Is Universal Accessibility on Track?

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Abstract. Even if the evolution of accessibility engineering is generally considered as impressive, one can question whether it is producing the expected result or not. A deeper analysis can discover that theoretical improvements and practical demonstrators coming from research are not producing proportionate enhancements in the lives of users with disabilities. Starting from an analysis of the role of the research, development, and manufacturing, this paper develops a critical review of the current situation regarding the application of science and engineering to the accessibility field, in order to find the cause of possible weak points, failures and misapplications.

Keywords: Universal accessibility management · Social impact

1 Introduction

Universal Accessibility has experienced significant advancement in the last decades due to diverse efforts. A major factor in this advancement has been the application of science and engineering methods and techniques to enhance accessibility. These include pre-market accessibility features included with virtually all mobile and fixed Information and Communications Technologies (ICTs). These features aid those with motor difficulties (e.g., finger dexterity), sensory loss (e.g., low vision or blindness) and cognitive disabilities (e.g., difficulty understanding the operation of features) to access these technologies more easily.

It is evident that in the last decades, Universal Accessibility has very much advanced and the quantity and quality of Assistive Technology products available to people with disabilities has enormously risen. Nevertheless, analyzing the current situation of the Universal Accessibility and the Assistive Technologies available in (some) markets worldwide one can question if there is a balance between the technological, economic effort and the results available. In addition, if this is true, what are the causes and how can it be corrected.

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2 Manufacturing Accessibility

Assistive technologies and universal design differ in their focus [1]. Assistive technologies are developed and applied to maximize societal participation by individuals with disabilities in carrying out the functional tasks of daily living. Universal design has a focus on the functionality of design for as wide a segment of the population as possible without concern for individual needs [2]. However, many of the accessibility features built into mainstream ICT devices had their origin in assistive technologies. These include: SMS transmission (texting), Closed Captioning, Voice Recognition, On-screen Keyboards, Speech Synthesis, Word Prediction and Digitized Speech. Thus, the assistive technology design parameters, which are more directly related to the needs of individuals who have disabilities should be incorporated into the design of accessible mainstream products as much as possible.

For electronic assistive technologies (e.g., augmentative communication, computer access, appliance control, sensory aids and cognitive assistive technologies) inclusion of the principles of universal design together with the incorporation of accessibility features in mainstream products has made opened new opportunities for people with disabilities [1]. However, universal design does not completely eliminate the need for assistive technologies because the variety and complexity of individual needs are too great for inclusion in a single product [3]. For these assistive technology application areas, two complimentary approaches-universal design and specialized assistive technologies (AT) will be required [3]. Both approaches will require the use of mainstream technologies since low cost AT will depend on the use of mainstream products that have useful AT application features. Mainstream products are likely to be more accessible to people with disabilities even if they are not specifically designed with those individuals in mind, i.e. using universal design principles [3].

ICT devices like smart phones and tablets have the capability of running AT applications previously requiring laptop or desktop computers [4]. Among the thousands of apps developed for these devices, many are directly related to addressing needs of people with disabilities. Many more can be of benefit to people with disabilities even though they were developed for the general population. There is also recognition that ICTs can be a critical enabler to developing countries that are moving toward the information-based society. They can also provide access to society (work, communication, leisure) for persons with disabilities.

A major approach for creating access to mainstream technologies by people with disabilities is the development of specialized application program (apps). These are designed to make a mainstream device (e.g. tablet) operate like a special designed assistive device. A common example is their use for augmentative communication. Many applications function like a full-featured speech-generating device (SGD). The cost of the mainstream technology and app is less that 10 % of a purpose-built SGD. The availability of these mainstream technologies and apps result in increasingly inexpensive hardware and software, availability of alternative access methods and the opportunity to use standard software applications in the same device (e.g., email, internet browsing, word processing) [5, 6]. To use these devices, however, the individual with a disability must be able to access the smart phone or

tablet both physically and visually. This is where universal design comes in. The most effective app is useless unless the individual has access to the technology on which it runs.

