Interaction Models for iTV Services for Elderly People

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Abstract. The increase of longevity is one of the most important advances in modern societies. However, as people get older there are multiple changes that occur at physiological, social and psychological levels. On the one hand, aging can generate more opportunities to have free time to consume products or services that are informative or playful. On the other hand, it is also more likely that social and digital exclusion situations would appear. In this framework, the use of television as a device to support dedicated services has been a viable solution to overcome the referred problems because it is a close technology to the elderly population. However, in the process of developing a product or service (in this case, for television), it is necessary to consider the users' needs and expectations, being this a continuous challenge in the connection between different modes of interaction with different services. The present study will begin to explain what an interaction model is, adapting this definition later to interactive television services. Subsequently, literature on existing iTV projects and the interactions they offer (last five years) will be reviewed, providing a clear knowledge about the modalities that were used. Following the analysis, the current situation of iTV services for the elderly and their interaction paradigms will be addressed, in order to identify the most common practices on the design of interaction models for future projects in the field.

Keywords: iTV services · Elderly · Interaction models · Inclusive design

1 Introduction

With the evolution of the ICT's (information and communication technologies) the television started to offer more forms of interaction than just 'push' media and one-way mass communication [1]. Users have started to interact directly with television content, being able to control notifications that appear on the screen [2], access social networks, contact other users, or even insert text on the television screen [3]. Another example is the possibility of extending the interactive capabilities of iTV (interactive television) services by using an second screen (a tablet or smartphone) [3, 4]. Yet, user experience is not only enriched by an interactive television content, but also, pertinent to include, the interaction models provided by different iTV services. An interaction model can be defined as "*a conceptual model that represents the communication between the user and the Information System by means of a user interface*" [5], being iTV the

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Information System provider in this study. Regarding the communication, this is carried out by different channels of input and output, being the medium through which the information travels. The interaction is then performed when the user output is the input of the computer (in this case, of the iTV service) and vice versa [6]. However, the interaction performed in iTV systems can not only be performed in graphical interfaces, being also possible for the user to resort to other modalities such as voice, touch or even gestures. It is important to emphasize that in the human being, his input channels are vision, hearing and touch, and output is the movement of fingers or hands, voice, eyes, head, among others. Almeida [6] emphasizes the touch as the most used modality, being used normally in smartphones or tablets. Other modalities such as body gestures and eye gaze are equally important. Although, voice outputs and inputs are gaining popularity in current technologies, being the most natural interaction for the human being [6]. Taking into account these arguments and the objectives of this study, "*a conceptual model that represents the communication between the user and the iTV service by means of a set of interactive modalities*" is suggested as a definition for interaction models to interactive television services. However, although this definition emphasizes that an interaction can resort to different modalities, it does not explain what modalities to use in an iTV service. In order to meet a better design [7], the product or service should be adapted to the needs of the widest range of users as possible, i.e., to be inclusive in order to provide a good experience and a sense of belonging [8]. For the validation of this argument, the present study focuses on elderly users, being people who normally have difficulties in interacting with smart televisions, electronic program guides (EPG) or due to lack of accessibility television interfaces [9]. This is mainly due to the natural process of aging, leading to physiological, social and psychological changes [10, 11]. However, it is noteworthy that these users use television as the main means of information and entertainment [2], making viable the iTV services as a means of improving the user's quality of life. Although there is an increasing research on interactive television field, it is essential to provide a clear picture about which are the recent approaches in iTV interaction and which are their strengths and limitations, namely on elderly people. Thus, recent literature about the general existent iTV projects and the interactions they offer will be reviewed, providing a clear knowledge about the modalities that were used. Then, the iTV projects suitable for elderly people and how they fulfil users' needs will be analysed separately. In the end of the study, the actual challenges and opportunities provided by these iTV projects will be identified.

