Sightlence – A Haptic Interface Translation of Pong

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ABSTRACT
Sightlence is a haptic game interface translation of Pong. The goal of the game design was to answer the question if it's possible to design computer games that only communicate through the haptic modality, if it's possible to translate classic computer games to the haptic modality, and if it can be accomplished with ordinary gamepads.

The two-fold purpose of answering these questions was to explore if it is possible to make computer games more accessible with haptic interfaces, and the possibility of using the haptic modality alone in a manner similar to the graphic and audio modalities when designing computer games.

The Sightlence game demonstrates that game designers can create haptic game interfaces with expressive capabilities closer to that of its graphical and audio counterparts even though it's currently not common to do so in game development projects.

Categories and Subject Descriptors
H.5.1 [**Information Interfaces and Presentation**]: User Interfaces---haptic I/O

General Terms
Measurement, Design, Experimentation, Human Factors.

Keywords
Haptics, user interfaces, game design.

Project webpage
http://www.sightlence.com

1. INTRODUCTION
As computer games have become a natural part of mainstream culture the demand for better accessibility in games have begun to increase as well. Accessibility with regards to sensory perception is currently accomplished through compensation of one sense with another, which almost always entails compensating impaired vision with increased auditory cues or vice versa. Computer games currently require at least one of those senses to be playable. That unfortunately means that people are excluded from participating in computer game culture if they lack both.

The Sightlence game is an exploration in how game designers can use the haptic modality as a third design material during game development instead of being primarily limited to the graphical and audio modalities. This allow game developers to create new gameplay experiences for existing players and increase accessibility for those that are currently excluded from computer game culture because of sensor impairments.

2. STATE OF THE ART
In this paper the term haptics is being used as an umbrella term for both kinaesthetic and cutaneous perception [1]. Haptics is used in computer games today but primarily to enhance information that is already being presented in another modality. A gun being fired for example might have haptic vibration in addition to its graphical and audio feedback. An interesting but rare example is the lockpick minigame in Fallout 3 [2] where both graphical and haptic feedback is necessary and also dependent on each other. There have been attempts to create haptic computer game interfaces in academia [3][4] but they have unfortunately used expensive or custom-built hardware. Such hardware has also not been a guarantee that they succeed with translating all interface elements and game mechanics into haptic signals. They have instead been either partial translations [4] or relied on other interface modalities for several of the game mechanics or interface elements.

3. GAME DESIGN OVERVIEW
Sightlence is a haptic computer game interface translation of the classic computer game Pong. Neither sight nor hearing is therefore required to play the game. The rules and game mechanics remain true to the original Pong. Since people are currently not used to playing with haptic computer game interfaces the Sightlence game was altered in a few ways though to make it easier to play.

The game is primarily a two-player game and each player uses two gamepads to play the game. This is because of the limited hardware capabilities of the Xbox 360 gamepads but it also means that the hardware is more affordable. The player holds one gamepad in their hands and that gamepad is used to give input to the game and also for receiving haptic feedback related to the paddle. The other gamepad is kept in the lap and it's used to receive haptic feedback that is mainly related to the ball.

The paddles are significantly bigger compared to the original game and their size is equivalent to a quarter of the size of the play area along the Y-axis. The vibrotactile motors in the Xbox 360 gamepads are imprecise in signal onset and release so it would be difficult to give haptic feedback for a small paddle.

The ball also bounces with 45 degrees angles when it hits either the paddle or the wall instead of being variable and determined by the area of the paddle being hit by the ball. Being able to determine the angle of the ball's trajectory is an interesting aspect of playing Pong but using it proficiently requires greater skill and familiary with the interface and was therefore left out.

The initial speed of the ball when it's first launched is reduced compared to the original game in order to make the first few bounces easier. The Sightlence game then increases the ball's speed with 10 percentage points for each successful bounce so the game becomes progressively harder the longer the round lasts.

4. PLAYER INPUT, GAME TUTORIAL, AND THE GRAPHICAL INTERFACE

Pong has a few game mechanic, and graphic and audio interface feedback that enable a person to play the game. The Sightlence game has the same number of inputs, it offers haptic feedback, and they can all be seen in figure 1.

