Improving Interactive TV Experience Using Second Screen Mobile Applications

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***Abstract*—The past two decades have seen a shift in the multimedia consumption behaviours from that of collectivism and passivity, to individualism and activity. This paper introduces the architectural design, implementation and user evaluation of a second screen application, which is designed to supersede the traditional user control interface for primary screen interaction. We describe how NSMobile, our second screen application, can be used as a pervasive multimedia platform by integrating user experiences on both the second screen and primary screen. The quantitative and qualitative evaluation of user interactions with interactive TV content also contributes to the future design of second screen applications.**

I. Introduction

The past two decades have seen a shift in the multimedia consumption behaviours of consumers from that of collectivism and passivity, to individualism and activity, both in the home and in mobility situations outside of the home. Concurrently, there has been a secondary shift towards non-linear usage patterns as consumers move away from the classical model of linear broadcast TV.

There is a growing body of research indicating that consumers are beginning to spend a significant amount of time interacting with mobile devices and other technologies whilst watching television. Although this synchronous viewing behaviour reinforces perceptions of the television as a lean-back medium, that requires low levels of cognitive loading [7], it does not diminish the continuing active role played by viewers. Media multitasking could be perceived as a threat to the traditional television viewing model, but it also presents opportunities to exploit how multiple screens could support and further engage viewers.

Despite the growing number of second screen applications, little is known regarding the impact of mobile second screen applications on interactive TV content as well as the right balance between improved engagement and distraction [3].

In this paper we outline the architectural design and evaluation of a second screen application, which is designed to supersede the traditional remote control for primary screen (i.e., predominantly television-based) interaction. We also outline the design and results of lab-based user evaluations providing both quantitative usability analysis and subjective feedback of user experience.

II. Background and Related work

The explosion in digital and mobile device ownership has greatly changed the focus of social and interactive TV to enhancing user experiences with tablets and smartphones as second screen devices [2]. We have also seen recent developments around semantic video applications that adapt existing single-screen applications to multi-screen environments based on author or user choices [6] and multi-screen orchestration that connects TV programs with "social sense" using mobile devices [4]. Kusumoto et al. studied the effects of complementary information and tweets on the media experience indexed by a comprehensive self-report questionnaire [5]. Centieiro et al. designed a second screen betting application for realtime interaction during live sports TV broadcasts as the means to improve user engagement [1]. There have also been psychological studies on the split of attention, cognitive load, perceived comfort, and the maximum number of screens that could be watched at the same time [8]. In spite of the myriad of mobile applications, most of the existing second screen designs focus on incorporating third-party contextual information as the adjunctive elements to the primary screen. There is currently lack of empirical study how mobile device can directly enable interactive TV and its impact to the overall TV viewing experience.

III. NSMobile Application

NSMobile is an integrated second screen mobile application designed to work in conjunction with internet-based IPTV set-top box (STB) or Smart TV.

A. Content discovery

NSMobile provides a virtual remote control, which is rendered as a touch-screen facsimile of the physical remote control (Figure 1). This enables interaction through the STB interfaces on the primary screen. Furthermore, whenever the TV interface requires text input (e.g. for search), the mobile device's touchscreen keyboard can be used to input text rather than the virtual remote control. This process is fully synchronised across the primary and secondary screens. NSMobile also provides a number of supplementary mechanisms for facilitating local content discovery, including EPGs, search, play history, and favourite (Figure 1).

(a) Virtual RC (b) Content discovery (c) Grid, Carousel, List (d) Subtitles (e) Chapters (f) Quiz

Figure 1. NSMobile user interfaces

NSMobile implements three manifestations of user interfaces: *Grid*, *Carousel*, and *List* (Figure 1(c)). The usability and user preference of these interfaces will be addressed in the user evaluation section. Beneath each of these interfaces is the programme and detailed metadata levels presented as a list-based interface of VoD assets, with the option of playing live television.

1) Subtitles: Subtitles can be ported by utilising a set of JSON files with time-encoded values measured in time with the audio in the video stream being displayed on the primary screen. For subtitles in NSMobile (Figure 1), the process of periodic state updates from STB is used to maintain correct timing (e.g., for automatic re-synchronisation after seeking).

Traditionally the subtitles would overlay the video stream. We are used to the convention of having subtitles appear at the bottom on primary screen, as it allows for rapid reading. Moving this to a second screen may have the effect of viewers paying more attention to the second screen and neglecting the primary screen in favour of understanding the speech. The ability to connect and pull speech data could be useful in situations where audio is unavailable, disrupted or cancelled out from background noise. Furthermore, this would allow subtitle information to be displayed in an array of different languages, based on user preferences.