2 Method

A systematic review was carried out to analyse the different modalities existing in different iTV projects and later analysed those that are directed to elderly users. This review was based on the PRISMA Statement [12]. It was reviewed articles written in English and Portuguese that were published between 2013 and 2018 (last 5 years), which covered interactive television projects. Subsequently the results were manually filtered to find projects targeting elderly users. From the obtained data, the conditions to analyse the interaction models that were used by each iTV project were given, in order

to understand the existence of possible similarities or differences in their interaction models. The research was conducted in SCOPUS and Web of Science databases using the following keywords in the search: ("interactive television" OR "itv" OR "interactive tv") AND ("app*" OR "application*" OR "project*"). In order to restrict the results according to the content of this study, specific filters of each database were also used.

Regarding the inclusion criteria, the age of the user was used as reference to the manual filtering, in order to understand which projects were developed for elderly people (ages above 60 years were selected according to the information obtained in the analysed projects). However, it is important to consider in later analysis the iTV projects in general, due to World Health Organization [13] definition of *Healthy Aging*, highlighting the diversity among people where "*Some 80-year-olds have levels of physical and mental capacity that compare favourably with 30-year-olds. Others of the same age may require extensive care and support for basic activities like dressing and eating.*". Thus, the obtained results should be analysed and take into account those that *"improve the functional ability of all older people"* [13] and that are accessible to the widest range of users. All articles that did not address iTV projects, or did not present enough data that characterize the interaction model that they have, were excluded, being pertinent to this study to identify and understand the modalities adopted.

Regarding the study selection and data extraction, the obtained results were explored through a detailed review of the articles' and conferences' titles and abstracts, enabling to exclude all documents that did not met the required criteria. It was also excluded all documents that were not available to review or were duplicated.

2.1 Results

Throughout the research, 802 potentially eligible articles were identified, of which 562 were from SCOPUS and 240 from the Web of Science (Core Collection) databases. Following a refinement by date range and subject area, it was possible to obtain 365 results from SCOPUS and 89 from Web of Science, resulting in a total of 454 potentially eligible articles. After the removal of duplicates (n = 77), of results that do not address iTV projects and that are not for review (n = 144), 233 articles were obtained. At the end of the refinement process, projects that did not have a functional iTV system (n = 174) were excluded, ending with 59 articles that identifies 49 iTV projects. The whole process of refinement of the research is illustrated in Fig. 1.

3 General Findings

The main findings and details of the 59 selected studies, which characterize 49 iTV projects, were organized by the name of each project, articles' author and year, the user's age, hardware available for interaction and the respective interactions[1].

[1] To consult the tables with all the obtained iTV projects, access the URL: https://zenodo.org/record/2583119.

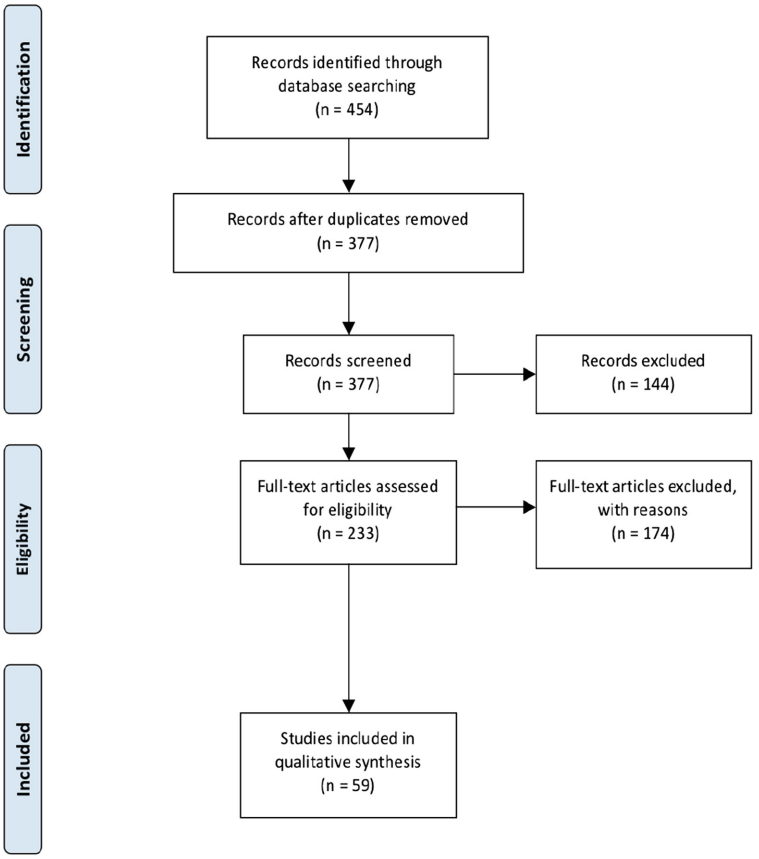

Fig. 1. PRISMA flow diagram [12].

