1. Introduction

Computer technology is continuously evolving. New processors, devices, apps ... are emerging each day. Moreover, electronic devices, like computers, mobile phones, tablets, PDA’s, GPS’s ... are used by more people and with new purposes in a way that they are almost essential in our lives. When we talk about computers or technology and how people use it we have clearly to talk about interaction. Human Computer Interaction involves the study, planning, and design of the interaction between users and computers.

Interaction between users and computers occurs at the user interface which includes both software and hardware. The interface is the space where interaction between humans and machines occurs and the success or failure of a product relies largely on its interface.

There have been changes in the way products work, look, act, and react to people who use them. Through last years, many developments had took place in this area, many of them related to hardware and new devices for interaction, but also in the field of metaphors, paradigms, interactions styles, standards, and so on. Progress in the field of device development has changed interactions methods like mice and keyboards to new technologies that lets users interact in a more accessible manner without requiring long periods of learning and adaptation. From the old input commands style through direct manipulation or augmented reality, from the very old and heavy monochrome screens to modern smartphones, many improvements had completely changed the way we interact with technology.

But this revolution has not finished yet. Fortunately, there are also many areas where we can improve in order to make the interaction process easier, more enjoyable and better for the final user. In other words, there are many challenges that can be accomplished in the field of human computer interaction.

As it has been said before, there are three elements involved in the interaction process: users, software and hardware. In this work we will talk about some challenges related to each element. Of course there are other numerous challenges for the discipline, but we will focus on some of them we consider they are relevant. First of all we will write about challenges concerning users. More specifically we will consider two groups of users whom interfaces must be designed carefully: older adults and users with cognitive disabilities. In the third section, interface challenges related with software will be reported. On the fourth section hardware devices and challenges concerning them will be described, focusing mainly on brain computer interfaces and proxemic interfaces. This work ends with a conclusion and a list of references that have been mentioned along the explanations.
2. Users: Design for users with special necessities

3. 2.1 Older adults

Society is getting older. By 2030 the percentage of the population over age 65 will range from 17% to 29% within Asia, North America and Europe. People are living longer, remaining more active into older age and staying in their homes longer before finding the need for “assisted living” arrangements. Such a change in demographics brings with it important changes in the demands for products and services. Although older adults are less likely to use technology compared to younger or middle-aged adults, they also use a wide variety of technologies (1). They have many opinions about computers, Internet ... Although some of them find no problem using them, the extent of frustration encountered when dealing with these products is quite evident in other users.

There are different problems they encounter when dealing with technology: financial limitations, ignorance about how to use it, feeling of fear to “break” it, health difficulties ... Product instructions and usage information are frequently not easy to comprehend, more over in the case of elders. Approximately 25% of the problems they have encountered using technology could potentially be solved taking into account this users collective (for example enlarging letter size or using easier to understand labels) (1).

Sometimes older adults have no choice but to use new technologies, for example, telephone voice menu systems, mobile devices, airport check-in kiosks ... These technologies are presumably designed with the expectation that anyone should be able to successfully interact with it, but frequently older adults report frustrations in their interactions because those products have not been designed to accommodate the limitations of this collective. A correct application of Universal Design is a challenge that had been studied for years and that should be still considered in the next year.

Biological, psychological and/or social problems arise with age: deficiencies in sensation and perception, working memory declination, slower and less reliable information processing, slower and less successful acquisition of new procedures, selective attention problems, movement impairment, relationship difficulties ... Tools and techniques must be offered to mitigate these problems. They can be achieved through the design of specifically input/output devices; adaptive applications, specific task analysis, usability and interactions methods are also mechanisms that could help to this goal. Involving a representative sample of adults in these tasks could help to understand some unique characteristics of older adult populations that must be considered when researching for them.

Healthcare technology is a critical concern for adults of all ages, but especially for older adults (due to their propensity to illness and chronic conditions). Activities such as coordinating physician appointments, remembering to take medications, processing information about recently diagnosed ailments, monitoring chronic conditions are part of the tasks that could be helped by technology and that can be improved in the next months.

Finally, a right design of training and instructional programs for these users is a responsibility for a proper use of technologies: specifically designed teaching programs are needed to integrate elders into a society where digital illiterates have a high risk of social exclusion. Adaptive training, the use of simulation or the inclusion of e-learning methods are important guidelines to consider when designing those programs.
2.2 Cognitive disabilities

Defining cognitive disability is not easy and definitions are usually broad. It could be said that a person with a cognitive disability has greater difficulty with one or more types or mental tasks than an average person. While a person with profound cognitive disabilities will need assistance with almost every aspect of daily living, someone with a minor learning disability may be able to function adequately despite the disability, even to the extent that the disability is never diagnosed.

