Exploring the Usability of Video Game Heuristics for Pervasive Game Development in Smart Home Environments

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Abstract. Over the last years, a variety of pervasive games was developed. Although some of these applications were quite successful in bringing digital games back to the real world, very little is known about their successful integration into smart environments. When developing video games, developers can make use of a broad variety of heuristics. Using these heuristics to guide the development process of applications for intelligent environments could significantly increase their functional quality. This paper addresses the question, whether existing heuristics can be used by pervasive game developers, or if specific design guidelines for smart home environments are required. In order to give an answer, the transferability of video game heuristics was evaluated in a two-step process. In a first step, a set of validated heuristics was analyzed to identify platform-dependent elements. In a second step, the transferability of those elements was assessed in a focus group study.

1 Introduction

While early ubiquitous computing applications were mostly restricted to the business context, the concept of Ambient Intelligence gets slowly adapted to the home domain. Within the last years, several applications emerged [1, 9], that aimed at integrating information, communication and sensing technologies into everyday objects and environments. By creating so-called 'Smart Home Environments' a vision of future living spaces is propagated, where people are supported and assisted in their everyday activities by information technology [13]. In parallel to the development of smart home applications, there is vigorous research in the area of pervasive gaming. Aiming to bring digital games back into the real world, a variety of concepts and prototypes emerged within the last years. A detailed overview of existing systems as well as a classification of current game genres can be found in [10]. The trend towards novel interaction concepts and physical interfaces is also visible in commercial products. New game consoles like, e.g., Nintendo DS, use touch pads and microphones as alternative interface technologies. By offering additional entertainment opportunities, novel controlling devices will play an increasing role when designing pervasive games [8]. Commercially available products include, for example, dance pads or car steering wheel with additional foot pedals. More recent examples, like Sony's EyeToy [6], allow players to control games by gestures and body movements. In

order to make use of such new interaction technologies, new interaction metaphors and game elements have to be developed, posing new challenges to games designers.

The recent developments in interface and game design allow enhancing digital games with social interaction concepts, which attracts new groups of users. A recent survey by the Entertainment Software Association showed, that 35% of American parents play computer and video games. Among these, 80% play video games with their children, and two thirds (66%) feel "that playing games has brought their families closer together". Following this trend, it seems only natural to integrate new game concepts in the development process of ambient intelligence environments. One of the first projects, that considers pervasive gaming as an integral part of smart home environments is the Amigo project [5]. In addition, also commercial applications become available, that help developers to extend gaming experience into real-life environments. Philips' AmBX [12] technology allows game developers to control real-world artefacts using a special scripting language. Compatible hardware such as lights, fans or heaters, can be controlled according to the digital game setting and by that foster a pervasive gaming experience.

2 Using Heuristics for Game Development

When developing new games, the use of heuristics proofed to be very successful in order to achieve major design goals [11]. Today, a variety of different design heuristics for video games exist (see [3] for a literature overview). Nevertheless, choosing the appropriate heuristic is still a problem, as most heuristics are isolated, repetitive and sometimes even contradictory [14]. Desurvire et al. [2] addressed this problem by aggregating existing guidelines and defining a comprehensive set of heuristics for playability. The so-called 'Heuristics for Evaluating Playability' (HEP) consist of four categories:

- *Game Play* (a set of problems and challenges a user must face to win a game),
- *Game Story* (collection of all plots and characters),
- *Game Mechanics* (structure by which units interact with the environment), and
- *Game Usability* (interface and interaction elements, e.g., mouse, keyboard).

Each heuristic was tested on an evolving game design in order to assess its face validity and evaluation effectiveness. The results validated the set of aggregated heuristics and proofed their usefulness for creating usable and playable game design.

3 Goal and Approach

Although novel input and output devices are available, very little is known about the successful integration of pervasive gaming applications into smart home environments. Using heuristics to guide the development process would be an easy and promising approach. But even if validated heuristics exist, it is questionable, whether heuristics originally defined for video games, can also be employed when designing pervasive games for smart home environments.

