Recommendations for Gesture-Based Residential Interactive Systems Inspired by Diversity

Ana Carla de Carvalho Correia[1], Leonardo Cunha de Miranda[1], Heiko Hornung[2], and Juvane Nunes Marciano[1]

[1] Department of Informatics and Applied Mathematics,
Federal University of Rio Grande do Norte (UFRN), Natal, Brazil
{anacarla,juvane}@ppgsc.ufrn.br, leonardo@dimap.ufrn.br,
[2] Institute of Computing, University of Campinas (UNICAMP), Campinas, Brazil
heix@gmx.com

Abstract. Gestural interaction is becoming an important mode of interaction with residential systems, be it with or without using physical artifacts such as remote controls or cell phones. When constructing respective gestural vocabularies social implications need to be considered. The importance of the residential environment to users and the heterogeneity of user profiles make the theme diversity an important concern in the development of these applications. Therefore, the main goal of this paper is to describe the recommendations for diversity that support the inclusive design of residential interactive systems based on gestures.

Keywords: accessibility, usability, domotics, gesture-based interaction, smart home, home automation.

1 Introduction

One of the first challenges of developing residential interactive systems based on gestures is the requirements elicitation. The search of a more unobtrusive integration of the technology into the environment has led to an increase of the use of perceptual technologies [11] for residential applications. Analyzing publications in this context (e.g. [7,13,20,25,27]), we noticed that the development of these systems is primarily focused on technological requirements, and that there are few studies on user interaction with the system [3].

Due to the heterogeneity of users that are part of this context, the inclusion of concerns about diversity in the development of residential applications becomes an important aspect. From this perspective, going beyond the technological requirements, we found that usability and accessibility of user interaction with the system are only considered in a limited way in literature. Norman and Nielsen [19] already mentioned the need for further exploration and study.

In previous work [3], we reported on Human-Computer Interaction (HCI)-related challenges in the context of gestural interaction with residential applications. In this paper we report on the recommendations that can mitigate these challenges by

C. Stephanidis and M. Antona (Eds.): UAHCI/HCII 2014, Part I, LNCS 8513, pp. 337–345, 2014.

considering requirements for a development oriented to diversity, such as issues related to culture [12], ergonomics [18], and gender [1,21], among others.

Considering the questions related to diversity that inform the inclusive design for residential interactive systems based on gestures, the construction of these recommendations is based on two important topics for any system in development, i.e. usability and accessibility. A goal of this paper is to support developers during the requirements elicitation phase.

The paper is organized as follows: in Section 2, we present the description of the recommendations for diversity; in Section 3, we present a real usage scenario; in Section 4, we discuss our proposal; in Section 5, we present the conclusion.

2 Recommendations for Diversity

Different authors found that traditional usability models, methods, or guidelines have to be revisited for gestural interaction, especially in the context of residential applications [3,19]. Similarly, accessibility guidelines need to be reevaluated. We did not find guidelines or recommendations for smart homes that specifically consider gestural interaction. However, already existing guidelines for smart homes (e.g. [8,24]) might be built upon, and existing general usability or accessibility standards and guidelines, e.g. [9,10,26] might be adapted. Furthermore, we follow the argument of Chi [2] and acknowledge that accessibility and usability should not be considered as two separate or dichotomous concepts.

The construction of this set of recommendations is not specified to any graphical of visual interfaces or technologies that allow gestural recognition. The recommendations allow specifying the context of use in a systematic way, also simplifying the process of describing the context and thus reducing reliance on specialists.

Analyzing usability and accessibility literature [5,6,14,15,16,17,18,19,23], we realize that diversity regarding gestural interaction is still an underexplored topic. We did not find scientific literature about diversity-specific recommendations or guidelines. for gestural interaction with residential applications and hence focused on literature in the area of Web applications. In Table 1 we describe recommendations inspired by user diversity regarding physical, perceptual and cognitive abilities, using the following coding: (C)ognitive, ph(Y)sical, and (P)erceptual.

