Interaction Paradigms on iTV: a survey towards the future of television

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ABSTRACT

One of the main research subjects in the interactive TV (iTV) field is related to the conceptualization of innovative user interfaces. The attention of the scientific community in this area is quite extensive, since the television continues to represent a significant role in everyday life. This paper presents a survey based on recent scientific publications that discuss innovative trends of interaction with television as well as TV features currently being studied and developed paving the way for future releases to the market. In this context, the main goal of the paper is to address several approaches with potential to predict what we can expect in the following generations of iTV solutions. To accomplish this, a systematic survey in the databases of ACM and IEEE was conducted, focusing on publications addressing advances in user interfaces and their related interaction paradigms. The results digested from the 31 selected articles provide a discussion about how the next probable ways of interaction with television can influence people daily life.

Keywords

Television, Interactive TV, User Interfaces, Interactive Devices.

1. INTRODUCTION

Over the last decade, we witness a significant change in the TV ecosystem that goes beyond the increase of media content offered, addressing new features that are available to consumers, namely, the Catch-up TV, Time-shift and other On Demand services [1]. In parallel, several technological developments in the iTV field are fostering innovations in the conventional structure of the television, aggregating social components and recommender systems that personalize the user experience [2].

Furthermore, the advancements in the TV ecosystem also encompass new ways and methods to interact with the TV (or with devices connected to it), resorting from new technologies in the Human-Computer Interaction (HCI) domain, which makes possible to control all the features mentioned above using different User Interface (UI) approaches [3]. This is special relevant as the television has had a significant influence in the habits and routines, becoming one of the most used devices every day facilitating the access to information and entertainment [1] [3]. Because of this significant role, players of Managed Operator Networks (MON) have invested in alternative new services and multimodal means of interacting with TV that go beyond the traditional interaction paradigms, enabling them to take advantage of new features making a difference in their offer to the market [1]. Therefore, the industry leveraged a substantial number of interactive modes that allow to control these systems with different devices, such as smartphones, voice controllers and cameras (with gesture recognition). Also, different smart devices appear as complementary platforms for watching TV content in the household or in mobility [4]. Notwithstanding the fact that a plenty of solutions for iTV already exists, there are still room for designing more disruptive TV ecosystems.

The survey presented in this paper was conducted under project UltraTV being developed by a consortium of public and private partners, gathering the academic field and the telecommunication industry. One of the objectives of the project is to develop a disruptive ecosystem of interactive TV, enabling a service with advanced features, in addition to providing modern interaction technologies, allowing the user to control the television through different devices. Furthermore, the project aggregates the possibility of integrating new graphical user interfaces, turning the experience of watching TV more pleasurable and engaging.

This paper is organized as follows. The methodology associated to the survey is presented in the following section. Next, with the goal to address innovative commercial products, section three presents the industry status quo. Section four introduces the most relevant papers selected in the survey. The fifth section presents a discussion towards the future of iTV and the final section provides the most relevant conclusions.

2. METHODOLOGY

Systematics reviews have become an increasingly significant aspect of research for gathering advance knowledge regarding a specific area and have been detailed previously [5]. The first step of the research in the ACM and IEEE databases (where it is possible to find technical content about advances in user interfaces and their respective paradigms of interaction) was the definition of the correspondent keywords. In this scope, we designated “main keywords”, i.e. essential words that were used, not necessarily simultaneously, and “secondary keywords”, which were used in conjunction with the main keywords. Interactive TV; Immersive TV and Television were the adopted main keywords. The utilized secondary keywords were: Holographic; Multiscreen/Multi-user/Smart Watches; Recommender Systems; Social/Social component; Eye Tracking/Eye Gaze; Gesture interaction/Hands free interaction/Gesture control/Motion control; Brain Computer Interaction (BCI) and Voice controller.

It is important to emphasize that the main keywords are all correlated to the pivotal point of this study, which is television. The others are associated to relevant descriptors of UIs and TV features. These secondary keywords were not used together in the same query. Papers and proceedings published before 2015 have been excluded, as well as papers related to workshops and courses. The year-based exclusion criterion took into account the fact that the project related to this survey started in 2016 and with the fact that there was already one relevant review published in 2015 [6].