Comparing PC and console games, Grassioulet [4] found, that the platform in general has great impact in game design. Looking at the results, there is reasonable doubt, that existing heuristics can be transferred to other application domains. The impact of the

platform should be even stronger for more immersive and involving platforms like smart environments, where the border between game and reality is additionally blurred by the integration of everyday objects into the game.

The goal of this paper is to explore, whether existing heuristics can be used by pervasive game developers, or if specific design guidelines for smart home environments are required. In order to answer this question, the usability of HEP for pervasive game development in smart home environments was evaluated in a two-step process. In a first step, the HEP were analyzed to identify elements, that are independent from the platform and those which are not. In a second step, a focus group evaluation was conducted, in order to assess whether the platform-dependent elements are transferable to the smart home domain.

4 Analysis of HEP

As mentioned above, the HEP consist of four types of heuristics. The heuristics of the 'game play' and 'games story' category refer only to aspects, which are not related to the game platform. Therefore, the elements of both categories are considered to be also valid for entertainment systems in smart home environments. All other elements were individually analyzed and it was assessed if they can be directly applied to pervasive games, or if adaptation is necessary. The following table shows the results for the elements of the 'game mechanics' category.

Table 1: Heuristics of the 'game mechanics' category and the assessment of their transferability to the home domain.

Game Mechanics		**Assessment of Transferability**
M1	Game should react in a consistent, challenging, and exciting way to the player's actions (e.g., appropriate music with the action).	Considered to be independent from the platform.
M2	Make effects of the Artificial Intelligence (AI) clearly visible to the player by ensuring they are consistent with the player's reasonable expectations of the AI actor.	As the effects of AI can be much more intrusive in pervasive games, specific heuristics on appropriate behavior might be necessary.
M3	A player should always be able to identify their score/status and goal in the game.	As pervasive games are generally more involving, score and status information might not be appropriate.
M4	Mechanics/controller actions have consistently mapped and learnable responses.	Pervasive gaming applications in smart home environments are likely to include everyday objects as controller. Transferring this heuristic without validation is not possible.
M5	Shorten the learning curve by following the trends set by the gaming industry to meet user's expectations.	Considered to be independent from the platform. (but: problems might occur, as industry trends do not yet exist)
M6	Controls should be intuitive, and mapped in a natural way; they should be customizable and default to industry standard settings.	As games in smart home environments are likely to be controlled using smart artefacts, this heuristic is of particular importance in the design process.
M7	Player should be given controls that are basic enough to learn quickly yet expandable for advanced options.	The integration of multiple devices is an important characteristic of pervasive games. Therefore, this heuristic is of similar importance as M6.

The elements of the 'game usability' category were analyzed in the same way. The results are shown in Table 2.

Table 2: Heuristics of the 'game usability' category and the assessment of their transferability to the home domain.

Game Usability		**Assessment of Transferability**
U1	Provide immediate feedback for user actions.	Considered to be independent from the platform.
U2	The player can easily turn the game off and on, and be able to save games in different states.	Earlier evaluations [13] showed, that this is a general requirement when designing smart home environments.
U3	The player experiences the user interface as consistent (in control, color, typography, and dialog design) but the game play is varied.	As the interfaces of smart environments are designed to be unobtrusive and therefore not necessarily perceived as game interfaces by the user, the heuristic might require adaptation.
U4	The player should experience the menu as a part of the game.	Considered to be independent from the platform. (but: menus are usually rare in smart environments)
U5	Upon initially turning the game on the player has enough information to get started to play.	Considered to be independent from the platform.
U6	Players should be given context sensitive help while playing so that they do not get stuck or have to rely on a manual.	Considered to be independent from the platform.
U7	Sounds from the game provide meaningful feedback or stir a particular emotion.	Considered to be independent from the platform.
U8	Players do not need to use a manual to play game.	Considered to be independent from the platform.
U9	The interface should be as non-intrusive to the player as possible.	Considered to be independent from the platform. (but: is a general requirement of the development smart environments)
U10	Make the menu layers well-organized and minimalist to the extent the menu options are intuitive.	Considered to be independent from the platform. (but: menus are usually rare in smart environments)
U11	Get the player involved quickly and easily with tutorials and/or progressive or adjustable difficulty levels.	Considered to be independent from the platform.
U12	Art should be recognizable to player, and speak to its function.	As the interfaces and interactions used in smart environments differ significantly from the ones used in video games, this heuristic might not be applicable when designing pervasive games.