Afterwards, all the studies that were more oriented to elderly users were selected manually, obtaining 10 iTV projects.

3.1 User's Age

From the analysed projects in general, 26 articles showed the age of the users. Regarding the different stages of age, there was a great diversity, from projects like "UltraTV"[2] [14] that was tested with users from 12 to 54 years old (and that the age contributed to the respective project to obtain different results), or the "TV DISCOVERY AND ENJOY"[3] [15] that was tested by young adults between 22 and 26 years of age. Nevertheless, from the obtained data, it was possible to observe that the average age of the users is 44.04

[2] More information about the "UltraTV" project: http://www.alticelabs.com/site/ultratv/.

[3] More information about the "TV DISCOVERY AND ENJOY" project:http://socialitv.web.ua.pt/index.php/projects/sponsored-projects/tv-discovery-enjoy/.

years (projects that do not address users age were excluded), being considered as middle-aged adults. Of the more oriented studies for elderly users, the first reference to this age phase was found in the "IDTV-HEALTH"[4] [16] project, identifying the users as elderly from the age of 55; And in the project "+TV4E"[5] [2] from the 60 years. However, the most referenced age among iTV projects for elderly users was 65 years (n = 5). Regarding the highest age found in user tests, it was 99 years in the "SIX" [17] project, as well as 93 years in the "IDTV-HEALTH" [16] project, and 80 years in the "Nutrition Tracker & Photo Browser" [18] and "Vital Mind"[6] [19]. Therefore, it was possible to observe that the average age of the elderly users is 66.05 years (considering only the projects where the user was considered elderly).

3.2 Hardware

It is important to consider that television was not counted as hardware to be analysed, for which it is already associated its use in the projects under study. Thus, it was analysed the hardware or devices used by the users to interact with iTV services. In most projects, the use of the smartphone or tablet (n = 35) is preferred, followed by remote control (n = 12). An example of a project that used the smartphone or tablet is the "Senior Cloud"[7] [4], a social iTV system, where the elderly users can communicate with other users who are watching the same TV content, tapping the application to navigate between content and write to other users. Regarding remote control, the "+TV4E" [2] is given as an example, being a service that provides informative content through the injection of videos in the linear transmission of television. The user, while watching certain television content, receives a notification, which can interact by clicking on the remote control buttons, having access to the additional content. However, there are some projects that have resorted to unconventional hardware for television interaction. In the project "Don't open that door"[8] [20], the user interacts with gestures with the contents of the TV show "Supernatural", using a camera setup (Kinect; n = 8). Another example is the "Bubble UI" [21] that uses a remote control (Arduino Uno microcontroller board and sensors) that controls the television contents when doing tilt, press or even puff the device. In "immersiaTV"[9] [22], the user interacts with the TV content through a Head Mounted Display (HMD; n = 2), which enables new ways of producing television content, such as immersive multi-screen tv experience or omnidirectional content viewing. In the "SIX" [17] project, a remote control with the shape of a cube and with an Inertial Motion Unit (IMU; n = 1) was created, that when turning to respective side of the cube upwards, it plays a certain function in the television.

[4] More information about the "IDTV-HEALTH" project: https://cicant.ulusofona.pt/noticias/idtv-health/.

[5] More information about the "+TV4E" project: http://tv4e.web.ua.pt/.

[6] More information about the "Vital Mind" project: http://dcgi.fel.cvut.cz/en/research/vital-mind-vm.

