Informatics as Semiotics Engineering: Lessons Learned from Design, Development and Evaluation of Ambient Assisted Living Applications for Elderly People

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Abstract. Assisted Living Systems with Ambient Intelligence technology raise new challenges to system and software engineering. The development of Assisted Living applications requires domain-oriented interdisciplinary research – it is essential to know both the domain and the context. It is also important that context-descriptive prototypes are: (1) an integrated description that describes system, work processes, context of use; and (2) a formal description. Because (1), designers, including end users, are provided with a means to investigate the system in the context of the envisioned work processes. Because (2), investigations into questions of formalization and automation, not only of the system, but also of the work processes, can be made explicitly and become subject for discussions and further elaboration. Adapted engineering approaches are required to cope with the specific characteristics of ambient intelligent systems. Elderly are the most demanding stakeholders for IT-development – even highly sophisticated systems will not be accepted when they do not address the real needs of the elderly and are not easily accessible and usable. Communication processes are essential in that respect. The evolution and, in particular, the spread of unambiguous symbols were an necessary postulate for the transfer of information, as for example in sign language, speech, writing, etc. In this paper, we report on our experiences in design, development and evaluation of computer applications in the area of ambient assisted living for elderly people, where, to our experiences, engineers highly underestimate the power of appropriate knowledge on semiotics and we demonstrate how we can emphasize universal access by thinking of informatics as semiotics engineering.

Keywords: Semiotic engineering, Informatics, Elderly.

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1 Introduction and Motivation for Research

Elderly people are the most demanding stakeholders for IT-development – even highly sophisticated systems will not be accepted when they do not address the real needs of elderly and are not very easily accessible, useful and usable [1], [2], [3].

It is very interesting, that people first expressed their ideas with cave drawings and the first figure systems and later the oldest known writing systems were developed from these drawings (Pictograms). According to Peirce (1932) [4], the basis of the communication process is a linguistically and culturally determined (established), but still evolving interpretation of signs, consequently semiotics is the basis of the exploration of subject and operation modes of communication processes. According to Nake & Grabowski (2001) [5], Semiotics is considered fundamental to the understanding of Human-Computer Interaction (HCI).

However, Nake & Grabowski go particularly further: They are of the opinion that Informatics should be viewed as technical semiotics or semiotics engineering – instead of computer science. This is a tough statement and not quite understandingly taken by computer scientists. However, if we want to change and really emphasize universal access to technology, then we have to consider that interaction between human and computer is characterized by communication, however, a type of communication that lacks decisive communicative features: it is rather a process of pseudo-communication, where the interaction is viewed as the coupling of two autonomous processes: a sign process (carried out by the end user) and a signal process (carried out by the computer system). Consequently, problems of software design (functionality and usability design) are specific problems of the coupling of sign and signal processes.

The three main goals of informatics (correctness of algorithms, efficiency of programs, and usability of software systems) turn out to be nicely related to the three semiotic dimensions: 1) Correctness is a matter of syntax to be answered by considering formal aspects only; 2) Efficiency is a matter of semantics related to the object world; and 3) Usability, taking interest and motivation of the end user into account, is a matter of pragmatics [6].

2 Related Work

Various technical based solutions to the problem of the elderly's increasing need for care have been developed throughout the world (Smart Homes, refer e.g. to [7], [8], [9]; assistive service robots [10], [11], [12] or portable emergency systems e.g. [13], [14], [15] etc.).

An interesting recent work was done by Picking et al. (2010) [16]: They performed a case study on the development of interfaces for elderly within their home environment; i.e. they developed ambient user interfaces, integrated in familiar home artefacts, such as televisions and digital picture frames, which are adaptive to users' expected increasing physical and cognitive needs; interfaces familiar to the user population were found to be a key factor for universal access in the sense of Stephanidis & Savidis (2001) [17].

