Novel Gaming Applications for Smart Home Environments[1]

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[1]This chapter is based on an earlier article by the authors

1 Introduction

The requirements for pervasive gaming applications from the previous chapter inform the development of a smart home gaming platform that integrates various physical interaction devices. This allows for the realization of immersive, stimulating entertainment applications without having to deal with the complexities that ubiquitous computing environments introduce to the development of interactive applications.

The alteration of the physical reality of the players enhances the immersiveness of the gaming experience. According to the preferences of the subjects in the last chapter's study, this is an important feature beyond traditional computer and video games needed to convince the more hesitant population of older consumers.

Another prominent requirement found in the study was the easy integration of various physical interaction devices in a game session. Since board games were nominated in the study as references and benchmarks, the gaming interfaces discussed here mainly relate to interaction metaphors found in board games.

A prominent feature of many board games are beautiful and sometimes custom-painted playing pieces that feel good to touch, to collect, and to place on the game board [5]. Even though these tangible components and game boards contribute to the enjoyable user experience, their purely physical nature also narrows down the range of realizable games and sometimes leads to awkward interaction patterns. Whenever dynamically changing game worlds, complex game rules, or multi-sensual stimulation is desired, the static nature of traditional board game media prohibits the realization of believable and immersive game concepts.

On the other hand, playing computer games introduces many highly interesting possibilities that enhance game play. Game presentation is rich with audio and visual support and game content is limited only by the imagination of the developers. Players can get immediate feedback on their actions in the game world which fosters emotional involvement and the feeling of immersion into the game. The drawback of computer games, however, is the lack of social interaction in a face to face setting. Although multiplayer computer games do convey a sense of

awareness and console games offer co-located (shoulder to shoulder) multiplayer game modes, human-to-human interaction is still primarily mediated by a computer screen.

In order to improve the social gaming experience, the next generation of tabletop games should combine the advantages of computing technology with the social impact of board games while controlling their weaker properties. To preserve the social situation and the group dynamics of face to face game sessions, the game board on the table surface should remain the primary interface while being augmented with beneficial features known from computer games. This way, "a new hybrid class of games can be formed" [8] to bring forth new gaming experiences.

2 The STARS Platform

To research the opportunities of this hybrid class of computer augmented tabletop games, we have developed an experimental platform called STARS. The STARS platform consists of a specialized hardware setup that allows integrating different kinds of devices with a game table that each have the potential to enrich the gaming experience in one way or another (see figure 1). An associated interaction framework supports finding an optimal and natural interaction design for STARS games under varying device configurations. The actual gaming applications are built on top of a STARS software layer that unburdens the developer from anticipating the exact set of input devices and interaction styles during a game session.

3 Hardware Setup

The STARS hardware test bed is based on so called Roomware components [15] which are room elements unobtrusively augmented with information technology.

The game table is the main component of the STARS platform. Several other input and output devices are also integrated to realize additional benefits such as private and public game information, multimodal input, or enriched presentations. The supported set of devices is described in the following sections along with their primary functions.

Figure 1. A STARS game session.

3.1 Game Table

The prominent game table provides different, dynamically altered game boards that are displayed on its surface. Physical playing pieces provide a tangible interface that feels identical to the interface of traditional board games. The playing pieces are detected by an overhead Axis Network camera that also determines the positions of the players by tracking the players' hands when they reach over the table surface. The current hardware for the game table is the InteracTable [15] Roomware component. Its touch screen is used for displaying the game boards and additionally for menus that players can interact with using their fingertips. An integrated RF-ID antenna detects physical tokens placed on the table surface. We currently use these to initiate and terminate game sessions by simply placing a tag on the table to begin, and removing it to end and save a game session. This way, the players avoid dealing with mouse or keyboard to get a game going.

