Development of the Motion-Controllable Ball

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ABSTRACT
In this report, we propose a novel ball type interactive interface device. Balls are one of the most important pieces of equipment used for entertainment and sports. Their motion guides a player's response in terms of, for example, a feint or similar movement. Many kinds of breaking ball throws have been developed for various sports(e.g. baseball). However, acquiring the skill to appropriately react to these breaking balls is often hard to achieve and requires long-term training. Many researchers focus on the ball itself and have developed interactive balls with visual and acoustic feedbacks. However, these balls do not have the ability for motion control. In this paper, we introduce a ball-type motion control interface device. It is composed of a ball and an air-pressure tank to change its vector using gas ejection. We conducted an experiment that measures the ball's flight path while subjected to gas ejection and the results showed the prototype system had enough power to change the ball's vector.

Keywords: Ball interface, augmented sports, air pressure

ACM Classifications: H5.2 [Information interface and presentation]: User Interfaces.

General terms: Experimentation, Human Factors

INTRODUCTION
Balls have been developed and used for various sports and games since ancient times. In recent years, the progress in interactive technology has enabled us to develop nontraditional balls, which are equipped with various sensors and displays [1]-[5]. In these studies, balls are represented by visual and acoustic media and produce new and intuitive interactions that use the change of a ball's color and the output of a sound. However, these studies have not referred to the motion of the ball. Many ball players intuitively react to the ball trajectory. this means the motion of the ball is an important source of information for ball game players. For example, a breaking ball can demand a certain strategy from the ball thrower. The goal of the motion-controllable ball project is to develop a ball that can change its vector by unexpected or expected timing for the opponents. Such a ball should provide us with a new way for humans to interact. In this paper, we suggest applications and introduce a prototype.

UIST'10, October 3–6, 2010, New York, New York, USA.
ACM 978-1-4503-0271-5/10/10..

RELATED WORKS
Much research has been carried out on ball-type interfaces.
For example, Izuta et al. developed a ball called the "Bouncing Star" [1]. It is a rubber ball for sport that is equipped with LEDs, a wireless module and various sensors. It can control the LED's color by the action of the ball as detected by various sensors.
Tsukada et al. developed a ball called the "Chameleon Ball" [5]. It is an acrylic ball that is equipped with a color sensor, a proximity sensor and LEDs. The color sensor reads the color of the object that is detected by the proximity sensor and changes the ball's color to the same color as the object.
Gili et al. developed a ball called "The Embroidered Musical Ball" [2]. It is a soft ball that has an embroidered pressure sensor inside it. It can emit various sounds from a PC by simple physical gestures such as squeezing and stretching.
These studies enabled new types of interactions with balls, but the techniques were limited to visual or auditory effects (e.g. changing color or generating sounds). Focusing on the motion of the ball will generate a novel way to interact with balls. Therefore, we propose a ball that changes its vector.

THE BALL THAT CHANGES ITS MOTION VECTOR
In ball sports, the presence of a breaking ball generates a playing strategy between players and makes the ball sport more interesting. For example, breaking balls (e.g. a forkball, curveball, etc.) that exist in baseball generate interactive strategies between the pitcher and batter. However, aerodynamic components that generate a breaking ball mainly depend on the speed of the pitched ball. If it is slow, the ball cannot generate a major change of vector. In addition, the desired change of vector is hard to control because it requires long-term training. Therefore at present it is possible to change the vector of the ball only in limited situations. In this paper, we suggest that it is easy to generate a vectorial change in a ball's flight. More precisely, we suggest its vector can be changed without special training. Once this method is established, the ball that changes its vector can be used for various situations. Some examples follow.

Dodgeball with vectorial change of ball
Dodgeball is a ball sport in which players participate both outside and inside the court, and that involves hitting a ball to an opponent inside the court. Players can pass the ball between the outside and inside of the court through the inside court of opponent's team. If the vector of the ball is changed, the ball can hit the opponent with unexpected timing.