De Souza et al. (2010) [18], stated that HCI evaluation methods tend to be proposed and used to verify the interactive qualities of specific systems and design strategies and the showed that, under certain conditions, inspection methods can be safely used in scientific research in HCI and extend their advantages beyond professional practice; on the example of the Semiotic Inspection Method (SIM), de Souza et al. argued that its interpretive results are objective, can be validated and produce knowledge comparable to that of more widely accepted methods.

3 Theoretical Background

Semiotics deals with the relationship between symbology and language, pragmatics and linguistics. Information and Communication Technology deals not only in words and pictures but also in ideas and symbology; Gang Zhao (2004) [19] defines semiotic engineering as: "*a process of creating a semiotic system*", which he describes as "*a model of human intelligence or knowledge or logic for communication or cognition*".

A much neglected potential tool of Information Communication, it has been a prerequisite of the sociologists, psychologists, and philologists and is now being re-discovered by the technical community (ICT) as a possible aid to acceptance by non-technically educated users. Presenting information in a recognisable symbology not only facilitates communication, it also increases intuitiveness – an important aspect of usability.

The classic example of misunderstood iconography is, of course, the much quoted use of a mobile-phone icon rather than a dial phone icon. While a great deal of usability testing is made based on the physical disabilities of the elderly, such as diminished vision, hearing and dexterity, the application of standard semiotic principles to develop a more acceptable and intuitive control system based on the adaption of symbol recognition principles is less well-researched

While the baby boomers have accustomed themselves to this ubiquitous technology and are happy and comfortable with biometrical device mechanisms, the 65+ generation – who are now beginning to need these aids – are less able to identify with those who they think of as being the technical generation. This is not made easier by the tendency to base the symbology of the interfaces on a later generation of adults. While there is no universal determining factor or circumstance responsible for an elderly person's need to leave their home and enter a care facility, there are a number of aspects of living which must be fulfilled to enable an autonomous, if not completely independent, life style.

These aspects vary with location and physical and mental health and can be ameliorated by social support systems and the integration of technical aids into their daily activity. Any scientific study on the ability and applicability of technical aids to reduce risks and facilitate sustaining a social support system must include the important area of *acceptance* on the part of the elderly user. Since suggestions for solutions involve the use of connectivity & social webs, cognitive stimulation (games) and information collectivity and familial monitoring, these concepts must also be understood by the people involved.

Some of the infrastructures that offer the most advantages for the elderly as users, such as social interaction programs, are currently designed with young people in mind

as take full advantage of their ability to recognise the same symbols and to possess the same semiotic data base as the designers.

Once it is accepted that demographic pressure makes it necessary that common applications are designed for a wider age spectrum, one aspect of semiotic engineering could offer designers the key to increasing acceptability among non-homogenous groups.

Based on the results of our research, elderly users welcome methods of retaining autonomy by increasing their self-help abilities and making social interaction more risk free, whenever this is not considered "too complicated". Their families and care givers are more concerned with assessing risk factors; early detection of weakness and falls or danger situations. But no matter what their differences, it was understood that – should the elderly people fail to accept the technology, it would be of no value to them or their families and a high level of acceptance depends on good design as well as recognising both needs and fears.

4 Design Aspects

De Souza (2001) [20], suggests that designers attempt to bridge the designer/user gap by de-emphasising the computer – except as a medium – making the primary communication between *human user* and *human designer.* This approach could prove useful in designing for the elderly, since it would mean concentrating on the end users communication methods and symbology, rather than the classic *designer – interface – user* triangle.. Interface design for the elderly often concentrates on the physical aspects of design – size, manipulability, simplicity and clarity, since these are the aspects most obvious to the end users. Increased functionality and sophistication of the devices has led to the simplification of universally recognised symbols. However, the term *universally recognised* assumes a cultural homogeneity not always given, even within a single community. The use of design semiotics could also increase those metrics of usability of most importance: efficiency and acceptance.

While the design of a monitoring device interface is a different type of challenge to the design of a social networking interface for a full computer screen, the basic rules of symbol recognition and conformability still apply.