As a consequence of the search in the previously mentioned databases, 40 papers were considered as possible to use in this survey, although only 31 were selected as they comply with the following adopted criteria: being original papers (published after 2015) addressing proposals or potential applications of interaction with the TV ecosystem. The steps for the selection of the papers to use in this survey were the following ones: in the first step, the titles were analyzed. We also excluded those that do not fit the

inclusion criteria of this study. After this phase, a pre-selection based on its content was done through the reading of the abstract. Next, all the selected papers were fully read to decide on the final selection of the documents that effectively illustrate relevant research that should be considered in the context of the UltraTV project.

3. INDUSTRY SITUATION

Currently, the changes on the TV consumptions habits encompasses a growing wealth of non-linear content, made possible by a set of technological developments that occurred in MON allowing the use of services and new features adapted to consumer's behavior [1]. In parallel with these developments, there are the media centers, such as the Apple TV and Chromecast, which operate like true set-top-boxes and offer online content through Applications (apps), as well as smart TVs that, in addition to linear services, provide nonlinear content via the internet access. Within this context, there are specific populations, as younger audiences and specialized consumers that are constantly searching for more adequate solutions allowing flexibility on the choice of which contents they will prefer to watch and in the way they will choose to consume it [3]. The answer of the commercial players to this request goes beyond providing new features and making feasible new modes of interaction, with possible access to second screen options, as well as the diversification in what concerns HCI possibilities [3].

Regarding new ways of interacting with the TV content, there are many innovative technologies oriented to this device, such as new remote controls that encompass touch surfaces, voice controllers and haptic recognition systems. Hence, we have seen the inclusion of touch surfaces like the Apple TV remote and the touchpad of the Sky Q Pay-TV operator; and the addition of QWERTY keyboard or infrared control and gyroscope, like the air mouse implemented by TBEE [8][9][7]. TBEE remote control also allows using voice commands for searching content, as is also the case of the LG Magic Remote, which has a voice recognition option. In addition, systems such as LG and TBEE box also allows the navigation through contents using natural movements of hand and arms to interact with the system [10][7]. These technologies recognize the movements of the user, although with distance and accuracy restrictions [11]. However, these technologies often do not provide a satisfactory user experience, since the consumer often experiments navigation errors led by sensory disconnection. In these situations, the applied command has a gap between what the consumer wants and how the system answers (e.g., overshooting in touch surfaces, meaning that the finger went too far and the focus switched to another item than the desired one). These kinds of situations show that there are still a lot to be made in the gesture area. An example of another multimodal interaction used by commercial players is the Low-cost brainwave-reading headset that has been developed in a project from BBC, which allows the users to control the new version of the iPlayer by using their minds. Until now, some tests have been made but the system is still not available for consumers [12][12]. Concerning different and innovative graphical interfaces approaches, BBC has several new prototypes that include 360º images, virtual reality and holographic TV [13][14].

Some of the main factors contributing for an engaging user experience are related to proposals that combine social networks, recommendation, content sharing and emotions. The Humax ON offers intuitive and accessible buttons for sharing contents with friends in social networks. By logging in the client's account, this device works as a second screen that allows swiping the social network app interface to the TV screen, in a "picture in picture" style [15]. The Facebook Videos app brings to the Apple TV recommended videos, considering the user's behaviors and provides sections such as "shared by friends", "following" and "recommended" with customized contents for users. The contents are shown in a carrousel format, with comments and views inserted under the video [16]. Additionally, the Vodafone app Live on TV allows the clients to share their recorded "live" contents with a maximum of five friends [17].

It is common nowadays to have alternative screens for watching content and controlling the TV. In this context, controlling TV using wearable devices is starting to gain attention. Vodafone provides this type of control by using smartwatches as a remote and a second-screen to display the content and get information about a program [17].

4. INTERACTION TRENDS ON iTV

In this section, the selected articles are presented in different subsections, according to their disruptive feature. In the first subsection, the papers involving a variety of kinds of interaction are addressed, whereas in the second subsection we present the selected papers associated with interaction services, such as multi-screen features, recommender systems, social components, emotional recognition and viewer behaviors. In each subsection, the papers were divided into different sectors, corresponding to their disruptive category.

4.1 Multimodal Interaction

Within the scope of this survey, 19 papers regarding multimodal interaction were selected. From these, seven were published in 2015 and 12 in 2016. Concerning the addressed interaction modes, 11 articles are related to gestures and movement recognition systems (all present interaction proposals that include motion). Four of the articles report about disruptive graphical interfaces, like holographic displays, 360º omnidirectional graphic interfaces and experiences that aggregate virtual and augmented realities. Furthermore, there is one paper related to BCI, other that introduces the idea of natural interaction through smell, another one that addresses the control of the TV by using a voice-controlled system and one paper about how interaction can be performed through eye gaze. Therefore, it is possible to group 15 papers within a natural interaction category, which includes gestures, voice, gaze, smell and cognition whereas the other four papers present new possible graphic interfaces to display TV content. The presentation of the papers will be made according to their disruptive characteristics. Thus, the articles are arranged in categories in the following subsections.

