ASSISTIVE TECHNOLOGIES AND TECHNIQUES FOR WEB BASED EGOV IN DEVELOPING COUNTRIES

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Abstract: Electronic government (eGov) is intended to serve the whole spectrum of the population. To be able to access services and thus benefit from eGov, many users require assistive technologies and techniques (ATT). This demand is implied by auditory, visual or other impairments but also by low literacy skills. Thus, in the context of this paper the term ATT is interpreted in a broader sense compared to the classic definitions of the term "assistive technology" that relate to impairments or other special needs. This paper explores the range of ATT on the background of the special conditions found in developing countries. We investigate which types of users benefit from ATT in which ways and discuss which categories of users have requirements that are not yet covered by the current stage of development of ATT. The reasons for the remaining problems regarding access may be due to factors related to the country context or due to current technological limitations. Some lessons learned from our findings will be presented which indicate directions for further research.

1 INTRODUCTION

Electronic government (eGov) is intended to serve the whole spectrum of the citizens in a society. Developing countries have characteristics that significantly differ from developed countries affecting directly the design of eGov systems (Hornung and Baranauskas 2007). To illustrate our case we pick Brazil as a representative of this category of nation. Knowing that the situation in developing and emerging countries throughout the world is not uniform we will point out this fact whenever we believe that our considerations are not universally valid. The context of this paper is thence defined by the design of web based eGov services, the country context of Brazil and our HCI perspective towards it. Guiding principles of our research are those of Universal Design, i.e. instead of focussing on solutions for people with specific impairments we search for solutions that facilitate the access for all, in the sense of the largest possible audience.

A web based eGov service is accessible via the Internet. Thus, it is typically accessed via a web browser or other client-side interfaces (e.g. media players with text and graphic rendering facilities or any other custom-built application). Although web based services can also be accessed via other clients like mobile handheld devices or digital interactive television, we limit our discussion in this paper to computer based clients. The reasons for this decision are a small (mobile handhelds) or virtually non-existent (digital interactive television) market-penetration on the one hand and too many open questions regarding universal access to these devices on the other hand. Nevertheless, we believe our considerations can also contribute to discussions of those two classes of client devices.

We situate our discussion on web based eGov applications, i.e. services created by a governmental institution to be accessible via the Internet. eGov services can be categorized in three different levels: a first-level service offers static information (e.g. texts of laws, health information, etc.), a second-level service enables the execution of an electronic process (e.g. income tax declaration), whereas a third-level service offers participation in democratic processes (e.g. discussion forums, wiki-style creation of draft laws). The main difference to non-eGov services is

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that the content of those services tends to be more complex than that of other web applications such as shopping sites or social networking services (by which we do not mean that the design problem to create easily accessible non-eGov sites is trivial).

The goal of this paper is to compile a list of technologies and techniques that can be employed for building and using web based eGov services. Furthermore we propose criteria to evaluate the items on this list and give indications on technologies and techniques best suited to our context.

The paper is organized as follows: Section 2 contextualizes the discussion on the challenges we face in developing countries regarding interaction design for eGov. Section 3 surveys recent literature on related subjects. Section 4 presents our compilation of assistive technologies and techniques focussing on solutions that make sense in our country context. We also present some lessons learned from the technologies and techniques analysis to deal with our major challenge: illiteracy. Section 5 concludes.

2 COUNTRY CONTEXT AND USERS – THE CHALLENGES

The Brazilian population is characterized by a vast diversity regarding different demographic dimensions, disabilities, literacy and digital divide. The aim of this section is not to draw a statistically comprehensive picture of Brazil. Since the scope of our work is the potential inclusion of all citizens, a small, but significant number in any given demographic dimension is sufficient for that dimension to be further considered. About 10% of the Brazilians have a visual impairment, and about 5% have auditory or motor impairments respectively (IBGE 2000).

As there are different methods for measuring literacy there are also different statistics regarding literacy in Brazil (IPM 2005; UNDP 2007). In the context of the latest Human Development Report of the United Nations Development Programme, literacy is defined as the percentage of people of ages 15 and older "who can, with understanding, both read and write a short, simple statement related to their everyday life." (UNDP 2007, p. 368) and thus an adult illiteracy rate of 11.4% is diagnosed for Brazil. Regardless of the methods and definitions of literacy, the proportion of illiterate and semi-literate Brazilians cannot be ignored.