When referring to semiotics of gender, we are not referring to the symbols people use to recognise gender or gender roles, but rather the effect gender has on the symbols and signs used and the subjective feeling of the relevance of symbols. Social semiotic visual analysis, in particular the study of visual depictions of gender, has concentrated on investigating the extent to which the behaviour of a generation of people has been cognitively imprinted by symbolism – for example, that Computer Journals in the 1950s and 1960s rarely showed a female scientist. ICT is more affected by the possible influence of gender on sign recognition, familiarity and cultural acceptance. Is there a truly a difference in acceptance dependent on the gender of the user? Does the level of abstraction affect intuitiveness differently?

Are different designs required in order to obtain the same level of acceptance from a both genders? Is this affected by increasing age?

HCI Students have been using semiotics, often unknowingly, in designing web pages, user access applications and icons for some time. However, actively

differentiating between their own, culturally formed, understanding of certain signs and symbols and that of their end users had been at most unconscious and usually unnecessary. It was generally assumed that any difficulties experienced by the elderly in using technological devices were traceable to physical causes. When designing web pages for people with sight problems, scalable text was a matter of course and scalable icons soon became standard. Hard of hearing users were given special adaptive programs to enable them to convert sound files to text. Since so many elderly people merely stated that 'technology made them uncomfortable' it seemed obvious that it was an 'age thing' or a cultural thing, and could only be changed by intensive education. The question of the suitability of the icons, or whether the symbols or terminology could be adapted to enable people with a different cultural background to decipher their meaning, was not often asked.

In our study, we concentrated on the extent to which adapting symbology can achieve positive feedback in ICT situations, while taking possible previous negative influences into account.

While computer interfaces have become a great deal more interactive and icons are generally accepted, a number of technical devices still use a simple abstract symbology unknown to many elderly people (see figure 1). The necessity to pack a quantity of functions onto a small space, has led to a climate of reduction.

Fig. 1. Universality of typical abstract symbols in current remote control devices (Sony & Cyclops)

Unsurprisingly, designers who have grown up with this symbolism, from computer games to TV remotes, find it rather hard to accept that not all elderly people are actually aware of the purpose of every symbol on their household appliances, let alone the controls of their more complicated devices. Since these abstract symbols have now been taken as standards by many different developers, designers must make it clear to users what they mean by these symbols and users must be instructed to understand and respond to the information.

5 Methods and Materials

The emphasis in any evaluation from an engineering point of view is on documenting and analysing the way the device works in practice. In order to identify and understand important influences on operation and achievements, *semiotic engineering* deals

with the recognisability of the symbology and understanding of the language used, therefore, our usability evaluation considered how the interface design influenced the acceptance and intuitiveness of usage. For an evaluation from a behavioural view, it is necessary to consider how the elements designed interact with each other and with the user. For this purpose, scenarios are used, since with these, we were able to give the users a purpose and a goal, which was far preferred to 'free experimentation'.

At the same time a reiterative formative evaluation was made in order to generate information that could be used to refine and improve the programmes and visual interfaces from an early stage. The participants in our usability testing groups were heterogeneous groups of males and females aged between 55 and 90. One group was completely autonomous, one group lived in a home for the elderly and the last group was in need of full-time medical supervision in a geriatric hospital. As can be expected in this age group, there were more women than men.

The devices tested ranged from low tech test applications on various hand held devices and tablets designed by HCI students of the Technical University Graz (www.hci4all.at), to a high-tech, fall sensor device, specially designed for the elderly [21]. The tests were conducted in three sections: demonstration; questionnaire; informal discussion. The students who supplied the low-fi devices were given no guidelines as to the type of symbology most acceptable to their age group. Once the testing cycle was underway, they were able to supply each other with feedback regarding understanding, competence and suitability of the symbols chosen. Analysis of the participants understanding and acceptance of the icons used in the software served to indicate users' communication symbols and translation images.

