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Virtual and Tangible User Interfaces for Social and Accessible Pervasive Gaming

Wendy Ann Mansilla, Andreas Schrader, Soenke Dohrn, Alma Salim

ISNM – International School of New Media at the University of Lübeck, Germany

Abstract

Nowadays, more advanced multimedia and feedback tools and assistive technologies enable enhanced gaming experiences. However, many publishers in the gaming market prefer to stay mainstream resulting in a limited variety of gaming experiences available to physically impaired gamers. This is especially the case for physically impaired gamers experiencing some social digression when playing computer games or complex physical games. We describe a simple pervasive gaming approach using tangible user interfaces developed in-house that involves both physical and virtual experiences. In real world, playing board games may be hard, tiring or perhaps impossible for disabled people. The challenge of our work is to allow for supplementing physical activities on such games using enhanced interface technologies.

1 Introduction

The use of Tangible Interfaces has been suggested by Ishii as an approach for human-computer-interaction (Ullmer & Ishii 2000). He demonstrated the functional use of Graspable and Tangible User Interfaces (TUIs) using physical objects as intuitive interfaces. TUIs apply combined virtual and real-world physical concepts and personal experiences that may be considered more "intuitive" since they follow familiar metaphors. To the disabled people, TUIs thus can be the solution to overcome hardware difficulties that they are facing when playing computer or real-world games.

Some projects such as the Mercator project (see Mynatt & Edwards 1992) and TiM project (see Archambault, et al. 2001) address graphical user interface accessibility issues and use of assistive technologies specifically for nonsighted people. However, available assistive technologies are sometimes expensive and may not always fit all sorts of user interface requirements, therefore, home-brewed tangible user interfaces (e.g. Jung et al. 2005) can be a functional approach.

To develop a single holistic game that covers all sorts of disabilities may not be possible. Some games attempt to solve this problem by providing configuration functionalities such as levels of parameterisation on the size of the objects, speed and distance of the action, life and tolerance of the game, and sounds[1]. The majority of these accessible computer or video games support not only audio or visual customisation but also other high level assistive technologies such as voice recognition[2] or Global Positioning System[3]. Although these games provide accessibility support, the question of how to aid physically impaired people experience social rewards from non-computer based games (e.g. board games) remains unanswered.

2 Accessibility Problems in Computer Games

The game design requirements depend on the level of disabilities of the players. There are two important issues that need attention regardless of the disability of the players: social gaming experience and accessible user interface.

2.1 Social issues in computer-mediated games

Computer-mediated communications (CMC) (i.e., Internet, Emails, chat rooms, or network games) for social purposes is one of the main concerns in the social presence research arena. Despite claims that CMC has some negative effects, e.g. significant amounts of Internet users decreased their traditional social interactions and social support (Kraut et al. 1998; Clay 2000), there are strong benefits suggesting that CMC is a good tool for physically disabled people to improve their status (Baym 1995), increasing their independence, self reliance and potentially affecting positively their sense of self confidence (Coombs, 1989). Some experts also noted that using CMC provides social and emotional support for disabled persons since they can easily communicate with other people without worrying about social expectations that restrict them in face-to-face interaction (Brennan et al. 1992).

Although traditional media use was perceived by others as irrelevant to computer media access, computer service was seen as a useful supplement to traditional media instead of a complement or displacement mechanism (Lin 2002). Computer media can be a rewarding supplementary tool to help disabled persons play real-world social games that may otherwise be too difficult or impossible for them to play. Although there are increasing efforts towards providing accessible games to disabled people, further research is required to make computer games more socially rewarding for disabled people in real-life situations.

[1] See Arcess games (http://www.arcess.com/), Tachido (http://www.jeux-france.com/news1798_tachido-un-jeu-pour-mal-voyants.html), and Shades of Doom (http://www.gmagames.com/sod.html).

[2] See Game Commander (http://www.gamecommander.com/).

[3] See Terraformers (http://www.terraformers.nu/).

2.2 Disabilities that hinder game usability

Estimates on individuals with disabilities that may need accessible games may vary. According to Wyoming Institute for Disabilities (n.d.) the major categories of disabilities that are hindering game usage are cognitive, hearing, motor and visual. We try to summarise the main impacts of these categories related to gaming in terms of hardware and software problems in Table 1 (see http://www.igda.org/accessibility/; http://www.w3.org/WAI/).