4.1.1 Natural Interaction

As referred, 11 of the 19 articles are related to haptic/gesture recognition systems aiming to achieve high accuracy and to provide more reliable caption of the movements. Despite the fact that some gestures recognition systems have been implemented by commercial players, the studies focus in new technics and methods to offer alternatives to create multimodal interactions. In this scope, several solutions are being tested, such as single layer electrodes in a touch panel design for 3D touch sensing [18]; smart gloves [19]; radiofrequency sensors [20]; smartphones working as a mouse in the air [4]; new remote controls with tilting, pressure and breath sensors [3]; Kinect [21] cameras for improving haptic recognition [22][23][24]; the exploration of

direct/indirect modes of input with pen and touch [25]; and solutions for multi user gesture controls for TVs [26].

Other relevant discussion that is worth to be made is related to the possibility of viewers to engage with live action television shows. In this context, the idea of the article [24] is to allow people to interact with other participants in a live show on TV and to provide the sensation of being part of the show. It introduces the idea of using real-time 3D reconstruction methods for future interactive TV application. In the paper, the technology that allows the generation and animation of photo-realistic 3D model of each user is the key to make the idea become true. It uses a novel and fast algorithm for real time body reconstruction that generates a real-time 3D representation of the participant at home, along with the extraction of the motion parameters of his data. Subsequently, the data is sent over the internet to a server for animation, rendering and insertion of the 3D user model in a broadcast stream. A video demonstration has been made for public view [27]. Additionally, article [21] introduces a low-cost platform which integrates Tele-immersion (TI) advances, which is a new technology for future interactive 3D applications that allow people to be located at different places simultaneously, sharing the same virtual environments and facilitating real-time interaction between different users. This platform presents realistic user representations by applying multiple commercially available RGB-D (Depth Sensor) with a multi-sensor calibration scheme. The 3D body and motion of each user is captured in real-time and transmitted inside remote virtual environments, leading to a 4D media, which can be consumed by several devices like tablets, virtual reality headsets or 3DTVs. The platform was verified and demonstrated via a prototype TI game – SpaceWars [28].

On the other hand, another interaction mode addressed is the BCI, which uses a movie that responds to the brain and blink data from users. In the paper context, the movie was constructed with four coexisted channels of footage. Simultaneously with the reproduction of the film, blinking and levels of attention and meditation were recorded by a commercially available EEG device, affecting which footage participants saw. This scenario provides an eyesight of what is possible to control using cognition factors and what we can expect for the future of interaction with TVs [29]. One of the highlights of this study is accessibility. People who have physical impairments can benefit from these systems in the moment they start to control the TV with autonomy. Additionally, since the interaction form does not include voice, this mode of interaction can be useful for people with cerebral palsy, who present motion and speech disorders.

Concerning the other interaction papers selected in this survey, voice control is one of the natural interactions that is worth to mention. In this framework, the system proposed in the respective paper uses an Android based voice controlled system, which works with Simulink and the signal is transmitted as far as the Bluetooth range, using Android apps. Further, the voice control is useful for selecting and changing the TV channel. The system achieve this with high efficiency and is also able to handle multiple devices allowing sending commands to individual devices simultaneously. In this context, in a near future, it might be possible to make a universal modem, which could help users to get benefits from all service provider companies with a single device which will be able to control any kind of channel [30].

Moreover, there are two more natural interactions addressed by the articles, which are interaction through smell and eye gaze. In the first case, the study presents a new reproducible olfactory display that releases orange smell when an orange appears on the screen. The most probable useful context for this kind of reaction would be advertising in which smells can acquire a key role. It is well known that the odor effect used by stores can create positive shopping experiences, e.g., the odor experiences when the consumer is watching a hamburger propaganda can determine the purchase of the product [31]. Furthermore, another interaction mode introduced was the eye gaze [32]. The system presents one eye-shaped display that can point out gaze direction just as accurately as the human eye and can determine the exact direction to where the consumer is looking. Therefore, the system is able to recognize specifically commands by eye gaze. Since there is only one article related to smell and one regarding eye gaze, more studies need to be conducted for a real application in the industry. However, this kind of interaction can be a promise for the next generation.