The demonstrations of the applications and devices to be tested were kept purposely simple, since we wished to evaluate intuitiveness and symbol recognition. The applications and devices used for the Geriatric Hospital were neither as complicated – nor the tests as long – as those for the other two groups. As a result, we received less direct data and more subjective information. Unsurprisingly, the most enthusiastic group were the residents of a home for the aged. They were also the most critical of the displays. The autonomous group were primarily interested in functionality and saw any misunderstanding of icons as affecting speed of use and reliability, while the residents were more critical of needing to ask for help if something was not intuitive. The questionnaire used a six-point Likert scale divided into five main areas: usefulness, attractiveness, usability, comfort and acceptance, randomly sorted. The participants were given the questions on a sheet of paper, with the request to ignore any question they were unable to answer - rather than just ticking any box. However, the main data was acquired during the informal discussion, since this was the time when the participants were no longer 'on their guard' and able to relax and share their subjective responses to the question of intuitive usage; ease of use; simplicity of texts and autonomous control. We were able to spend some time with the participants discussing their perception of purpose and understanding.

6 Discussion and Lessons Learned

Pleasant test environments helped towards avoiding a clinical atmosphere and enabled the participants to take part in a relaxed discussion. The students were able to get an

idea of the size of the gap existing between what they considered obvious terminology and symbolism and that of their future users. The older participants were in a position to explain their difficulty with many of the icons and symbols used in modern technology. While older people often experience impairment of their fine motor skills, necessitating physical modification of any technological aids offered, the main factor in their reluctance to use some of the aids offered appeared to be their fear of not being able to understand the terminology, icons and symbols used. Language development is natural and expected; however, when combined with technology, it can cause uncertainty. Some of the devices tested were primarily designed to enable elderly people to retain, and in some cases regain, their autonomy, some to assess the willingness of the participants to play games, which aid in increasing acceptability (2010), while others were designed solely to discover the preferences of the elderly people and to start creating a sign base.

While it was agreed that the controls, whether buttons, icons or symbols, needed to be large enough to be identifiable, the form of the actual symbols were far more important. The monitoring device was able to prove this conclusively.

While the display used numbers and letters, the purpose of the buttons was denoted by pure symbols, which caused some initial difficulty among the participants (see figure 2). Even after these were explained, doubts were expressed as to whether, in an emergency situation, the correct alarm button would be pressed. The markings signs have no intuitive value, since they are not based on any recognised cultural symbols.

Fig. 2. Symbols on the fall monitoring device [21]

While the monitoring devices were of more interest to the women than the men – something that was possibly explained by one of the women when she stated that, in her generation, fewer men are required to care for elderly relatives. Some credence must also be given to the theory that that men are less willing to admit to weakness or need, or are just more wary about monitoring in general.

7 Conclusion and Future Work

One of the main lessons learned during this work can be put in one sentence: Intuitiveness is in inverse proportion to the level of abstraction. While Nake (2001) [5] concluded that people's anthropomorphisation of computers is deeply rooted in semiotics, thus providing a reason for attributing human characteristics to non-living things, we saw no evidence of this tendency among the older participants. Thus, it is

possible to assume that the exchange of communication is disturbed at the level of interpretation. Whether this is due to unfamiliarity or is an integral aspect of age requires more intensive study than we were able to give it at this time. It does confirm, however, that designers must be willing to increase their understanding of the symbols familiar to the older generations and adjust their designs accordingly.

To the astonishment of the students the scroll symbol caused the most consternation; not only were many of the participants unfamiliar with the symbol, they were unfamiliar with the concept. Web pages designed for the elderly must therefore either use a page-turning format, rescale sections of the outlay to fit a single page, or carry a more explanatory symbol for continued in the next panel.

While the students who participated in the design, development and subsequent testing were able to accept and understand the difficulties felt by the older participants, there appeared little consensus as to a solution. Since many standard icons and symbols are already in place, particularly in social networking systems, developing a permanent parallel system of symbology may be neither practical nor desirable.

Many of the existing social networks & information centres have been designed with younger generations in mind, even those specifically aimed at the elderly, use standardised symbols, icons and links, which will need to be interpreted. As yet no data base of recognisable symbols has been established for translation purposes. One difficulty is the speed with which the participants accept the (to them) new concepts and symbols. Although this is an extremely positive development for our participants, it makes establishing a basis of recognised and understood symbols more challenging. While we did notice a gender-based reluctance, this dissipated rapidly and there appeared to be no bias in the levels of acceptance once the new concepts were explained and understood.