Table 1. Recommendations for gesture-based residential interactive systems

Recommendation	Description	Ability
Help	The system should provide means to aid the user to deduct or remember how to use the system and its gestures	C
Confidence	The system has to provide confidence to the user in performing a command	C
Memorization	Property of construction of gestural vocabulary guided by the memorization capacity of the gestures of its users	C
Satisfaction	System's ability to produce comfort, relaxation and enjoyment to the user	C

(**Table 1.** *Continued.*)

Recommendation	Description	Ability
Effort	Ability of the system to be used with the minimum physical and mental effort from the user	C & Y
Stress	The system should avoid psychic disturbances on the functioning of the system, derived from repetitions of unnecessary commands, complex interaction flow, misinterpretation of commands, inappropriate gestures or feedback out of context	C & Y
Discomfort	The gestures should be designed so that even with many repetitions, they can be used without causing discomfort to users	C & Y
Progressive learning	Mechanisms that guide the user of the simplest tasks to the most complex, encouraging continuous learning	C, Y & P
Culture	Appropriateness of gestures to cultural habits in which they are immersed	C, Y & P
Feedback	Various informational output resources to the user	C, Y & P
Gender	Ability of the system to adjust its functioning considering particularities that differentiate users of different genders	C, Y & P
Customization	Property of the system to allow the users to configure their gestural commands the way they prefer to	C, Y & P
Metaphorical property	Metaphoric property of gestures to express their functionality	C, Y & P
Learnability	The system should help the users through mechanisms that can help them understand and apply the gestures	C & P
Completeness	The gestural interaction must have commands that are complementary to additional features of the application, for example, open/close and on/off	C & P
Predictability	Property of navigation in the system that induces the sequence of gestures used for a given task, i.e., the sequence of gestures used should be predictable to the user	C & P
Coordination	The sequence or number of members used in the gestures must comply with the coordinative ability of its users	Y
Balance	The gestures should be designed so that even during its execution, users do not lose balance	Y
Explosion	Ability of users to execute commands with variations in speed and intensity	Y
Tension	Gestures should not keep the muscles tight during execution	Y
Ergonomics	Related to characteristics of the human anatomy, anthropometry, physiology and biomechanics, in building gesture	Y & P
Accuracy	Property of the system to recognize the gestures to a certain degree of tolerance	Y & P
Efficiency	System property that determines how efficiently the human and automation resources are used by the application	P
Operability	Property that expresses how much operational is the gestural vocabulary of the application, in terms of its construction and ease of setup/configuration	P

Fig. 1 graphically illustrates these items of recommendations, highlighting the contemplated skills and embracing in an inclusive way the diversity that the group of users needs in the physical, perceptual and cognitive framework.

