only a part of the issues to be considered at the design stage, the human factors and the impact of the potential robotic aids in the users life are not always clear enough. Therefore, an analysis of the present situation with some historical perspective can help to promote a debate on the desirable achievements or even the ethic limits of this technology. A point of reflection is the fact that although the progress of robotics in the field of disability has been notable, there are no robots in this area that have reached a significant level of users.

I. INTRODUCTION

In the last decades great efforts have been devoted to the development of technology for the increase of autonomy and independence of people with disabilities, efforts that have been addressed as well to the elderly that progressively lose their mobility and their capacity of being self dependent with age.

During the period lasting from the late 80s to the early 90s, there were a significant number of projects addressed to the development of robotic systems, conducted within national and international programs. These projects on assistive robotics were addressed to provide disabled people with robotic assistants that enable them to gain some autonomy in their daily lives, either at home or at work.

In Europe, a special program TIDE was launched in the late eighties to encourage the development of technology for the disabled. The first robotic prototypes designed for the disabled that in the seventies were mainly orthetic devices, as the Utah arm, gave place to numerous impressive projects. The Utah arm is one of the myoelectric commercial clinical hand prosthesis today, together with the Suva hand of Ottobock, the Vasi hand and the Waseda Hand. Mioelectric controlled prosthesis started to offer good performances in the eighties, but up to now there are no yet solutions that enable users controlling more than two or three independent movements, in general opening and closing and wrist rotation. Fig. 1 shows these hands with their cosmetic gloves as unavoidable complement for their acceptability.

More complex control is required for lower limbs that need a microcontroller to generate the orders based on the other healthy limb actions or on predefined patterns and sensor data.

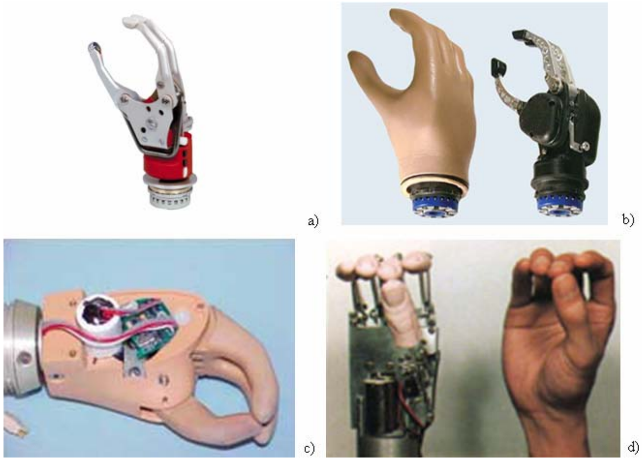

Fig. 1. Current prosthetic clinical hands: a) Suva hand, b) Utah hand, c) Vasi hand, and Waseda hand.

The low acceptability of these systems, even considering the technological progress achieved, is due not only to their cost but also to the power requirements and the still too limited performances which sometimes do not compensate the burden that the prosthesis produces to the user.

When dealing with assistant robots, for assistance in daily living and in labor, similar conclusions can be extracted. An assistant arm can provide autonomy to the disabled 24 hours a day. The first efforts come from projects like DEVAR (stand alone robot) and MOVAR (robot mounted on a mobile base), from the Veterans Administration trying to provide solutions for amputees and quadriplegics from the Vietnam war. Some voice applications were developed for a labor workstation or for personal daily life assistance. Unfortunately, this vocational robot still remains as a prototype, fig. 2.

In Europe, MANUS a wheelchair mounted robot with seven degrees of freedom was designed to be foldable and thus able to accompany the user wherever he or she goes with the wheelchair. MANUS became a commercial product in the nineties and has been used in multiple personal daily tasks, fig. 3. RAID for assistance in labor, mounted on a workstation became a complete system integrating complementary devices such as a turning pages mechanism, a tool exchanger, and so, all controlled from the user's wheelchair controller, fig. 4. Instead, MOVAID, fig. 5, was conceived as a robot mounted on a mobile base for assistance to the user at home, therefore assuming not only the challenges of controlling a manipulator robot but also the requirements of a mobile platform moving in an indoor environment, a home, with several rooms and areas where maneuvering was not trivial. This system considered the fact of using docking points for precise tasks and self-feeding. Besides these ambitious projects other assistant robots as Handy, a manipulator specialized in feeding the user, Tou and ISAAC, soft stand alone intrinsically safe robots and other prototypes have been designed and tested to cover the needs of quadriplegics.

