Collaborative Digital Sports Systems that Encourage Exercise

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Abstract. Although the importance of health and exercising as a way to maintain fitness and physical wellbeing is widely recognized, it is often difficult for people to persist with a regular workout schedule. In this paper, we propose a solution to this problem through "Collaborative Digital Sports." This is a digital sports environment where participants are given a shared goal. Through the use of body motion sensors and video projection feedback, this environment works as a fitness playground that requires physical movements by participants. This environment is adaptable to the fitness levels of the participants, as its sensor-feedback loop is digital and unencumbered by real sports equipment. Based on this concept, we designed and implemented two collaborative digital sporting activities. The "Group Jump Rope Orchestra" is a simulated jump rope environment where people are required to synchronize jumping over a projected rope as it periodically swings by. The "How Many Legged Race!?" is a variation of the three-legged race that can accommodate any number of participants as they synchronize their steps. We tested these sports environments with numerous participants and discovered that the cooperative nature of these digital sports helps motivate the players and fosters a shared sense of caring among them.

1 Introduction

Fitness is an effective exercise to maintain and enhance health. However, exercising alone can be tedious and demotivating, and hence difficult to continue with on a regular basis. In contrast, competitive team sports, such as soccer and basketball, demand that each player exhibit responsibility and make a serious effort. However, players need a certain degree of training and skill in order to enjoy sports.

We thus propose "Collaborative Digital Sports," an environment that aims to keep users motivated to exercise. This environment effectively combines digital technology with the social aspect of team sports to enable users to stay motivated to work out, and also nurtures camaraderie among them. In this paper, we describe two instances of collaborative digital sports systems and report on feedback from the participants.

2 Collaborative Digital Sports

We define Collaborative Digital Sports as composed of the following three elements:

1. Encourages collaboration among participants
A collaborative sport is a competitive physical activity that requires that all participants work together. The collaborative element encourages participants to make an effort, stay committed to the activity and not give up because they are part of a team.
2. Easy to play
Complicated rules make it difficult for people to participate in any activity. We have kept the rules of the sports and the required movements simple, so that anyone can play.

3. Adaptable
In order to keep participants motivated, we make use of digital technology so that the parameters of the sports – the skill level of the sport, the number of participants, etc. – can easily be adapted to the situation. We believe that this flexibility in the design of our digital sports prevents participants from abandoning the activity on account of boredom or lack of skill, and also enhances their enjoyment.

We have implemented two examples of collaborative digital sports systems in accordance with the aforementioned elements. The first sport is "The Group Jump Rope Orchestra", which is modeled on the game jump rope and orchestral music. The second sport is "How many legged races!?", which is a variation of the well-known three-legged race. Both sports involve teamwork.

3 Example 1: Group Jump Rope Orchestra

Group Jump Rope Orchestra is a collaborative digital sport system that is a mixture of the game jump rope and the dynamics of an orchestra. In this sport, the participants jump over a virtual rope that is projected onto two screens, one on the floor under the participants' feet and the other on the wall, as shown in Fig.1. Their collective activity causes orchestral music to play.

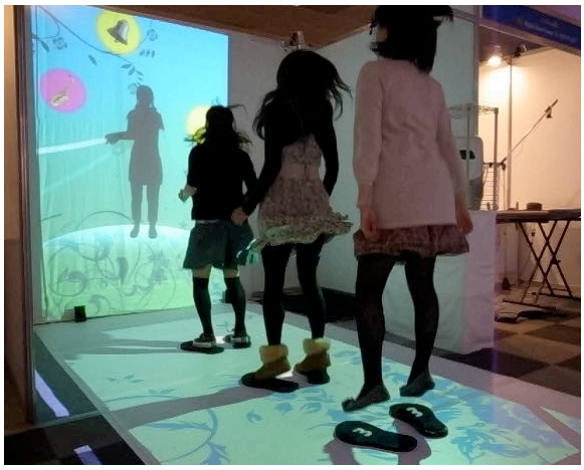

Fig. 1. The Group Jump Rope system. A virtual rope is projected on two screens at the front and the floor. Participants jump when the rope passes under their feet.

Elements of Group Jump Rope. Group Jump Rope is a sport that involves two players holding a long rope and swinging it together, and any number of players in between them trying to jump over the rope so that it passes under their feet and over their heads. The game becomes more challenging as the number of players increases. In order to succeed at it, all participants have to adapt to a shared pace and rhythm. This instills a sense of unity and collective satisfaction in them.

