International Journal of Engineering & Technology, 7 (3.24) (2018) 680-684

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper

Implementation of Screen Archery Studio for Realistic Screen Sports Experiences

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Abstract

Background/Objectives: The need for realistic indoor screen sports has increased due to environmental and social factors. This paper aims to develop a screen archery studio where the general public may enjoy archery, an elite sport.
Methods/Statistical analysis: A studio for screen archery consists of a video output component, including a projector and screen, and a system recognition component, comprised of a VR archery shooter, IR camera, and NFC reader device. The VR archery shooter is a device that implements virtual reality in places where real arrows may not be used for safety reasons. The realistic studio for screen archery has an advantage in that it can provide dynamic game contents in a narrow space. The provided content has two modes: Olympic game mode and hunting mode.
Findings: The studio in the proposed system provides elements that immerse players in the game as well as the experience of sports events that are not easily experienced in daily living. In particular, the recurve bow used in the VR archery shooter is the same equipment as is used in actual indoor archery fields or games to increase the feeling of realism.
Improvements/Applications: Although the provided content is currently limited to Olympic and hunting modes only, more active screen archery content is in development, including moving archery targets, which are the goal of a future study.

Keywords: *Virtual sports, Screen archery, Virtual archery shooter, Alternative experience, Studio for experience*

1. Introduction

As the value of individual pursuits has become important in the recent society, modern people are more interested in activities that are difficult to experience in their normal daily lives. This also applies to sport activities as a part of daily living[1, 2]. With this change in society, the number of places for virtual reality (VR) indoor and outdoor sporting experiences has increased. This phenomenon has even extended to overall sports events, such as golf, baseball, sky, bicycle, tennis, bowling, and fishing[3-5].

Screen sports are not only a fun game experience, they also provide physical exercise. Since screen sports are similar to actual sports, but more easily accessible, and utilize the actual sports equipment used in real events, they can provide the same effects as a real experience[6, 7].

The screen archery proposed in this study has the advantage of using actual equipment, which is a requirement for a realistic screen sport, and providing a sporting experience in a narrow space. The proposed screen archery system has the following novelties.

- The studio for the experience of screen archery has interactive elements to maximize user experiences as well as dynamic game elements that are similar to indoor archery experiences in a narrow space.
- Players can obtain the same experience as using real archery equipment empirically by using a VR archery shooter to provide a realistic game feeling in virtual space while using real bows in real space. In addition, the VR archery shooter ensures the safety of players so that a variety of ages, from children to the elderly, can enjoy the game.

In Section 2, sports events related to screen sports are discussed, and previous studies related to screen sports that implement the existing screen archery system are presented. In Section 3, the components of the studio for screen archery are introduced, and in Section 4, the system structure of screen archery and details related to content implementation are explained. Finally, Section 5 presents the conclusion and future research of the studio that developed the screen archery system proposed in this study.

2. Related Works

One of the most typical examples of screen sports is screen golf. A large number of studies on screen golf have been conducted on golf event analysis and sportainment content as well as the equipment and training system[8-10] Golf, which is considered an elite sport, is provided in a screen sport form to provide entertainment to the general public, allowing them to enjoy golf. This is a good example of sportainment features that can be applied to other sports events and implies that elements that are easily accessible to the general public through changes in awareness of daily sports activities should be included for the promotion of the public engaging in daily sporting activity. Screen golf is popular because it provides an alternative experience so users can select their preferred field with the freedom of play time.

A previous study called“Interactive Experience Room Using Infrared Sensors and User’s Poses ”implemented a virtual game space based on object information in real space, developing a

space that provides the experience of throwing a ball in a small space with a user experience design (UX) feature[11]. This may be integrated into baseball, volleyball, or handball. The objects that were recognized could be anything throwable in real space. The size of the items that can be used in the game was applied depending on the game. Furthermore, the experience of immersion could be enhanced by the fact that the game can be played using only the gesture of a player as a command. The fabrication of a mesh-using IR sensor that recognizes objects and the content planning and production to apply this mesh have become the foundational studies for the implementation of a studio for screen sports. However, the ball-throwing game was limited to providing an experience rather than reflecting the characteristics of actual sports events.

