Pong

Game Design Document

February 8, 2023

Contents

1 Overview

Based on the original pong, this rendition is tweaked to be a party game to be played by two people in an audience of several people. It is implemented in digital hardware RTL to be deployed on an FPGA with an HDMI video and audio interface with 720p60 being the targeted video mode. An ESP32 with custom BlueRetro firmware, hooked up using an SPI bus, is used for input.

2 Gameplay

A ball bounces on the top and bottom of the game screen. Two players control a paddle each on the left and right side of the screen. When the ball hits a paddle it bounces. If it misses the opposing player scores and a new ball appear.

2.1 Design goals

Goals with the game to motivate design choices.

- High pace short matches to engage multiple players and audience
- No game result shall be given beforehand, neither a match nor a game is ever lost until it is lost
- Skill shall be rewarded, hitting the ball shall have a high skill cap so that it feels rewarding making a good hit
- The game shall mostly test player precision rather than reaction

2.2 Ball

Desirable behavior of the ball:

- Predictable bounce on wall to be fair regarding reaction time.
- No ball spin or oddly shaped ball (as oval) as wall bounces must be predictable.
- Preserve ball X speed during bounces to keep game at a steady pace and rhythm.
- Increase ball X speed slowly as game progress to keep games short and more tense.
- Not implemented. Consecutive "power" hits charge ball and keeps it charged until it eventually splits into two, triggering multiball, for more action and excitement.

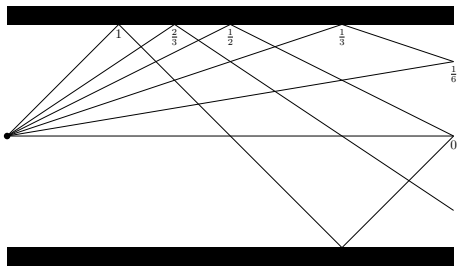

Figure 1: Illustration of different ball slopes and trajectories.

2.2.1 Slope

A 16:9 display with some space reserved for scores results in a playing field with an aspect ratio of 2:1. In order to get a maximum of one or two wall bounces per turn the ratio between X and Y speeds must be between 2:1 and 1:1. A number of slopes less than that must also be available for variation meaning those ratios between X and Y speeds must be possible to represent. Having zero slope should be reserved for serve to prevent an indefinite stalled game where both paddles are placed to bounce straight back and forth indefinitely.

2.2.2 Multiball

This section has some thoughts on multiple balls not implemented in the game. A charged ball splits on middle line with new ball bouncing. No split when bouncing on paddle as the two balls would be locked in the same X position. Scoring options:

- Dropping last scores - leaves room for strategy and is fair.
- Score each - unfair if too close, hard to balance.
- First scores and aborts - unfair if too close.

Splitting the ball creating more balls can make the game longer. Split balls should be kept slightly out of phase to avoid a tie situation and leave room for consecutive splits.

2.3 Paddles

Paddle behaviors considered but not implemented:

- Paddle acceleration increase skill cap to hit ball at high speed.
- Paddle movement in X direction.
- Reduce paddle size as game progress to make games shorter.
- Asymmetric paddle size for catching up.

- Triangle shaped paddle to let direction be affected by position of hit.
- Ball speed affected by paddle position and speed increase skill cap.
- Additional input to time the ball hit to enhance the feeling of the hit and timing for speed or other bonus.
- Placing paddles in a perfect straight forward position shall not cause an infinite game.

2.3.1 Bounce

By preserving the X component of the ball velocity game pace is not affected by bounce and the rhythm of the game is kept. The remaining y_o component of the outgoing ball velocity can be modeled as

$$y_o = \alpha y_i + \beta y_p + \gamma y_v$$

where y_i is the incoming velocity and, y_p and y_v are the contributions from the paddle position and velocity. The original pong and breakout with clones bounces typically has $\alpha = 0, \beta = 1, \gamma = 0$, and so does this implementation as well to keep the bounce simple and predictable. It would also be possible to preserve the bounce only in the middle, e.g. $\alpha = \{1 \text{ at middle}, 0 \text{ at edges}\}, \beta = 1 - \alpha$.

2.4 Serve

The timing of the serve is not player controlled to keep game at a steady pace. The serve is not a test of reaction, but a test of precision. To ensure both players are ready for a serve they place their paddles in a ready area in the center of their sides, where the serve will be received, see 3.1. Launching the ball from the middle towards the player serves as a pitch, after which the receiving player has control, e.g. having the serve is an advantage.

2.5 Autonomous players

In order to practice, test and demo the game one or two autonomous players, agents, can keep the game going when human players are passive. Autonomous players are not yet implemented.

2.5.1 Movement

To be fair, the agent control the paddle through acceleration as the human players. A binary D-regulator can be used to set the paddle acceleration to move against a target position. The target position can simply be the ball position or a linear prediction ahead of the ball. The paddle should not track the ball all the time but only when the ball is close enough, how close can be a skill-level parameter. When the target position is far from the paddle it can

pick a home position to be able to react faster. As an extension to hitting the ball the agent can get offensive, trying to hit the ball close to the edge of the paddle.

2.5.2 Engagement

The autonomous player engage after 10 seconds of inactivity on the ready screen, but never when a player is in the ready area. Also never while a game with scores is active as players may simply be inactive to pause the game. When an autonomous player is engaged the paddle color is desatured as an indication. When an inactive player becomes active the game is reset and the autonomous player disengaged.