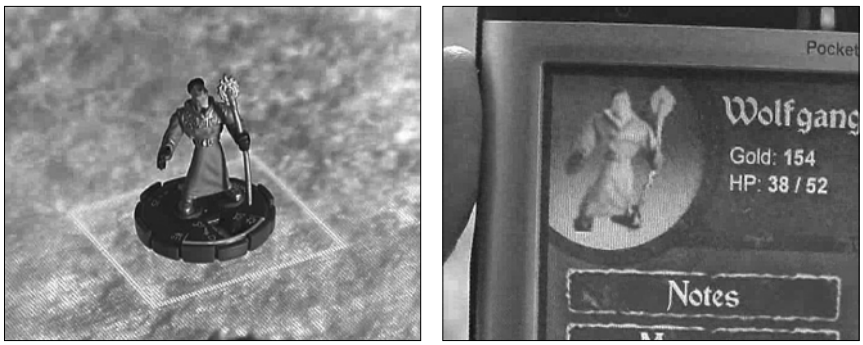

Figure 2. A physical playing piece (left) and its virtual counterpart (right) on a private PDA display.

3.2 Large Vertical Display

The information on large vertical displays can usually be well perceived from many perspectives. Consequently, a large vertical display (the DynaWall [15]) can be utilized within STARS to show public information that each player should be able to view at any time. In the case of STARS games with a more competitive nature (such as our adaptation of Monopoly™) the large vertical display might give a permanent overview of the individual players' scores to instigate the rivalry between them. For more cooperative games (such as KnightMage) the vertical display might reflect the advancements that the entire group has made so far by

Figure 3. Private communication via PDAs.

creating a joint map of a dungeon that the individual players explore (see wall display in figure 1). For atmospheric effects in interactive storytelling applications or role-playing games arbitrary media such as videos or animations can also be played which might be triggered by the storyteller or the game master. Currently, the DynaWall is the only public display in our setup; with an increasing number of players it will become necessary to add a second display to ensure that no disadvantages occur when the display is located behind a player's back.

3.3 Personal Digital Assistants

While the large vertical display's role is clearly related to public information, small handheld computers, i.e. personal digital assistants (PDAs), are private artifacts that each player can bring to administer private data or enter private commands. In many tabletop games, the player's PDA can conceptually be defined as a medium for accessing the virtual parts of a physical playing piece, i.e. the physical pawn is augmented with a virtual counterpart that can be accessed via the player's PDA (see figure 2). Consequently, a hybrid game entity emerges that has physical properties such as its position on the game board as well as game dependent virtual properties such as character attributes (health, strength, etc) or an inventory of carried objects.

Another important function of the PDAs for games involving both competition and cooperation [18], e.g. any Diplomacy type game and most treasure hunting dungeon romps, is private communication between players. Any player may send messages to other players via the PDA.

Currently we use standard Compaq IPAQ 3950 and Toshiba e740 Pocket-PCs with integrated 802.11b to connect to a game session. Additionally, so called Viewports can be used to access virtual properties of playing pieces by just pointing the device at them as described in [14].

3.4 Audio Devices

Atmospheric audio is an often neglected, but highly effective means to facilitate immersion into a game. Some games even use audio as their first interaction channel [10].

In STARS, public loudspeakers are used to emit ambient audio samples or music to atmospherically underline the action at the game table. As a corresponding private device, players can wear earphones to receive private text messages or atmospheric audio samples. The earphones are meant for clandestine information from the game logic; other players are usually not aware of this information, so that ideally no social protocols are violated by private audio information.

Microphones from headsets are available for verbal commands to the STARS game logic. Speech recognition is currently based on the Microsoft Speech API and utilizes command lists that allow picking known commands from uttered sentences. This provides a good-enough robustness for natural language variations. Speech is mostly used for multimodal input in conjunction with physical actions on the playing pieces, e.g. to specify what action a player wants to perform on a newly entered location.

