Virtual Pong

How inertial tracking can turn objects into a game controller

Anand Doshi, anandpd@umich.edu
University of Michigan, Ann Arbor, MI 48104

Abstract
This paper demonstrates the use of a readily available Inertial Measurement Unit (IMU) mounted on an object as a game controller, and the use of spatial sound effects to make the game accessible to the visually impaired.

Introduction

Game controllers have evolved over the years from ergonomic buttoned remote controllers to rods with inertial sensors (PlayStation / Wii). Some gaming consoles like the Xbox 360 use Kinect to track movement using video and depth perception, without any physical controller. However, these use specialized hardware and work only with their corresponding consoles. With the use of Inertial Measurement Units (IMUs)[1], one could potentially convert everyday physical objects into gaming controllers, that could potentially be platform independent. Such controllers take advantage known affordances of various objects to control suitable actions in a game and provide a richer experience to the user. This is demonstrated in this paper by using a ping pong paddle as a controller for a virtual game of pong. An IMU combined with the use of stereoscopic sound effects and haptic feedback could make for an engaging game for the visually impaired.

Related Work

Hyper Ping Pong Paddle is a game that uses an IMU and a speaker to simulate a ping-pong rally without the use of a screen[1]. The paper on Real-Time Immersive Table Tennis Game for Two Players with Motion Tracking by Li et al. uses head and hand motion trackers, along with 3D graphics and physics based ball-animation to create in a virtual immersive two-player ping pong game [2]. Boyer et al. used an IMU to capture table-tennis strokes in real-time [3]. Todi et al. demonstrated the use of everyday objects as controllers with the use optical tracking [4]. This paper differentiates itself by providing both a visual display and stereoscopic audio feedback catering to a wider audience of users, proposes a virtual and immersive gaming experience, but with both single and potential multiplayer modes, and considers the use of general purpose IMUs to turn everyday objects into game controllers, making for a low cost, non-proprietary and platform independent approach to gaming for both general users and those with disabilities.

1 Inertial Measurement Unit consists of an Accelerometer and Gyroscope, and is used to measure acceleration and rotational motion of the object along 3 axes on which it is mounted.

Virtual Pong

This demonstration uses the Inertial Measurement Unit of a smartphone to control the timing and force exerted by a paddle in a virtual game of pong. A ping-pong paddle with an attached soft-case forms the housing for an iPhone. Once the iPhone is placed in this case, GyrOSC—an iPhone app, is used to send acceleration and yaw measurements to a computer using the Open Sound Control (OSC) protocol. OSC uses the computer's IP address and an open port to transmit these measurements over an external network using User Datagram Protocol (UDP). This data is received by a program written in Processing using a third-party library called OscP5. The data is then separated into acceleration and yaw measurements.