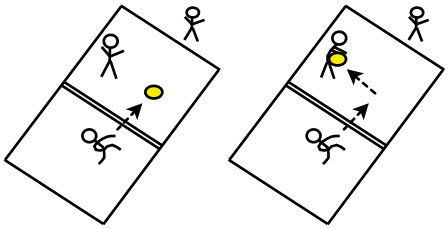

Figure 1: Dodgeball with vectorial change of ball. We can pretend to pass the ball to a teammate and hit the ball to an opponent.

Adjustment for difference in ability

In a ball sport (e.g. baseball, dodgeball), if the difference in ability between the teams is great, this system may have potential to reduce this difference in ability by permitting only one team to change the ball's vector.

SYSTEM

The assumed condition (e.g. usage environment) materially affects the system. For example, if we use a ball that rolls on the ground, we need to construct a system that considers the rotation of the ball and the force that arises between the ball and ground. In this paper, we suggest a method that focuses on a "ball moving through the air at low speed".

In this study, to create a vectorial change, we use the injected pressure of gas stored in a tank within the ball.

Apart from the outlet, a button that opens and controls the outlet is attached. The control of the injected gas is achieved by holding the button down using a servomotor attached to it. Figure 2 shows the system structure.

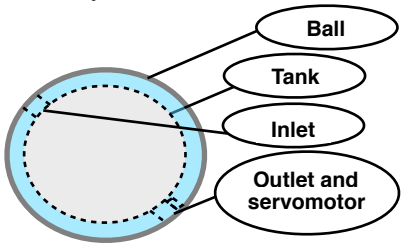

Figure 2: The structure of the prototype system. A ball for random change of its vector creates by single-shots of gas ejection.

In the future, a method to affect the change in direction of the ball during a ball game is necessary, for example, push the button on the ball to eject gas a few seconds later, recognize a gesture of a player inside the playing field, receive an indication of a player outside the playing field, and so on. These methods must be proposed along with the game design because they should differ from game to game.

PROTOTYPE AND EXPERIMENTATION

To confirm the viability of the above system, we made a prototype. The ball's diameter is 16cm and the device weighs 500g. The ball used was a Phlat Ball from Tucker Toys Inc., and the tank used the long magazine from a toy gun, the Walther P99 from MARUZEN. Figure 3 shows the prototypes of the device and tank.

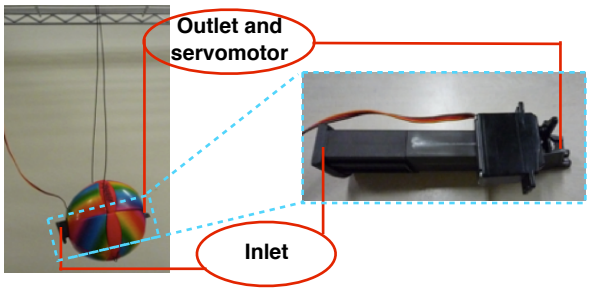

Figure 3: Prototype (left) and the tank (right).

We measured the flight distance of the prototype. We filled the tank of the prototype with gas and hung it up by a string (as in Figure 3). In this configuration, we ejected gas from the tank. The gas ejection caused flight of about one meter parallel to the ground. This flight was caused only by the gas ejection; therefore it was adequate for changing the ball's vector by gas ejection while the ball is flying. From this result, we confirmed that it was possible to change the ball's vector using the prototype system as indicated.

CONCLUSION AND FUTURE WORK

In this paper, we proposed a ball whose vector is changed by gas ejection from a tank within the ball. We measured the flight distance of the prototype and confirmed the possibility of a vectorial change. However, our system does not yet have the ability to allow control of the vector by the player. The control of the vectorial change is random at this time.

In the future, we will improve the gas ejection system and develop a control system for the vectorial change of the ball. We also plan to install image recognition technology and other sensors, like accelerometers and gyrometers, to be used in the control system.

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