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LINKING PHYSICAL AND VIRTUAL INTERACTION SPACES

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Abstract: We explored how game flow can be influenced by adding a physical interaction space to an existing screen-based computer game. In this article we investigate how narrative influences the shifting of a player's focus of attention between physical and virtual interaction spaces.

Key words: interaction space, flow, narrative, game support robots

1. Introduction

Earlier research addressed support robots to enhance the gaming experience of a screen-based computer game [1]. From this study we learned that it is difficult to attract the attention of children to the perception space formed by the physical agents. Once children enter a flow state [2], their sense of time becomes distorted and they tend to forget the world around them. This observation led us to explore physical and on-screen strategies to break game flow in an effective and user acceptable way. Here we present the third phase of our research in which we investigate whether narrative can be used to induce smooth shifts of a player's focus between physical and virtual interaction spaces.

Survey: Sects. 2 and 3 introduce flow and interaction spaces. Sects. 4 and 5 develop a taxonomy. Sects. 6 and 7 are about the concept of narrative. Sec. 8 is about our new design and the user trials. Finally Sec. 9 contains the conclusions.

2. Flow

Csikszentmihayli [2] describes a mental state called flow, which includes the kind of state a player may enter when totally entangled by the game. In [3] and [4] the altered state of the flow experience is described: an optimal experience, characterized by a sense of playfulness, a feeling of being in control, concentration and highly focused attention, mental enjoyment of the activity for its own sake, a distorted sense of time, and a match between challenge at hand and one's skills.

In Fig. 1, flow is characterized as a situation where both skills and challenges are high. This figure has also been used by Eggen, Feijs, Van de Graaf, and Peters [5] to explore ways of helping players to get out of flow: there are two

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directions in which flow can be broken. Either reduce the ability to apply skills (disturbing messages, blocking the keyboard) or reduce the challenge.

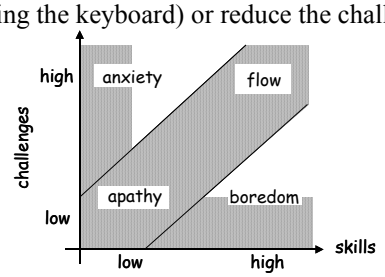

Figure 1. Challenges and skills determining flow.

3. Interaction Spaces

Flow is a suitable concept to describe the immersive game experience of children. The user interface of a computer game consisting of a screen and a keyboard and a mouse is mostly a Graphical User Interface (GUI). Following Fjeld et al. [6] an interaction space is a place where action and perception coincide (in general it is ideal if they coincide). The technical and conceptual components of the GUI can be described with the MVC model, see Fig. 2, after Ullmer and Ishii [7]. In this model the presentation (V=View) and control (C) components are separated. In other words, the space where user actions are executed (i.e., arrow keys on the keyboard) and the space were the results of these actions are evaluated (i.e., the screen that displays the computer game graphics) are not integrated. Theoretically, this means we can distinguish two different user-system *interaction spaces*.

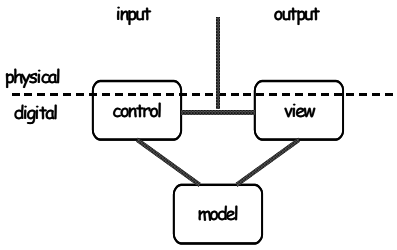

Figure 2. Interaction model of Graphical User Interface.

In our research on computer game play, we observed that children's visual attention is almost exclusively focused towards the computer screen whereas the game control devices seem to be ignored completely [1]. With respect to the basic execution-evaluation cycle of user-system interaction [8], the execution stages, including the setting of the goal, its translation into intentions and an action sequence, and the physical execution of this action sequence, have become fully automated and are performed subconsciously. Another way to look at this phenomenon is to note that the game player has embodied the control device and has become fully immersed in the game, cf. Dourish [9]. From this discussion we conclude that, in the case of computer game-play, and from a user point of view, the execution space "disappears" and that the evaluation space (i.e., the screen) remains the only user interaction space where game play takes place. In the remainder of this paper we will call this interaction space the *virtual interaction space*.

In our earlier work on breaking the game flow, we constructed a second interaction space by introducing a physical character to the computer game [5]. From now on we refer to this interaction space as the *physical interaction space*. By adding a physical artifact to the computer game we created a so-called Tangible User Interface (TUI). In [7] this class of user interfaces is modeled by the MCRpd model.