As to digital literacy, in a 2005 survey of the IBGE, only 22.9% of the Brazilians over 10 years stated that they had accessed the Internet during the last three months. 50.0% of those have accessed the Internet from their own homes. Considering those who exclusively accessed the Internet from their own homes, 38.5% had dial-up access only. The 77.1% who didn't access the Internet during the reference period of three months, 37.2% didn't have access to a computer at all (IBGE 2005).

Considering that a great percentage of the Brazilian population does not have access to computers and the Internet from their homes, telecenters and internet cafés or other public spaces play an important role in providing access to technology and will be considered accordingly in this paper. In Brazil, many telecenter initiatives are government-driven, whereas in other countries non-government organizations play an important role as well. In either case, long-term cost-efficiency and sustainability are important requirements to consider.

We have not yet defined the term "digital literacy", neither do we intend to give a formal definition. In our context, the minimum requirements for the interaction with an eGov service are the proficiency in the use of keyboard, mouse and other peripherals, as well as the ability to use browser-like interfaces that contain text, text input areas, multimedia areas (images, audio or video), links, and buttons or other clickable active areas. Looking at the statistics we presented, we have to presume that a significant part of the Brazilian population does not show sufficient competencies to interact with web based eGov services without further assistance, be it personal or via technology.

Given the context and user scenario described above, we face some challenges that differ from the canon of literature we encountered about assistive technologies. Regarding the users, we are not in a position where we know their competencies and needs, like for example a company that has to fit out a number of workstations to suit the needs of its employees with for example physical or other impairments. Neither is our situation that of an organization or institution that offers a facility where for example people with visual impairments can access computer terminals and count on the help of a trained attendant.

Following the principles of Universal Design, we have to think about solutions that enable people with all possible competencies to use eGov services. Regarding the country context, we can not simply create incentives for people with special needs to buy their own assistive technology that optimally suits them. In the public or quasi-public areas of access (telecenters, internet cafés, etc.), we can not rely on trained personnel that always can assist users with special needs. Since telecenters are only available in about 50% of the Brazilian municipalities (IBGE 2006), we may often encounter places where private internet cafés provide the only possibility to access computers and the Internet. Considering the lack of public-private partnerships in this area, we can not expect that internet cafés provide all assistive technologies required by potential users in their surroundings. Another challenge that we face are low digital literacy skills of potential users.

3 RELATED WORK

This paper does not intend to give a comprehensive overview of the field, and some of the technologies presented in this paper are already well known since quite some time. However, we will present exemplary solutions that address some special needs or competencies discussed in further sections and that represent recent developments in the area. The solutions presented show some ideas regarding how to enable the access to eGov services in general as well as how to facilitate access to web based applications for users with low literacy skills and users with auditory, cognitive, motor or visual impairments.

Pilling and Boeltzig (2007) provide a starting point by identifying the lack of assistive technologies as one barrier to the access to eGov services. However, since they follow a strategically focused approach and base their investigations to initiatives in the U.S. and U.K., their findings have only limited applicability to our context.

Independently of different ways of measuring literacy, many people in developing countries have low or no reading skills at all (UNDP 2007). Since eGov services are supposed to reach and benefit especially people with low literacy skills, one essential challenge is to provide access to these users. Medhi et al. (2007) investigate different options to audio-visually represent healthcare-related concepts to people with low or no literacy skills. Their main findings point out that auditory information is very important for comprehension, but can confuse the subjects due to multimodal effects when used together with visual information; richer information not always results in better understanding. They also examine when to use static images (i.e. photos and drawings) and when to use videos or animations and conclude that it depends on the content to be represented.

The average reading level among the group of deaf people is significantly lower than that of the hearing. Furthermore images and icons that are meaningful to the hearing might not be so to the deaf and hard of hearing. For the community of deaf people, the effort in reading text in a spoken language is comparable to the effort in reading a foreign language. Kennaway et al. (2007) explore the possibilities of providing signed content in web based applications. They identify advantages of signing avatars over videos and propose a set of tools for the generation and delivery of signed content via a browser plug-in. One of the challenges lies in dynamically generated text with a previously unknown structure; this problem has a similar complexity to the automatic translation between spoken languages and thus signing avatars yield comparable results.