Mobile technologies utilize an array of highly coordinated fine-motor movements for access (e.g., pinching, swiping left to right, touching) that require significant motor, cognitive, and sensory-perceptual skills, [6]. There is a set of individuals for whom an app and mainstream technology is well suited, but there are many who will not be able to access these options. The number of AT applications is growing rapidly, and there are many for people with disabilities.

Dolic et al. [7] compared the technical characteristics and capabilities of purpose-built SGDs to mainstream tablet devices. A major difference between most SGDs and mainstream technologies is providing access to multiple communication functions and electronic tools (e.g., accelerometers, GPS tracking, cameras) that could enhance access and functionality. Mainstream mobile technologies are frequently smaller and lighter than purpose-built SGDs. Mainstream tablet devices can be as much as 15 times less expensive than purpose-built SGDs, making them more accessible to users in countries where they are not subsidized by medical or social funding agencies. They also include a wide variety range of mainstream smartphone applications such as texting, browsing the internet and GPS navigation [6].

Another aspect is the social impact of special purpose assistive technology. For a child or adolescent using a purpose-built SGD carries a stigma that sends a message about being different and calling attention to his disability. An iPad with and SGD app sends a message that says “I’m cool” and I have the latest technology [6, 8].

Because purpose-built SGDs are often based on custom computer systems and software, the capability of the device cannot be expanded by installing additional applications made by the broader community making them less generally useful than a more universal device. These apps are available with mainstream mobile technologies. Part of the cost difference between purpose-built AT and mainstream technologies with AT apps is the support that AT manufacturers supply [9]. They repair devices that fail to operate properly, often providing service loaners while a device is being repaired. They also assist clients during the assessment process by demonstrating equipment and assisting with obtaining funding for the SGD or other AT. The cost for the additional services that provide obvious benefits to clients is included in the price of the product, making traditional SGD and other AT devices significantly more expensive than comparable mainstream devices. However, the lack of support can be a major detriment, however, for those individuals who purchase a mainstream device and Augmentative and an Alternative Communication (AAC) app and then realize that there is little or no support for their use [10]. “Some service providers for people with disabilities have also been reluctant in exploiting the full potential of “mobile technology aps”, as their role and incentives is based on having clients come to them for evaluation and fitting of special assistive technologies.” [3, p. 108].

Mainstream smartphone and tablet devices use operating systems developed and optimized for mobile devices where as many purpose-built devices use customized PC operating systems. Mobile operating systems like iOS and Android are optimized for touch

screen interfaces and for consuming low power. In contrast to purpose-built SGDs mainstream mobile devices lack alternative input capabilities using switches, head control or eye pointing. Bluetooth-enabled switch interfaces can compensate for this in part [1].

3 Novelty of the Research and Development of Technology Applied to the Universal Accessibility

A large research activity in accessibility can currently be observed. The number of scientific conferences and journals that directly or indirectly cover topics such as design for all, universal design, accessibility and assistive technology has substantiality increased. Our starting point is whether the advancements in practical terms are proportional to the effort devoted to research. Novelty of the results is a key parameter to analyze the evolution of the research in universal accessibility.

The question is: is innovation scarce in accessibility research and development? Speaking about the current situation of HCI research, Kostakos [11] wrote "We simply roll from topic to topic, year after year, without developing any of them substantially", synthesizing the impression shared by several researchers that HCI current paradigms have reached a blockade. The application of HCI techniques to the development of accessible human-machine interfaces is a factor in this blockage. Several researchers have the feeling that the tendency is to "play variations on a theme". Technological advancements frequently allow a number of enhancements in terms of efficiency and reliability, associated with better development, but not the real novelty that can be expected from research. In fact, a superficial analysis of the abstracts of papers published in scientific journals and conferences show some recurrence in a number of topics that already have a consolidated theoretical support. In many cases, small technological contributions to previous findings are found in these papers.

It is remarkable that a large number of technological advancements have occurred without considering accessibility issues. Subsequently, they have required extensive efforts to make them more accessible (when it was possible). For instance, two relatively recent technological advancements have greatly affected the way of life of people with disabilities: the internet/Web and mobile telecommunications. Both of these were initially barely accessible for several people with special needs. Even if currently they represent an open window to social participation for people with disabilities, they have required, and still require, large efforts to enhance their accessibility.