3.5 Integration and Substitution of Devices

STARS adapts to a varying setup of available devices and substitutes them where appropriate. During a running game session, devices can be dynamically added and removed (with the exception of the table) to allow e.g. late players to log in their PDAs to a game in progress. The concrete role a device plays in a given game situation and device configuration is determined by a multimodal interaction framework described below. The device management layer itself is based on RichNet, developed in [14].

4 Interaction Framework

During a game session, interaction behaviors of players can be diverse. There might be short bursts of information to be communicated clandestinely from one player to another. Or there might be spatial formations of playing pieces to be collaboratively developed on the game board. There might even be fierce discussion not involving the platform at all.

For such diverse interaction needs, different media and interaction styles are more suitable than others. The STARS platform assists in finding the optimal

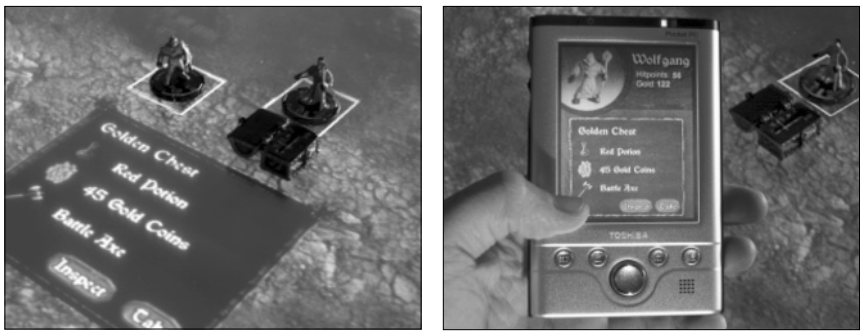

Figure 4. Manipulating a game object publicly (left) and privately (right).

set of devices and interfaces by matching the interaction characteristics of each available device with the properties of each so called Interaction Request a game application might formulate. Such an Interaction Request might be to let a player pick an object from a chest either privately (figure 4, right) or publicly (figure 4, left), depending on other players witnessing the action or not. Not having a PDA available for private interaction might have caused the Interaction Manager to present the dialog spoken over the earphones or rendered rotated towards the player's viewing angle on the table surface, so that other players would be hampered perceiving it. The actual devices involved and the corresponding interfaces in a given game situation are determined by the Interaction Manager considering several findings from modality theory [1], for instance that linguistic input and output is "unsuited for specifying detailed information on spatial manipulation" or that static graphic modes are suitable for representing large amounts of (complex) information.

4.1 The Interaction Manager

The Interaction Manager maps Interaction Requests from the higher level of the game logic to the lower level of the so called Interface Services implemented for each device. Thereby it takes into account hints within the Interaction Requests about certain characteristics a device should have. It also provides a high-level programming interface that allows STARS games to formulate Interaction Requests without anticipating the concrete setup of devices available.

Finding Device Compositions

A rule-based system determines how to map an Interaction Request to one or more interaction devices[2] . It regards the hints an application provides for the generation of the interface and compares them with the characteristics for every device available as well as for combinations and certain constraints for more complex Interaction Requests. A Suitability Index is calculated for each combination of modes with the highest index being the most suitable. Indices are calculated by weighing every hint about the characteristics of the desired interaction with the attributes of the regarded mode. The sums of these weighings make up isolated suitabilities of single modes to serve for input or output. Suitability Indices can thus be expressed as:

$$I_m = \text{argmax}_m\{ \sum(i = 0..\max \text{Attr}) \text{Hint}_{mi} * \text{Attr}_{mi}\}$$

Single suitabilities are further moderated by rules about their combination. The result of each of these calculations is a Suitability Index from which the highest one is chosen.