The literature review reveals that accessibility for users with cognitive disabilities is a field where much work still has to be done. Based on the principles of Universal Design, Sevilla et al. (2007) propose guidelines to redesign conventional web content in order to make it cognitively accessible. A comparative study shows that for example short-memory problems do occur in the conventional version of a web page but not in the cognitively accessible version of it.

Assistive technologies for users with motor impairments are often hardware based solutions, e.g. alternative input devices. However, there are also software based solutions that improve the accessibility of standard input devices like trackballs or mice. These solutions are especially interesting in our context since they are potentially easier to deploy and maintain in a large scale basis. Wobbrock and Gajos (2007) compare the target acquisition paradigms “area pointing” and “goal crossing”. As opposed to area pointing, users do not click in an area but pass over a target line. Although it seems that users with motor impairments prefer goal crossing and are able to achieve a better performance in certain conditions, many open questions still remain, e.g. how to design goal crossing interfaces or which competencies of users with motor impairments are best suited for this kind of interfaces.

Screen readers and refreshable Braille displays represent the contents of web pages in a linear manner to the blind user. Besides being time consuming, the linearity also may complicate the comprehension of the content, since images, tables and other structural information are perceived differently than by a user with no visual impairment. One approach to overcome this limitation is the use of haptic devices that provide tactile feedback. Kuber et al. (2007) present a participatory approach to design feedback for web based applications. Besides mostly used as a complement for screen readers and other solutions, haptic devices can possibly facilitate the access of users with visual impairments that have no familiarity with the use of screen readers. However, the work on haptic devices has not yet reached a maturity that permits its use in our context.

4 ASSISTIVE TECHNOLOGIES AND TECHNIQUES

The term "assistive technology" is often defined as a set of technologies "[...] that increase, maintain, or improve the functional capabilities of individuals with disabilities[1] [...]" (U.S. Department of Health and Human Services 2007). Although such technologies are not restricted to computer systems, but also include devices found at the work places or homes of people (e.g. phone foot switches or arm and elbow supports), within the limits of this paper only computer related artefacts are of interest to us. Due to the context previously described, we will include people without impairments but with low literacy skills into our considerations regarding accessibility. Thus we will take a broader view on the subject and use the term "assistive technologies and techniques" (ATT) to describe solutions that have the potential to enable and facilitate the access and use of web based eGov services for our target audience, i.e. citizens with all possible special needs and competencies. This includes assistive technologies, but also methods, best practices or other solutions like earcons (Brewster 1998), the use of multimedia content in web pages, etc. Our work is therefore in-line with the shift from research and development which considers assistive technologies for people with disabilities to Universal Design of solutions for the largest possible audience (Law et al. 2007).

There exists a wide range of special needs implied by conditions such as physical (motor, mobility), sensory (auditory or visual) or cognitive impairments, development disability or mental retardation. Table 1 displays a list of categories of assistive technologies examined under the aspect of five significant dimensions:

- *Beneficiary*: denotes the category of user who benefits from the solution: users with auditory, motor or visual impairments (columns A, M, and V) or users with low literacy skills (column L).
- *Input/Output (I/O)*: denotes whether a technology is used during data input (I) or output (O).
- *Implementation in hardware or software (HW/SW)*: software based solutions work without special hardware (e.g. screen magnifiers); hardware based solutions generally work independently of the application (e.g. braille embossers). The fact that hardware based solutions generally require a driver or other software to function is neglected here, however there are hardware based solutions where the software part is significant (e.g. biometric devices) or where dedicated hardware solutions exist besides the software-only solutions (e.g. speech synthesizers). These cases are denoted by "HW/SW".
- *Maturity*: in our context a technology is considered mature, if it functions with acceptable error rates in our scenario of public access areas with many different users that are potentially unskilled in the use of the technology. The technology has to function under a wide range of environmental conditions since background noise, light, temperature, etc. cannot be controlled. Our measure is a qualitative one and can not be backed up by quantitative data. A "+" indicates a sufficient, a "-" an insufficient maturity level. A "+/-" indicates that the technology has an unacceptable maturity level under certain circumstances (e.g. handwriting in the case of optical character recognition and unavailability or low quality of speech synthesizer voices for some languages).
- *Training*: denotes whether an assistive technology can be used without prior training. We do not quantify the amount of training required. A "-" means that no training is required, although the user will improve her performance with increasing familiarity. Technologies with a "+" require a certain amount of prior training. Apart from that, there also exist technologies that have to "learn to interpret" the user input (e.g. voice recognition software). A "(-)" means that the user does not need any training but other knowledge to be able to use the respective technology (e.g. users of refreshable Braille displays need to know Braille).