4.1.2 Disruptive Graphical Interfaces

Other important approach is related to the user interface, which aggregates graphical concepts and is crucial for many costumers. Four of the selected papers present different disruptive technics. One of them addresses the presence of 360º video and images, using an extension of the JPEG, called OmniJPEG [33]. Other one presents holographic images, using a Light-Field 3D Display (LFD) that reconstructs a real or virtual image in 3D space and uses the full-parallax LFD, which is one of the principles of holographic stereogram to construct an interactive 3D touch interface, which grants capacity of interaction with the user [34]. The third paper presents a completely new way to watch TV, using mixed reality technology, combining Augmented Reality (AR) and Virtual Reality (VR) simultaneously, in which it will be possible to interact with the content [35]. Finally, the fourth paper [36] relates with multi-screen innovations, taking advantage from the implementation of an AR system for multi-screening TV by detecting the position of any rectangular objects and projecting multiple virtual tablets, which recognizes touch gestures.

4.2 Interaction Services

We selected 12 papers that show recent technologies for TV services. Within them, three papers have been published in 2015, seven in 2016 and two in 2017. The articles present systems that involve the promotion of the social component, recommender systems, emotion recognition with innovative multimodal platforms and apps in second-screen devices. Additionally, within the data collected there is one paper that addresses monitoring of the viewer's habits while the TV is on, including collecting information about the audience of a channel or a program. Almost of the articles combine two or more features in the same proposed system. Further, all systems presented in the articles are based in algorithms and new platforms that support the proposed technologies. The selected papers, that show recent technologies for TV services, will be presented in the next subsections, divided according to their disruptive features. Since most of the papers address more than one feature, the following subsections are separated according to combined subjects.

4.2.1 Human monitoring systems and recommendations

Regarding the selected articles selected in this survey, there are some important disruptive ideas that are worth mentioning. Paper [37] presents "REFLEX", a new platform that recognizes and interpret the facial expression using a recognition system and recommend the content based on the emotional state of the user. REFLEX understands and recommends the best TV content for the user to watch, helping the shift from the current feeling state to a new mood. Another article addresses a proposal of creation of

account decomposition through personas, which is a common viewing patterns observed in online TV accounts, for a better recommendation algorithm that goes in the direction of each persona's habits and preferences [38]. Concerning groups of users, paper [2] presents a group recommender system, taking into account multiple users involved in specifics ephemeral groups, in order to help in choosing item choices, such as movies and places to go. Such recommendations will be given according the general profile of the group, which will be constructed taking into account the preferences and profile of each member. With the aim of getting knowledge about TV-watching data of the clients, article [39] proposes a system composed of a smart TV, smartphone and smartwatch. The aim of this system is to acquire user's behaviors while watching TV, their movements, activities in home environment (e.g., know the exact location that the customer is or the exact place of the house the client spend more time), as well as collecting audience data.

4.2.2 Social Component and multi-screening

Considering social components, papers [40] and [47] introduce technics and technologies, like tele-presence, which allow the participants to feel the presence of multiple users, providing a real-time presence sensation, and a multi-view system, which allows two users to transition between collaborative and independent activity, choosing (or not) to share the same screen. Paper [41] presents "SAM", a new platform that incorporates the creation of a dynamic social community related to the user profiles, preferences, diverse devices connected and content usage in order to enable media content syndication enriched with comments, ratings and recommendations as well as additional programed-related information. Article [42] reports on sharing media experiences synchronously at-a-distance. The sync-watching was considered in two different perspectives, being one among TVs and smartphones and another including virtual reality head-mounted display combined with RGBD sensing.

In addition, a system that presents an asynchronous video-sharing platform that uses *Emotars* to share affect and to enhance the sense of togetherness and collectivity is proposed in [43] . Since the *Emotars* are emotional avatars, they allow viewers to share their affects and experience with others without revealing their real facial expressions. Further, the creation of recommendations for ephemeral groups presented in paper [2] highlights the social factor aggregation in iTV contexts.

Moreover, the proposition of companion apps in second-screen devices with supplementary contents of a specific show has been discussed by [44] and [45] for better improvement of user's engagement with TV contents, providing complementary information such as relevant facts, quizzes and related social media content. Still regarding social TV apps in a second screen device, [46] designed two apps, which support critical live-viewing of reality TV and offer opportunities to engage with issues of political concern in social discussions. Through these apps, users are allowed to join groups of discussions and to manifest their opinions concerning specific subjects.