5 Focus Group Study

In order to validate the heuristics that were considered to be platform-dependent, a focus group study was conducted. To avoid any influences, the heuristics were not presented to the participants during the study. Instead, the goal of the focus group discussion was to define the requirements of future entertainment systems from a user's perspective. The results were later compared with the heuristics to check, whether they could be confirmed or have to be adapted.

The study was conducted with N=10 participants of two age groups. The first group consisted of 3 men and 2 women aged between 16 and 25, the second group consisted of 2 men and 3 women aged between 32 and 38. Both groups included singles and attached persons as well as persons with and without a permanent occupation. The group with the older participants also included persons with and without children.

The study was structured into two parts. In the first part, a scenario describing an intelligent home environment was presented verbally to the participants. Instead of exclusively focusing on entertainment, the general idea of ambient intelligence was introduced and the technical possibilities of smart home environments were outlined. This was followed by a group discussion on future entertainment system. The participants started to talk about their current entertainment activities at home and discussed the possibilities to improve the entertainment experience in the future. To understand the context and structure of the various statements, the key ideas were documented on cards. After the discussion, the participants clustered the cards and rated the importance of each cluster using a metaplan technique.

The second part started with the presentation of several scenarios in a gallery-like setting. Each scenario was illustrated with pictures and subtitles, and displayed on a large whiteboard. The participants had 30 minutes to go through all scenarios without any comments from the test conductor. Each scenario focused on a different aspect of smart home environments, ranging from entertainment over information and communication applications to household automation. The fact, that the scenarios were not restricted to entertainment should help the participants to understand design alternatives, and to identify general problems of Ambient Intelligence in home environments.

The presentation of the scenarios was followed by a second focus group discussion, where the participants had to discuss the general idea of Ambient Intelligence. Based on the ideas presented in the scenarios, they were first asked to discuss potential risks and benefits, and then derive requirements for such systems. Similar to the first part, the general ideas were collected and rated by the participants after the discussion.

6 Results

The most important requirement named by participants of both groups is, that all effects and features, like for example the adaptation of the environment to the game, are controllable by the user. Most participants emphasized, that the interaction must be easy, quick and intuitive. Several people suggested interfaces with speech input and output. These requirements refer to the following heuristics:

- M4: Mechanics/controller actions have consistently mapped and learnable responses (‘easy and intuitive interaction’),
- M6: Intuitive controls mapped in a natural way (‘speech input and output to achieve intuitive and easy interaction), as well as
- U5, U6 and U8: Upon initially turning the game on, the player has enough information to get started to play; context sensitive help; no manual needed to play (‘easy, quick and intuitive interaction’).

Not covered by the heuristics is the requirement, that users have always to be in control of the system. As all participants liked traditional board games, they were initially rather

reserved regarding the need for new entertainment systems. This is also supported by the fact, that both groups mentioned traditional board games as the benchmark for future entertainment systems.

There was agreement among the participants, that future entertainment systems should provide the opportunity to play with real game pieces and game boards. If possible, the participants want to play together with friends, like they are used to do. Nevertheless, the entertainment system should be able to replace human players if required. In general, the system should support community interactions between players, but stay in the background unless required. Special effects (like holographic artworks and sound) were regarded as good ways to increase the involvement, but still have to be controllable by the user. In addition, it is expected, that future entertainment systems provide better graphics and more realistic game worlds. According to the participants, the gaming experience would be enhanced by adapting the environment to the current game situation. These requirements refer to the heuristics:

- M1: Consistent, challenging and exciting way of reaction to player's actions ('optional special effects'),
- M2: Effects of AI clearly visible to player and consistent with his expectations ('replace human players without changing the gaming experience'),
- M5: Short learning curve by following trends ('adding value to existing games instead of something completely new'),
- M6: Intuitive controls, mapped to natural standard ('play with real game pieces like used to'),
- U2: Turn on and off the game easily ('turn special effect on and off'), and to
- U7: Sounds provide meaningful feedback or stir a particular emotion ('special effects to increase involvement').

