Imaginary Reality Basketball: A Ball Game Without a Ball

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Abstract

We present *imaginary reality basketball,* i.e., a ball game that mimics the respective real world sport, i.e., basketball, except that there is *no visible ball*. The ball is virtual and players learn about its position only from watching each other act and a small amount of occasional auditory feedback, e.g., when a person is receiving the ball.

Imaginary reality games maintain many of the properties of physical sports, such as unencumbered play, physical exertion, and immediate social interaction between players. At the same time, they allow introducing game elements from video games, such as power-ups, non-realistic physics, and player balancing. Most importantly, they create a new game dynamic around the notion of the invisible ball.

Author Keywords

Physical gaming; augmented reality gaming; probabilistic; imaginary interfaces; motion capture.

ACM Classification Keywords

H.5.2 [Information interfaces and presentation]: User Interfaces.

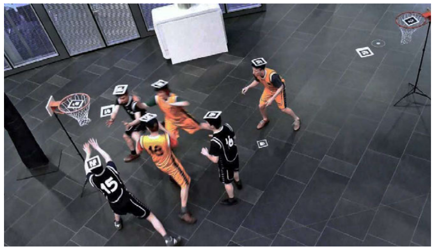

Figure 1: Six players in a game of *Imaginary Reality Basketball*. Player 15 on the Black team has thrown the *imaginary ball* at the basket and scored. There is no visible ball; players get all information from watching each other act and a small amount of auditory feedback.

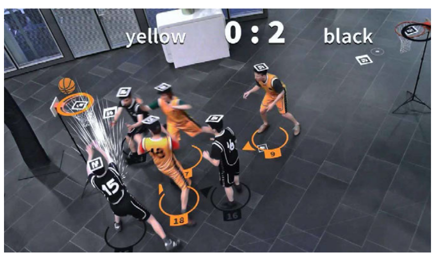

Figure 2: Under the hood & invisible to the players, the system represents the imaginary ball as a large number of *ball particles,* each of which represents one plausible ball trajectory. Players are tracked using hand-worn accelerometers and marker hats followed by an overhead camera.

Introduction

Sports, such as soccer or basketball, offer many desirable qualities. They are highly immersive [2], lead to physical exertion, and create immediate social interaction between players. Unfortunately, physical games are limited by the constraints of the real world, restricting their game mechanics to what is physically possible.

Researchers have tried to merge physical and virtual play in display-based augmented reality games such as Human Pacman [3] or AR Quake [5]. These games overlay a virtual world onto the physical world using hand-held or head-mounted see-through displays. This allows these games to introduce virtual game elements, such as power-ups or creating virtual game elements that are not limited by the rules of physics.

Unfortunately, the use of displays takes away many of the qualities of physical sports, as players now perceive the world only indirectly through displays, which are of limited resolution, limited field of view, and exhibit inevitable lag. This causes many subtleties to be lost, such as details of body language, facial expressions, and co-player actions taking place in the user's visual periphery.

We propose a different approach: We drop the displays, thus creating a sort of "screenless AR" (elaborating on the notion of screenless mobile devices called *imaginary interfaces* [4]). Instead, players obtain most of the information they need to play from watching co-players' positions, movements, and gestures. In addition, but only where necessary, we provide a small amount of auditory feedback to disambiguate. The result is a new class of interactive games.

Imaginary Reality Gaming

Figure 1 shows a scene from imaginary reality *basketball*, one of the games we have implemented [1]. Like every imaginary reality game, it mimics the respective real world sport—except *there is no visible ball*. Players learn about the position of the virtual ball by watching each other act (unlike [6]). Occasionally, players *hear* the ball make contact with a physical object or being played by a person, which disambiguates the ball's location. In between, the ball position is *uncertain*. The scene ends with Player *15* on the Black team is throwing the imaginary ball at the basket, scoring.