Disregarding entries that only indirectly benefit certain categories of user (entries marked as "(x)"), a look at the table shows that there seems to be quite some solutions for people with visual impairments, not quite as many for people with auditory, cognitive and motor impairments and very few solutions for people with low literacy skills.

Regarding the deaf and the hard of hearing, the solutions presented in the table either require literacy skills (TTY/TDD conversion modems), are only suited for very specific purposes (light signaler alerts) or are not yet mature enough to be used in a large scale off-laboratory scenario (gesture recognition, sign synthesis).

Apart from technologies for data input (keyboard filters and hardware based input devices), there seem to be no technologies specifically developed for users with cognitive impairments.

[1] We intentionally ignore discussions about the appropriate use of terms like "disability" or "impairment" in this paper.

Table 1: Assistive technologies.

ASSISTIVE TECHNOLOGY	BENEFICIARY					I/0	HW/SW	MATURITY	TRAINING
	A	C	L	M	V				
Screen enlargers, screen magnifiers					x	O	SW	+	-
Braille embossers					x	O	HW	+	(-)
Screen readers					x	O	SW	+	+
Speech and voice recognition		x	x	x	x	I	SW	-	+
Text-to-speech (TTS) or speech synthesizers		x	x		x	O	HW/SW	+/-	-
Refreshable Braille displays					x	O	HW	+	(-)
Keyboard filters		x	(x)	x	x	I	SW	+	-
On-screen keyboards				x		I	SW	+	-
Light signaler alerts	x					O	HW	+	-
TTY/TDD conversion modems	x				x	I/O	HW	+	(-)
Alternative keyboards	(x)	x	(x)	x	x	I	HW	+	(-)
Touch screens	(x)	(x)	(x)	(x)	(x)	I	HW	+	-
Other alternative input devices (e.g. electronic pointing devices, wands, sticks)				x		I	HW	+	(-)
Peripherals (e.g. micro, web cam)	(x)	(x)	(x)	(x)	x	I/O	HW	+	-
Scanners	(x)	(x)	(x)	(x)	(x)	I	HW	+	-
Optical character recognition (OCR)	(x)	(x)	(x)	(x)	(x)	I	SW	+/-	-
Biometric identification devices	(x)	(x)	(x)	(x)	(x)	I	HW/SW	-	-
Motion capture, gesture recognition	x					I	HW/SW	-	+
Text-to-sign or sign synthesis	x				x	O	SW	-	(-)

Solutions for people with low literacy skills are under-represented. This is not astonishing since many assistive technologies emerged from the “computer at work” context in developed countries that show high literacy rates. Furthermore the challenge for users with low literacy skills is not the sensory access of computers or contents. Thus, solutions for this user category will be mainly based on assistive techniques described below.

Assistive technologies for people with motor impairment are focused on hardware based solutions for data input.

Although it seems that assistive technologies for people with visual impairments are well represented in the table, solutions for people with the most severe impairments, i.e. blindness and very low vision, require a certain amount of training (screen readers, speech recognition) or further knowledge and skills (Braille).

Another aspect that is not explicitly shown in Table 1, but nevertheless important refers to cost. Regardless whether public access points are run by government agencies or non-government organizations, cost will play an important role for the deployment of assistive technologies in developing countries. There will be trade-offs between the academically desired optimal solution (making available the technologies that are best suited for the users that use a given point of public access) and the practically feasible solution. An example are alternative input devices for people with motor impairments, some of which accommodate very special needs. Regarding the issue of cost, solutions will be preferred that suit more than one special need. Software based solutions are preferable to hardware based ones: maintenance is cheaper and often free implementations already exist, although they not always offer all functionality of commercial solutions.

To summarize the analysis of Table 1, although there exist many different categories of assistive technologies that attend many special needs, the number of potential solutions diminishes when we consider our specific context. Since according to our literature research many authors have dedicated themselves to assistive technologies for auditory, motor and visual impairments and since solutions for cognitive accessibility require a research profile that differs from ours we restrict our further considerations to people with low literacy skills. Further comparative analysis of technologies or concrete products are out of the scope of this paper.