Only the requirement to foster community between players, is not covered by the existing heuristics.

While the requirements mentioned so far, referred only to functional aspects of future entertainment systems, the participants had also specific requirements regarding the hardware. Both groups addressed several issues regarding compatibility, extensibility and usefulness of the system. All participants want a flexible system with upgrade options. In addition, the systems should be portable, so that the participants can take the systems with them, if they move into another house. These requirements refer to the heuristic

- M7: Basic controls to learn quickly, but expandable for advanced options ('extendable, flexible system with upgrade options').

Not covered by heuristics is the demand for compatibility and usefulness. Generally, the participants want a useful combination of features realized in independent components, which should be integrated in one system. This refers to

- U3: Consistent user interface with varied game play ('integration of different components into one system').

Both groups also mentioned requirements, which are not restricted to the entertainment domain, but apply to all smart home systems. One of the major issues was usability. The system should be useful, timesaving, as well as easy to use and learn, and it should not

need any maintenance after it is installed. The group with the older participants also remarked, that the system should save power. They asked for low power consumption in general and an automatic change-over in stand-by mode, if the system is not used for a certain period of time. Further topics, addressed by many participants, were security and safety issues. The participants were concerned about (software) attacks from the outside, as well as about potential accidents caused by malfunctions of the system. They also feared surveillance, if systems use cameras to identify and track people within the home.

Several participants asked for entertainment systems that combine various functions. Like modern game consoles, which offer possibilities to watch DVDs and listen to music, future entertainment systems should combine a range of functions related to entertainment.

Most of the requirements mentioned by the participants could be directly linked to certain elements of the HEP. Nevertheless, some heuristics were not addressed during the focus group discussions. There were no statements from the participants regarding the following heuristics:

- M3: A player should always be able to identify their score/status and goal in the game.
- U1: Provide immediate feedback for user actions
- U4: The player should experience the menu as a part of the game.
- U9: The interface should be as non-intrusive to the player as possible.
- U10: Make the menu layers well-organized and minimalist to the extent the menu options are intuitive.
- U11: Get the player involved quickly and easily with tutorials and/or progressive or adjustable difficulty levels.
- U12: Art should be recognizable to player, and speak to its function.

The fact, that certain topics were not mentioned during the discussions does not necessarily mean, that they were not regarded as important by the participants. Instead, they might have been considered to be so elementary, that the participants did not think of them or found them worthwhile mentioning. Another explanation might be, that the heuristics were too specific to be mentioned in a discussion with potential users. This is especially likely for the usability heuristics listed above. Besides this, all of the formally non-validated heuristics were at least indirectly addressed by the participants, as they asked for entertainment systems, which are “easy to use” and “easy to learn”.

7 Conclusion

Generally, the heuristics seem to be transferable to pervasive gaming applications in smart home environments. It seems as if the requirements regarding the game mechanics are the same for all application domains.

With Sony’s EyeToy [6] and SingStar [7] first commercial products become available, which aim to foster social interactions between players. As the need for human-centered interaction was also mentioned in both focus groups, design guidelines for pervasive gaming applications should be extended with a heuristic addressing this topic. Therefore, it is suggested to complement the HEP with a heuristic like, “pervasive gaming application should support direct interaction between human players and use game elements which require direct interaction between players”.

The results also showed, that usability is an important requirement of potential users. As usability heuristics are based on human perception, learning and memory, they are likely to be similar for different applications domains. Nevertheless, it might be helpful to collect and extend existing usability guidelines, as they are also related to interface elements, which might be fundamentally different in smart home environments. Especially speech control, gesture recognition, or integrated and ambient interface elements might require adapted design guidelines.

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