Figure 3 shows a scene that progresses as follows:
(a) Player *9* on the Orange team (top left) chest passes the ball towards his teammate *18*. (b) *18* receives it (Audio: "eighteen") and (c) tries to pass it back to *9.*
(d) Unexpectedly, *16* from the Black team intercepts the pass (Audio: "sixteen"). He starts running towards the basket and (e) dunks the ball. (Audio: "Score! Two-zero for Black").

As mentioned earlier, imaginary reality games cannot only emulate real-world sports, but they also allow us to introduce power-ups and non-physical behavior, thereby introducing some of the richness of video games into physical sports. Figure 4 and Figure 7 illustrate this at the example of the "get-ball" and the "safe" power-ups, which appear periodically with an audio announcement over the marked center location of the playfield. Both figures use the "debug" view of our system, which reveals the ball etc; the players do not see any of this additional information.

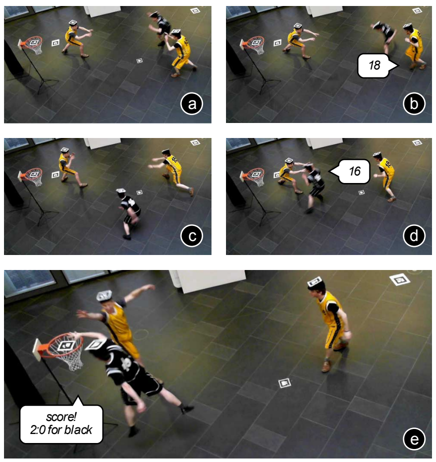

Figure 3: A game sequence in imaginary reality basketball leading up to a slam-dunk.

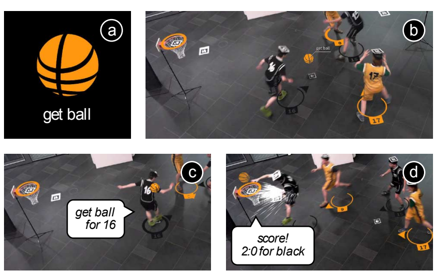

Figure 4: Imaginary reality games can offer non-physical elements in the form of power-ups. Here, the "get-ball" power-up provides the player picking it up with immediate possession of the ball.

System Architecture

As illustrated by Figure 5, the imaginary reality games system consists of three main components. The *tracking system* tracks players and their gestures (as well as playfield boundaries, baskets, and power-up locations). It reports player moves to our custom physics engine, which we call *quantum engine*. The quantum engine simulates the imaginary ball, computes the probabilities of outcomes, and reports these to the *game engine*. The game engine refines probabilities by applying handicaps and power-ups, etc. It then determines the outcome of the game move randomly based on these probabilities. Finally, the game engine conveys its decision to the players using auditory feedback.

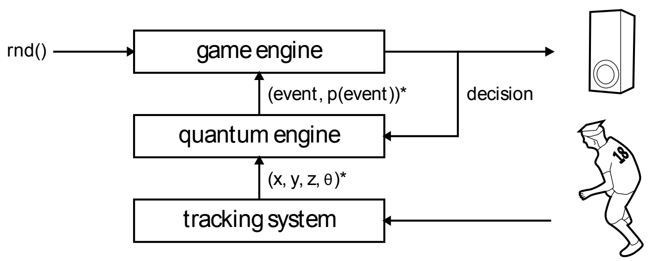

Figure 5: Imaginary reality games system

Figure 6 shows our tracking solution. An overhead camera (Microsoft LifeCam 1080p) monitors the 6×4m playfield. It tracks players' head position and orientation based on head-worn ALVAR markers (http://virtual.vtt.fi/virtual/proj2/multimedia/alvar). To allow the system to sense gestures, players wear tiny accelerometers with radio senders on their hands and belts (*Axivity,* http://axivity.com). A simple peak detection algorithm extracts players' game gestures, such as jumping, throwing, or catching a ball.