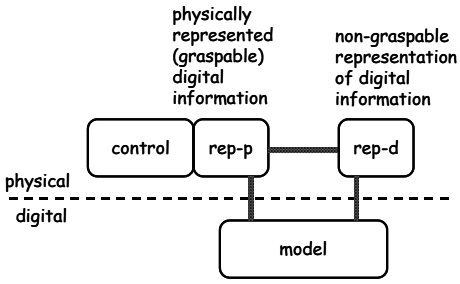

Figure 3. Interaction model of Tangible User Interface.

According to Ullmer and Ishii, the MCRpd model (Fig. 3) highlights the following characteristics of TUIs: Physical representations (*rep-p*) are computationally coupled to underlying digital information (*model*); physical representations (*rep-p*) embody mechanisms for interactive control (*control*); Finally, physical representations (*rep-p*) are perceptually coupled to actively mediated digital representations (*rep-d*).

4. A Taxonomy of Physical Game Extensions

In the previous section we have introduced the concept of interaction space and we have discussed the characteristics of an additional physical interaction space that can be constructed. In this section we propose a simple classification scheme to bring some order into the variety of existing and future physical game extensions, game support robots etc. If we consider a game extension or a game support robot to be an interaction space, then it follows that its two essential components have to be considered: *perception* and *action*. Here we consider both components from the user's (player) point of view; for example action means that the user can do an action and hence that the device is equipped with a sensor. For both action and perception four levels of relevance are considered: essential, helpful, informative, and absent. "Essential" implies that the extension needs to be used, but in a way the user is blackmailed, he *must* use it. The lowest level "absent" means that there is no perception or action. A given physical game extension or support robot is characterised by two levels: one for the perceptions and one for the actions.

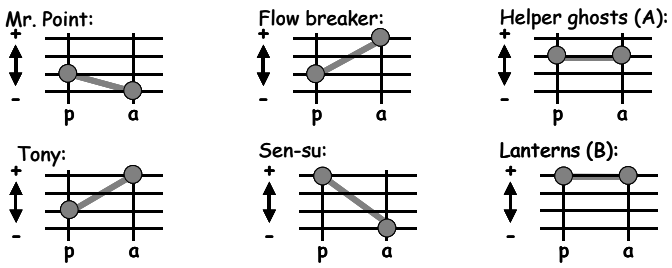

Figure 4. Game extensions in perception/action relevance taxonomy.

In Fig. 4 four earlier game extensions are classified into this taxonomy (details in Sec 5) next to two new ones (details in Sects. 6 and 7). Please note that both embodied conversational interfaces such as Rea [10] and autonomous or anthropomorphic robots such as Aibo or Kismet offer complex perceptions and accept complex, multi-modal interactions (thus they would rank very high in performance levels). The relevance of their interactions is high because they are to provide a complete interaction on their own, not as an add-on like physical game extensions or game support robots; the classification is not meant for these systems.

5. Examples and experiences

The support robots described in [1] were designed to make a screen-based computer game more fun and provide a richer game experience. One of the "robots" was Mr. Point shown. They were considered fun by the children; yet during intense game play children paid little attention to the physical agents next to the computer.

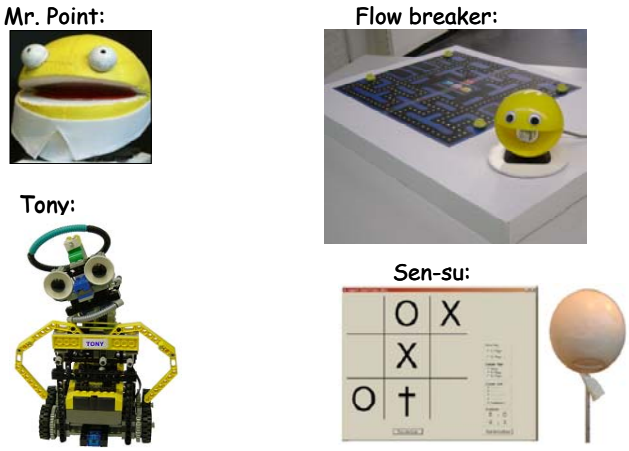

Figure5. Four examples of game/media support robots/devices.