Screen climbing provides the sports-like elements of climbing events, which are not universally popular in Korea, thereby adding sportainment-like elements. A variety of attempts using a light-emitting diode (LED) game and video have been used to attempt to add game-like elements to existing indoor sports climbing[12, 13]. However, the study "A climbing motion recognition method using anatomical information for screen climbing games" designed a studio and developed content for screen climbing[14].This game can be played using the entire body via a climbing wall used as a screen based on the user's movements. It has a significant advantage in that it provides a new user experience as an effort to popularize screen sports climbing. In contrast, it has several shortcomings; it is expensive due to the need for a wall where climbing holds are attached, which must be the same size as an actual indoor climbing wall, as well as a large space—a minimum 3 m x 3 m x 3 m installation space is required because the content is projected through a projector. As such, it is important to find sports events that exhibit the characteristics of sports events and the content advantage provided through a screen and implement them in order to design screen sports that provide a realistic and enjoyable experience.

3. Components of the Screen Archery Studio

3.1. Screen Archery Studio

Since the screen archery system requires a smaller space than that of an existing indoor archery field and employs a VR shooter, the studio only requires a low-height space. Since real arrows fly in real archery, basic required and safety distances are necessary for that experience. In contrast, screen archery does not need such distances, which allows for more efficient space utilization. For screen archery, an optimized space design that can be applied to the screen archery system while reflecting elements of real archery experiences is required.

Figure 1 shows the design diagram of the proposed screen archery studio for indoor archery experiences. The studio for screen archery consists of video output and system recognition components. The video output consists of a projector and a screen to produce and display the content. The system recognition portion contains a VR archery shooter, IR camera, and NFC reader device. The player information is stored in the NFC card for the purpose of storing personal information, such as user ID and previous game history, and log-in information should be acquired through the NFC reader. For the safety of the screen archery players and diversity of contents, a VR archery shooter is used. Here, IR cameras are used to check the position of the sensors installed in the VR archery shooter. The details of the VR archery shooter for screen archery are presented in the next section.

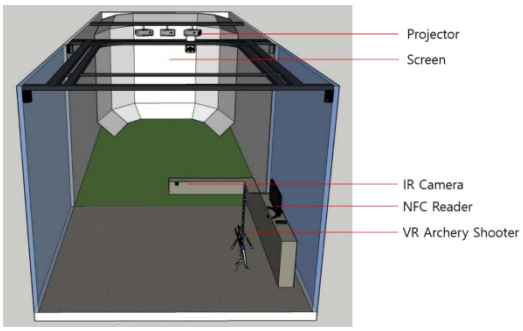

Figure 1: Design diagram of the screen archery studio for indoor archery experience

3.2. VR Archery Shooter for Screen Archery

The appearance of the VR archery shooter for screen archery is similar to that of a bow used for practice, which generally integrates recurve equipment. However, a sensor is embedded in the VR archery shooter to secure the location information of the player who lifts the bow, so the recognition module is mounted in the VR archery shooter. It is flexible enough to be mounted in any bow privately owned by a player. Figure 2 shows the exemplary setting display of a VR archery shooter mounted with sensors for screen archery and a recognition equipment module for fetching sensor values, such as shooting information and the location of the bow used by the player.