Individuals with cognitive impairments can potentially benefit from the use of novel computing technologies, social computational systems, context-aware systems and more. Technology may be effective for the diagnosis, management and treatment of several disorders like autism, Down Syndrome, traumatic brain injury (TBI) or less severe cognitive conditions like attention deficit disorder (ADD), dyslexia (difficulty reading), dyscalculia (difficulty with math) and learning disabilities in general (2).

There are guidelines (3) that address how to make web content accessible to people with disabilities, including cognitive ones. However, the implementation of these guidelines does not guarantee a fully access to the content. The wide variance among the mental capabilities of a personal with a cognitive disability complicates matters a lot.

A great deal of web content cannot be made accessible to individuals with profound cognitive disabilities, no matter how hard the developer tries. In those situations, some content will always be too complex for certain audiences. Nevertheless, as a challenge for the next years there are still some things that designers can do to increase the accessibility of web content to people with less severe cognitive disabilities.

Acquiring the specialization to develop accessible content for these users is a dare for developers. Practitioners have to work in conjunction with interface designers to share their knowledge and to guide them to develop new techniques for controlling auditory output, improving mechanisms to remember sequences and to complete sequential operations, reducing the amount of information on a single page, selecting appropriate layouts with no clutter, considering new methods to pick an option among large data sets, providing plain texts and definitions for unusual terms, minimizing the cognitive load while surfing, using graphics to enhance understanding and only when appropriate (never overusing them), developing assistive technologies or browsers with built-in adaptive features, providing consistent commands and features along the website, shortening menus, …

All these methods and techniques should be combined with experimentation and test with real users. The evaluation of the already existing technology and the new developments should also be made in conjunction with schools and institutions that cater to the special users. What differentiates cognitively disabled from other disabled users is that the exact problem and its extent is often not defined (unlike for other users such as visually impaired users), and those professionals are probably the best qualified ones to advice during the development and evaluation process.
3. Software: usability and device specific contents

3.1 Software usability

Ideally, all software should be easy to use and accessible for a wide range of users. But reality shows that applications and web sites, from large-scale companies to smaller ones, often fall short of the most basic usability and accessibility goals. There are different reasons to justify these fundamental hurdles: many companies do not do any usability tests. Other companies do but in the interest of speed or reducing costs they complete tests only at the beginning or at the end of the development cycle or with a reduced number of users, or considering a limited set of functionalities … Usability testing is not inherently difficult, but it is time and money consuming and hard to scale when it requires human observation of the people using the software been tested.

Automated usability tests can help identify problems and limitations in web-based applications and they can be run with minimal human intervention. It must be noted that these tests does not replace other human usability test, but they complement them. Another advantage is that automated tests can be run across a vast set of web pages a person would be impractical to conduct in person.

In addition to the basic challenges in usability (and accessibility) testing, there are also challenges in developing good automated testing frameworks (4). Academic research exists, but not only it has limited access but also companies need to translate the formal structure of those papers into something that makes sense to them. In other situations, many test-automation tools require their users to have technical and programming skills to write the tests. Differences among the various web browsers constitute another difficulty, or another challenge, with the test-automation software. Developing tools and frameworks that would make automated testing easier and more suitable for different applications is another challenge for the next year.

Creating meaningful summative usability tests for specific areas is another challenge for 2012. Even highly experienced usability specialists cannot agree on which usability issues will have impact on usability (5). Computer uses vary from simple web pages or applications to electronic health record systems. It is clear that the same usability tests and metrics (even automated ones) cannot be applied in all circumstances. The issue is in developing tests that are meaningful across different contexts and systems or even in developing effective tests for specific areas.

3.2 Contents accessed from different devices

Today, the number of users accessing the Internet from mobile devices is higher than those accessing from desktop devices. Research has shown that a significant percentage of people use the mobile web from the comfort of their home (6).