4.1 Lessons Learned for People with Low Literacy Skills

This subsection discusses assistive techniques for users with no or low literacy skills. In the context of this paper, assistive techniques are methods for facilitating access to web based content. In contrast to most assistive technologies, content becomes inherently more accessible when applying assistive techniques. Although limiting ourselves to the problem of literacy, we borrow from the body of methods intended to benefit users with other special needs. On the other hand, our considerations can possibly contribute to the areas we borrow ideas from as well.

The challenge for people with low literacy skills is twofold, since they are often novice computer users. Since many usability guidelines deal with the performance of novice users, we will exclusively focus on the literacy aspect.

According to Table 1, the set of assistive technologies adequate for people with low literacy skills comprises speech and voice recognition systems, text-to-speech synthesizers, keyboard filters, alternative keyboards, touch screens, scanners and other peripherals, optical character recognition software and biometric identification devices.

Voice recognition can be used for authentication purposes, speech recognition for text entry or navigation. Although these solutions seem the most interesting for this user-category, there are some indications that suggest they are not appropriate solutions for our context. Apart from technical problems like background noise or the recognition of natural, freestyle speech (Deng 2004), speech recognition systems usually initially need to be trained and adjusted to the individual user's characteristics. Moreover, speech recognition in public places collides with the user's privacy requirements.

Alternative keyboards with spatially clearly structured areas and differently colored keys (e.g. letters, numbers and "function keys" like enter, space, backspace, etc.) benefit users with low literacy as well as users with some cognitive or visual impairments and are a feasible solution in our context of public access points, since the coloring can be done even for keyboards already purchased and in use. Touch screens diminish the attention split between screen, keyboard and mouse, and thus not only benefit users with cognitive impairments but also users with low literacy skills.

Scanners and OCR software could be used to replace manual data entry that can be found on documents like utility or telephone bills. An aspect that cannot be neglected, however, is that these documents could contain other data that the user might not want to divulge.

A similar argument applies to biometric identification devices. Although the identification or authentication processes can be simplified, the registration of biometric characteristics like finger prints or iris scans in a government system can create other psychological barriers of access.

Although we could identify assistive technologies that bring benefits to users with low literacy skills as a side effect, much more potential lies in assistive techniques discussed in the remainder of this section. We identified the following categories of assistive techniques:

- *Accessibility, usability and other design guidelines and principles*: to our knowledge there exist no guidelines, recommendations or principles explicitly tailored to the requirements of people with low literacy skills and published by consortia like the W3C or other organizations. Apart from sources directly related to the subject matter (e.g. Huenerfauth (2002) or Medhi et al. (2007)), our findings reveal that many guidelines, recommendations or principles for users with other special needs also bring benefits to users with low literacy skills. Although intended for the deaf and hard of hearing, some of the findings of Fajardo et al. 2007 are directly related to literacy and thus applicable to our case. The simplification of web page structure and content that benefits users with cognitive impairments (Sevilla et al. 2007), also benefits users with low literacy skills, since a simplification will yield web pages with less textual information and texts presented in a language and grammar that is easier to understand.
- *Standards or recommendations*: generally, all standards or recommendations that deal with alternatives to text-based or visual interfaces, text layout, and the augmentation of textual information by multi-media content are relevant. This list comprises but is not limited to the W3C activities, recommendations or candidate recommendations (W3C 2007) CSS (Cascading Style Sheets, a mechanism for separating text content

from layout), the Multimodal Interaction Activity (provides the possibility to dynamically select the most appropriate mode of interaction), SMIL (Synchronized Multimedia, an XML-based language for interactive multimedia presentations), SVG (Scalable Vector Graphics, an XML-based language for describing 2D graphics and graphical applications), or the W3C Speech Interface Framework (including markup specifications like VoiceXML for telephone-based interaction with web applications). Although having great potential, new challenges arise to make applications accessible that use these techniques (Gibson 2007).