Table 1: Hardware and software interface problems experienced by disabled people

Disability Type	**Software (S) & Hardware (H) Problems**
Auditory (hard of hearing, Deafness) This impairment ranges from partial loss of hearing to total loss of hearing.	**S**: It may be hard for these types of gamers to follow a game whose story evolves by cut scenes. Furthermore, these types of gamers always miss important audio cues needed to understand the plot of the story. **H**: Games lack output feedback support alternatives that can help stimulate some important auditory cues present from output speakers or headphones.
Visual (Blindness, Low Vision, Colour Blindness) visually impaired is generally used to describe "all those who have a seeing disability that cannot be corrected by glasses" (Hopkins 2000).	***S***: Small and pixelated looking images or text graphics may not be visible or readable when enlarged. In addition, lack of colour contrast on the screen will make it difficult for colour blinds to see the game. Thus, games that are focused only on visual output such as colour cues to convey meaning will be hard or totally inaccessible by impaired players. ***H***: Games that are high on mouse-driven navigation are inaccessible for visually impaired people.
Cognitive These are disabilities that include inability to retain memory, problem solving, learning and perception difficulties, and attention deficits disorder.	**S**: For this type of player, lack of an easy navigational structure in games may infer gaming experience. In addition, complex game instructions may be too difficult to follow and understand. Lack of non-text materials (i.e. graphics, or pictures) is also seen as penalising for these players. **H**: Lack of several output devices such as speakers; tactile feedback output and other media may hinder comprehension and gaming experience of these gamers.
Motor These are disabilities that affect a person's ability to perform motor tasks such as manipulating and moving objects, inability to use a mouse or other input devices.	**S**: These gamers may find it difficult to follow the game speed. It may also be hard for them to respond quickly with game decisions that require urgent actions and precision timing using controllers. **H**: Games that lack support to alternative input devices may be inaccessible to these gamers. Even though some games support assistive tools such as "puff-and-sip" tools, this may cause fatigue to gamers.

3 The Fruit Salad Game

Considering the outlined problems in the previous section, a prototype game called "Fruit Salad" (FS) (http://www.isnm.de/projects/FruitSalad.html) was developed addressing the threefold core issues: (1) to play intuitively even without full preparatory instructions, (2) to

receive social and emotional feedback both physically (e.g. collaboration with another player or audience) and virtually (e.g. through avatars). (3) to be able to play the game even when the player is blindfolded or without sound feedback (see Figure 1).

FS is a two-player board game that comes with various physical objects that are embedded with sensors, motors and improvised force feedback. The board was assembled to host various removable fruit objects, represented by plastic representation of real fruits equipped with RFID tags. These are supported by avatar voice output or background sounds which inform the gamers about the exact positions of the objects in the board game.

The game starts with two players sitting in front of the board. The game coordinator positions on top of the board, 24 plastic fruits. The goal of the game is to gather "good" combinations of fruit objects into physical fruit baskets to make a nice and tasty fruit salad. The player who collects the most sweet fruits gets the highest score and wins the game.

To begin, one of the players presses a push button attached on the board. The player is then instructed by an avatar displayed on a screen to shake a "fruit shaker" to influence the spatial arrangements of the fruits on the board, initially randomise the game card, and trigger the animation of the virtual fruit shaker. Each player then alternatively draws a card by moving the fruit shaker. The cards give the player instructions on what to do. The possible instructions are: (1) Move man 1 step forward (i.e. move the pawn one slot on the board). Once the player reaches the third row of the board, the fruit chosen through this move has to be picked and added to the player's basket. (2) Shake the shaker again, or (3) No move.

The physical FS interface was constructed using the Physical Widgets or Phidgets (www.phidgets.com) building blocks. Phidgets bypass the difficulty of electronics, building circuit boards, and microprocessors. Since our group doesn't have an expert knowledge in electronic engineering, such gadgets provided a useful solution. The hardware components used were: dual axis accelerometer (embedded into the fruit shaker), force sensors (placed into the board of the game as push buttons), servo-motors (used to rotate the plates based on the number of shakes made by the player), RFID labels and RFID readers (placed inside the fruits and the fruit baskets).