Figure 1: Interface elements that must be conveyed by the haptic interface to be equivalent to its graphic counterpart.

Input	Output
Move player's paddle up	Ball position relative to the player's paddle on the Y-axis
Move player's paddle down	Ball position relative to the player's paddle on the X-axis
Play a new ball	Ball bounces against the game's upper or lower boundary
	Ball bounces against a player's paddle
	Paddle hits the game's upper or lower boundary
	Player scores a point

4.1 Player Input and Settings

The gamepad layout for the Sightlence game can be seen in figure 2. The input possibilities are also described below.

The players can navigate in the start menu and in the pause menu by pressing up and down on the Xbox 360 gamepad's D-pad or left thumb stick.

The players can control their respective paddle by pressing up and down on their Xbox 360 gamepad's left thumb stick.

The players can serve a new ball by pressing the Xbox 360 gamepad's green A button. The player who lost the last ball gets to serve the new ball. The first ball in the match is randomized.

The players can pause the game and enter the menu system by pressing the Xbox 360 gamepad's start button.

The players can toggle between full-screen mode and windowed mode by pressing Alt+F on the computer's keyboard if they are playing the game in Microsoft Windows. On the Xbox 360 there is only full-screen mode.

The player's can toggle between the different graphical interface modes by pressing the Xbox 360 gamepad's yellow Y button. The different modes are explained below.

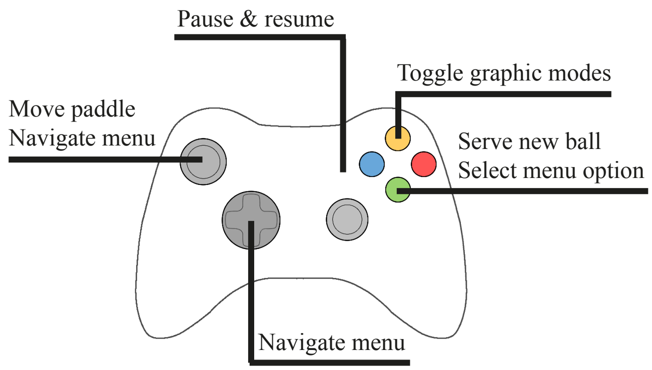

Figure 2: Xbox 360 gamepad layout for player input.

4.2 The Game's Tutorial

Since people are currently unused to playing computer games with haptic interfaces the Sightlence game includes a tutorial where all the haptic interface signals can be experienced. They are emitted in isolation from each other to help the player learn the signals without interference. In the beginning the haptic signals are overwhelming when several are emited at once. The tutorial menu can be seen in figure 2.

Figure 2: The tutorial in Sightlence provides isolated output of each individual haptic signal for learning purposes.

There is no continuous scrolling in any of the menus where pressing the Xbox 360 gamepad's up key at the top of the menu would make the selection icon rotate around to the bottom menu item instead. The menu has a hard ceiling and floor instead to make it easier for people with poor vision to navigate the menus since it allows them to count the number of steps from the top or bottom of the menu sceens.

4.3 The Game's Graphical Interface

The players can toggle between the game's different graphic modes, presented on the next page, by pressing the Xbox 360 gamepad's yellow Y button so that the game switches between showing: the graphical representations of the paddles, ball, and score; the graphical representations of the paddles, and score while the ball is kept invisible for the player; or the graphical representation of the score while the paddles, and the ball is kept invisible for the player. The different modes for the graphic feedback can be seen in figure 3, 4, and 5.

The score is always kept visible to the players because it was unfortunately not possible to present it through haptics because of the Xbox 360 gamepad's limited haptic capabilities. This could be solved in the future by adding support for Braille readers.

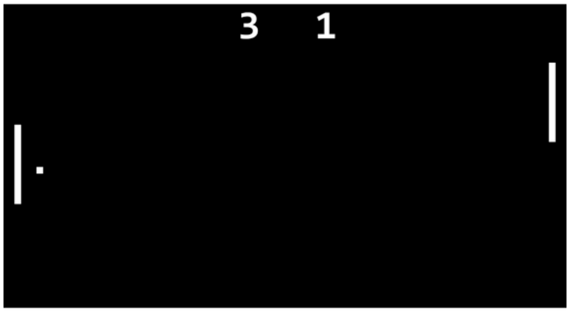

Figure 3: Sightlence with all game objects visible.