Programming the Interaction Manager

The programming interface to the Interaction Manager is designed to allow a device independent formulation of Interaction Requests. Even though it is possible to hint for specific Interface Services, a more generic and content-centered application development is facilitated. A second key feature of the Interaction Manager is the ability to dynamically alter Interaction Requests during program execution, i.e. Interaction Requests are not created using hard-coded API-calls, but reside in XML-based resources. This allows for tweaking Interaction Requests while a game is in progress. During runtime, a STARS application simply provides an identifier for the desired interaction. The Interaction Manager then retrieves a more detailed description from the resource database (interface type, mode hints, parameters etc), finds an appropriate device composition and after scheduling and synchronization with other Interaction Requests calls related Interface Services.

[2] It actually distinguishes between input and output modes to facilitate cross-modal interaction.

These services then retrieve the required data to build an interface and eventually create the interface. After a terminating condition has been met, the interaction result is transmitted back to the application as defined in the resource database.

Interface Services

Interface Services are implemented for every supported device and manage the creation, presentation, and tracking of interfaces. Their functionalities vary with the characteristics of the device's modes. Due to the somewhat limited domain of board gaming in terms of interaction variations, the number of services currently implemented is yet manageable. There are Interface Services for output and for input/ tracking of user actions. Output services rank from simple DISPLAY(resourceID) to several more complex MENU() variations. What a service such as DISPLAY() actually does, depends on the parameters in the resource database and mostly on the specific device characteristics, e.g. an earphone's only way to display a resource is to read any text/ audio sample included or otherwise fail. Input services include the tracking of pawns, spoken commands and various pen/ finger related services. In addition to the input and output services, several higher level services exist that wrap single basic services for handling dependencies, for instance when the same device is used for joint input and output.

A Simplified Example

A game programmer might request the position and identity of an object to be conveyed clandestinely to a single player, for instance when he has detected a hidden trap some squares ahead. Given that only the privacy level and the capability of conveying spatial information were relevant, and that an earphone [a] had a privacy capability of 255 and a spatial capability of 50, a PDA [b] had 200/ 150, and the wall [c] had 0, 220 [3], and that no further constraints applied, the isolated suitabilities were as follows for an Interaction Request with a moderate demand for privacy (100) and a low demand for spatial visualization (40).

$$I_a = 255*100+50*40=27500,\ I_b = 200*100+150*40=26000,\ I_c = 0*100+220*40=8800$$

[3] Real numbers can be configured at any time.

Since we do not regard input and output combinations here, the DISPLAY(request:Description , object:Name, object: PosRelative,) service of the earphone would be chosen resulting in a "you sense, trap, 4 squares north". The same service on the PDA would have brought up a map with the trap shown and the "you sense trap" string printed beneath, provided that the request:Spatial hint was higher than 40.

5 Designing the User Experience

As outlined above, the STARS platform is designed to integrate different devices in a sensible way. The question arises in how this helps realizing games that profit by the different computing devices and still preserve the social dynamics of a group setting. There are several crucial issues to observe when designing the user experience.

5.1 Virtual vs. Physical vs. Social Dimensions

In contrast to computer games that take place in the virtual domain only, and traditional board games that touch physical and social experiences alike, the STARS platform is designed to run across all three of these dimensions. Care must be taken to find the optimal distribution among these dimensions for every single game element. Some elements clearly belong into one domain or the other, but in many cases it is a matter of deliberate choice.

Pitfalls of the Virtual Dimension

When introducing computing functionality to tabletop games it is especially tempting to move a lot of game elements into the virtual domain, because the computer as a multi-purpose tool is seemingly well suited for a vast array of different tasks.

For instance, in many board games dice are used to generate random numbers that add variability to the game progression. Although random number generation is a trivial task for most computer programs, it might be a bad idea to skip rolling dice manually and move the task of adding variability into the virtual domain. For most players the physical act of rolling dice is a highly

social activity involving skillful rolling techniques which are permanently supervised by the other players to prevent cheating. STARS therefore leaves random numbers to the dice-rolling and negotiation skills of the players in the real world.

