

# PingPongPlus: Augmentation and Transformation of Athletic Interpersonal Interaction

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## ABSTRACT

PingPongPlus (PP+) is a digitally enhanced version of the classic ping-pong game. We have designed a digital layer of audio/visual augmentation on top of a conventional ping-pong table using a newly developed ball tracking system and video projection. The "reactive table" displays patterns of light and shadow as a game is played, and the rhythm and style of play drives accompanying sound. In the process, this project explores new ways to couple athletic recreation and social interaction with engaging digital enhancements. This paper describes the basic idea, research agenda, several applications, technical implementation, and initial experiences.

## Keywords

augmented reality, reactive surface, athletic / kinesthetic interaction, computer-supported collaborative play, interactive media art.

## INTRODUCTION

Computer-Supported Collaborative Play can take many forms. It runs the technical gamut from highly sophisticated networked video games to electronic board games. Most of the work in today's digital multiplayer games has lost the element of the physical presence of people and their kinesthetic interactions. We are interested in designing systems for collaborative play that push the physical world back into the forefront of design, without relying on simple GUI controllers (such as a mouse, keyboard, or joystick) [1]. Rather, in our model of collaboration, more emphasis is placed on the physicality of the people involved. We believe that a person's physical prowess, and sense of kinesthesia, can be leveraged to strengthen the quality of collaborative play. To do this, we have investigated new ways to interact with a surface and to sense activity. We seek to examine some of the ways digital augmentations can change traditional, physically-based game play and allow new interfaces with the digital world.

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## PINGPONGPLUS

PingPongPlus is a digitally enhanced ping pong game using a "reactive table" that incorporates sensing, sound, and projection technologies. The table displays patterns of light and shadow as a game is played, and the rhythm and style of play drives accompanying sound. For example, in one mode, a bouncing ball leaves images of

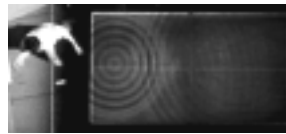


Fig. 1. Water Ripple

rippling water (Fig. 1).

## Technical Overview

PingPongPlus consists of two main elements: a ball-tracking system, and a graphics projection system (Fig. 2).

The ball position sensing is done solely through sound. When a ball hits, the sound travels through the table. Eight microphones mounted on the underside of the table pick up the sound. When a microphone detects a hit, a time value is assigned to that microphone, and sent to a computer through a custom made electronic circuit. The time values are evaluated on a 200 MHz PC by an algorithm that determines the location of the hit. The algorithm we have developed can pinpoint the ball's position within a few inches in a matter of milliseconds, which is good enough for our application.

The graphics are created in accordance with the ball tracking information. They are written in Visual C++ with a custom-made graphics package. A projector suspended 20 ft. above the table displays the graphics on to its surface.

## APPLICATIONS

Over 12 different applications have been developed and tested on the table. Five of the applications are discussed here. Through laboratory sponsor meetings, demonstrations, and exhibitions, hundreds of people have played with PP+, and their feedback was reflected in our iterative design.

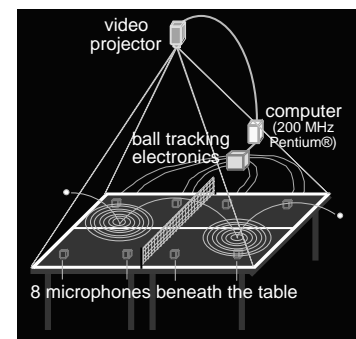


Fig.2. System configuration of PingPongPlus

### Water Ripple

The *Water Ripple* is a simple, causal augmentation. When a ball hits the table, an image of a water ripple flows out from the spot the ball landed (Fig. 1). Players found this to be one of the less distracting applications from the normal game of ping-pong, allowing them to concentrate on the game at hand, yet augmenting the game in a non-traditional sense. People often played with curiosity, rather than competitiveness, trying to examine what kinds of interference wave patterns they could create and view on the table. One child even climbed up on the table and created water ripples with his foot, rather than a ball.

### Thunderstorm

The Thunderstorm application incorporates game logic into its structure. By keeping the ball in play, rallying back and forth, the players “build up a thunderstorm.” At the beginning of a point, only calm, flowing waves appear on the table (Fig. 3). As the rally duration increases, the sound of a heartbeat gets faster, wind whips around the sound space, and the waves speed up. If the ball is kept in play for a long time, lightning bolts shoot from one side of the table to the other, connecting the ball’s last two locations. In this mode, we found that the style of game, the way people play, is changed due to the additional effects. When the wind picks up and the heartbeat gets faster, players tend to hit the ball faster and harder.

### Black-Out

With the Black-Out mode, we experimented with how augmentation can change strategies employed in a game. This mode is intended to be played in a completely dark room, where the only light comes from the bright white projection on the table. In this mode, a large black spot appears wherever the ball hits, effectively “taking light away” from the other person’s side of the table (Fig. 4). By concentrating hits in a single area, all the opponent’s light can be taken away in that space. The removal of light can be used strategically.

### Painting

This application explores the collaborative possibilities of the project. One side of the table is a blank canvas, and the other is a collection of two colors of “ink”. When a ball hits the black area of the “ink,” it leaves a black spot on the canvas (Fig. 5). Accordingly, when it hits the white “ink,” it leaves a white spot on the canvas side of the table. Through collaboration on color choices and placements by expert players, an interactive artwork can be made on the canvas. There is a shift here, from normal ping-pong to a different kind of collaborative game. The object is not to win a game, but it is to collaboratively create an image. This shows how augmentation can not only change the nature of game play, but it can change the object of the game itself.

### Comets

The Comets application continues to change the object of the game. In this mode, when a ball hits the table, it

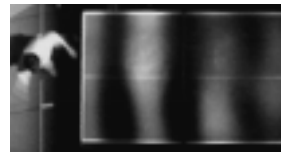


Fig. 3. Thunderstorm



Fig. 4. Black-Out

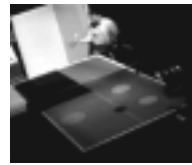


Fig. 5. Painting

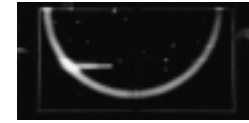


Fig. 6. Comets

“releases a comet” which travels up towards the net (Fig 6). When the comet hits the net, it creates a sound that is mapped to the place on the table the comet originated from. Experts using this mode could potentially use PP+ to creating music, or at least an interesting sound sculpture.

## DISCUSSION

We have been exploring a design space along the axis of competition-collaboration and augmentation-transformation. The more subtle augmentation of the *Water Ripple* mode does not change the basic nature of ping-pong play very much. In contrast, *Black-Out* provides players with new strategies to win a game. The *Painting* mode gives a new collaborative goal where players have tried to coordinate their play to paint on a “canvas” table.

Fig. 7 illustrates our design axis of augmentation-transformation and sample applications.

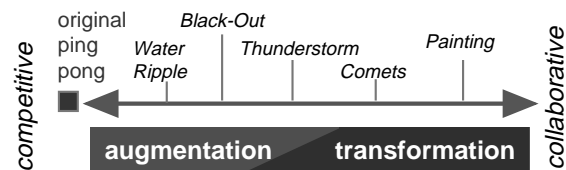


Fig. 7. Design space of PingPongPlus project

## CONCLUSION

We expect PingPongPlus will suggest new directions to couple athletic recreation and social interaction with engaging digital enhancements. By augmentation and transformation of physically-based games, new, engaging games can be developed in the physical/digital world.

## ACKNOWLEDGMENTS

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