- *Individual solutions*: The literature that elaborates individual solutions ranges from case studies that try to identify techniques by analyzing design processes or results to proposals that study novel approaches. Akan et al. (2006) develop an electronic screening tool for rural primary care, Plauché and Prabaker (2006) a telephone based system for market and ambient information that can be used uttering a set of pre-defined command words. A solution for novice computer users that also facilitates access for users with low literacy skills is presented by Chand and Dey (2006). Although these three and other solutions for users with low literacy skills are fundamentally different from each other (in the three examples above simple minimalist touch screen interface vs. completely auditory interface with speech recognition vs. creation of printed macros that are activated by a barcode scanner), they all follow similar principles: present a minimal and simplified interface, minimize or eliminate the necessity of reading or entering textual data, and using alternate media (audio, images, video) either redundantly or exclusively.

Our literature study showed that a body of best practices seems to be evolving. Auditory feedback is considered crucial. Apart from giving explicit linguistic feedback, we could draw inspiration from solutions that are intended for users with visual impairments (e.g. Eiriksdottir et al. 2006), techniques that use abstract non-speech sounds to facilitate menu navigation or similar tasks (e.g. Brewster 1998; Dicke et al. 2007).

The principle to create simple and minimalist interfaces that avoid unnecessary complexity is also found in the literature about Universal Design and cognitive impairments.

Another best practice that seems to be consensus is the use of visual information like drawings, photos, animations or videos. Although certainly very important, the use of related techniques has to be carefully planned since there exist no universally valid rules regarding which kind of visual representation is optimal. Furthermore cognitive effects have to be considered when using textual, auditory and visual representations simultaneously. Leahy et al. (2003) discovered that depending on the task complexity and the redundancy of auditory, textual and visual information, it is sometimes better to use fewer types of different media.

5 CONCLUSIONS

This paper presented an overview of ATT in the context of challenges we face in developing countries when considering interaction design for eGov. Our overview has shown that although there are a variety of assistive technologies, there remain many gaps, especially considering the scenario of public access points in developing countries. We have shown that particularly for users with low literacy skills, assistive techniques may offer many possible solutions to be investigated. Although there is no clear body of rules regarding the optimal employment of the techniques, since many of them depend on various factors, they encourage further research. Some of these solutions are now being investigated in the context of interaction design for an eGov project in Brazil.

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REFERENCES

Akan, K. D., Farrell, S. P., Zerull, L. M., Mahone, I. H., and Stephanie Guerlain, S. (2006). eScreening: Developing an Electronic Screening Tool for Rural Primary Care. In *Systems and Information Engineering Design Symposium, 2006 IEEE*, pages 212–215.

Brewster, S. A. (1998). Using nonspeech sounds to provide navigation cues. *ACM Trans. Comput.-Hum. Interact.*, 5(3):224–259.

Chand, A. and Dey, A. K. (2006). Jadoo: a paper user interface for users unfamiliar with computers. In *CHI ’06: CHI ’06 extended abstracts on Human factors in computing systems*, pages 1625–1630, New York, NY, USA. ACM Press.

Deng, L. and Huang, X. (2004). Challenges in adopting speech recognition. *Commun. ACM*, 47(1):69–75.

Dicke, C., Sodnik, J., Billinghurst, M., and Tomazic, S. (2007). Spatial auditory interfaces compared to visual interfaces for mobile use in a driving task. In *ICEIS 2007: proceedings of the Ninth International Conference on Enterprise Information Systems*, pages 282–285, Funchal, Madeira, Portugal.

Eiriksdottir, E., Nees, M. A., Lindsay, J., and Stanley, R. M. (2006). User preferences for auditory device-driven menu navigation. In *Proceedings of the Human Factors and Ergonomics Society 50th Annual Meeting*.

Fajardo, I., Cañas, J. J., Salmeran, L., and Abascal, J. (2006). Improving deaf users' accessibility in hypertext information retrieval: are graphical interfaces useful for them? *Behaviour and Information Technology*, 25(6):455–467.

Gibson, B. (2007). Enabling an Accessible Web 2.0. In *W4A '07: Proceedings of the 2007 international cross-disciplinary conference on Web accessibility (W4A)*, pages 1–6, New York, NY, USA. ACM.

Hornung, H. and Baranauskas, M. C. C. (2007). Interaction Design in eGov systems: challenges for a developing country. In *XXXIV Seminário Integrado de Software e Hardware, SEMISH/CSBC2007. Anais do XXVII Congresso da SBC*, pages 2217–2231, Rio de Janeiro, Brazil.

Huenerfauth, M. P. (2002). Developing design recommendations for computer interfaces accessible to illiterate users. Master's thesis, University College Dublin.