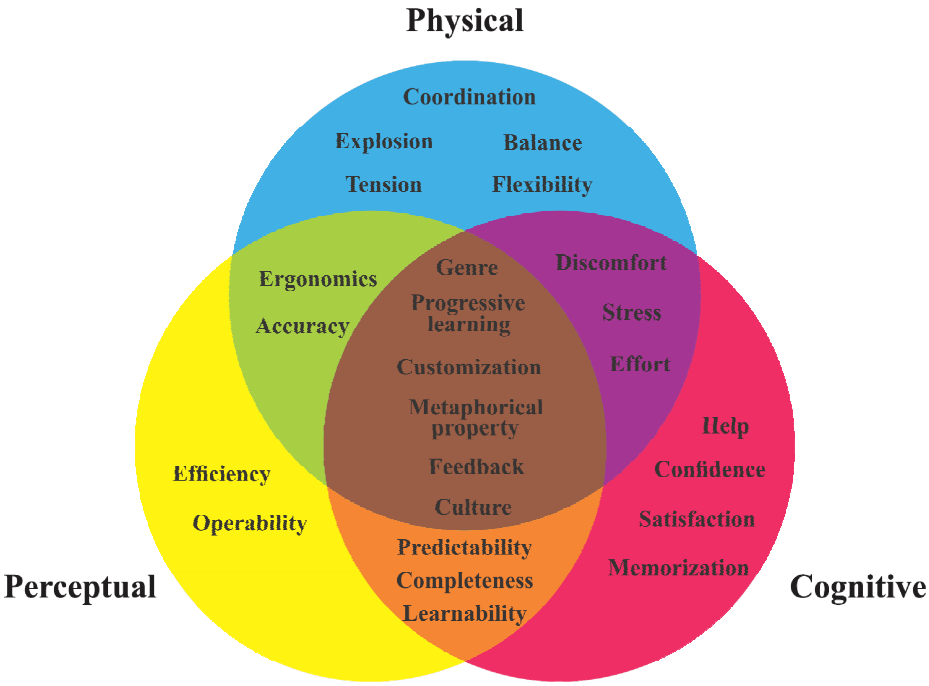

Fig. 1. Recommendations classified by physical, perceptual and cognitive skills

Some items of recommendations might influence others. Consider for example memorization. If each interaction object has a unique gesture, the gestural vocabulary of the application is extensive and people will probably not learn the commands easily. But what would be the "ideal" amount of commands for an application with respect to diversity? As we do not yet have that answer, some steps can be performed as in the reuse of gestures itself. To give a concrete example: a gesture of farewell or goodbye to turn off a TV might also be used to turn off a stereo system or a fan. We can also use other metaphorical properties for each given service, or, still, use completeness to help memorization. That is, to additional features, their gestures are also performed in complementary way, for example, open and close the arms.

Feedback can facilitate progressive learning displaying messages of how the gestural command is performed, which are the options that the user can perform, or help messages that may also be gradually hidden from the application. The variety of ways to externalize the information includes acoustic, haptic, or visual feedback. Feedback should be given directly by the application since a user is not necessarily near a controlled device where the effect of the action could be directly perceived.

Other recommendation that are beyond the usual field of usability and accessibility have been added to this set, for example, culture, which refers to a study of the

cultural context in which the application is deployed. Since we know that there are particular gestures in different cultures or with different meanings in each of them. Although today there is still no explicit evidence of what the ethnic differences of gesticulation are, considering cultural aspects avoids gradually decrease the cultural identity of certain user groups within the context of an application [12].

Another important item of recommendations is gender. There are still many open research questions. In addition, an important factor is the large number of men in Information and Communications Technology (ICT)-related professions that may be implicitly bring a bias towards the development of products that not adequately consider gender-related aspects [1,21]. Coordination, balance, tension, explosion and discomfort are recommendations that should influence directly and mainly the construction of the gestural vocabulary of the application. All presented recommendations are intended to provide a reflection for the application development.

3 Usage Scenarios

The recommendations is large and complex enough to possibly pose a barrier to developers that would like to employ this set. Specific studies on each category of the recommendations are necessary to facilitate understanding of respective impacts on application design, evaluation and use.

Knowledge of these recommendations helps developers to adequately consider diversity in their designs. To illustrate the recommendations, we presented the recommendations (Table 1) to a group of undergraduate and graduate computer science students who were involved in a research and development project in the area of gesture-based residential systems. The group identified four items to be explicitly addressed in their project.

The group's research and development project was at an initial stage. The most prominent idea in the group was developing a system that targets diversity. Another feature already defined was that the application would be perceptual, i.e. would not use any physical device to aid the recognition of gestures for the application. Thus, a goal was to enable the user to control doors, lights, air conditioning and other features seen as basic in a residential application from any location within the house. The development team had prior knowledge of usability and accessibility.

In this scenario, the recommendations already supported the requirements elicitation for the system. Exposing the recommendations to the development team, it was perceived that all members identified new requirements. The additional recommendations were related to customization, memorization, discomfort and metaphorical property: **customization**, since the physical skills of the users may interfere in the gestures performance; **memorization**, due to the need to relate functionalities with gestures; **discomfort** because of the gesture repetitions; **metaphorical property** because of similarities among chosen gestures and static or animated graphical interface elements.

Regarding customization, the user can assign gestures to the services that the application provides. When designing the graphic interface, the number of commands

for navigation in the system was reduced to five, i.e. horizontal movements (right/left and left/right), vertical movement (up/down), selection (forward motion), and back (rearward movement). While the up/down movement appeared, the down/up movement was eliminated from the gestural vocabulary due to the use of a carrousel widget. The gesture for interacting with a carrousel widget has a metaphoric quality. To decrease the discomfort of the execution of the gestures, they were limited to the trunk region of the body, allowing users to use the application while sitting.

The team implicitly used other concepts, such as: completeness in the horizontal movement; confidence, clearly stating to the user that the requested service has been properly executed or not; decreased effort; flexibility in the choice of gestures and precision, seeking to improve the representation of gestural commands to be better recognized by the application.