Orchestral Elements. An orchestra consists of a large group of musicians playing different instruments. The music becomes grander as the number of musicians and instruments increases. In order to sound harmonious, all musicians need to play their respective parts in accordance with the directions of the conductor.

The first of our two digital sports combines the elements of Group Jump Rope and an orchestra.

3.1 System Configuration

The system consists of two screens, two projectors, pressure sensors embedded in foot-shaped sponges, two speakers, phidgets (USB I/O module), and a PC (Fig.2). Two animations are projected on two screens, one each on the floor under the players' feet and on the wall facing them. The front screen shows a girl swinging a rope, while the image of a rope swinging in correspondence with the movement of the girl's arm is projected on the screen on the floor. The pressure sensors embedded in the foot-

shaped sponges on the screen on the floor detect whether the participants are jumping at the right time. The sensors are connected to the phidgets[1] and the PC, which produce relevant animations and sounds. The PC – a MacBook Pro – runs the Adobe Flash Builder software.

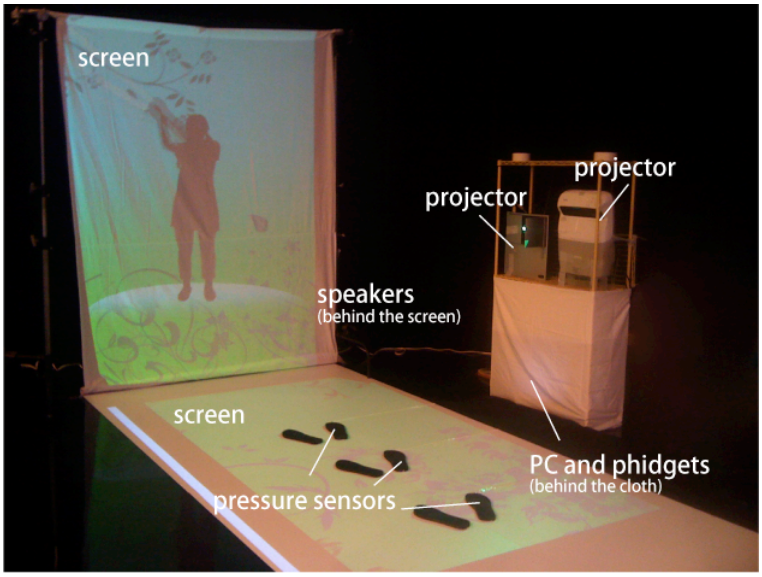

Fig. 2. System configuration for Group Jump Rope Orchestra.

3.2 Usage and Feedback

The virtual rope makes a sound as it "brushes" the floor, at which time the players are supposed to jump over it. When one player jumps at the correct time and avoids the rope, the sound of one orchestral instrument – a violin, say – is played. When another player does the same, the sound of another instrument is played. When all players jump at the correct time, all instruments in an orchestra are played. A new participant can join the game at any time. Pictures of the musical instruments being played are projected onto the front screen according to the number of players and the instrument "played" by each player (Fig.3-1). If a player fails to clear the virtual rope, the music stops, a discordant sound is played and the animation changes as shown in Fig.3-2. If the participants manage to play an entire piece of music, the sound of applause is played and the animation changes, as in Fig.3-3.

Participants of the Group Jump Rope Orchestra system have a variety of musical compositions and animations to choose from. The speed of the rope can also be adjusted.

[1] Phidgets: http://www.phidgets.com/

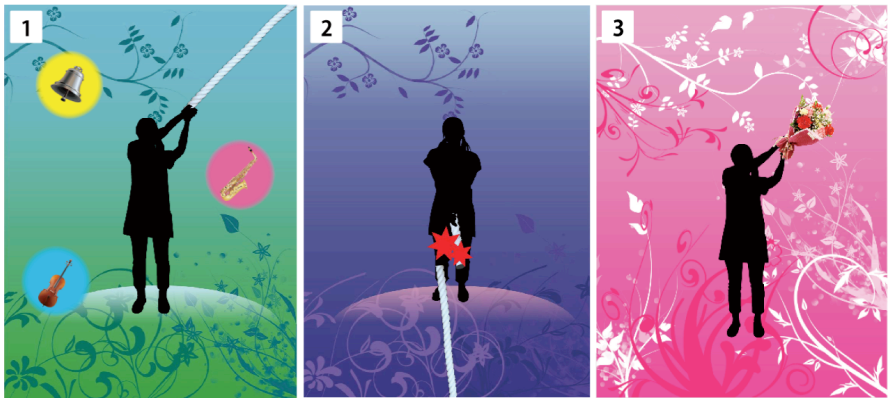

Fig. 3. The front screen animations: (1) Pictures of musical instruments appear according to the number and the role of the participants. (2) When someone fails to clear the rope, the music stops, a discordant sound is played and the animation changes. (3) When the musical piece is successfully played to completion, applause is heard and the animation changes.