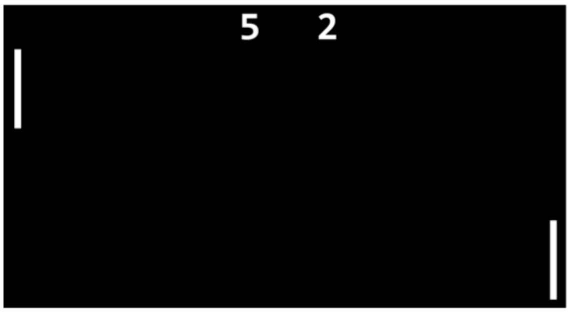

Figure 4: Sightlence with only the paddles being visible to the players while the ball has been turned invisible.

Figure 5: Sightlence with all game objects turned invisible. The game is now played only with its haptic game interface.

5. GAMEPAD

The Sightlence game makes use of the Xbox 360 gamepads for player input, and for output of the haptic feedback. They were selected because the game was initially developed using Microsoft's XNA for Microsoft Windows and Xbox 360 compatibility. The current generation of off-the-shelf gamepads is quite similar in capabilities and most would be equally valid choices.

The game uses two gamepads for each player since the haptic vibrotactile motors in the Xbox 360 gamepads have limited capabilities. The players are therefore each assigned a hand gamepad and a lap gamepad. The hand gamepad is used for providing input to the game while both gamepads are used for receiving haptic feedback. The gamepads are assigned as follows: gamepad one for player one hand gamepad, gamepad two for player one lap gamepad, gamepad three for player two hand gamepad, and gamepad four for player two lap gamepad.

There are many hardware devices to choose from if a designer needs more advanced capabilities than most gamepads currently offer. Kinaesthetic feedback is for example not a feature in the current generation of gamepads. While the haptic capabilities of the gamepads for the Xbox 360 and PlayStation 3 are limited compared to more expensive offerings they do offer a few significant advantages. Their low cost and wide availability makes them both affordable and easily obtainable for many computer game players, and since they are shipped together with the game consoles they have a high market penetration. A game designer that decides to create a haptic computer game interface for the Xbox 360 or PlayStation 3 therefore has has acces to the entire respective market. Using more powerful, specialized, or custom-made but more expensive haptic devices have technical advantages but also limitations in the reach that computer games designer that use them can achieve. For highly specialized computer games, for example training procedures in surgery, this is most likely not an issue but for computer games targeted at a wider audience it might be.

The final decision of which haptic devices to use should therefore be based on the requirements, player needs, and limitations that the game designer must consider during development. For the Sightlence game it was seen as more important to create a computer game that can be made available to as many people as possible in order to democratize accessibility to computer game culture. It was therefore natural to use gamepads from the current game console generation rather than more expensive devices.

6. HAPTIC FEEDBACK

The following haptic outputs are given by the hand and lap gamepads in order to convey information about the game.

6.1 Hand Gamepad

The hand gamepad is used for getting haptic feedback from the game related to the paddle.

6.1.1 Signals for the relation between the ball and the player's paddle along the Y-axis

When the ball is above the player's paddle along the Y-axis: the player's hand gamepad's high-frequency vibrotactile motor emits a continuous haptic signal with weak amplitude strength.

When the ball is below the player's paddle along the Y-axis: the player's hand gamepad's high-frequency vibrotactile motor emits a continuous haptic signal with strong amplitude strength.

When the ball and the player's paddle are in line with each other along the Y-axis: the player's hand gamepad's high-frequency vibrotactile motor is silent.

For playability reasons it was necessary to make certain changes for when the haptic feedback is activated for the relation between the ball and the player's paddle along the Y-axis. The haptic signals aren't activated when the ball passes beyond the upper and lower edge of the paddle but rather a bit before to avoid a situation where the player feels that they are about to successfully bounce the ball and then inexplicably lose it as it goes over the paddle's edge and out of bounds. This situation is less noticeable for graphical representations.