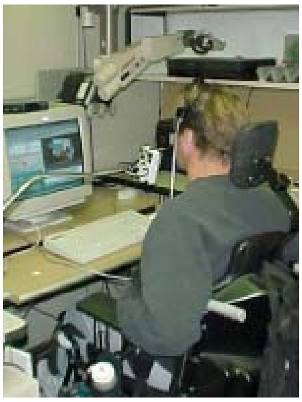

Fig. 2 PROVAR

Fig. 3 MANUS

Fig. 4 RAID

Fig. 5 MOVAID

In all these projects great advances were achieved and interesting prototypes were developed that provided quite a variety of performances and abilities. However, although a few of them have become commercial products, none has reached a significant number of users because they have not got yet enough global acceptance, and consequently it is not yet possible to say that robotics is currently a common technology in the disability field.

The trend now, following the Japanese interest in humanoid or human or animal like robots, is developing the so called robot assistant or robot companion. A representative European example is Care-o-Bot, a semi humanoid that was conceived in the late eighties and has been progressing in their successive models since then. Fig. 6 shows the present version of Care-o-Bot. In this direction the European project Cogniron has been devoted to develop more human skills and perceive human intention for this new robot companion concept.

In another level, the great number of Japanese edutainment robots has started to have an impact to the society, and one of the first prototypes, Papero, fig. 7, a commercial robot since 2001, is already a companion to elderly, identifying people, reminding them to take the pills, or so, and alleviating their loneliness by talking to them.

Fig. 6 Care-o-Bot

Fig. 7 Papero

Unfortunately, and as a general rule, in spite of the great progresses in all the research areas concerning assistant robots, the use of these devices among potential users has not spread out as expected, or as one could have thought some years ago observing the popular acceptance of cars, mobile phones and other technological products.

The lack of practical applicability of the main prototypes developed should be searched among a set of causes that could be summarized as follows:

a) Lack of efficiency of some systems. The systems that are more efficient are those which are the simplest, from the technological point of view. More complex systems, especially those based on robotics still present functioning limitations and a notable percentage of failures. Here, a failure does not necessarily mean system deterioration or malfunctioning, but simply, the non-achievement of the goals, being such failures as no correct grasping of an object or the non-adequate recognition of the environment.

b) High cost of technological systems. In general, the cost of technological systems, especially robotic systems, is too high to be affordable by most of the potential users

c) Non-acceptability. Technological resources are usually excessively visible or voluminous which makes them not only less compatible with the limited size of housing but also create a visual burden for the user, that impedes giving an appearance of normality, which they desire.

The question now is: In the near future, can these negative aspects be sufficiently diminished in the way that assistive robotics can be used for a higher number of people with progressively reducing mobility or with mobile disabilities?

II. THE FUTURE DEVELOPMENT OF TECHNOLOGICAL RESOURCES FOR THE DISABLED

In the next years, a progressive development of technological resources oriented to provide disabled with more autonomy is foreseen. On one hand, there will be further development due to the progressive reduction of costs and improvement of performance of all electronic applications, and the disability sectors will not be an exception.

On the other hand, the increasing demand of such aids that generates a potential market with an increasing commercial interest, with no doubt has to encourage a lot of companies to develop and generate offers of such equipment.

Considering this, is it possible to formulate a low risk prediction assuming that, from the technological point of view, it will be possible to develop technological aiding systems more efficiently and more economically but also make them more acceptable to most potential users?

Considering such progress, the future developments can take three different directions:

a) The availability of highly improved robotic arms. The advances in such robots have to be considered from multiple points of view: from the kinematics point of view, robots with redundant degrees of freedom provide more accessibility in the domestic environment, which usually carries with it multiple restrictions; with more load capacity; with more versatile and polyvalent hands; with more control capabilities due to more autonomous and efficient controllers and with more capabilities to interact with the users, even considering their mobility limitations that frequently impede them to use the common computer interfaces. These assistant arms, which are much closer to the “ideal assistant”, could perform much more aiding functions in the daily tasks of these people.

b) The second direction could depart from resigning using such intelligent polyvalent element, dexterous and strong that the user can always carry with him wherever he goes, due to the technological difficulties of designing such robotic systems. The difficulty of carrying the robot and adapting it to the user’s wheelchair, which is more and more light, small and portable each time is another reason for avoiding the use of complex robotic systems. The alternative solution would consist of the development of a set of specialized elements which are dispersed along the common places of the user’s habitual environment: the kitchen, dining room, bedroom, bathroom, workplace, etc. These elements, already free from the restrictions derived from the user’s mobility should have a reduced size and should be fixed and specialized work elements, without power problems. These could be better integrated in the user home and work environment and be more efficient, more imperceptible and maybe also more economical due to its specialization, which in consequence would make them more acceptable.

c) Finally, it would also be possible to develop new mixed techniques, formed by a set of technological elements “embedded” in each environment, without renouncing to the users’ availability of being accompanied by an interface-arm within his domestic environment, in a way that this arm can cooperate with the technological elements located at every strategic place.

