Interactive TV Potpourris: An Overview of Designing Multi-screen TV Installations for Home Entertainment

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Abstract. Home entertainment systems comprising multiple TV screens offer new opportunities to display more content, accommodate more viewers, and deliver enriched user experiences. In many cases, such installations take the form of mixed-reality environments, in which video projections coexist with physical TV sets. We refer to such installations as *interactive TV potpourris*, due to their composite nature of hybridizing individual TV screens of different natures, form factors, and potential to render different multimedia types. This work discusses current implementations for interactive TV potpourris, identifies technical and interaction challenges, and pinpoints future research and development directions. It is our hope that this work will encourage new explorations and developments of TV potpourris.

Keywords: interactive TV, TV potpourris, interaction techniques, multiple displays, home entertainment.

1 Introduction

Users' increasing demands for sophisticated TV technology in terms of more content [4], integration with personal devices [6], and simple and effective control of the TV set (e.g., gestural interfaces [14]), have recently started to be accommodated by the TV industry manufacturers. However, fully matching users' expectations with today's single-screen TV sets represents a considerable challenge. For instance, although web browsing is supported by the software platform of all Smart TVs, it cannot take place at the same time with TV channel watching because of the limited real-estate of the physical TV screen. Consequently, users frequently resort to employing second-screen devices [4,6] to compensate the shortcomings of the main TV screen.

We address in this work collections of TV screens (i.e., more than two screens that are co-located on the same living room wall) that are part of a single, unified home entertainment system. We refer to such systems as *interactive TV potpourris*, due to their composite nature of hybridizing individual screens of different form factors (i.e., display size and aspect ratio, such as 16:9 or 4:3), that display different content, occupy distinct locations in space, and present different interfaces (e.g., remote controls or gestural interfaces). A potpourri of interactive TVs (iTVs) is therefore

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composed of more than two screens that hybridize into the same unified entertainment system in the attempt to provide more content and functionality beyond traditional single and two-screen TVs. In this paper we describe existing technical solutions that implement such systems, summarize interaction challenges for interactive TV potpourris, and point to interesting questions regarding the human capacity to manage the visual information flow that iTV potpourris are able to deliver. We hope this paper will contribute towards a better understanding of today's technical and interaction challenges for these installations and, consequently, encourage the community to further investigate the opportunities delivered by such systems.

1.1 Technical Implementation of Interactive TV Potpourris

A simple way to explore scenarios with multiple TV screens, without recurring to complex hardware installations involving physical TV sets, is to employ video projections [12,13]. The result resembles the output of augmented reality systems that project digital content onto the real environment in order to deliver enriched user experiences for various application scenarios [11]. Previous research outside the interactive TV community has already explored such installations. For example, Cotting and Gross [5] experimented with displays adaptable in form and size projected on the surfaces of tabletops; Vermeulen et al. [15] enhanced the walls of a room containing technical equipment with visual feedback designed to help users understand the technical intricacies of the room and guide them into using the various technical facilities of the room; and Wilson et al. [16] introduced the Beamatrom, a steerable video projector that can display images at any location inside a room. The Ambilight lighting effects installation for Philips TVs[1], the NDS Surfaces concept [9], and the IllumiRoom prototype of Jones et al. [8] for Microsoft XBox are all part of the same attempt to enrich the user experience with elaborated visual effects.

The interactive TV wall system of Vatavu [12] was the first installation to combine multiple video projected TV screens, independently controlled in terms of location, size, and the content they deliver (Figure 1a). The goal of the TV wall was to go beyond current limitations of the physical TV set, such as its post-purchase inability to be customized in terms of desired size and limited possibility to install it at different locations in the living room. In order to facilitate users' adoption of a complex TV environment comprising many controllable TVs, the authors reused the viewers' existing expertise of employing point & click interaction metaphors on windows operating systems. The AROUND-TV system [13] went further and explored interactive TV potpourris that combine both video-projected and physical TV screens in a hybrid, digital-physical augmented TV space (Figure 1b). Viewers are still able to control each individual screen with point & click techniques, but more sophisticated interactions are also possible, such as "dragging" TV content running on the physical TV set outside its bounding area, or employing widgets projected on the wall, next to the screen, in order to control the TV transmission (e.g., "go to next channel" or "increase volume").

[1] http://www.research.philips.com/technologies/ambilight/index.html

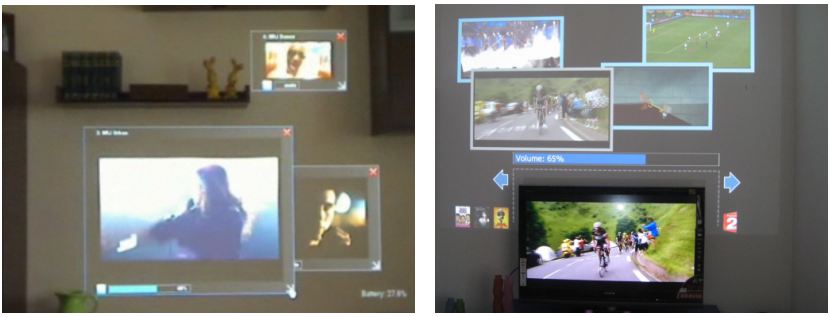

Fig. 1. Two interactive TV potpourris installations: (a) the TV wall [12] with multiple TV screens video projected on the living room wall and (b) the AROUND-TV system [13] in which projected screens co-exist with the physical TV set

Technical challenges reported by these works are high processing power demands needed to display multiple video streams, accommodating video projectors to work at resolutions that enable full-HD quality for the projected TV screens, and video projecting on walls and furniture of different colors (e.g., dark colors). In order to guide further development of such installations, Vatavu [13] provided a series of design principles for augmented-TV spaces that include: (1) context-dependent augmentation of home entertainment, (2) multi-tasking home entertainment spaces, (3) sophisticated control, (4) natural forms of interaction and gradual transition to new input modalities, (5) seamless integration with personal devices, and (6) scalability to more viewers. We can further add to these challenges the need to design and develop new infrastructures and software architectures for TV potpourris to accommodate the complexity of delivered content from multiple sources. In this direction, Falchuk et al. [7] discussed the motivation, design, and uses of high experience coalition-based services and described how such services fit an architecture for co-located devices.