[7] More information about the "Senior Cloud" project: http://sc.cyber.t.u-tokyo.ac.jp/en/index.html.

[8] More information about the "Don't open that door" project: https://gvu.gatech.edu/research/projects/dont-open-door.

[9] More information about the "ImmersiaTV" project: http://www.immersiatv.eu/.

As a final example of the analysed projects, "Windy Sight Surfers" [23] allows to create immersive experiences by simulating the wind (n = 1) of a particular video using a "wearable" camera (GoPro Hero 2), a 360º camera for cylindrical projection (Sony Bloggie Handy Cam1) and a wind accessory (Arduino Mega ADK that controls two fans). Regarding the more oriented hardware for elderly users, the remote control (n = 7) is highlighted. In 40% of the projects, the smartphone/tablet (n = 4) was addressed. However, the use of unconventional hardware such as cameras setups (n = 2) was relatively low.

3.3 Interactions

From the analysis of the hardware, it was possible to observe some of the interactions coming from the iTV projects/services. However, it is intended in this section to present all interactions found in the analysed projects, as well as the modalities necessary to carry out the respective interactions. In Table 1 it is possible to observe the number "n" of projects that present a certain modality and the interactions that come from it, as for example, in the modality touch gesture, it is possible to identify tapping as one of the possible interactions.

Table 1. Modalities and the resulting interactions of the iTV projects from the last 5 years.

Modalities	Interactions
Visual Output (n = 49)	Graphical/Textual (n = 48) Lightning (n = 1)
Tangible (n = 3)	Vibration patterns (haptic) (n = 3)
Audio (n = 37)	Text-to-speech conversion (hearing) (n = 1) Verbal or any audio output (hearing) (n = 28) Sound/voice recognition (speech-to-text conversion) (n = 7) Non-verbal vocal interaction (NVVI) (n = 1)
Touch Gesture (n = 34)	Tapping (n = 27) Dragging (n = 4) Screen-pressing (n = 1)
Breathing (n = 1)	Puffing (n = 1)
Proprioception (n = 1)	Body perception or context awareness (n = 1)
Thermoception (n = 1)	Feeling on the skin or experience sensing (n = 1)
Gesture (n = 37)	Body movement (n = 3) Object movement/manipulation (with tilt, press, turn a specific cubes' face, etc.) (n = 5) Reactive (n = 2) Mimetic (n = 2) Head movement (n = 2) Hand movement (n = 4) Grabbing and dropping (n = 1) Sling (n = 1) Sit (n = 1) Swipe (n = 1) Pinch to zoom (n = 1) Key pressing/click (n = 14)

Concerning the obtained modalities from the studied interactions, the most used was visual output (n = 49), followed by audio (n = 37) and gesture (n = 37) and touch gesture (n = 34). The least used were tangible (n = 3), breathing (n = 1), proprioception (n = 1) and thermoception (n = 1). From the interactions inside these modalities, it stands out the use of graphics and texts for visual output interaction (n = 48), audio outputs and text-to-speech conversions for hearing (n = 29), key pressing (n = 14) and movement of objects as gesture (n = 5), and the tapping as touch gesture (n = 27). Concerning the less used interactions, there is vibration patterns from tangible interaction (n = 3), puffing modality from breathing (n = 1), body perception or context awareness from proprioception (n = 1) and experience sensing from thermoception (n = 1).

Subsequently, a second table (Table 2) was also created, where the analysed projects were manually filtered, being included only those that were oriented for elderly users.

Table 2. Modalities and the resulting interactions of the iTV projects that are more oriented for elderly users (Filtered from Table 1).