Then, either way, one can expect that technology facilitates the autonomy of the disabled and the elderly, which can achieve capacity and quality of life without dependence. Anyhow, considering these options a question arises: Can the capability of living without dependency on other people, or with a minimum level of personal assistance constitute quality of life?

From the practical point of view, the companies specialized in providing technological equipment to physically disabled persons to increase their independence, offer everyday new technological resources, ranging from new materials to robotics. These companies also rely on the support of many research centers, making possible with this cooperation to significantly increase the market supply of this kind of aids and to appreciably reduce their cost. Thus, more potential users can reach these products, fig. 8.

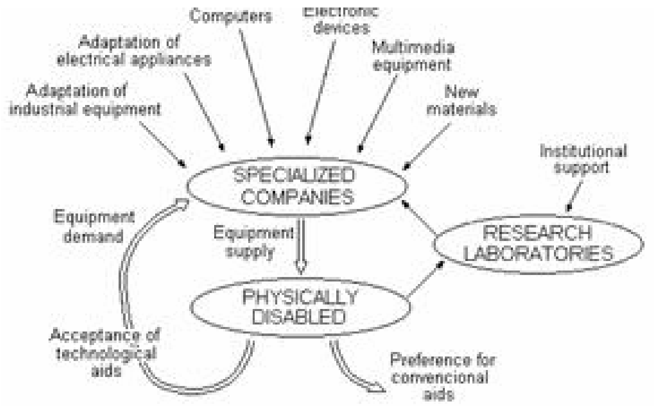

Fig. 8 Impact of technology an robotics as support to the disabled

III. TECHNOLOGICAL AIDS AND QUALITY OF LIFE

Quality of life requires not only assuring that all daily needs can be covered, that is feeding, personal hygiene, health, entertainment and intercommunication with others, but also quality of life means the way these needs are satisfied.

The ethical debate on technology initially focused on the bivalence of military or civil use. But in the field of assistive robotics this debate should be extended to the degree of “humanization” in assistant attention.

Technologically speaking, it is possible to achieve high levels of tele-assistance. A disabled person can be assisted and remotely controlled with all sanitary and social guaranties. It is even possible to develop robotized beds with enough articulated motorized elements to change the users’ position and with the ability to automatically change the bed sheets, maintain a daily 24 hours tele-assistance and also supply food by the means of automated tools. It is technologically possible to conceive an assistance center as a factory, with input of food, materials, clean clothes etc, and output of food remains, dirty clothes, and so, having as well, special devices to assist the patients or residents, manipulate them, etc. The problem to tackle is the achievement of the assistance improvements relying on the technological resources while maintaining a high level of humanity.

The challenge of satisfactorily reaching the acceptability requirements are accompanied by the need of considering all direct and indirect effects of technological development. A future solution could be the development of “invisible technology”, which means, the design of equipment that produces the desired efficiency but that it is not perceived by the user.

IV. Conclusions

A debate on the goals and expectative of assistive technology should be open as well as on the strategic decisions to be taken in the future for the assistance to disabled and elderly. The debate should rely on ethical issues and on the considerations of the user’s acceptability of the potential products, another factor not so relevant in other application fields. Fig. 9 shows a graphic with the main issues involved in user’s acceptability of a product.

It is also important to consider users in a wide way. The user of these technologies is not only the disabled that needs the technological product to gain some autonomy, but also the human assistant that frequently has to make great physical efforts to move the disabled at the expenses of his/her own health.

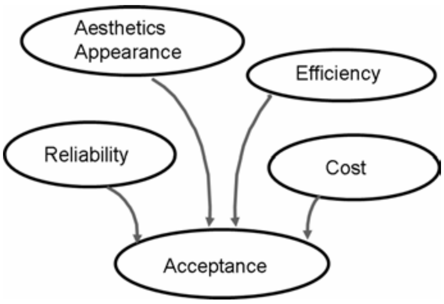

Fig. 9 Issues involved in user’s acceptance

Other bothering or disgusting assistive tasks can degrade the relationship between the user and relatives, being thus necessary to make the right decisions when committing for assistive technology and robotics.

Humanoid robots open new possibilities as well; great efforts are done in their development and improving current performances, but conceiving a humanoid robot as a real substitute of a human, having similar performances, is not yet realistic.

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