Our future work will be to investigate the practicality of designing and implementing a layered architecture system to provide a translation layer service, for social support systems for the elderly. Linking to this service would provide age-appropriate interfaces with direct connections to local networks, age-relevant social services and relevant state departments.

Acting as a conversion interface, it would be able to provide access to existing systems, currently considered indecipherable by the elderly – for example: online ticket offices. Further advantages could be achieved by using local connectivity & social webs, environmental adjustments (adaptivity, adaptability), making use of concepts including: collective intelligence, cognitive stimulation (games) and information collection, many of which are designed for use by the elderly, but which can only be accessed using standard gateway services.

One of the infrastructures under consideration is cloud computing, which offers an abundance of possibilities and advantages for the elderly, e.g. end users are able to access applications without local PC updates [22].

A further point of study will be the transparent overlay of an avatar – similar to that offered for people with hearing problems [23] – a central gateway could then provide icon-piloted access to available standard applications with an automated interaction. Whether this would provide the elderly with the aid required would depend on its sophistication and their acceptance of a 'virtual translator'.

Both the conversion interface and the avatar translator would eventually become obsolete as the level of computer sophistication rises. What is needed at the moment

is the *semiotic prop,* which will allow the elderly to use – and enjoy using – the wide variety of available technology without fear of the consequences of misunderstanding a computer command.

References

1. Holzinger, A., Ziefle, M., Roecker, C.: Human-Computer Interaction and Usability Engineering for Elderly (HCI4AGING): Introduction to the Special Thematic Session. In: Miesenberger, K., Klaus, J., Zagler, W., Karshmer, A. (eds.) Computers Helping People with Special Needs, Proceedings, Part 2, pp. 556–559. Springer, Berlin (2010)
2. Holzinger, A., Mukasa, K.S., Nischelwitzer, A.K.: Introduction to the special thematic session: Human-computer interaction and usability for elderly (HCI4AGING). In: Miesenberger, K., Klaus, J., Zagler, W., Karshmer, A. (eds.) Computers Helping People with Special Needs, Proceedings, pp. 18–21. Springer, Berlin (2008)
3. Mukasa, K.S., Holzinger, A., Karshmer, A.I.: Intelligent User Interfaces for Ambient Assisted Living (IUI4AAL 2008), p. 128. Fraunhofer IRB Verlag, Stuttgart (2008)
4. Peirce, C.S.: Collected Writings on Semiotics. In: Hartshorne, C., Weiss, P. (eds.) The Collected Papers of Charles Sanders Peirce 2, p. 135. Harvard University Press, Boston (1932)
5. Nake, F., Grabowski, S.: Human-Computer Interaction viewed as Pseudo-Communication. Knowledge-Based Systems 14(8), 441–447 (2001)
6. Holzinger, A.: Usability Engineering for Software Developers. Communications of the ACM 48(1), 71–74 (2005)
7. Demiris, G., Rantz, M.J., Aud, M.A., Marek, K.D., Tyrer, H.W., Skubic, M., Hussam, A.A.: Older adults' attitudes towards and perceptions of 'smart home' technologies: a pilot study. Medical Informatics and the Internet in Medicine 29(2), 87–94 (2004)
8. Rialle, V., Duchene, F., Noury, N., Bajolle, L., Demongeot, J.: Health "Smart" home: Information technology for patients at home. Telemedicine Journal and E-Health 8(4), 395–409 (2002)
9. Koskela, T., Vaananen-Vainio-Mattila, K.: Evolution towards smart home environments: empirical evaluation of three user interfaces. Personal and Ubiquitous Computing 8(3-4), 234–240 (2004)
10. Nguyen, H., Kemp, C.C.: IEEE: Bio-inspired Assistive Robotics: Service Dogs as a Model for Human-Robot Interaction and Mobile Manipulation. IEEE, New York (2008)
11. Nauth, P.: Goal Understanding and Achievement for Humanoid Assistive Robots. In: Tavangarian, D., Kirste, T., Timmermann, D., Lucke, U., Versick, D. (eds.) Intelligent Interactive Assistance and Mobile Multimedia Computing, pp. 287–294. Springer, Berlin (2009)
12. Ghorbel, M., Haariz, M., Grandjean, B., Mokhtari, M.: Ieee, Toward a generic human machine interface for assistive robots: the AMOR project. In: 2005 IEEE 9th International Conference on Rehabilitation Robotics, pp. 168–172. IEEE, Los Alamitos (2005)
13. Holzinger, A., Searle, G., Kleinberger, T., Seffah, A., Javahery, H.: Investigating usability metrics for the design and development of applications for the elderly. In: Miesenberger, K., Klaus, J., Zagler, W.L., Karshmer, A.I. (eds.) ICCHP 2008. LNCS, vol. 5105, pp. 98–105. Springer, Heidelberg (2008)