Another example for overestimating the virtual domain is the movement and actions of so called Non-Player-Characters (NPCs) in role playing games. While the advancements in the field of artificial intelligence make the computer controlled actions of such NPCs more and more believable in computer games, they still pale against the richness of the social interaction with a human game master or storyteller. Although there is room for both human and AI controlled NPCs even in the same game, we do not support developers with corresponding tools to create AI behavior as in computer games yet.

For many games where rule variations exist, it is also a good idea not to implement all of the rules into the software, but to leave them to the social protocols of the players around the table. After all, part of the fun comes from flexibly re-evaluating rules in the context of a particular game situation and the development of house rules is easier, if no computer logic denies rule variations.

Benefits of the Virtual Dimension

The addition of computing functionality brings also beneficial effects both to enhance existing deficits of traditional media and to create entirely new experiences.

Realistic Rules, believable Game Relations
More complex board games are often prone to using simplified or unrealistic relations between game objects. This is for keeping the game play fluent enough by not extensively dealing with manuals or complex calculations. By modelling parts of the game logic in a software application, more realistic object relations can be achieved that do not disturb the game flow and lead to more plausible effects of game actions.

Persistency and Session Management
Many board games take longer than the typical two or three hour period of a single session. Thus, persistency becomes an issue which includes recording game events

Figure 5. Dynamically altering the game board through a game event.

and possibly the creation of a corresponding game history. This can automatically and implicitly be realized in computer applications minimizing unpopular paperwork.

Advanced Game Boards

The static game boards of traditional tabletop games can be enhanced in various ways by representing them in the virtual domain. Dynamic virtual game boards can change during the course of the game as shown in figure 5, where a key was inserted into the locked door. Boards can also be larger than what is shown at one time. A corresponding fog-of-war for unexplored areas can be realized elegantly, which is also shown in figure 5, left.

In addition to the physical playing pieces (which are augmented by virtual counterparts), purely virtual game objects can be displayed on the game board. These virtual objects may not be tangible, but they can fulfill important functions within a game and add to the user experience e.g. by having audible properties such as doors that creak.

Relief from Mundane Tasks

Repetitive activities that do not contribute to the fun are part of most board games. Many of them can be eliminated by letting the computer shuffle cards or build up game boards[4]. Additionally, the pre-processing of role playing adventures and

[4] Depending on the nature of the game, some mundane tasks may include opportunities to take a short break or talk with each other and thus might have their justification.

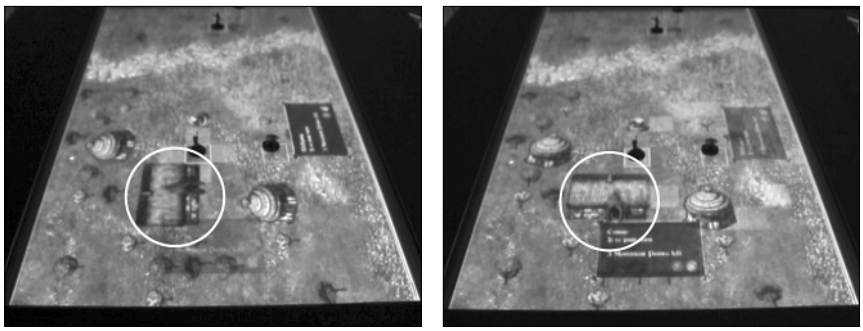

Figure 6. Rotation for the players' viewing angles.

tabletop campaigns can be facilitated by providing the game master with software tools to design dungeons, traps, treasures, etc.

5.2 Interface Issues

The interface to the game platform is an important factor to ensure the user experience to remain human centered and socially supportive. To prevent the impression of merely playing a computer game, we avoid using traditional interfaces involving mice, keyboards, or desktop monitors. Playing pieces remain the primary interaction devices during game play, because they provide the most natural interface to a board game and, as [16] note, as a tangible interface they unify control and representation.

