Application of Archery to VR Interface

Masasuke Yasumoto[1(✉)] and Takehiro Teraoka[2]

[1] Faculty of Information Technology, Kanagawa Institute of Technology, 1030 Shimo-ogino, Atsugi, Kanagawa 243-0292, Japan
yasumoto@ic.kanagawa-it.ac.jp

[2] Department of Computer Science, Faculty of Engineering, Takushoku University, 815-1 Tatemachi, Hachioji, Tokyo 193-0985, Japan
tteraoka@cs.takushoku-u.ac.jp

Abstract. A game controller that imitates a real object can provide a realistic experience. For example, a gun-type controller and a handle-type controller can give players a realistic experience of shooting and racing, respectively. In this paper, we present multiple interfaces comprising a bow and its components that we have developed and enhanced for application to different games and playing styles. Through these explanations, we demonstrate the potential of these interfaces for game application to xR.

Keywords: VR · Interface · Bow

1 Introduction

Various interfaces have been developed in the game field so far. In general, these interfaces are not generic but are limited to special use. For example, there is a gun-type controller for a shooting game, a handle-type controller for a racing game, and so on. These days in the xR field, applications for games are constantly coming out, but in the case of VR using HMD, the general purpose controller is mostly used. The reality offered by the controller is increased by supplementing it with images.

With AR and MR, it is difficult to compensate with CG images because players can actually see the handheld controller. They can also see the surrounding environment in the real world, so the reality of the controller itself needs to be enhanced in order to achieve an immersive experience.

In light of this background, we have focused on the bow as an instrument of reality and have developed various bow-shaped interfaces. Bows have been used all over the world for eons, so most people are familiar with the basic operation without having ever touched one. Also, the bow requires analog operation, in contrast to, say, a gun, which makes it safer than a gun, and people tend to feel it is fun to operate. To enhance the reality of the bow-shaped interface, in addition to the appearance, the force reality and force feedback are important; therefore, we have applied a bow and bow components to multiple bow-shaped interfaces by measuring parameters based on a real bow.

C. Stephanidis (Ed.): HCII 2019, CCIS 1033, pp. 90–95, 2019.
https://doi.org/10.1007/978-3-030-23528-4_13

Fig. 1. Bow-shaped interfaces in use. (Left: “Light Shooter”. Center: “3rd Electric Bow Interface”. Right: “VAIR Bow”.)

Our multiple bow-shaped interfaces are shown in Fig. 1. The “Light Shooter” with Electric Bow Interface [1] is based on a traditional Japanese bow and is used in combination with a projector. The “3rd Electric Bow Interface” [2] is based on a western recurve bow and is a standalone system incorporating a mobile projector and a computer. The “VAIR Bow” is a VAIR Field device [3] that is part of the new physical e-Sport trend; it has been developed with a smartphone and an HTC VIVE Tracker.

In this paper, we describe the characteristics of the bow and the systems that implement these interfaces.

2 Bow-Shaped Interfaces

2.1 Bow Form

The bow-shaped interfaces that we developed are divided into a Japanese bow type (e.g., the Light Shooter) and an archery type (e.g., the 3rd Electric Bow Interface and VAIR Bow), as shown in Fig. 1. The Japanese bow has a structure in which the limb and the grip are integrated, while the archery bow’s limb and grip are divided. These bows also have a different way of setting the arrow: if the shooter is right-handed, the arrow needs to be set on the right side with the Japanese bow and on the left side with the archery bow. The Japanese bow has no attachments (e.g., scope), while the archery bow can be attached with a stabilizer, a clicker, a damper, and so on to enable stable shooting. In light of these features, the archery type is the more suitable device for a VR environment.

However, using these devices in the VR environment poses several difficult problems. First, they do not have a rigid body, as they are designed to curve and bend. It is not easy to fix various sensors to this type of structure, so durability is a problem in areas with strong movement. In fact, our initial prototype bow-shaped interface, which had sensors on the string and electrical wires, was not durable enough and the string broke after only a few shots. This happened not only because the string was tensioned but also because the string vibrated violently after shooting. In addition, for safety reasons our device used an air shot without an arrow, and this air shot also contributed to the low durability.

Another problem is the impact that the bow itself receives when a player draws and shoots. This impact actually disables the sensors attached to the

Fig. 2. Depiction of player drawing a VAIR Bow. HTC vive tracker and strain gauges are integrated into the bow's grip and bottom of the limb, respectively.

device. For example, an inexpensive acceleration sensor can obtain data with a margin of plus or minus two grams; however, there is much more acceleration than that when a bow is used, so it is easy to damage the sensors. Therefore, the 3rd Electric Bow Interface uses a 9-axis IMU, which has high durability with a margin of plus or minus 16 grams.

2.2 Bow Information

The requirements of bow-shaped interfaces vary depending on whether the application is for game playing or sports training. In the case of game playing, the most important thing for players is to feel good and have fun, while for sports training, it is more important for the players to feel like they're using something real. Our interfaces were developed for game devices, but the information they obtain during usage is accurate enough to be used in sports.

Our bow-shaped interfaces obtain three items of information: the direction of player's aiming, the position of the device, and the degree of player's drawing the string. First, the direction of aiming is the direction of shooting a virtual arrow. When a player aims with the scope attached on the device, the point that the scope reticle shows is the shooting direction.