2) Chapters: Chapters provide a shortcut to skip to predefined sections of a TV program. The data is defined in JSON encoded files, with a start and end time, which can be loaded into the second screen engine (Figure 1). This provides the viewer with a fluid interface for skipping through content, rather than having to manually seek through of content. A short preview of the chapter could be played, or even a description could be displayed on screen, detailing what happens within the chosen chapter. Descriptions are valid for the chapter feature, providing users with more control over what they are skipping to.

3) Quizzing: Quiz functionality within the NSMobile application shares similar underlying principles as the subtitles function. A manifest file has a start and stop time defined to set a period of time in which a question is valid. When this time period is reached, NSMobile triggers a pause of the playback on primary screen. The question is then presented on both the primary and secondary screens. A viewer can then select an answer on the second screen, which is logged by the engine, and then the playback on the primary screen is resumed. After the question times out, a viewer is presented with a message on the second screen, stating the answer is either correct or incorrect. At the end of the multimedia stream the answers are totalled and a viewer is given an overview of their score. One potential use case for this functionality is with educational programs. If the program had a section in which a question is asked and the viewer given a list of answers, a student can practice with a great learning experience, breaking away from the norm of memorization directly from written material. The same feature can also support audience participation and polling of reality TV shows or song contests.

IV. User Evaluation and Discussion

A. Experiment Design

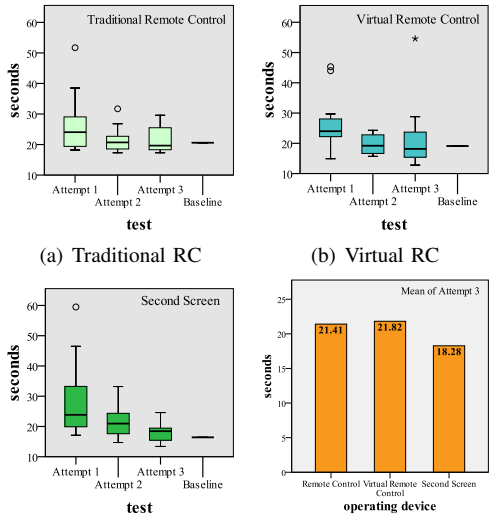
In order to systematically study the benefit of second screen application in improving the user experience of interactive TV content, we conducted a usability test. 12 participants were recruited who had no prior experience with the NSMobile. Of these participants, 9 were male, and 3 female. The age of participants ranged from 25 to 45. The usability test lasted one hour in three sections.

The first section of the test consisted of two quantitative evaluations of the time taken to complete content discovery tasks. The first task involved navigating through a series of menus to the EPG of popular video-on-demand assets. Participants were then asked to play a particular item on this list, and skip 4 minutes into the content. Participants performed this task with the traditional remote control, the second screen's virtual remote control, and the second screen EPG. The second task involved using the search mechanism to find and play a particular piece of content. Participants performed this task with the traditional remote control, and the second screen. Each test was repeated three times. The order of operation for each task was cycled, in order to mitigate the impact of the learning effect on our results. The second section consisted of a demonstration of various NSMobile features (e.g., roaming screens), and a qualitative interview. The final section was a questionnaire about remote

controller preference for particular tasks, their usability, and the desirability of particular second screen features.

B. Results and Discussions

For the evaluation of the first section of the usability test, each of the participant's three attempts with each of the three operating devices was timed. Figure 2(a), 2(b), and 2(a) shows the box plots of the collected data across all participants, along with the mean values for the third attempt using each operating device (bottom right). In order to compare the participants' performance with each operating device, we include a measure (baseline) of the performance of an experienced user performing an identical task.



(a) Traditional RC (b) Virtual RC

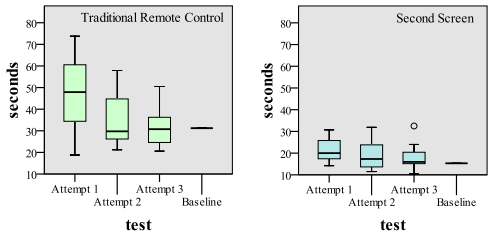
(c) Second screen (d) Comparison

Figure 2. Comparing Operating Devices for Task 1

For the traditional and virtual remote controls, participants perform on average, similar to an experienced user by their second attempt. For the second screen, this gap is larger, but it remains a nominal difference. For all operating devices there are outliers in the first attempt, which can be attributed to certain participants having difficulties in initially understanding the mode of operating each device. The four outliers for the first attempts were spread across three participants. It is observed that by the third attempt for both the traditional remote control ($M : 21.4, SD : 4.1$) and virtual remote control ($M : 21.8, SD : 11.3$), the difference in mean completion time is small, but there is greater variation in the samples.