To improve the original physical interfaces, the perception of the game board is enhanced in STARS. This includes visually impressive boards that dynamically change while the game progresses. The problematic issue of positions and viewing angles in traditional tabletop games (someone at the left side of the table perceives a different image than someone at the opposite right side) is tackled by auto-rotation instead of abstract, un-oriented game boards and playing pieces that look mostly the same from any viewing angle [8]. STARS can rotate any object on the game board around its own axis to that angle the current player can perceive best (see houses and trees rotate in figure 6). This includes window objects (if present) that additionally grow in size with rising distance to the current player ensuring optimal visibility.

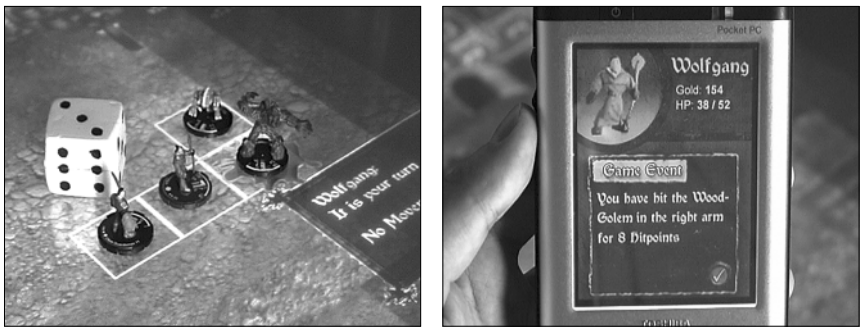

Figure 7. Public and private aspects of a single game event.

Also, window objects belonging to other players can become half-transparent to prevent obscuring parts of the board (see figure 6, right parts). A game can hint whether single game objects should be sensitive to orientation (steps of 45°, 90° or free), whereas performing the orientation itself is part of the software framework.

Whether the auto-orientation works well for a given game depends on the amount of detail of the game objects. When a lot of text is displayed, changing the orientation is usually appreciated by the players. For more primitive game objects, the benefit of rotating objects is less significant.

5.3 Private and Public Interaction

Whenever cooperation and competition meet in a game, the notion of public vs. private information, communication, and negotiation becomes a highly interesting field of research [see 6]. When players are forced to cooperate to be successful, but only one player can win, social dilemmas and the need for clandestine communication arise as an addition to the open face-to-face interactions. Conspiracies may be forged in secrecy, while the open diplomacy at the game table may speak a different language. As described in the hardware section, private communication channels are supported by private STARS devices.

A second interesting concept of hybrid board games is the distribution of private and public aspects of game events among different interaction devices. Figure 7 (left) shows four characters involved in a fierce battle. One player, Wolfgang, hits an enemy golem who shrieks for all to hear. On the game board, a small blood symbol is drawn around the golem (figure 7) that is obvious for each player, too. What only Wolfgang sees, however, is the exact location and the amount of damage he inflicted (figure 7, right). Similarly, in figure 4 it is obvious for everyone that Wolfgang has opened a chest, but as long as nobody is standing beside him, only he learns what the chest contains.

6 Realized Games

Several STARS games have already been implemented to investigate how the hybrid platform contributes to user satisfaction and fun. Our most advanced games so far are an adaptation of the popular board game Monopoly™, and KnightMage, which is a role-playing game about the exploration of a dungeon and its treasures. While there is currently no single game to realize all of the potential of STARS, each game stresses a different set of features which are described below. Both games utilize the platform's session management system with an easy to use tag-based interface to bring persistency to any STARS game.

6.1 STARS adaptation of Monopoly

The Monopoly Adaptation profits greatly from the rotation functionality shown in figure 6, because a high amount of textual information is involved with the original Monopoly game. The mundane tasks of shuffling and stacking cards are discontinued, because random events are directly displayed on the virtual game board. Due to the virtual representation of game money, there are several statistical functions available. On the wall display a permanently updated diagram is shown that gives an overview about the financial development of each player and thus facilitates a strategic planning of buying and selling properties as well as it instigates competition among the players. As a twist to the original rules, money can be clandestinely transferred between players, so that secret alliances against the leading player are fostered. This introduces an interesting new game element that makes use of private communication features of the STARS platform.