4 Discussion

There are several attributes of a house that make it a home, which is much more than a physical entity [22]. According to Dovey [4] a house is an object and home is an emotional and significant relationship between people and their houses, that is, the house is where the experience of home occurs. This definition shows the importance and complexity of the context, and resonates well with approaches in HCI consider issues beyond the technological nature of residential systems.

A contribution of this paper are the recommendations that resulted from an analysis of the interaction with gesture-based residential applications. These recommendations promote the consideration of diversity during the development of residential applications as well as reflections about gesture-based interaction in these applications. The identified recommendations go beyond accessibility and usability and include aspects such as accuracy, stress, culture, genre, flexibility, balance, coordination, ergonomics, tension, discomfort, completeness, explosion and metaphorical properties. In the present stage of this research, developers might be supported in the step of eliciting the requirements of application.

Current visions of gestural interaction design do not consider diversity sufficiently. Diverse perspectives on these applications should be investigated so that the impact of technological immersion on user's lives and family relationships can be evaluated. Correia et al. [3] identified the visual, haptic and acoustic resources in residential applications to support gestural interaction. These features can help the user to utilize the functionalities the application provides.

Another important point to this discussion is the requirement of customization, which is a means to promote diversity and facilitate the access of users with or without disabilities. By offering customization, users can define or adapt gestures that match their personal preferences or capabilities.

Gestural interaction, even if informed by the recommendations presented in this paper, might be inadequate for certain users; for example, quadriplegics are limited to performing movements above the neck. Even considering memorization, predictability of gestures or through the mechanisms of continuous learning, the controlling of

many remote devices in a house with many rooms might exert a large cognitive load on the user. Thus, we emphasize the need to other mechanisms to mitigate this kind of problems, such as multimodal interactions, or visual interfaces.

Although the presented recommendations are not exhaustive, they contribute to making explicit and reflecting about some important values of designing residential systems. Besides being used during requirements elicitation, e.g. in form of a questionnaire, the list of recommendations also serves to broaden the discussion and research about gestures used in these applications.

5 Conclusion

This paper presented recommendations for residential systems with gestural interaction, grounded in the points of view of usability and accessibility. Besides adapting concerns of these two areas of study other recommendations were added to best suit the diversity of users. The main contribution of this research includes identifying key recommendations that aim to support the inclusive design of residential applications of gestural interaction.

We also presented a scenario of real use, along with the classification of the recommendations according to physical, perceptual and cognitive abilities. The tabulation of these recommendations allows the study of methodological grounding of development, contextualizes the conceptual visions of accessibility and usability found in the literature for domotic and gestural contexts, and instigates reflections about building applications' gestural commands.

As future work, we will apply the proposed recommendations during requirements elicitation process of design projects, e.g. through questionnaires. These experiences will contribute to refining and validating our recommendations. Since many recommendations have interdependencies, another step will be to articulate requirements derived from the recommendations with design values in order to support prioritizing requirements.

Acknowledgements. This work was partially supported by the Brazilian Federal Agency for Support and Evaluation of Graduate Education (CAPES), by the Brazilian National Council of Scientific and Technological Development (CNPq grant #163408/2012-2), by the Institute of Computing at University of Campinas (IC/UNICAMP), and by the Physical Artifacts of Interaction Research Group (PAIRG) at Federal University of Rio Grande do Norte (UFRN), Brazil.

References

1. Bardzell, S., Churchill, E., Bardzell, J., Forlizzi, J., Grinter, R., Tatar, D.: Feminism and Interaction Design. In: CHI Conference on Human Factors in Computing Systems, pp. 1–4. ACM (2011)
2. Chi, E.H.: The False Dichotomy Between Accessibility and Usability. In: 10th International Cross-Disciplinary Conference on Web Accessibility, pp. 1–2. ACM (2013)