2 Interacting with TV Potpourris

Interactive TV potpourris need appropriate interfaces that would go beyond the interaction possibilities offered by standard remote controls. Indeed, the research community has many times warned against the complexity and ineffectiveness of such control devices in many cases (such as in the living room ethnographic study of Bernhaupt et al. [3]). Consequently, hybrid solutions combing remote controls and gestures have started to be proposed and investigated in terms of performance [2].

Vatavu [14] addressed the problem of interacting with collections of TV screens and conducted the first comparative study on two of today's emerging gestural interfaces for interactive TVs: (1) hand-held remote devices with embedded motion-sensing features and (2) free-hand gestures captured by ambient video cameras. (The TV industry currently provides solutions for both scenarios, such as the LG's Magic

Remote[2] or Samsung's free-hand gesture control system[3].) The study employed a participatory design methodology [17], in which participants were asked to suggest commands for a large set of twenty-two frequent TV control tasks. Commands were proposed in terms of buttons, motion gestures, and combinations of buttons and gestures. The study reports several findings that can be employed to guide the design of gestural interfaces for collections of TV screens, such as: (a) recommendations to reuse point & click and drag & drop interaction metaphors when working with graphical items; (b) recommendations to prefer buttons to motion gestures for cases in which buttons are available and intuitive, without agglomerating the design of the remote control; and (c) empirical findings that recommend to explore culture-specific and full body gestures. We rely on these findings to address in the following a current debate on the use of gesture commands for iTVs, applicable to iTV potpourris as well: remote controls vs. free-hand gestures.

Buttons vs. Motion Commands. One of the findings of [14] was that people prefer button commands when they can choose between using a button and performing a motion gesture. The reason is that buttons are simpler to use, require minimum effort, and are easier to remember than motion gestures. This finding was supported by a large majority of participants' suggestions, with 76% recommending buttons and 65% using buttons exclusively. Vatavu reports that the first intention of the participants when suggesting a command was to think of a button with an intuitive meaning that could be used to execute that command. However, participants agreed that not too many buttons should exist (with a total of 15 buttons resulting from the experiment). Buttons were preferred when the task to perform had an abstract nature (e.g., Mute), for which they were not able to associate a suitable gesture. Instead, gesture commands were preferred in about 20% cases. These findings show that people are familiar with remote controls and they tend to prefer them in 4 out of 5 cases, but motion gestures are still perceived as useful (e.g., when left/right or up/down motions can be intuitively mapped to commands such as "go to next channel"). Also, these findings suggest that TV remotes implementing a combination of buttons and motion commands represent a good compromise for today's TV viewers.

Technical vs. Non-technical People. Vatavu [14] reports that people with non-technical backgrounds preferred button commands, while technical people were able to reuse interaction metaphors from desktop computing including point & click and mouse drawing (e.g., drawing a rectangle to create a new TV screen and drawing the question mark symbol to invoke "help"). Obviously, non-technical people will face many challenges with a TV interface relying on motion gestures exclusively. This finding supports our previous recommendation of a hybrid design of the TV remote, including buttons and motion input. We expect that such a hybrid design will allow a smooth transition to gestural interfaces for different population groups.

[2] http://www.lg.com/global/magicremote/
[3] http://www.samsung.com/us/2013-smart-tv

Human Factors and Visual Attention. Although collections of interactive TVs can bring many benefits in terms of control and content, we expect some limitations to occur in terms of viewers' capacity to manage the increased visual complexity of the information being delivered. Attention is the capacity to selectively process information subsets instead of taking into account at each moment the entire amount of information that is available [1]. By definition, attention leads people to focus on a single task at a time. However, attention can be divided between several information sources, especially when the senses associated to the different sources are uncorrelated, e.g., when one drives and talks to the phone at the same time. This divided attention of uncorrelated senses works well, even if individual performances of each sense are decreased in comparison to sustained attention on a single task [10]. In the case of interactive TV potpourris, the same senses (vision and hearing) are used for all screens: while ears focus on the audio signal of the main TV transmission, eyes are likely to be drawn by other content displayed on different screens. We can therefore suspect that a multi-screen TV environment will increase the cognitive load of the viewer in such a way that, when improperly designed, the TV experience might not always be perceived as relaxing. These hypotheses could be true if the screens arrangement does not follow a proper structure (i.e., all screens having the same size, without a clearly identified main TV screen) or if all screens display the same type of information. However, studies are needed in order to fully understand the human capacity to adapt to the complex visual information that multi-screen TVs provide.

3 Conclusion

We described in this work existing solutions for implementing interactive TV potpourris, for which we identified technical and interaction challenges, reported preliminary experimental findings, and pointed to some design recommendations. TV potpourris are made available by the advances in interaction and visualization technologies; however, the balance between the number of screens, what content to display, and how to design interaction techniques are all crucial for their adoption. We hope this work will benefit the iTV community and will encourage the practitioners of interactive TV to further develop on top of existing potpourris scenarios in order to deliver new interactive TV applications and enriched user experiences.

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