4 Economic Aspects

One of the main reasons for the gap between technological developments and market products can be found in the difficulty of the path from science results and marketable products.

In fact, the economics of universal design have multiple factors. On the one hand modifying a product after production to meet the needs of a person with a disability is expensive and this cost can be avoided by designing in the necessary accessibility features. These universal design features may cost more than a design without them.

Thus, there is a level of skepticism in industry due to the increased emphasis on economic sustainability and profit worldwide [3]. Because of limited profits and very competitive markets companies tend to adopt the concept that "people with limitations should be a duty of the welfare system in the different countries and should not be an obstacle to the main aim of industry, i.e., to the generation of profit" [3]. There are some technologies, such as telecommunications equipment where companies may have a governmental mandate to make the products accessible to a wide range of users "without much difficulty or expense." The last part of that quotation gives companies great latitude. To accomplish this goal companies look at the costs and the resources available to address accessibility [12]. Large companies with more resources will be expected to do more than small companies with limited budgets, for large mainstream companies "being forced (e.g., by legislation) to take into account all users is considered by them an undue interference in their goal (serving the mainstream customer and maximizing profits.)" [3].

Time and cost to develop a product can be affected by inclusion of universal design. Bjork [13] evaluated the design of two supportive seating products. One using universal design and the other a modular system that could be adjusted to fit a variety of users. The development of the universally designed system took four times as long as the design and development of the modular system.

4.1 Marketability of the Research Results

Back to the difficulty of converting the results of research into a marketable product, some experts consider that basic science does not need to produce practical results. However, there is some consensus that applied research's results are nearer to the product. We must not forget that research on universal accessibility and assistive technology is clearly located in the area of applied research.

Researchers often complain that their achievements are not welcome by the industry. Research proposals frequently claim that they would end "with a significant contribution to the welfare of people with disabilities…" and similar statements. However, projects too frequently finish with an interesting prototype that is hardly marketable. The reason may be that many projects developed in academia often ignore the requirements that convert a good prototype into a commercial product (that include redesign, manufacturing, testing, standards compliance certification, drafting manuals, marketing, distribution, maintenance, recycling program, etc.).

In general, scientists do not question, "Is there a market for this product?" Therefore, failure to be marketable can be related to the requirements stated by Clarkson [14]: Products must be Functional, Usable, Desirable and Viable (the last in the business/market sense).

Therefore, one of the causes for low marketability can be found in the roots of the research. Several research projects are triggered by the availability of a new technological advancement, that "supposedly can support" the user needs. The problem is that their validity has not been checked by means of rigorous users' needs studies. As a result, these projects frequently produce fancy technology that can hardly be adopted by the users. In addition, good research practices do not mean good product design.

According to Clarkson [14], to manage development risk, the key questions are: "Are you building the right products (or services)" and "Are you building the product right?".

On the other hand, projects developed by academic research institutions have access to recent, expensive and complex technology that facilitates the proliferation of technology availability-driven projects. In addition to produce expensive prototype devices (that are frequently difficult to be understood, learned and used), the use of sophisticated technology makes more complex the process to convert scientific results into marketable products.

5 Political and Social Aspects

Accessibility is far from being "universal", principally due to economical differences [15–17]. Universal accessibility (and Design for all) refers to the quality of being accessible by any individual. Nevertheless, statistical studies show that "universally accessible technology" is out of the reach of the most part of the human population in the world. The most important reason is economical: people with disabilities cannot afford buying accessible equipment, because it is expensive.

The resolution 58th "Disability, including prevention, management and rehabilitation" adopted by the World Health Assembly in 2005 states that 80 % of people with disabilities live in low-income countries and that poverty limits access to basic health services, including rehabilitation services [18]. Citing an study by Frye (1993), Arne et al. [19] state that "rehabilitative services in the developing world reach only 1–2 % of the disabled population", in addition, "Much of the AT in use in these countries are either technically outdated and not adapted to local circumstances or imported sophisticated technology beyond common people's reach".