New mobile devices are developed almost every day. Many of them have more computational capabilities and are much smaller than the computers we used to use few years ago. As an example, the new Galaxy Nexus (7) phone has a 1280x720 HD screen resolution over a device with 1 Gb Ram and 32 GB disk, all running in a 1.2GHZ dual core processor. This device has also functionalities as NFC, gyro, barometer …

But the characteristics of these devices (small size, touch interaction …) raise the need to make additional efforts to ensure an optimal interaction experience. Moreover, numerous apps are used either from a mobile device or a desktop computer. With users browsing internet and using apps from an increasingly diverse range of devices, platforms and browsers, new techniques like progressive enhancement (8) and responsive web design (9) are essential concepts
that must be understood in order to reach the best user experience. In some situations, it is necessary to provide users with a high level of continuity between different contexts, serving one content to countless browsers and devices. In other situations, people deserve different contents and services depending on where they are or whether they are stationary or mobile (desktop/laptop or mobile).

From now on one important challenge that should be addressed in the next months is realizing that interfaces must not be designed for browsers/platforms/devices but they will have to be designed for people. Only in that moment browsers/platforms/devices will be really transparent to users, forgetting the “how” and considering only the content.

4. Hardware: BCI and proxemic interactions

4.1 Brain computer interfaces

There is strong evidence that future human-computer interfaces will enable more natural and intuitive communication between people and all kind of sensor devices. Brain computer interfaces are an example of this evolution. These interfaces are based on electrical signals produced by brain activity that can be detected on the scalp, on the cortical surface or, even, within the brain. These signals are then translated into outputs that allow users to communicate with the computer without participation of peripheral nerves and muscles (10). One of the main advantages is that provides new communication-and-control mechanism for whom conventional methods are ineffective (for example quadriplegic or users with severe disabilities).

There are different recording methods to measure brain activity: invasive, partially invasive and non-invasive methods. Using invasive methods electrodes are implanted directly into the grey matter of the brain. One of the main characteristics is that they produce the highest quality signals and enable fast recognition of mental states and even achieve complex interactions. The disadvantage is that the brain’s complex reaction to an implant is still imperfectly understood and might impair long-term performance. These methods could help to repair damaged sight through direct brain implants (11) and it could be possible to provide new functionality to persons with paralysis.

Partially invasive BCI devices are implanted inside the skull but rest outside the brain rather than within the grey matter. They produce better resolution signals than non-invasive BCIs where the bone tissue of the cranium deflects and deforms signals and have a lower risk of forming scar-tissue in the brain than fully invasive BCIs.

Non-invasive methods use electrodes on the surface of the scalp to record the brain’s electrical activity. This method is preferable for humans but it suffers from a reduced spatial resolution and increased noise due to the distance from brain tissue, the separation from it by the coverings of the brain, skull, subcutaneous tissue and scalp. This way, only the synchronized activity or large numbers of neural elements can be detected. One of the most usual non-invasive methods is electroencephalography (EEG): it is easy to use, portable and has a low set-up cost. The main disadvantages are the extensive training required before users can work the technology and that they require some level of skill in the person placing them and periodic maintenance to ensure sufficiently good contact with the skin.

Although many improvements had taken place in the last years, there is an opportunity to apply these technologies in the interaction process. First of all, one of the major problems is the necessity of mechanisms that can provide fast, accurate and reliable control signals.
Noninvasive and invasive methods would both benefit from the improvement of the recording methods. Secondly, we demand investigations to get the meaning of signals measured or, in other words, to know better how the brain works. A widespread use of this technology by individuals with little or no disability is another challenge for the future (10).

Recent developments in computer hardware provide compact portable systems that are extremely powerful. Initiatives such as “epoc” – a 299$ neuro-headset with its own SDK (+500$) developed by Emotiv (12) – will certainly contribute to generalization and new research in this area. Once these challenges are reached, we could try to achieve higher ones, like the development of devices that could be controlled by thoughts.

4.2 Ubiquitous computing – proxemic interactions

Ubiquitous computing (ubicomp) is a post-desktop model of human-computer interaction in which information processing has been thoroughly integrated into everyday objects and activities (technology is everywhere and we use it all the time without thinking about it because it is “invisible” to the user). The idea of ubiquitous computing as invisible computation was first articulated by Mark Weiser in 1988 at the Computer Science Lab at Xerox PARC.