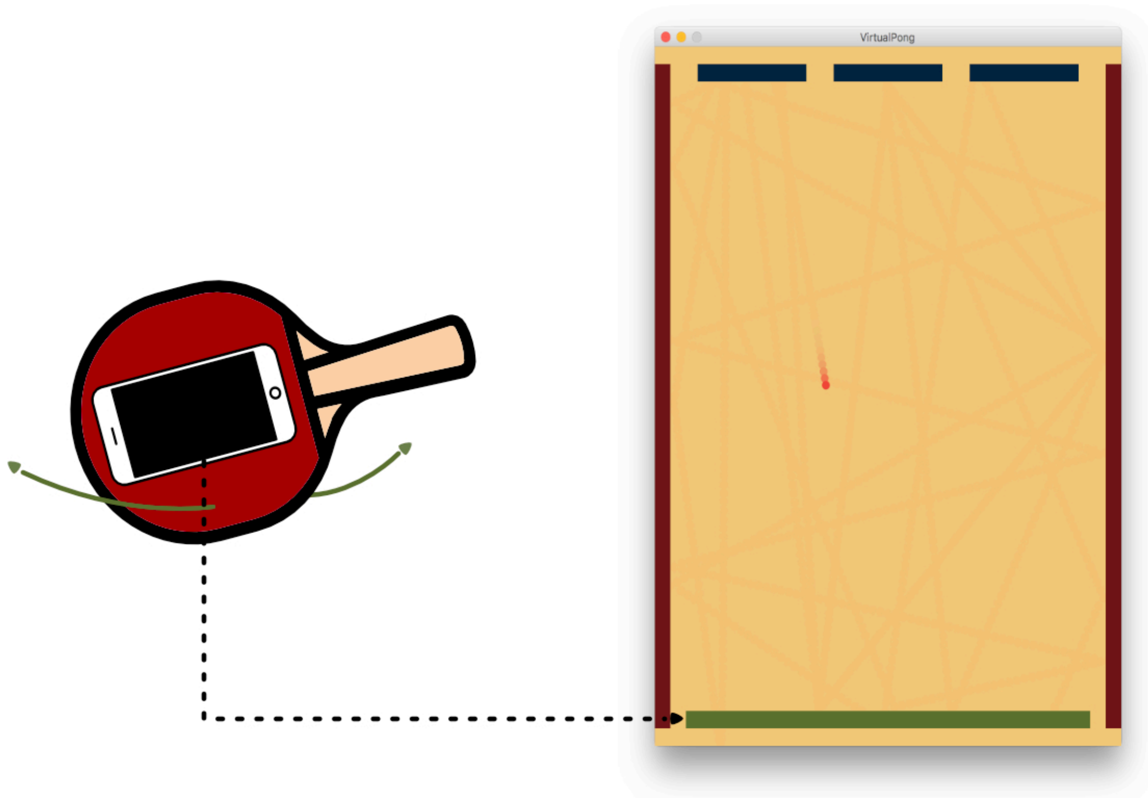

Figure 1: Schematic Diagram

The game, written in Processing, consists of vertical 600px by 800px virtual table, 3 horizontal barriers separated by gaps of 35px at the top, 2 vertical table edges on the sides, a large horizontal paddle at the bottom and a ball having 5px radius. The horizontal barriers at the top are programmed to exert force with a random angle and magnitude when a ball hits one of them. The table edges are programmed to speed up the ball, vertically, by a factor of 1.2, if a ball hits either edge. The game starts when the yaw measurement oscillates once between a positive and a negative threshold, which is achieved by rotating the paddle alternatively in clockwise and anti-clockwise directions. At the start of the game, the ball is located on the central barrier, which exerts a random force on the ball. This force and the resultant acceleration speeds up the ball in a particular direction. The ball may bounce on one of the 2 sides of the table, speeding up in the process. Following a zig-zag or angled trajectory, the ball arrives on the top edge of the virtual paddle. Just before this time, the player is expected to swing the physical paddle in a fashion similar to playing ping-pong. The accelerometer measurements as a result of this movement are accumulated from the start of the movement till the ball touches the paddle. This accumulated accelerometer reading is applied as a force on the ball if the timing is right, and as a result, the ball speeds back to the top towards the barriers, at an angle and magnitude determined by the accelerometer readings on the X and Z axes. The ball continues to bounce back and forth between the barriers and the paddle, till it slips through the gaps, either between the barriers or on the sides of the paddle. The player wins if the ball slips through the gaps on the other side.

The aim of this project was to build a virtual game for the visually impaired with the aid of sound cues. However, it proved difficult to simulate the ball physics, the effect of virtual force on the ball due to the accelerometer readings and the resulting sound effects, without a visual representation first. It implies the difficulty of designing a virtual game without any visuals, as visual thinking naturally maps to spatial dimensions compared to auditory thinking. Once the 2D visuals for the game were implemented, different sound effects like the tapping of ball on the barrier, that on the paddle and a pulsing sound like that of a sonar were added using the Minim library for Processing, to make the game accessible to the visually impaired. By controlling gain and panning, the location of the ball could be tracked, whether it is at the top, left, right or approaching the paddle at the bottom. However, the use of gain control on the sonar like sound effect proved less effective to give the impression of distance, as the pulse had a fixed frequency and did not indicate any urgency for the player to hit the ball. The player, when blindfolded, relied a lot on luck to hit the ball, as the gain in sound did not indicate the speed of the ball, which could have been effectively implied by increasing the frequency of the sonar sound effect.

The use of a ping-pong paddle as a controller affords various moves like the forehand, backhand, block, chop, etc. which translate to different accelerometer measurements in the IMU [5]. Apart from these expected and desired movements, unexpected movement of swinging the the paddle by holding the rubberized part instead of the handle, is also sensed by the IMU and affects the game. Other unexpected moves like throwing the paddle in the air or dropping it may be detected, depending on the axes of acceleration. Although ping-pong is played while standing, nothing prevents the player from playing this game while sitting or lying down.

Result, Reflection and Future

This simple game effectively demonstrates the use of inertial tracking for control. However, many features were not implemented due to the lack of time, primarily, a moving and rotating paddle, a score counter and a better ambient sound with modulated frequency to indicate the approach of the ball towards the paddle or away from it. With readings from 2 IMUs, it could be further developed into a two-player game. Different objects provide different affordances, which can make them effective controllers for different types of games, when equipped with an IMU. The same concept can be used for other video/audio games like cricket, hockey, tennis, racing, etc.

In its current state, this game does not work effectively for a visually impaired or a blindfolded player, but with further improvement using better sound effects and larger error margins, it could be developed into an effective one. Stereoscopic or binaural sound has been used effectively for making games for the visually impaired, but such games are often experiential, with little input or actions from the player. Combining such sound effects with inertial tracking could open up new possibilities, not only in gaming, but also to train the visually impaired in the use of tools.

Conclusion

With the proliferation of affordable Inertial Measurement Units, sensing movement has become commonplace. Gaming consoles come equipped with inertial sensors, but are highly specialized and expensive. Also, the use of binaural or stereo sound has been very limited in the gaming industry. The combined use of affordable IMUs mounted on everyday objects and the use of spatial sound effects could be the next stage in gaming, as well as the beginning of new training methods.

References

1. V. Savov, "Hyper Ping Pong is like real table tennis, only without the ball, table or opponent (video)," Engadget, 24-Jun-2011. [Online]. Available: https://www.engadget.com/2011/06/24/hyper-ping-pong-is-like-real-table-tennis-only-without-the-ball/. [Accessed: 31-Oct-2016].

2. Y. Li, L.-K. Shark, S. J. Hobbs, and J. Ingham, "Real-Time Immersive Table Tennis Game for Two Players with Motion Tracking," 2010 14th International Conference Information Visualisation, 2010.

3. Eric Boyer, Frédéric Bevilacqua, François Phal and Sylvain Hanneton, "Low-cost motion sensing of table tennis players for real time feedback, " The 13th ITTF Sports Science Congress, Paris, France, 2013.

4. K. Todi, D. Degraen, B. Berghmans, A. Faes, M. Kaminski, and K. Luyten, "Purpose-Centric Appropriation of Everyday Objects as Game Controllers," Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems - CHI EA '16, 2016.

5. "Table Tennis Strokes, Drills, and Selecting Equipment," Table Tennis playing guide covering the strokes and drills. [Online]. Available: http://www.pongworld.com/tips/tips_tech.php3. [Accessed: 31-Oct-2016].