In terms of *interaction spaces* this can be easily understood. In the flow state, attention is very focused on the interaction space that is related to the flow, i.e. the GUI. This led to another project [5] to explore the idea of a flow-breaker, shown in Fig. 5. The goal is to help the game player stop at a preset time. When time is almost up 1,2,3 or 4 extra minutes can be obtained by taking the physical agent and letting it 'eat' one or more pills, which are LEDs on a board. The physical interaction space that forms the stage for the support robot was re-designed to strengthen the coupling with the virtual on-screen world. The narrative of the computer game provided the 'leitmotif' for the design. User trials showed that by forcing the players to shift attention from one action space to another the flow state can be broken. Jun Hu [11] developed a system that uses a robot, Tony, to act as an interface to interactive media. This physical agent is very strongly integrated with the narrative. Manipulating the agent will influence the final outcome of the media shown and the media shown will determine the agent's behavior. In [12] a balloon-like physical agent, Sen-su, is developed that reveals hidden knowledge about the game, a tic-tac-toe with hidden bombs.

6. Narrative

Let us identify the ingredients of narrative (in a broad sense, including non-linear aspects and non-textual representations). This will be used in the next section to devise both a strong and a weak narrative for connecting a secondary interaction space to a Pacman-like game.

In literary theory, Greimas [13] proposed a kind of universal model for a narrative's underlying plot, the ‘actantial model’ based on a number of characters. These include the subject (i.e., the main character or hero), an object of value, a helper, and an opponent. Moreover there are a destinateur, initially pushing the hero towards his goal, and the receiver, to receive the object of value once conquered. These are the basic roles at the level of a story's deep structure. Next to the deep structure, there is also a surface structure, which is concerned with choosing representations and with positioning the roles and the events in time and in space.

With respect to the time-ordering, Laurel [14] proposes the so-called "flying wedge" model, in which a plot is a progression from the possible to the probable to the necessary. Probability makes the narrative interesting; it creates surprise and climax. For interactive systems `engagement', which is defined as the state of mind to be attained in order to enjoy a representation of an action (willing suspension). Closely related is the first-person experience, reflecting where one stands in relation to others and the world. A key component of this first-person experience is `agency', which is the power to take action.

7. Design of a Narrative

How can we devise both a strong and a weak narrative for connecting a secondary interaction space to a Pacman-like game? In terms of Greimas' model, the player is the hero, the dots, the bonuses, the score-lists and the attainment of the next level are the objects of values, the energizer pills are the helpers, and the ghosts are the opponents. At the deeper levels we recognize themes of all times: the quest for food, the difficulties of a labyrinth, and the changes in attitude of enemies. At the surface levels we see abstract, humorous and colorful representations and sounds of the same nature. A change in color and “face” shows the ghost's status (blue = afraid). Causality, probability and timing are as follows: the changes in attitudes of the ghost are caused by the hero eating energizer pills and by the passing of time. The ghosts move randomly but intensify the hunt after an initial wandering phase. The game moves towards a climax when the hero runs out of energizer pills.

The secondary interaction space used for the experiment of the next section involves four simple interaction devices, each of which has a one bit input and a one bit output. They are the simplest type of game-support robot imaginable (it's like the alternating bit protocol in computer science, extremely simple but yet a good carrier for experiments). These four objects form an interaction space. We consider three aspects of the connection, at different levels. From "deep" to "surface", these are:

- (P) plot,
- (T) timing,
- (R) representation.

First we describe a version denoted “A”, having a strong narrative connection. The secondary interaction space is concerned with information and control of the ghosts. Each device is logically connected to one ghost and shows the afraid/aggressive

status of the ghost that is in the maze (the blue color changes do not work anymore). Hitting the ghosts by the user causes the corresponding ghost to turn afraid for a random time. The user therefore is forced to look at the devices and hit them while playing, in a kind of complex parallel or time-interleaved fashion. The representation is that the devices look like the ghosts (abstract, humorous and colorful), and change from lighted (aggressive) to not-lighted (afraid). Characterizing the strength of the connection as a (P,T,R) triple we find it to be (strong,strong,strong).

Version B must have a weak connection. The extra interaction space is a separate game: the user has to observe and imitate a four-step sequential pattern. It has to be played each time the hero's life has been taken (e.g. three lives). It is interleaved with the main game, but the interleaving is coarse-grained (minutes, not fractions of seconds). At the representation level, the devices have an aesthetic quality comparable to that of the helper-ghosts, but without referring to the Pacman theme. They are lantern-like objects controlled by hitting. They have the same complexity: 1 bit in and out each. The connection is (weak,weak,weak).