6.1.2 Signals for when the ball bounces against the players' respective paddle

When the ball bounces against the player's paddle: the player's hand gamepad's low-frequency vibrotactile motor emits a short haptic signal with strong amplitude strength.

When the ball bounces against the opponent's paddle: the player's hand gamepad's low-frequency vibrotactile motor emits a short haptic signal with weak amplitude strength.

These two signals use sound as a metaphor for how distance affects perception where a sound source that's close to a person is experienced as louder than an identical sound source one that is far away. How such metaphors translate across modalities in computer games, and especially for people that lack experience of sound, is a question left for future studies.

6.1.3 Signal for when the player's paddle collides with the game's upper and lower boundaries

When the player's paddle collides with the game's upper and lower boundaries: the player's hand gamepad's low-frequency vibrotactile motor emits a continuous haptic signal with average amplitude strength.

While most haptic signals in the Sightlence game are part of a signal pair with the only internal difference between the two being their respective amplitude strength this was not necessary for this signal. The reason for this is that the players in this case give themselves kinesthetic feedback in addition to the tactile feedback from the game. This helps them discriminate between the two even though their tactile feedback is identical.

6.2 Lap Gamepad

The lap gamepad is used for getting feedback from the game related to the ball and the following outputs are used.

6.2.1 Signals for the relation between the ball and the player's paddle along the X-axis

When the ball is moving towards the player's paddle: the player's lap gamepad's high-frequency vibrotactile motor emits a continuous haptic signal with increasing amplitude strength.

When the ball is moving away from the player's paddle: the player's lap gamepad's high-frequency vibrotactile motor emits a continuous haptic signal with decreasing amplitude strength.

6.2.2 Signals for when the ball bounces against the game's upper or lower boundaries

When the ball bounces against the game's upper boundary: the player's lap gamepad's low-frequency vibrotactile motor emits a short haptic signal with strong amplitude strength.

When the ball bounces against the game's lower boundary: the player's lap gamepad's low-frequency vibrotactile motor emits a short haptic signal with weak amplitude strength.

6.3 Scoring Points

When a point is scored both vibrotactile motors on both gamepads for the players are activated for 2 seconds, and then they alternate between activation and silence 3 times with a 0.5 second interval. The winning player's vibrotactile motors emit a haptic signal with strong amplitude strength while the losing player's vibrotactile motors emit a haptic signal with weak amplitude strength.

7. CONCLUSIONS

Sightlence is a game design project that demonstrates that it is possible to design computer games based entirely on the haptic modality. It's just a first translation though so more are needed to explore where the limit is in expressive capability both for the gamepads and for human haptic perception of haptic computer game interfaces. It shows that computer games can be developed with haptic computer game interfaces in order to offer existing players new gameplay experiences, and to make computer games more accessible for people that have previously been excluded from participation in computer game culture.

The Sightlence game's other contribution is to show that despite of hardware limitations it is possible to design haptic computer game interfaces for the gamepads of the current generation of game consoles. Avoiding exotic or expensive hardware devices gives more people the opportunity to finally experience both contemporary computer games, and their historical predecessors through haptic computer game interfaces. Other game designers and academics will hopefully begin exploring haptics as an interface modality for games and expand our understanding of it.

8. FUTURE RESEARCH

The current version of the Sightlence game was designed to help answer questions about how the haptic modality can be used as a design material for creating computer game experiences. This goal was accomplished but it also opened up a few new directions of research that are now being explored.

We've begun designing an additional interface modality for the Sightlence game in the form of audio. Audio only computer games have been explored before but we are attempting to create three modality translations that are experientially equivalent. This would allow three modalities to be used, modified or removed to create the sensory richness and interface experience that a player wants. We hope that this can help explore the tension that exists in the co-dependencey between a game's rules and interface.

9. ACKNOWLEDGMENTS

We would like to thank Dr. Mattias Arvola for supervising the Sightlence game project, and Mr. Andreas Bygdell for producing the audio for it. We also want to extend a special thanks to all the wonderful people that participated in the project.

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