Both the virtual and traditional remote controls show similar interquartile ranges, and ranges of high-end completion times, however, the difference lies at the lower end. As indicated by the median and short lower tail of the traditional remote control's box plot, this operating device appears to hit a hard lower limit for completion times, but with some consistency in the frequency that participants could do so. In contrast, some participants are able to complete the same task using the virtual remote control at higher speeds. We attribute this to the speed with which discrete button presses can be triggered using the touch screen's multitap mechanism, compared to the delay involved in pressing and releasing a physical button and the infrared processing that must occur. Task completion time with the virtual remote control, however, was observed to be inhibited by an increased error rate. After an initial introduction, participants were able to use the traditional remote control without looking down at the device when pressing buttons. Despite the novelty of the device, this applied not only to repeat presses, but when moving between keys. For the virtual remote control there was a notably higher error rate as participants tried to apply this mode of behavior, with increasing frequency as they gained experience with the device. Participant completion times were hampered by these increasing errors, along with the additional delay from the requirement of looking down and then back to the primary screen after each press, in order to continually reinforce that a correct action is made. NSMobile attempts to mitigate this issue by triggering "clicking" sounds.

For the second screen, the third attempt ($M : 18.2, SD : 3.6$) yielded a lower mean and variability for content discovery than that which was provided by the other operating devices, which used the primary screen interface. Furthermore, unlike the other operating devices that performed similar to the baseline on the second attempt, the results suggest that performance may continue to improve with increased use.



(a) Traditional RC (b) Second screen

Figure 3. Comparing Operating Devices for Task 2

Unlike the first task, the second that involved text input shows a significant difference in the performance of the two devices across all attempts (Figure 3). For the third attempt, completion times using the second screen ($M : 18.04, SD : 5.68$) remained significantly faster than the traditional remote control ($M : 31.96, SD : 8.91$), whilst also showing less variability. This difference can be attributed to two factors. First, a difference in error rates. The mean error rate across all participants and attempts with the traditional remote control was 1.28, but only 0.11 with the second screen. Second, the greater cognitive load required when typing with the traditional remote control. When typing, participants would often focus on the remote control and key presses, rather than the actual characters appearing on

the primary screen. In order to mitigate errors resulting from this behavior, participants would look between the primary screen and remote control after each key press, a process increasingly taxing when multiple presses (on the numeric keypad) are required for a single character. In contrast, the mobile device also allowed the search term to be displayed locally, which expedited any validation process.

A further series of question was asked to determine functional desirability on the second screen application. The majority of participants expressed an interest in using the second screen to operate a TV, and to browse the TV guide. More specifically, where this interest was expressed, it was that the functionality be integrated into a mobile phone.

The participant preference for each of the EPG interfaces is inconclusive with the list at 33.33%, the grid at 25%, and the carousel at 41.67%. Although the questionnaire was originally designed to determine EPG preference, it was observed during the trials that preference constituted different things for different tasks. For premeditated, tasks (e.g., playing a video-on-demand asset) the participants preferred the list and grid interfaces. Participants considered the linear format of these interfaces to facilitate the content discovery process, as they were not "cluttered" with other information (e.g., programme listings for other channels). For unpremeditated content discovery the carousel was considered most appealing due to the exploratory nature of the experience. Over half of the participants considered the ability to copy playback across display devices to be desirable. However, the roaming screen variant of moving playback between display devices was perceived to be more preferable. Highlighted during the participant evaluations was the opportunity of this functionality to supersede the traditional model of time-sharing primary multimedia consumption devices within the household.

Participants were asked to indicate whether they would use the three second screen functions integrated into NSMobile. Chaptering was the most popular of these functions. One participant stated that although they would primarily use this function for "additional material" in conventional contexts, they were keen to highlight how it could be applied to traditional television.

Subtitling attracted little interest amongst the sample. One issue highlighted by participants was the required continual shifting of focus between the primary and second screen.

Participants were open to and proactively suggesting alternative uses of subtitling on second screen. For example, when you wish to store a local transcript of a primary screen's audio, or for public advertisements and how subtitling could eliminate noise pollution.

The majority of participants (58.33%) found the quizzing functionality desirable, and all consolidated their desires around specific genres: educational, documentaries, and quizzes. Multiple participants stated that they could see a more general application in interactive TV services in order to increase audience engagement. For example, with soaps or talk shows. For all second screen functions, the importance of optionality about their use was stressed.

V. Conclusions

In this paper we present an integrated second screen application NSMobile for interactive TV. We also presented a user study consisted of both a qualitative and quantitative analysis to investigate the user experience of interactive TV with the help of second screen applications. We found that the perception of second screen varies and it's content specific. Some features do not significantly improve the efficiency of content navigation *per se*, though the novelty of user-TV interactions through a second screen device has an overall positive contributing effect to the user experience. Quizzes and chapters was perceived as desirable functionalities and our future work will look into how such features influence user behaviours in content retrieval and social interactions.

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