6.2 KnightMage

The role playing game KnightMage (see figures 4 – 7) deals with the exploration of a dungeon filled with treasures, equipment, and most of all, monsters (the name comes from the MageKnight playing pieces used in the game). Players have to cooperate to survive against the monsters in the dungeon, but at the same time strive for individual riches. A focus of the game lies in demonstrating the presentation capabilities of STARS. The game boards are very large and change during the course of the game, e.g. by opening doors as in figure 5. The wall display is used for an overview about the areas of the game map already explored. Sounds and music add to the atmosphere at the game table, too.

The game rules in KnightMage profit by computer support, without conveying the impression of merely playing a computer game. For instance, the players' carrying capacity (gold, items etc.) is not simply determined by the number of items found, but realistically calculated regarding both the weight and the dimensions of the items. To preserve the human centered group dynamics, other game elements such as the placement of monsters in the dungeon are deliberately not represented in software so that the game master can spontaneously decide about them depending on the current game situation and thus create a more interactive game play than a computer simulation. As described in the preceding sections, KnightMage also showcases dealing with private and public information as e.g. in combat or when plundering chests.

7 Game Experiences

We are currently using STARS extensively to investigate new game concepts and to develop new games with the platform's programming interface. While our own experiences with the platform are favorable and support our vision of integrating the best of virtual and physical game elements, a public test is necessary for real-world validity.

On an event called Girl's Day (www.girls-day.de) which was organized by the German Ministry of Education and Research took place at our research institute, we had the opportunity to observe and videotape eight different groups of 11-14 year-old girls interacting and playing with our STARS setup over the course of a

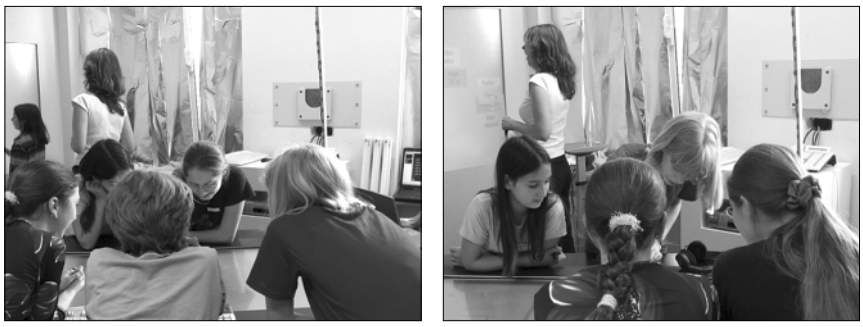

Figure 8. STARS on Girls Day.

day (see figure 8). Since this was the first opportunity to gain real-world feedback, we chose not to test hypotheses in a controlled experimental setting, but conducted a formative evaluation in which we "let the girls loose" and observed them during the games as well as asking them about experiences and suggestions afterwards.

As a general observation, the main goal of STARS to support the joyful and direct interaction between humans has clearly been achieved. All of the girls had great fun with our interactive table and the social group situation has always been preserved. However, while some of the new game concepts we introduced were immediately understood by most, it took a while until the girls adopted them and e.g. made sensible use of the clandestine communication means. We attribute this to the rather short period of time each group had to get acquainted with STARS. Most girls were highly impressed with the presentation richness of STARS both including the visual quality and the audio output.

What we previously underestimated was the level of stability needed both in software and in hardware. For instance, the camera above the game table was fixed firmly enough for our own use, but some groups shook and bumped either camera or table so badly, that we had to re-calibrate the camera recognition software during a running game session. Beforehand, we had invested quite some effort to let the software cope with varying lightning conditions, but did neglect the image alignment issue.