4 Example 2: How Many Legged Race!?

"How many legged race!?" is a Collaborative Digital Sport that combines the three-legged race and digital technology. A three-legged race is one in which a team of two people runs together, with one person's right leg tied to the other person's left leg. This sport requires that the participants cooperate and synchronize their steps to move forward quickly. As the number of players per team increases, to a maximum of four in our system, the race becomes more challenging.

Fig. 4. Overview of How Many Legged Race!?

4.1 System Configuration

This system consists of a screen, a projector, two pressure sensors per participant, a Gainer (USB I/O module)[2] and a PC (Fig.5). A screen is set in front of the participants and a simulation is projected. When all participants step in concordance, the simulation moves, enabling the participants to take a video tour of the simulated environment while racing. The software runs on Flash and the values of the pressure sensors are obtained through Gainer.

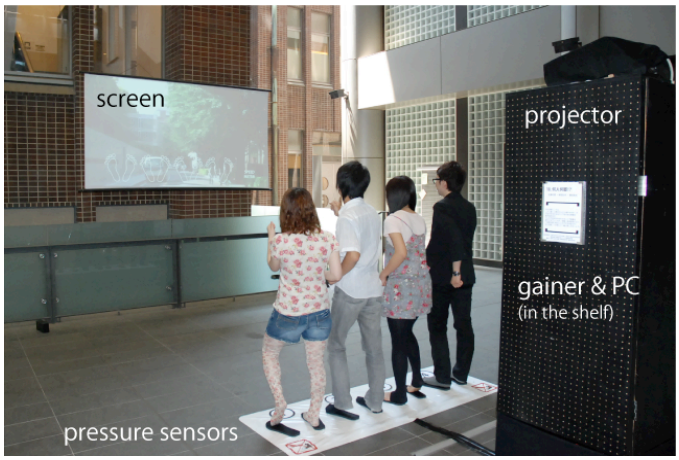

Fig. 4. System configuration of the "How Many Legged Race!?" system.

Use of sensor values. The values from eight pressure sensors, in case four players are involved, are used to detect two factors: the number of participants and the harmony of each team's step. As shown in Fig.6, if sensors 1 and 2 are pressed, the system detects one player; if sensors 3 and 4 are pressed, the system detects two players, and so on. A new player can join in at any time. In contrast with the Group Jump Rope Orchestra system, the speed of the players' movement is not determined by the system in this sport. Participants can move at the pace of their choice so long as all players in a team move at the same speed and step in concert. Unlike the actual three-legged race, teammates in this digital incarnation do not actually have adjacent feet tied together, and so can easily join into or drop out of the game. However, each player still needs to move as if one of her feet were tied to that of her partner's. For instance, when there are two players on a team, they should take steps 1 and 4, and 2 and 3 in concert. When a team consists of four players, they should take steps 1, 4, 5 and 8, and 2, 3, 6 and 7 in concert.

[2] Gainer: http://gainer.cc/

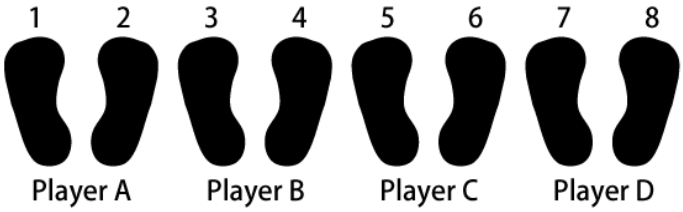

Fig. 5. (1) The number of players and (2) whether they are stepping correctly are both detected from the values of pressure sensors.

4.2 System Usage

The system launches when participants step on the foot-shaped contours and start walking or running. The participants can see if their steps have been detected on the screen before them. The screen also indicates participants' speed. When a team's stepping is concordant, the virtual video on the screen progresses; and when a team's steps are discordant, its indicated speed decreases, all the way to a complete stop if the team does not correct its step. The players can control the speed of progression of the movie by stepping quickly. The greater the number of players per team, the faster its speed.

5 User Experience

We tested these two sports systems with numerous participants at exhibitions and through demonstrations at conferences. In this section, we report the feedback from a wide range of participants.

The Group Jump Rope Orchestra system was exhibited for three days at the finals of the International Virtual Reality Contest[3] (IVRC), held at National Museum of Emerging Science and Innovation (Tokyo, Japan) from August 23-25, 2010. It was also demonstrated at Entertainment Computing conference in Japan in 2010, and at the ACE in the same year [5]. We will report the results of our IVRC exhibition, where visitors of all ages took an interest in the system.