3 Flow

The game loops between the ready/result and game states.

3.1 Readiness and results

Initially the paddles are placed outside of the ready area giving each player an opportunity to identify their side by moving their paddle (into the ready area). The ready area highlights when the paddle enters it to indicate that the player is ready. When both players are in the area it fades away as a countdown and the serve happens when the area is gone. If either player leaves the area during the countdown it is aborted and is restated once both players are ready again. During this phase the result from the previous game remains visible. The system is susceptible to one player stalling which is acceptable for this two player local game since playing is pointless unless both players are engaged.

3.2 Game pace

To control game pace and game length ball speed is increased every third bounce. Having an odd number of bounces between each increase helps to even out advantages between players. Constant linear ball acceleration parameterized by its initial velocity v_0 and acceleration a together with video parameters result in a gradually decreasing time between bounces and a higher pace in the game, see figure 2. In order to balance the low speed in the beginning with games that become fast quickly acceleration could be changed depending on current speed.

3.3 Scoring

Desired properties of scoring for a 1v1 match:

- Discrete and simple to make winning condition clear.
- Prevent draws.

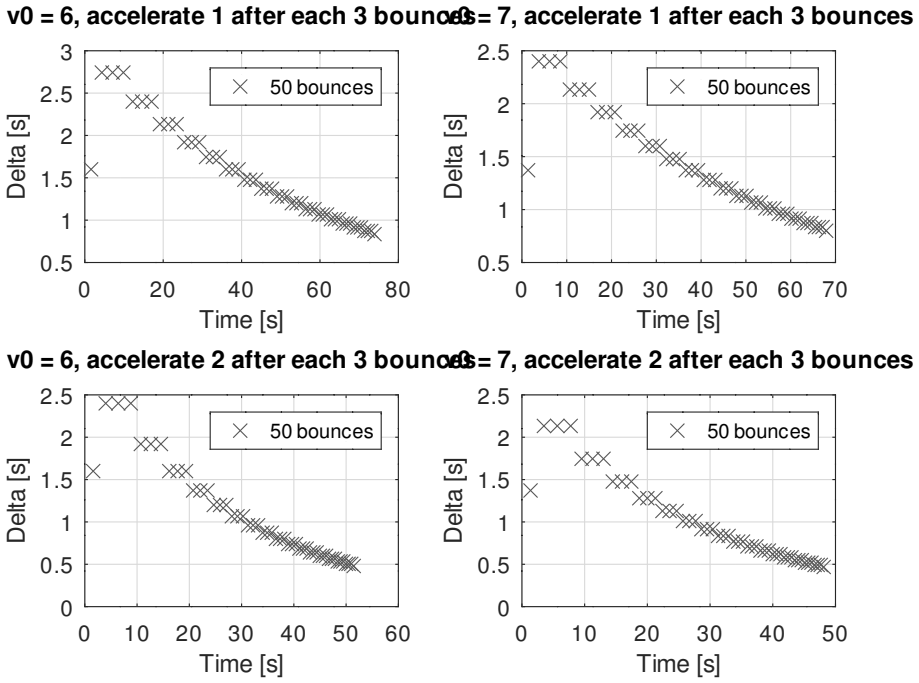

Figure 2: Time between bounces over time.

- Best of M best of N would increase tension but would make games long.
- Use absolute score counting for shorter games as relative advantage score counting would lead to longer games.

Settle for a simple first to N system with an empty bar to be filled up, setting the goal.

3.3.1 Catch-up

There are several options for catch-up, but none has been built into the scoring system to keep it simple and keep game length down.

Scoring area can be changed as game progress for evening out games, so that the player behind is never more than one point behind and it would make games shorter.

Based on score, an advantage such as serve or paddle size, is not good since the advantage is gone once the underdog has caught up simply prolonging the game.

An even or nothing scoring point in the middle of each paddle line keeps the game alive for players behind. The leading player would aim away from middle while the player behind aim anywhere at an advantage.

3.3.2 Many VS many

Tracking of score to engage players not in the current game, or a tournament, is currently left out as it is not part of the core game.

3.3.3 Presentation

Scores are displayed in a bar at the top of the screen. In case it is unclear that scores are counted when a ball is lost an effect could be used to make it more prominent. As player focus is on the ball an object originating from where the ball exited the screen moving to the score position in the score bar can be used to shift focus there. When counting scores positively the object would move to the opposite side of the screen, across the score bar. By counting negative scores instead the object would not cross the score bar and could be covering the "life" that is reduced for the player that lost the ball.

4 Graphics

Graphics are represented by rectangles that can be shaded using second degree 2D base functions to particularly create circles and gradients with alpha blending.

5 Audio

Basic waveforms and noise with sampled envelopes for pitch and amplitude are mixed to create stereo sound.

During the ready period when the active area fades out a countdown sound is used to add focus and tension to the game.

Audio effects when the ball bounces enhance the feeling of a rhythm in the game. Hitting the paddle is a positive event while bouncing on the wall is neutral.

When a player scores it is marked with a positive sound.

An experiment was made with ambient sound following the ball to emphasize the focus of the game, then silence to mark the serve. This did not give the attended effect and was removed.