Also, STARS is currently tailored towards turn-taking interaction styles. This is both because of the single touch functionality of the current game table and the auto-orientation features of the game boards. While, in principle, the camera recognition

software is capable of detecting multiple simultaneous pawn movements, we did encounter several situations where it failed to correctly sense the state of the game board, when several hands were reaching over the table at once. In addition, we had not anticipated the target group of our research being half as tall as we are. Due to the somewhat large dimensions of the game table hardware, some girls stood up to reach the edges of the game board, disturbing the camera recognition. For everyday use in a real world setting, a different setup with other, more robust and sensing technologies is therefore recommended, as for instance novel multi-user table hardware such as the DiamondTouch [e.g. used in 11, 17].

An issue related to the hardware of the game table came up with the KnightMage game, where the dragging of game objects from one window to another was still possible. The single touch functionality of the table does not support simultaneous drags, so that every time two girls attempted to drag an object simultaneously, objects jumped around the display. In two instances, these accidents led to intensive experimentation eventually resulting in deliberate shooting at each other with game objects. While this was funny, it did not work towards the atmosphere of the KnightMage game. We later disabled dragging and switched to traditional menus.

While these technology related issues can be (or in parts have already been) overcome, we found that the private communication channels worked well and did not hamper the group situation, as [3] have found. Especially private audio signals often had a social effect when a girl did not manage to hide that she was listening to a private message and the others urged her to tell about it.

In general, the sample games presented worked quite well, because the game rules were either known or easy-enough to convey. The durations of the games were inappropriate, though. For both games, we had to interrupt each game session long before an end was reached. While this was not overly frustrating, it would still have been better to provide shorter games with 5 to 15 minutes of typical length.

8 Related Work

The first commercial foray into hybrid toys was presented in [12]. The toys integrate insights from child psychology to help children learn through play by sensibly mingling computer games with physical toy representations.

Similar to STARS, [8] are also developing a hybrid board game called False Prophets, in which players jointly explore a landscape on the game board utilizing multiple devices such as PDAs. As with STARS, the aim of the False Prophets project is to unify the strengths of computer games and board games. However, False Prophets is not a platform for developing multiple different games, but is currently limited to an exploration setting.

Björk et al. [2] presented a hybrid game system called Pirates! that does not utilize a dedicated game board, but integrates the entire world around us with players moving in the physical domain and experiencing location dependent games on mobile computers. Thereby, Pirates! follows a very interesting approach to integrate virtual and physical components in game applications, even though the actual game play on the PDAs always remains virtual and does not integrate hybrid elements except for player locations.

A more recent location based gaming application with a similar approach was presented in [10]. The focus of the Schminky game project is to employ a sound based game for handheld computers in a café in Bristol, UK, and gather real-life data from groups of café guests. Apart from the very unique game play, Schminky is also interesting in terms of the exemplary design process.

The Tangible Viewpoints system [9] is a beautiful tangible table interface for multimedia storytelling applications with a very rich presentation and tangible objects as in STARS. However, its focus is limited to storytelling and it does not integrate mobile computers for private interaction.

Ishii et al [7] have created a hybrid gaming application called PingPongPlus that augments a ping pong game table with several output modes such as sound and graphics projected at the table surface. Some of the group's other important works on tangibles are presented in [16].

[11] present an interesting interface for playfully dealing with photographs on top of a DiamondTouch multi-user interactive table. Even though their focus is not directly on games, they share the vision of supporting recreational face-to-face interaction with unobtrusive and natural interfaces to the digital world. A more recent presentation of multi-user gestural interaction on tabletop systems can be found in [17], which is especially interesting due to

the presented methods of conveying private information via projection onto user's palms.

An interesting approach to an interactive table was presented in [13]. The Smart Table can sense positions and orientations of multiple objects through a very sophisticated metal grid sensor surface. In contrast to STARS, the focus of Smart Table is to provide a robust enabling technology than a prototype for new forms of interaction design.

9 Acknowledgements

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