14. Kleinberger, T., Jedlitschka, A., Storf, H., Steinbach-Nordmann, S., Prueckner, S.: An Approach to and Evaluations of Assisted Living Systems Using Ambient Intelligence for Emergency Monitoring and Prevention. In: Stephanidis, C. (ed.) Universal Access in Human-Computer Interaction, Pt Ii, Proceedings - Intelligent and Ubiquitous Interaction Environments, pp. 199–208. Springer, Berlin (2009)
15. Heinbuchner, B., Hautzinger, M., Becker, C., Pfeiffer, K.: Satisfaction and use of personal emergency response systems. Zeitschrift fuer Gerontologie und Geriatrie 43(4), 219–223 (2010)
16. Picking, R., Robinet, A., Grout, V., McGinn, J., Roy, A., Ellis, S., Oram, D.: A Case Study Using a Methodological Approach to Developing User Interfaces for Elderly and Disabled People. Computer Journal 53(6), 842–859 (2010)
17. Stephanidis, C., Savidis, A.: Universal Access in the Information Society: Methods, Tools and Interaction Technologies. Universal Access in the Information Society 1(1), 40–55 (2001)
18. de Souza, C.S., Leitão, C.F., Prates, R.O., Amélia Bim, S., da Silva, E.J.: Can inspection methods generate valid new knowledge in HCI? The case of semiotic inspection. International Journal of Human-Computer Studies 68(1-2), 22–40 (2010)
19. Zhao, G.: Application semiotics engineering process. In: Maurer, F., Ruhe, G. (eds.) Sixteenth International Conference on Software Engineering & Knowledge Engineering (SEKE 2004), pp. 354–359 (2004)
20. Desouza, C.S.: The semiotic Engineering of User-Interface Languages. International Journal of Man-Machine Studies 39(5), 753–773 (1993)
21. Holzinger, A., Searle, G., Prückner, S., Steinbach-Nordmann, S., Kleinberger, T., Hirt, E., Temnitzer, J.: Perceived usefulness among elderly people: Experiences and lessons learned during the evaluation of a wrist device. In: International Conference on Pervasive Computing Technologies for Healthcare (Pervasive Health 2010), pp. 1–5 (2010)
22. Alagöz, F., Calero Valdez, A., Wilkowska, W., Ziefle, M., Dorner, S., Holzinger, A.: From Cloud Computing to Mobile Internet, From User Focus to Culture and Hedonism - The Crucible of Mobile Health Care and Wellness Applications. In: ICPCA 2010 International Conference on Pervasive Computer Applications 2010, pp. 1–9 (2010)
23. Kosec, P., Debevc, M., Holzinger, A.: Sign language interpreter module: Accessible video retrieval with subtitles. In: Miesenberger, K., Klaus, J., Zagler, W., Karshmer, A. (eds.) ICCHP 2010. LNCS, vol. 6180, pp. 221–228. Springer, Heidelberg (2010)