A number of children visited our exhibit and began playing Group Jump Rope Orchestra even before being instructed, and seemed to enjoy it a lot. They returned to our exhibit several times to play the sport over and over again. It seemed that people were more motivated to play with others than alone. A few children were initially scared to play the game but enjoyed it a lot once they tried it. People who were initially poor at the sport improved markedly with time, and even asked us to raise the skill level.

[3] IVRC 2010: http://ivrc.net/2010/

The How Many Legged Race!? was shown for six days at an exhibition at the University of Tokyo from June 10-15, 2010. It was also demonstrated at the Virtual Reality Conference in Japan in 2011. Most reactions to the system were similar to those to the Group Jump Rope Orchestra. Most participants were calling out "one, two, one, two..." as they took steps in order to keep step with each other. It appeared that this practice made them feel more motivated and friendly.

We also noticed that safety was a major attraction of these digital sports. The danger of serious injury often inhibits people from playing physical sports. Our digital sports have no such associated risk, which is a major advantage.

6 Related work

Many studies have been conducted on supplementing sports with digital technologies. PingPongPlus adds visual effects to a ping-pong table by sensing ball-impact timing and position using acoustic sensors [1]. Although the visual appearance of the game is altered, the game remains unchanged. In contrast, Eureka Computers introduced "E-Sports Ground," where a projection on a floor becomes a major part of the sport [2]. Since a player's motion is recognized by 3D sensors (such as Kinect), it is possible to design digital sports without using physical instruments. For example, players can "kick" a projected virtual ball. Our collaborative sports also use digital projection and sensors and introduce the idea of collaboration to foster camaraderie and keep players motivated.

Rope Revolution combines physical rope motion with digital projection [3]. Similar to our Group Jump Rope Orchestra, Rope Revolution supports multiple players on the same field. Combining physical equipment with digital sports would provide greater engagement between player and sport, but it might also limit sport design flexibility. For instance, with the use of a real rope, it becomes more difficult to change its speed according to the player's skill. We choose a fully digital solution for our sports systems because of its flexibility and cost-effectiveness. We also think that our collaborative sports scenarios are sufficiently real to prompt players to actually use their body movement.

"Jogging Over a Distance" supports communication between and among joggers [4]. Combining GPS and 3D audio, it supports pace-awareness between runners, so that collaborative or competitive running is possible even when runners are geographically separated. At present, our systems only support co-located collaboration, but we also think that our design can be extended to accommodate distributed collaboration.

7 Discussions

7.1 Tradeoff between Reality and Flexibility

In our design, we have chosen purely digital environments where the feedback to participants is in the form of image projection and sound effects and no sporting equipment is used. At the same time, we could also design a similar environment with a hybrid of real and virtual objects, as in the case of Rope Revolution [3].

We think that there is a tradeoff between the two approaches. On the one hand, participants using physical instruments, such as an actual rope or a real racket, might experience the sport more realistically and would be able to engage it more seriously. They might also be able to better use their bodies with the real instrument, such as spinning the rope or swinging the racket. On the other hand, such physical instruments might limit the flexibility of the sporting design. For instance, when the motion of the simulated rope is directly correspondent to a real rope, it might become difficult to control its speed according to the skill-level of the participants. In addition, fully digital sporting environments might be less expensive than real ones. We also expect that giving players a common goal would help them take the sport more seriously, even when the environment does not have a physical instrument.

7.2 Possibility of Distributed Collaborative Digital Sports

In our current systems, the participants are expected to gather at the same place and work out. We are now considering extending this to a distributed version, where people can remotely participate in the same sports field even when they are geographically separated. For example, a distributed version of Group Jump Rope Orchestra would connect players to their remote teammates by showing their body motions as projected silhouettes. Other communication channels, such as audio, would also be used. In addition to normal voice communication among participants, this audio channel would also convey nonverbal information, such as the sound of their footsteps. We expect that the existence of a common goal would help keep players motivated to play, even in a distributed environment.

8 Conclusion

In this paper, we proposed “Collaborative Digital Sports”, a digital sports environment where participants are given a shared goal. We designed and implemented two example systems based on the concept of Collaborative Digital Sports, and tested with numerous participants at exhibitions and conferences. The feedbacks from these places confirmed that these systems motivated participants. We believe that there still is a potential for this Collaborative Digital Sports such as adjusting levels on each participant, and using in distant places.

References

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