Both mini-designs can be modeled with the functional components of Ullmer and Ishii's MVC and MCRpd . See Figs. 6 and 7.

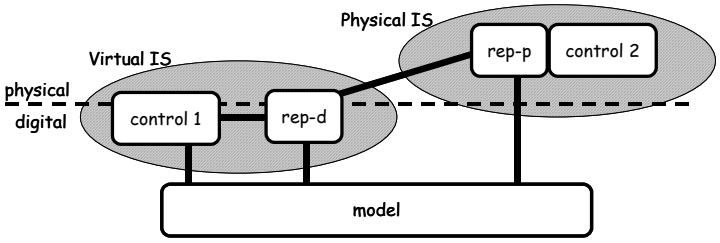

Figure 6. Interaction models for Mini-Design A.

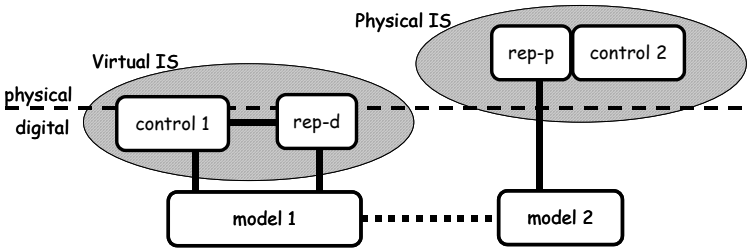

Figure 7. Interaction models for Mini-Design B.

For mini-design A, the virtual and the physical interaction spaces (IS) are strongly coupled and both link to the same underlying game model. The virtual and physical ISs of mini-design B are not coupled and both link to different models. A weak link between the two game models in B enforces the two games to be played sequentially.

8. Design and User Trials

The helper ghosts are shown in Fig. 8 and the lanterns in Fig. 9. The devices were made by Feijs, Peters, Frens and Van de Graft.

Figure 8. Second interaction space consisting of four helper ghosts (A).

The game is a Pac Man clone, called *Snack Attack*, coded in Euphoria, developed by M. Packard for his publicly available "crash course in game design". The devices communicate to the adapted software via a serial port of the laptop.

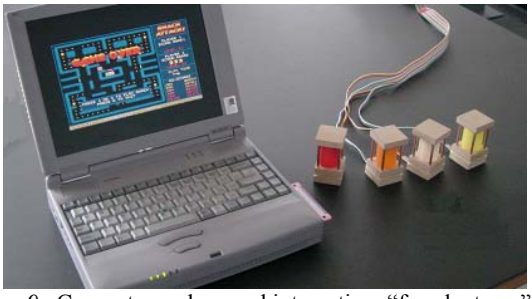

Figure 9. Computer and second interaction "four lanterns" (B).

We ran test trials with four 10-year old children, two girls and two boys. We used a flow questionnaire and video-camera based observations, next to a structured interview afterwards to reconstruct the subject's understanding of the narrative. The children played ABAB or BABA. Each round (A or B) was 8 minutes. The helper-ghosts and the lanterns were to the right of the laptop. The findings were as follows:

- The children considered both the A and B versions cute and funny.
- The A game is harder than the normal Pacman game; three of the four children were more in the anxiety state rather than the flow state;
- Playing A, the children had difficulties using the ISs simultaneously. They tried to use both hands, not switching. They hardly used the information of the helper-ghosts (this differed per subject; one girl got information through the parafovial field). For B these problems were not observed.
- The children were well able to explain the relation between the interaction spaces, both for A and for B.

Fig. 10 illustrates the third observation nicely: the subject, who is right-handed, needs his right-hand for the arrow keys and tries to use the other hand for the helper-ghosts. Still, observing the helper-ghosts is difficult. Another situation would arise if we would allow the children to play a very long time. The positions of the helper-ghosts could be learned and they could be hit without looking. The problem of

perception (to know the status of the "real" ghosts) remains, although parafovial perception could diminish it.

Figure 10. Subject trying to turn both interaction spaces into one.

9. Concluding remarks

The work presented in this paper is a first step towards a framework, which eventually may be used to design games and game-support robots such as to meet different design goals (e.g., adding fun, adding challenges, breaking the flow, etc.). Key concepts are flow, interaction space and narrative. The trials suggest that even with a strong narrative link, switching from one space to another cannot be done without endangering the flow state. On the contrary, if there is a strong narrative link between two activities, the player tries to merge them into one interaction space.

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