5. A DISCUSSION TOWARDS THE FUTURE OF TELEVISION

One of the meanings of disruption is related to technologic innovation, which primarily underperforms the commercial predominant market demands but gradually keeps up and potentially overpowers it. This study took into account two parameters to measure disruptive level: interactive modes for controlling the TV and interactive services, which comprise features to increase the user experience when using the TV. The current iTV scenario shows the trend of the youngsters to open up for a new age on the television scenario. The current commercial products may give us clues of what might be coming next, but still do not really provide what these demanding consumers are looking for.

It is notorious the existence of a huge multisensory tendency in the future interactive systems, which aggregate multimodal interactions and explore one or more than one sensorial system, combining natural interaction such as smell, voice, eye gaze, gestures and even interaction by cognitive stimulus. Since there are many papers oriented to motion interaction approaches, it is possible to conclude that many current solutions have been addressed in this direction. This fact allows us to prospect that better and more efficient systems, with higher precision in the caption of movements, are coming in a near future. It might be possible, for example, to invite friends for a game, which will be played wearing smart gloves, or by gestures in a 3D touch panel design. Simultaneously, the advances on new interactions solutions, namely TI technology and by using real-time 3D body reconstruction methods, people might be able to participate in TV shows from home, as well as to share the same virtual space with others. These features can increase social aspects, once it might be possible to participate in a show and share the experience with friends.

In the same manner, it might be possible in the future that consumers will choose their perfume by just feeling the smell through an advertising on the TV or by the smartphone. In addition, the smell feature applied to propaganda could make easier to choose a place to eat by seeing an advertisement in which is possible to feel the smell of the food. Taking advances in this multisensory profile, it is possible to foresee that these future systems will be potentially used in the rehabilitation field to stimulate sensorial systems and obtain motor, social, emotional and affective improvements, thus, providing accessibility. In this sense, disabled people might be able to control the television using their eyes or even with cognition through headsets. The prospect of not having to hunt for the control remote, replacing batteries and everything else will be like a dream come true.

Display promises might go beyond the current High Digital 4k options with the appearance of several ways to watch a content via different graphical interfaces, which encompass mix realities, holographic and 360º images. Moreover, interactive surfaces might provide alternative means of sharing activity in groups. The options of what is possible to do if any rectangular surface could be transformed in a television display are wide. People could invite their friends for new movie experience if the walls could transform the home environment in a real cinema. Further, movies could be watched in an interactive holographic display, or with a mix reality approach, which renews all the watching experience enabling to feel like if the user is really inside the movie.

Concerning Interactive Services, different platforms might present, through different ideas, the possibility for obtaining a complete profile of the clients, their preferences, time they usually watch TV, as well as info about their habits and behaviors. The acquirement of new knowledge of client's preferences and behaviors is useful for the development of more efficient recommender systems that can improve the user experience. A large number of related studies to understand users' habits and preferences highlight the tendency to create more precise recommender systems satisfying customer needs and providing more precise recommendations in the future. In this sense, the

television might offer the specific content for a client in the right time he is used to watch it. The future of the TV might include modern systems in which social recommendations can be made by friends or family. Further, systems might suggest content for improve user's mood. As referred, players of MONs and other commercial systems look forward to offering engaging products for increasing the user experience.

Additionally, advanced behavior monitoring features and several social multi-screen apps will be available. Thus, it might be easier to engage in social groups and to be a part of a cluster in television context with the improvement of social dynamic networks connected to TV apps. The possibility of contributing with a real time TV subject (e.g. political or social subjects) and to share opinions with friends by the social TV app could increase the engagement around major society issues. In addition, sync watching might be more feasible so people in separate places can watch the same content at the same time, decreasing distance among them and increasing even more the social character of the TV.

6. CONCLUSIONS

Viewing TV habits have been suffering several changes, which requires several innovations. In this paper, we presented a survey about what can be expected in relation to the future of the interaction with the TV based in the academic research. Grounded on the reviewed cases, some interactive features prove to have the potential to transform the way people will interact with the TV, by augmenting its usage or replacing it for second-screen devices. Interaction with TV will definitely change in several domains, encompassing social features and multisensory aspects that still are not common in the current TV scenario. Thus, the solutions addressed in the papers selected in this survey reflect how the technology of TV viewing may change in the following future. In this sense, the UltraTV project not only brings compiled data providing an overview of trends and disruptive approaches in the academy, but also shapes some of those ideas through innovative prototypes leveraging a new TV ecosystem.

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