In the developed world, Assistive Technologies are available to meet the needs of people with disabilities. However, because these devices are very expensive, much of the world cannot acquire AT. Because it is less expensive utilization of mainstream technologies with apps that function like AT devices, as we have described above, is needed to meet the needs of people with disabilities in lower income countries.

Mainstream technology is globally pervasive and its capability is constantly increasing. However, much of this technology is not accessible to individuals with disabilities. Advances in technologies that are not accessible to those with disabilities can increase the gap in available resources for work, school and community living between people who have disabilities and those who do not. As advances occur more quickly, the gap widens faster and the people who are poor and/or disabled lose out even more completely and quickly. This is a characteristic of cultural and societal "progress" over centuries–technology drives change, and creates both positive and negative outcomes in the process [20].

Due primarily to cost and availability of suppliers, much of the world has not had access to assistive technologies. There are many types of assistive technologies, primarily those based on computer technology, that have not been available to much of the world's population. Computer-based AT includes computer access, environmental control, cognitive assistive technologies, and augmentative communication.

Achieving widespread global availability of assistive technology applications at an affordable local price will have to be based on mainstream devices [3]. The largest area of growth internationally is mobile broadband internet access [21]. "Wireless-broadband access, including prepaid mobile broadband, is mushrooming in developing countries and internet users are shifting more and more from fixed to wireless connections and devices" (p. 1). This is good news for the global application of assistive technologies based on smart phones and tablets. However, the cost of these technologies is still too high in many developing countries, and there is a need to develop more affordable devices [4].

The International Telecommunication Union (ITU) the United Nations specialized agency for information and communication technologies provides an annual overview of the world's use of ICTs [21]. The ITU has developed the ICT Development Index (IDI) that compiles 11 indicators of development in communication and technology within a country, divided into access (40 %), use (40 %, percentage of use of internet, broadband and fixed or wired ICT) and skills (20 %, based on literacy and enrollment in secondary and post-secondary education). The IDI allows a more detailed look at ICT development than measures based strictly on number of cellphones or computers.

All of the sub-indices for developing countries increased between 2008 and 2011. The ITU (2013) report presents the IDI score and rank for 152 countries broken into four levels based on IDI levels. The two top levels of ICT use, penetration and skills based on the IDI have 26 % of the world's population and the lower two levels have 74 %. There is still a long way to go before the "digital divide" is narrowed substantially.

6 Weak Points and Misapplications

Regarding the difficulty that techno-science has to produce practical results in the area of accessibility, a number of issues that should be avoided and aspects that should be enhanced can be pointed out:

- Lack of knowledge on user needs. Design flaws or weaknesses relative to accessibility can occur when telecommunication product manufacturers do not focus on needs and preferences of users who have disabilities.
- Use of sophisticated technology makes the products and services more expensive, complex and frequently more difficult to use.
- Ethnocentrically designed devices and services are not able to solve specific accessibility problems in different economic and cultural contexts.
- Policies oriented to support technological research have difficulties to promote the arrival of resulting prototypes to the market.
- Low awareness by scientist of key issues at product conception time, such as the need for efficient provision and delivery systems (prescription, adaptation, tutoring, maintaining, etc.).

In order to enhance the situation, global policies are required that consider the whole population needing accessibility support and the complete lifecycle of the product, in order to produce durable enhancements in the accessibility field.

7 Conclusion

This paper starts from the idea that the technical, economic and personal effort devoted to the development of technical aids and universal accessibility does not seem to have produced proportional results in the availability of advanced support systems for people with disabilities. However, it is currently difficult to find accurate data to support this assertion. Therefore, a detailed taxonomy of the technological applications for accessibility would help to understand the current situation. In addition, we consider necessary to conduct diachronic studies on the evolution of the application of science and engineering to improve accessibility deem. Their results, along with existing synchronic studies of the current state of technology support in the various regions of the world, would allow rigorous re-planning of the techno-scientific efforts.

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