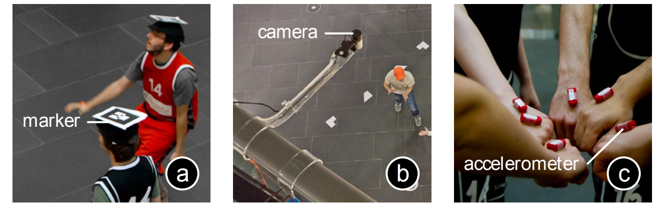

Figure 6: Our Tracking is based on (a) *ALVAR* markers (b) a webcam, and (c) hand-worn accelerometer (*Axivity*).

Imaginary Physics

The quantum engine is the key component of the imaginary reality system. It allows players to successfully play the ball, despite the uncertain ball location and despite the only approximate tracking.

Traditional approaches of handling imprecise input, such as enlarging targets, area cursors, sticky targets and target gravity techniques do not work for imaginary reality games, as they interfere with gameplay when scaled to this level: as illustrated by Figure 8, enlarged or magnetic players tend to fully "occlude" players behind them, preventing those players from *ever* getting the ball.

The quantum engine therefore takes a different approach: it first samples *all* plausible outcomes of the current move and their probabilities *and then* makes a well-informed decision, i.e., it chooses in *hindsight* which of the possible outcomes to "make real". Rather than computing the trajectory of *the* ball, it computes the trajectories of *many versions of* the same ball (500 of them). It does so by representing the ball as a collection of *ball particles*, each of which represents one plausible trajectory of the ball. The system's debug view (Figure 2) reveals the trajectories of ball particles as white lines. The quantum engine evaluates each particle using regular Newtonian physics. It then

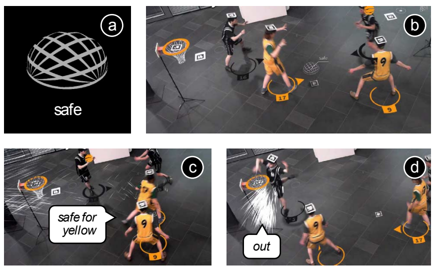

Figure 7: The "safe" power-up protects a team's basket. This prevents the opposing team from scoring.

aggregates the probabilities of each outcome and passes them on to the game engine, which applies modifiers, and decides on the outcome.

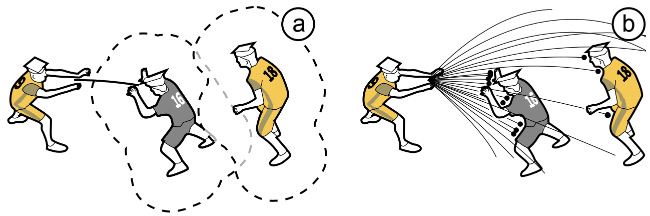

Figure 8: (a) Traditional enlarging of players helps pass the ball but also prevents the player on the left from *ever* passing past the opposing player in the middle. (b) The quantum engine instead samples all plausible ball trajectories, allowing it to pick outcomes that lead to enjoyable game play.

As illustrated by Figure 8b, our particle approach allows handling situations with multiple competing targets. As the shown player passes the ball, some ball particles hit the teammate, some the opposing player, and some go out. The quantum engine determines the raw probabilities of the three outcomes by simply counting particles. In order to increase the probability of enjoyable gameplay, the game engine now increases the probability of the pass to the teammate and decreases the probability of the ball going out. Finally, it makes the decision randomly according to these probabilities and announces it to the players.

Evaluation

We conducted a qualitative study with 30 participants (7 female) in the form of five 3 vs. 3 imaginary basketball matches on a 6×4m court. On a Likert scale (1 = unpleasant, 7 = enjoyable), participants rated game play as 5.9, so clearly enjoyable (details in [1]).

Conclusions

In this paper, we presented imaginary reality basketball, a physical ball game without a visible ball. Our main contribution is the game concept itself, which creates a class of games around an invisible ball. Our main engineering contribution is the quantum engine, a parallel physics engine that (1) allows optimizing gameplay, (2) can make decisions in hindsight, and (3) helps beginners get into the game, yet that (4) favors skillful play. As future work, we plan to explore the concept more broadly, to create more instances of imaginary reality games on a variety of platforms and at different scales.

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