Modalities	Interactions
Visual Output (n = 9)	Graphical/Textual (n = 9)
Audio (n = 9)	Text-to-speech conversion (hearing) (n = 1) Verbal or any audio output (hearing) (n = 5) Sound/voice recognition (speech-to-text conversion) (n = 2) Non-verbal vocal interaction (NVVI) (n = 1)
Touch Gesture (n = 4)	Tapping (n = 4)
Gesture (n = 10)	Object movement/manipulation (with tilt, press, turn a specific cubes' face, etc.) (n = 1) Hand movement (n = 2) Key pressing/click (n = 7)

Concerning the obtained modalities from the studied interactions, the most used was gesture (n = 10), highlighting the use of physical key-pressing or button-pressing gesture (n = 7). However, the hand movement (n = 2) and manipulation or movement of objects (n = 1) were among the less commonly used interactions by the elderly users. The second most used modality was visual output (n = 9), using graphics and texts; As well as the modality associated to audio (n = 9), more specifically to its output, such as text-to-speech conversions for hearing (n = 6). However, the sound or voice recognition (n = 2) and non-verbal vocal interaction (n = 1) were the least used interactions. Regarding the least used modality, it was touch gesture (n = 4), finding the tapping interaction in 40% of the projects.

4 Discussion

This review intended to understand the different iTV projects that have been developed in the last 5 years concerning the interaction models that have been adopted, as well as which hardware used to provide the means of interaction between the user and the iTV service. It was also possible to analyse and filter data to understand the current situation of iTV services targeting elderly people. The way to differentiate projects oriented for elderly people from projects to a wider audience depended on user's age, which varied. I.e., in projects such as the "+TV4E" [2], a 60-year-old user was considered an elderly user, while in "IDTV-HEALTH" [16] was considered elderly user at 55-year-old, and in some other projects, users were considered as elders only from the age of 65. However, it was concluded that iTV projects in general are usually targeted at middle-aged adults, with a mean age of 44.04 years. Although age is a questionable variable to define when a person is elderly [13], it should be considered as an indicator in the findings of this study. This is corroborated through the differences found in the results between projects for elderly people and middle-aged adults. In general, the hardware most used for iTV projects has been television and the smartphone or tablet (second screen). Yet, in projects that are more oriented for elderly users, the remote control was more used than second screen. Derived from this change of devices in the projects for the elderly, more physical gestures, such as the push of a button, were evident, while in the projects oriented for middle-aged adults the tapping was the most used, being an interaction carried out on the touch screen of a smartphone or tablet. From the studies of Bobeth et al. [18], the use of the remote control works well for linear tasks (e.g. zapping). However, elderly users have difficulties in performing non-linear tasks when compared to younger users, being the touch screen a solution to provide a more dynamic interface according to user needs [18], as well as providing a greater variety of modalities, being able to interact with different graphics, texts, audio or touch gestures like tap, drag, press, draw or pan. Other hardware that was little used on projects for elderly users were camera setups that can track gestures. According to Bobeth et al. [18], if the system can assure accurate real-time tracking, then it may apply short point-and-click gestures (hand gestures), being also possible to add sound or visual feedback on the system. Other opportunities for interaction are the implementation of voice recognition for audio assistance; Or even apply new technologies such as HMD devices, which provide more immersive television experiences that may require gestures like body movement, making possible to "*improve the functional ability of all older people*" [13]. The creation of projects together with elderly users also provided new opportunities to create new objects that facilitate interaction with television. For example, in the "SIX" project [17] it was developed a cube designed to work like a remote control, being customized by the user to play certain function in the television whenever it turns the respective side of the cube upwards. As it was highlighted the opportunity to implement more technological solutions found in iTV projects for middle-aged adults, the elderly user-oriented projects, present interaction solutions themselves that take into account the physical, psychological and social changes of these users, developing more inclusive iTV systems.

5 Conclusion

Despite the differences between iTV projects for elderly and middle-aged users, this inequality is what prompts to the creation of more forms of interaction to satisfy the needs of a wider spectrum of users. However, it has been shown that the projects oriented to elderly users have the potential to improve their interaction models, for example using the gestural dynamism present in the touch screen from second screens, or even use devices that can track freehand or body gestures. Other solutions covered go through the virtual reality provided by immersion in HMD devices, the use of voice recognition or the creation of new physical interactive objects. Nevertheless, it should also be highlighted that this study is limited to the interpretation of the obtained data from the selected databases, serving as a recommendation for future work the addition of more sources. It should also be considered that this review was limited between the years of 2013 and 2018, being this document useful to apply on future research on this field.

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