IBGE (2000). Instituto Brasileiro de Geografia e Estatística: Censo Demográfico (in Portuguese). Online available: http://www.ibge.gov.br/home/presidencia/noticias/27062003censo.shtm. Last accessed: 12/12/2007.

IBGE (2005). Instituto Brasileiro de Geografia e Estatística: Acesso à Internet e posse de telefone móvel celular para uso pessoal (in Portuguese). Online available: http://www.ibge.gov.br/home/estatistica/populacao/acessoainternet/default.shtm. Last accessed: 12/12/2007.

IBGE (2006). Instituto Brasileiro de Geografia e Estatística: Perfil dos Municípios Brasileiros (in Portuguese). Online available: http://www.ibge.gov.br/home/estatistica/economia/perfilmunic/2006/default.shtm. Last accessed: 12/12/2007.

IPM (2005). Instituto Paulo Montenegro: Indicador de Alfabetismo Funcional (in Portuguese). Online available: http://www.ipm.org.br/ipmb_pagina.php?mpg=4.02.00.00.00&ver=por. Last accessed: 12/12/2007.

Kennaway, J. R., Glauert, J. R. W., and Zwitserlood, I. (2007). Providing signed content on the Internet by synthesized animation. *ACM Trans. Comput.-Hum. Interact.*, 14(3):15.

Kuber, R., Yu, W., and McAllister, G. (2007). Towards developing assistive haptic feedback for visually impaired internet users. In *CHI '07: Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 1525–1534, New York, NY, USA. ACM.

Law, C., Jacko, J., Peterson, B., and Tobias, J. (2005). Universal designs versus assistive technologies: research agendas and practical applications. In *Assets '05: Proceedings of the 7th international ACM SIGACCESS conference on Computers and accessibility*, pages 2–3, New York, NY, USA. ACM.

Leahy, W., Chandler, P., and Sweller, J. (2003). When Auditory Presentations Should and Should not be a Component of Multimedia Instruction. *Applied Cognitive Psychology*, 17(4):401–418.

Medhi, I., Prasad, A., and Toyama, K. (2007). Optimal audio-visual representations for illiterate users of computers. In *WWW '07: Proceedings of the 16th international conference on World Wide Web*, pages 873–882, New York, NY, USA. ACM.

Petrie, H., Fisher, W., Weimann, K., and Weber, G. (2004). Augmenting icons for deaf computer users. In *CHI '04: CHI '04 extended abstracts on Human factors in computing systems*, pages 1131–1134, New York, NY, USA. ACM.

Pilling, D. and Boeltzig, H. (2007). Moving toward e-government: effective strategies for increasing access and use of the internet among non-internet users in the U.S. and U.K. In *dg.o '07: Proceedings of the 8th annual international conference on Digital government research*, pages 35–46. Digital Government Research Center.

Plauché, M. and Prabaker, M. (2006). Tamil market: a spoken dialog system for rural India. In *CHI '06: CHI '06 extended abstracts on Human factors in computing systems*, pages 1619–1624, New York, NY, USA. ACM Press.

Sevilla, J., Herrera, G., Martínez, B., and Alcantud, F. (2007). Web accessibility for individuals with cognitive deficits: A comparative study between an existing commercial Web and its cognitively accessible equivalent. *ACM Trans. Comput.-Hum. Interact.*, 14(3):12.

Takagi, H., Asakawa, C., Fukuda, K., and Maeda, J. (2004). Accessibility designer: visualizing usability for the blind. *SIGACCESS Access. Comput.*, (77-78):177–184.

UNDP (2007). United Nations Development Programme: Human Development Report 2007/2008. Online available: http://hdr.undp.org/en/reports/global/hdr2007-2008/. Last accessed 12/12/2007.

U.S. Department of Health and Human Services (2007). Research-based web design and usability guidelines – Glossary. Online available: http://www.usability.gov/guidelines/new/dictionary/index.html. Last accessed 12/12/2007.

W3C (2007). Homepage of the World Wide Web Consortium (W3C). Online available: http://www.w3.org/. Last accessed 12/12/2007.

Wobbrock, J. O. and Gajos, K. Z. (2007). A comparison of area pointing and goal crossing for people with and without motor impairments. In *Assets '07: Proceedings of the 9th international ACM SIGACCESS conference on Computers and accessibility*, pages 3–10, New York, NY, USA. ACM.