4 Evaluation

FS was showcased for the first time during the 2004 ISNM Open House event. The game's simplicity of use and social potentials were well received among players and audience. Players and audience were asked to answer open-ended questionnaires (about 15 questions) or interviewed patterned after the usability heuristics suggested by Nielsen (1993). The feedback gathered suggests that ease of use and social rewards (e.g. enjoyment and sense of competition) normally found on collaborative games was successfully met by FS.

However, some participants evaluated FS as quite difficult to play when blindfolded (to simulate visually impaired gamers) and most difficult to play without sound feedback (to simulate auditory challenged players). Outlined are the acquired suggestions to meet the needs of impaired gamers and the potential solutions implemented in Fruit Salad II (see §5).

- **Feedback to direct the attention of the gamer.** Although FS is initially designed with feedback responses through avatars for scoring and turns, many saw this functionality as insufficient to support auditory or cognitively impaired gamers. The solution is to install force feedback devices to direct the attention of the impaired gamers on the screen, to remind the players of their game turns or to stress the reactions of the avatar (as a form of multimodal feedback) aside from the graphical feedback displayed on the screen.
- **Track board items with voice output.** Initially, there was no voice output installed to aid visually impaired gamers keep track of the location being accessed on the board game and locate the player's pawn. The visually challenged players need to repeatedly touch the fruits to develop a strategy (e.g. to determine which board location will the player choose if given multiple options to pick a fruit from the board). The solution is to provide an RFID reader tracker that aids players to readily identify board positions and locate the player's pawn. Keeping track of the player's pawn is rated as the most difficult task for visually challenged players.
- **Implementation of subtitles.** Initially, FS does not provide an option to display readable subtitles on presented dialogs and avatars reactions. Many players however failed to capture some of the dialogues spoken by the avatars.
- **Alternative hardware input support.** Although FS highly utilises TUIs such as fruit readers, push button commands, or physical fruit shaker, other input alternatives are also seen by some gamers as important to consider. Thus, a keyboard input alternative (i.e. using the tab key or numeric keypads) to achieve similar effects is seen as a solution.
- **Option to repeat previous sessions.** Not all visual or auditory output from FS can be repeated again. The players particularly noticed the need to repeat some instructions, text or dialogue spoken by the avatars. The solution is to accommodate a "replay" functionality.
- **Graspable physical objects.** The initial FS uses very small fruits that are sometimes hard to grasp and to readily identify even by those who are not visually impaired. The solution is to use plastic fruits that are close to their real life size.
- **Expressive avatars add enjoyment.** Research strongly suggest that the cognitive and affective gratification-seeking factors were the strongest predictors of likely media service use (Lin 2001). In FS, the feedback suggests that expressive avatars provide affective gratification and add enjoyment to the game.
- **Sufficient colour contrast.** The colour used on the board and display such as yellow and orange is seen as the same for some colour-blinded observant. Providing alternative colour schemes for different types of colour blindness may be a good approach but to keep the game design simple, observing the general contrast of colours is enough.

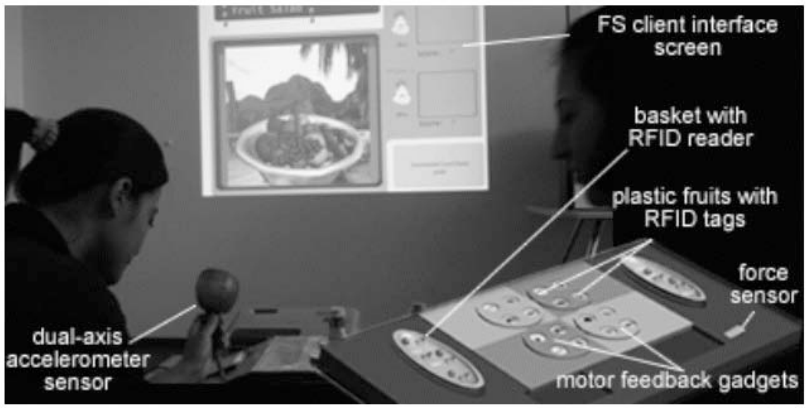

Figure 1: The client graphical screen and physical interface of FS

5 The Fruit Salad II

Based on the analysis of the requirements for accessible gaming from the previous section and the suggestions placed by the audience and players, we came up with an enhanced game design approach called "Fruit Salad II" (FS2). The new game installation consists of the following parts:

- Twenty four plastic fruits, which are combinations of sweet and sour fruits.
- A board. The board includes the following elements: (1)two round discs, each of which is connected to a motor. Each disc contains four slots where fruits are placed. (2) two fruit baskets (one per player) are integrated into the board. Each is equipped with an RFID reader, which tells the game logic the content of each player's basket. (3) two push buttons. The push buttons are used to start the game, ask for further instructions or ask help from the audience. Gamers can also use a keyboard input alternative using the space key to trigger the simulated card deck (see Figure 2b).
- RFID reader trackers. Trackers identify board positions and locate the player's pawn.
- A shaker. The fruit shaker is embedded with an accelerometer sensor. Moving the fruit shaker causes the board discs to rotate, randomises the game card, and triggers the animation of the virtual fruit shaker.
- Two Bass PC speakers (serve as an improvised force feedback positioned under the board of the game as a vibration pad).

A computer or wall display is used to show information about the game state to aid auditory impaired gamers perceiving events happening on the board game through the audio and voice being played. It includes each player's overall scores, graphical and text information.

Finally, the screen also displays a virtual fruit shaker and emotional avatars with speech and text output capability (see Figure 2a).

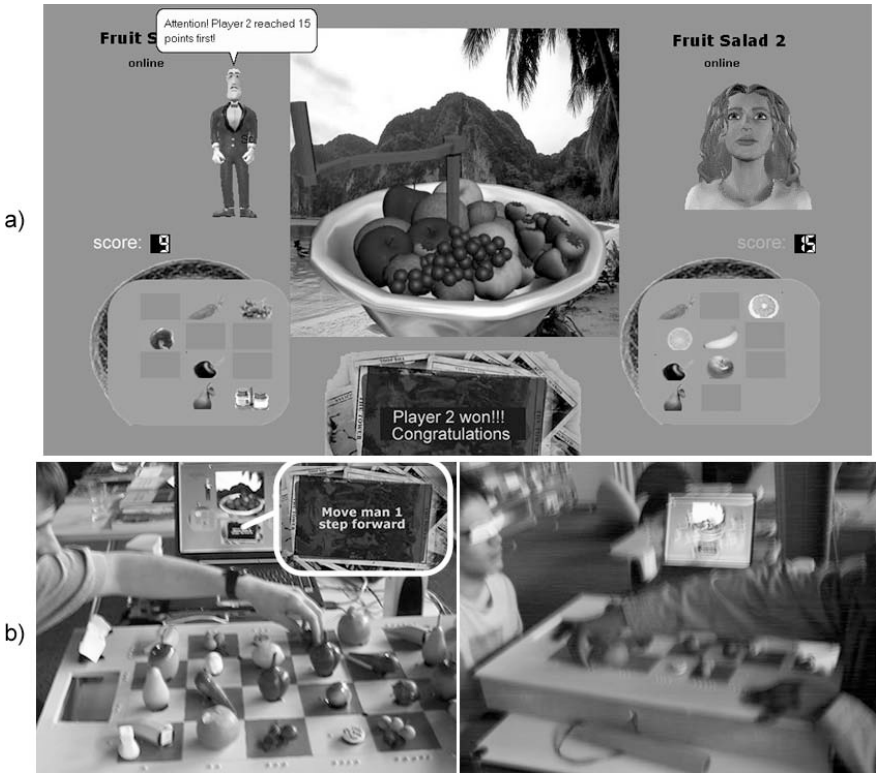

Figure 2: a) FS2 client interface screen; b) FS2 game board and tangible interfaces

Overall, there are six event-triggering possibilities in FS2. First is the shaker, second are the RFID-controlled fruit objects, third is the push button command, fourth are the RFID-reader fruit baskets, fifth are the RFID-reader character pieces or pawns, and lastly is the push button audience help. All of which provide visual and spoken feedback when used. In total, there are 2 push buttons, 1 shaker sensor, 2 motors, 24 RFID labels, and 4 RFID readers from the Phidgets building blocks and 2 improvised low-range bass speakers that are all connected to the physical board and are linked to the software game logic.

A high degree of physical interactivity (with the tangible game objects) and social interactivity (with the other player and with an audience) is thus combined with computer game features (game logic control, display) to fully address the specific needs of the target disabled players.