3. de Carvalho Correia, A.C., de Miranda, L.C., Hornung, H.: Gesture-Based Interaction in Domotic Environments: State of the Art and HCI Framework Inspired by the Diversity. In: Kotzé, P., Marsden, G., Lindgaard, G., Wesson, J., Winckler, M. (eds.) INTERACT 2013, Part II. LNCS, vol. 8118, pp. 300–317. Springer, Heidelberg (2013)
4. Dovey, K.: Home and Homeless. In: Home Environments, pp. 36–61. Plenum Press (1985)
5. Eason, K.D.: Towards the Experimental Study of Usability. Behaviour and Information Technology 3, 133–143 (1984)
6. Gabbard, J.L.: A Taxonomy of Usability Characteristics for Virtual Environments. Masters Thesis, Virginia Tech. (1997)
7. Gandy, M., Starner, T., Auxier, J., Ashbrook, D.: The Gesture Pendant: A Self-Illuminating, Wearable, Infrared Computer Vision System for Home Automation Control and Medical Monitoring. In: 4th IEEE International Symposium on Wearable Computers, pp. 1–8. IEEE (2000)
8. Guidelines for Design of Smart Homes, http://www.johngilltech.com/guidelines/guidelines_list.htm
9. ISO 9241. Ergonomics Requirements for Office Work with Visual Display Terminals (VDTs). Part 11: Guidance on Usability (1998)
10. ISO/IEC 9241. Ergonomics of Human-System Interaction - Part 110: Dialogue Principles (2006)
11. Karam, M., Schraefel, M.C.: A Taxonomy of Gestures in Human Computer Interactions. Technical Report ECSTR-IAM05-009, University of Southampton (2005)
12. Kita, S.: Cross-Cultural Variation of Speech-Accompanying Gesture: A Review. Language and Cognitive Processes 24, 145–167 (2009)
13. Kleindienst, J., Macek, T., Serédi, L., Šedivý, J.: Vision-Enhanced Multi-Modal Interactions in Domotic Environments. In: 8th ERCIM Workshop "User Interfaces For All", pp. 1–8 (2004)
14. Madan, A., Dubey, S.K.: Usability Evaluation Methods: A Literature Review. International Journal of Engineering Science and Technology 4, 590–599 (2012)
15. Mosqueira-Rey, E., Alonso-Ríos, D., Moret-Bonillo, V.: Usability Taxonomy and Context-of-Use Taxonomy for Usability Analysis. In: IEEE International Conference on Systems, Man and Cybernetics, pp. 812–817. IEEE (2009)
16. Nielsen, J., Loranger, H.: Prioritizing Web Usability. New Riders Press (2006)
17. Nielsen, J.: Usability Engineering. Academic Press (1993)
18. Nielsen, M., Störring, M., Moeslund, T.B., Granum, E.: A Procedure for Developing Intuitive and Ergonomic Gesture Interfaces for HCI. In: Camurri, A., Volpe, G. (eds.) GW 2003. LNCS (LNAI), vol. 2915, pp. 409–420. Springer, Heidelberg (2004)
19. Norman, D.A., Nielsen, J.: Gestural Interfaces: A Step Backward in Usability. Interactions 17, 46–49 (2010)
20. Rahman, A.S.M.M., Saboune, J., Saddik, A.E.: Motion-Path based in Car Gesture Control of the Multimedia Devices. In: 1st ACM International Symposium on Design and Analysis of Intelligent Vehicular Networks and Applications, pp. 69–76. ACM (2011)
21. Rode, J.A.: A Theoretical Agenda for Feminist HCI. Interacting with Computer 23, 393–400 (2011)
22. Saizmaa, T., Kim, H.C.C.: A Holistic Understanding of HCI Perspectives on Smart Home. In: 4th International Conference on Networked Computing and Advanced Information Management, pp. 59–65. IEEE (2008)

23. Shackel, B.: Usability-Context, Framework, Definition, Design and Evaluation. In: Shackel, B., Richardson, S. (eds.) Human Factors for Informatics Usability, pp. 21–38. Cambridge University Press (2011)
24. Smart Home Guidelines, http://www.tiresias.org/research/guidelines/smart_home.htm
25. Wahlster, W., Reithinger, N., Blocher, A.: SmartKom: Multimodal Communication with a Life-Like Character. In: 7th European Conference on Speech Communication and Technology, pp. 1547–1550 (2001)
26. Web Content Acessibility Guidelines (WCAG) 2.0., http://www.w3c.org/TR/WCAG20
27. Wilson, A., Shafer, S.: XWand: UI for Intelligent Spaces. In: SIGCHI Conference on Human Factors in Computing Systems, pp. 545–552. ACM (2003)