Ubiquitous computing environments have different digital devices and services that work together and simultaneously and many of them are not aware that they are doing so. Among these devices there are computers connected to the Internet, mobile computing devices, small and inexpensive networked processing devices, digital audio players, radio frequency identification tags, GPS, interactive tablets, etc. Ubiquitous computing offers challenges across computer science: in systems design and engineering, in systems modeling, in user interface design …

A major theme in ubicomp is to explore novel forms of interaction not just between a person and a device, but also between a person and their set of devices (13). In 1966 anthropologist Edward Hall coined the term “proxemics”, an area of study that identifies the culturally dependent ways in which people use interpersonal distance to understand and mediate their interactions with other people (14). In proxemic interaction, the belief is that we can design systems that will let people exploit a similar understanding of their proxemic relations with their nearby digital devices, thus facilitating more seamless and natural interactions (15).

Today there are many situations where different devices stay in the same room: smartphones, laptops, tablets … Most of the times there are considerable problems to interconnect these devices (user must have extensive knowledge to do it and it requires time to configure and manage the communication). Once the devices are connected there are still problems to perform tasks among them (for example sending a file from one device to another). It could be said that the presence of one device is blind to the presence of other devices. Even these devices are blind to other aspects, like number of persons in the room or presence/absence of other non-digital objects.

This is where proxemics can help: in the same way people expect to increase engagement or intimacy as they approach others, devices should increase their connectivity and interaction possibilities as they get closer to other devices. Greenberg (16) proposes five dimensions to measure proximity: distance between entities (for example one entity is or is not in the same room as another entity), orientation between entities (pitch/roll/yaw/facing toward/somewhat toward/away from the object), identity (exact identity/entity type),

Another related concept is ambient intelligence, referred as electronic environments that are sensitive and responsive to the
presence of people. Movement (speed of motion when an entity is moving toward or away from another entity) and location (the physical context in which the entities reside).

Although the concept of ubicomp (or even proxemic interactions) is well known, there are challenges that must be addressed: there is no “official” language to communicate these devices and it does not exist any rules of behavior among them (for example, can we establish a dominance/leadership among different devices?, how do the proxemic elements of the situation determine, or impact on, the communication of the participants?). Another important aspect is to set how the devices will react when they have inaccurate or incomplete information of the proximity of other devices? Finally, what is expected of this interaction paradigm? There are also other challenges in designing ubicomp systems that can be found at Marquardt and Saul Greenberg’s report (17).

4.3 Other device-related aspects

There is no doubt about the wide possibilities that BCI or ubicomp offer to the universe of human computer interaction. But there are also numerous challenges related with devices. What is common to many users is a desire to design ways of physically interacting with computers that fit their innate abilities. To mention two of them we can list wearable computers and transparent devices. Wearable computers are miniature electronic devices that are worn by the bearer under, with or on top of clothing. They are especially useful for applications that require more complex computational support than just hardware coded logics. Transparent devices look for devices that do not require a person’s attention during use: a technology that is so well fitted to and integrated with our own lives, biological capacities and projects that they are almost invisible in use (18). Next year we can walk in the way from opaque technology (the one that keeps tripping the user up) to transparent one.

5. Conclusions

All the challenges described in this work contribute to make the communication between users and computers better. Although the interaction process has notably progressed in the last years, there are many areas where it could be still enhanced. Some of them are related to users, especially with those that find difficulties using technology. Human-computer interaction for elders and users with cognitive disabilities presents many challenges that should be satisfied as soon as possible.

Information that must be accessed using a diverse range of devices or in different contexts constitutes another challenge for the next months. Adapting contents depending on the user location or delivering device specific information and functionalities will contribute to a better interaction experience. Finding methods and techniques to achieve this adaptation and extending its use among designers and developers is really a challenge that will be completed this year. On the other hand, the methods we use to make usability tests, an important aspect to measure software quality, could benefit from new improvements in automated usability tests.

Devices are another important component in the interaction process. Although there have been notable improvements in the hardware during last years, future human-computer interfaces should benefit from devices that enable more natural and intuitive communication between people and machines. Brain computer interfaces will clearly facilitate the way people communicate inputs and commands to computers. Getting different devices to communicate and working together is a challenge that proxemic interactions will achieve in the future. Although both these two concepts have been studied before, we have enumerated some questions that should be answered in the future.
We are sure there are lots of other challenges that will be faced during 2012 or next years. All of them should be analyzed carefully and tested properly with the targeted users. Any software/technique/method/hardware that contributes to improve the way we interact with computers will be welcomed.

6 References


17. Marquardt, Nicolai y Greenberg, Saul. Informing the design of proxemic interactions. Department of Computer