The player's position can be calculated by the angle of the bow and the direction of shooting, assuming that the player's position is fixed. The 3rd Electric Bow Interface utilizes this approach by using a sensor integrated into the device to obtain the parameters of the device's position. However, different players have different heights, different arm lengths, and different ways of holding the bow, so the relative position of the device from a fixed point (such as the ground) should be measured in order to calculate more precise parameters. The absolute position is also required if the player moves with the device on while playing the

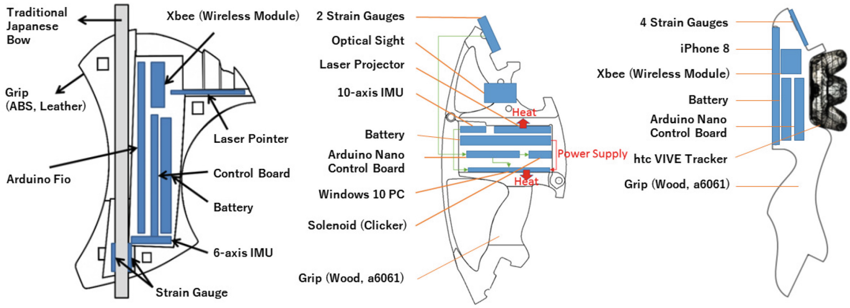

Fig. 3. Construction of interfaces. (Left: "Light Shooter". Center: "3rd Electric Bow Interface". Right: "VAIR Bow".)

game. When the player draws and shoots the bow from a fixed position, this positional information is required. The VAIR Bow, which is our latest interface, obtains the positional information by integrating an HTC vive tracker, as shown in Fig. 2.

The degree of player's drawing the bow is related to the flight distance and speed of the arrow. The larger this degree, the stronger force that the arrow receives. As mentioned above, it is difficult to set a sensor on the string or around the limb. To circumvent this, we focus on the fact that the metal in the grip is slightly distorted after drawing the string and transmitting this force to the grip. By measuring the relation between this amount of distortion and the degree of drawing the string, the flight distance and speed of the virtual arrows can be calculated. Our interfaces therefore obtain the parameters of the distorted amount with a strain gauge and then calculate them.

By using this information, our interfaces can provide an experience like a real simulation. However, as shown in Fig. 2, our devices use an air shot without a real arrow when players use them. When using a real bow and arrow, the player's hand touches the bow and arrow, and this friction also needs to be considered. Therefore, to enhance our interfaces, information on the friction should be measured and integrated in VR.

3 System

3.1 Construction

As shown in Fig. 3, the Light Shooter and the 3rd Electric Bow Interface are based on a traditional Japanese bow and an archery bow, respectively. The Light Shooter consists of a laser pointer, a microcomputer (Arduino Fio and control board), 6-axis IMU, Xbee (Wireless Module), and strain gauges. The 3rd Electric Bow Interface consists of a mobile laser projector, Windows 10 PC, 10-axis IMU, a microcomputer (Arduino Nano and control board), Solenoid, Optical Sight, and strain gauges. In addition to a microcomputer (Arduino Nano and control board), Xbee (Wireless Module), a battery, and strain gauges, VAIR Bow includes a smartphone (iPhone 8) and an HTC VIVE Tracker, unlike the other two interfaces.

3.2 Shooting Direction

Both the Light Shooter and the 3rd Electric Bow Interface obtain information on the shooting directions with fixed positions. The Light Shooter excludes the projector, which is fixed to the backside and contains the IMU, so shooting directions and aiming directions are different if the players' heights are different. The 3rd Electric Bow Interface includes the projector, which is set in the same direction as the sensor, so the differences of those directions are smaller than those of the Light Shooter. When a player holds this interface, an image determined from the parameters of the sensor and the player's height and arm length is projected in the shooting direction, as shown in the center of Fig. 1.

VAIR Bow obtains positional information with the HTC VIVE Tracker and is used in combination with an attached iPhone that displays the shooting direction, which makes it possible to create a more accurate simulation than the other two interfaces. However, the positional relation of the player's eyesight and the iPhone is unknown, so there is gap between the viewing angle of the image and the actual viewing angle. In the VAIR Field in which this interface is used, the player can see the display with a wider viewing angle than the actual one because the iPhone's display is so small that the player can barely see it if both angles are adjusted.

Therefore, to enhance the realism of the simulation, the iPhone should be replaced with a tablet, which has a wider display, and then the player's face position can be obtained with the internal camera.

3.3 Device Position

As mentioned above, in both the Light Shooter and the 3rd Electric Bow interfaces, fixed parameters related to each device position are used to obtain the position, but different players see different gaps between the shooting direction and the aiming direction.

In contrast, VAIR Bow obtains the device position with an HTC VIVE Tracker. The typical device using "AR Kit" with a camera is not accurate enough to obtain the device position. This device also loses the tracking when the player moves violently. Compared to the typical device, our VAIR Bow can obtain the device position with higher accuracy. Furthermore, its function is not affected at all if the player suddenly moves.

Therefore, we can apply this VAIR Bow to physical e-Sports applications such as "VAIR Field", where multiple players move around and shoot with a gun-type or bow-type device.

4 Conclusion

In this paper, we have described the construction and characteristics of several bow-shaped interfaces used as game controllers and simulators. We also demonstrated how to obtain necessary information and prospects. In the future, by using information that we cannot obtain currently and calculating it, we will apply these interfaces to sports training applications.

References

1. Yasumoto, M., Ohta, T.: The electric bow interface. In: Shumaker, R. (ed.) VAMR 2013. LNCS, vol. 8022, pp. 436–442. Springer, Heidelberg (2013). https://doi.org/10.1007/978-3-642-39420-1_46
2. Yasumoto, M., Teraoka, T.: Electric bow interface 3D. In: SIGGRAPH Asia 2015 Emerging Technologies, SA 2015, pp. 11:1–11:2 (2015)
3. Yasumoto, M., Teraoka, T.: VAIR field - multiple mobile VR shooting sports. In: Chen, J.Y.C., Fragomeni, G. (eds.) VAMR 2018. LNCS, vol. 10910, pp. 235–246. Springer, Cham (2018). https://doi.org/10.1007/978-3-319-91584-5_19