6 Fruit Salad II Architecture

The system architecture of FS2 consists of the following main components: (1.) Virtual Avatar Management (2.) Sensor Events Management (3.) Audiovisual Components (4) User Interface and (5) Game Logic (see Figure 3).

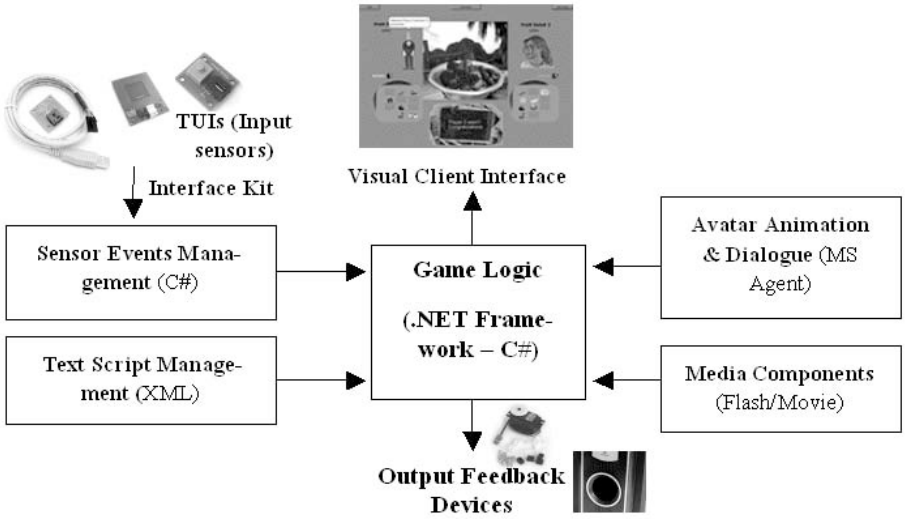

Figure 3: Layout of the system architecture of FS2

The Game Logic (GL) is the core processor of the entire application and functions as a mediator between other main components of the system. This component is developed in a C# .NET platform which is capable of integrating Flash controls (http://www.macromedia.com), MS Agent (www.microsoft.com/msagent/), and eXtensible Markup Language (XML) functionality. Once the user performs an action to the TUIs (that hosts the input sensors), the interface kit reads the analog output, converts it to computer readable form and sends it to the Sensor Events Management (EM) layer of the system. The GL layer of the application then receives events from the EM layer and processes these events. Once the necessary calculations such as scores of the players, drawing of the deck of cards, and other validations have been performed by the GL, it sends out corresponding responses such as updated graphics and avatar gesture animation, speech or sound output, player's score and others to the output feedback devices and/or to the visual client interface.

7 Conclusion and Future Work

We have demonstrated a game using a mixture of virtual and tangible interfaces that addresses not only some accessibility issues in games but also considered the social interactivity requirements that a game should support to aid disabled people playing a traditional board game. Based on the feedback gathered, the game represents a viable solution to address the specific needs of impaired gamers. The use of existing off-the-shelf development software (Flash, C#, MS Agent) and physical components (Phidgets) allows a relatively simple and affordable design that can be carried out by a small team and yet provides a convincing and usable end product.

Further developments of this work are threefold. First, we are planning to test Fruit Salad II (FS2) with disabled people, particularly visual and auditory impaired gamers. An initial user testing (14 students) was conducted with FS2. Majority of the participants were able to play the game (nonsighted or without sound feedback) with ease. In addition to Nielsen's usability heuristics, future work will include the user centred approach evaluation suggested by Duckett and Pratt (2001). They noted the relevant importance of an evaluation methodology that considers the "social, economic and political barriers that 'disable' people who have impairments" (p. 816). This includes gathering the user characteristics and social information needs rather than focusing too much on the format of information and physical disability itself. We are also planning to enhance the spatial sounds and audio by implementing the research results on the use of acousmatic presence to stimulate emotions in the game (2005, Mansilla & Jung). Finally, it should be possible to devise a more flexible or alternative approach to address even those disabled people who cannot access physical devices. The concept of using home-brewed or improvised devices could be adapted to the development of new versions of well-known existing games tailored for this audience, be it traditional board games or computer games.

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w.mansilla@isnm.de, andreas.schrader@isnm.de, s.dorhn@isnm.de, a.salim@isnm.de