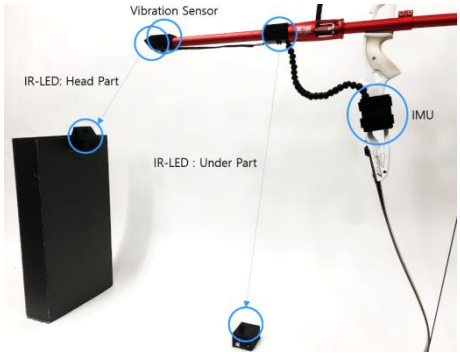

Figure 2: Structural diagram of the screen archery system using a VR shooter

In particular, the VR archery shooter is designed to mount various sensors, introducing the problem of wiring. Connecting lines were exposed externally, so additional housing created using a three-dimensional (3D) printer. Figure 3 depicts the 3D modeling case devised by the parts and shows where each of the casing sensors is embedded. The front part of the case in Figure 3(a) was designed to mount an IR camera at an angle of 45° to recognize the LED sensors in the front of the VR shooter, which had a different shape from the bottom case, as shown in Figure 3(b), where an IR camera was mounted. In addition, the LED case in Figure 3(c) had a slope of 45°, the same as the front case in 3(a), and four holes through which objects near the camera could be recognized without exposing the LED sensor externally. In particular, additional casing work was conducted to protect the sensors and the part where lines were connected to the Arduino Uno that processed the sensor values while fabricating the VR archery shooter. The length and range of the movements were supple to ensure the flexibility of the connected line length and movements.

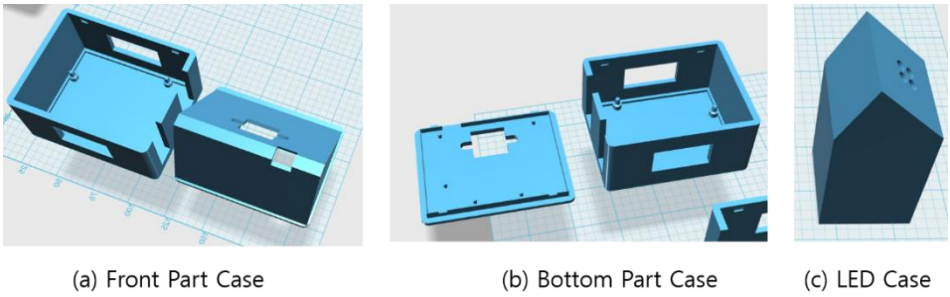

Figure 3: Example of the 3D modeling of a case by part for a VR shooter

Figure 4 shows a design example for the case in the middle part of the VR shooter, including the connecting lines. The reason for ensuring the flexibility of the movements of the connecting lines to the sensors mounted in the developed shooter is to resolve the damage problem in the sensors connected to the board due to the vibration of the arrows. To protect the connected lines, each of the casing modules is connected through the pantograph model, which is flexible. An inertial measurement unit (IMU) sensor was added, which included a six-axis gyro acceleration sensor to ensure the accurate location of the player lifting the bow as well as the bow and arrows displayed in the screen. The IMU had the problem that the generated values were calculated accumulatively due to the sensor's characteristics, which was corrected and applied to the system.

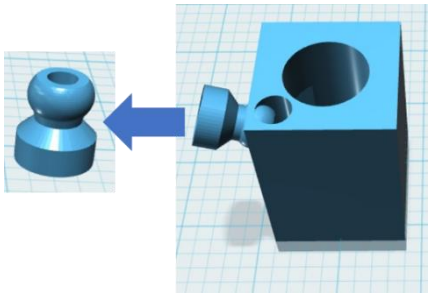

Figure 4: Example of case design to ensure flexibility between connecting lines

In the VR archery shooter, a value is generated as an arrow, which is not shot, sends a signal that hits the front side of the shooter to sense the moment that the player shoots. Figure 5 shows the graph of the vibration value recognized as soon as shooting occurs.

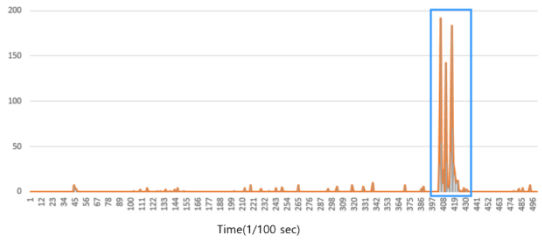

Figure 5: Example of vibration values recognized during shooting moment

As verified through the graph, values recognized at the shooting moment when the embedded arrow touches the end of the shooter were significantly different from the unspecific event values acquired through the vibration sensors when a player moves with the bow or is ready to shoot. The content and system structure for screen archery in the implemented studio are explained in Section 4.

4. System and Content for Screen Archery

4.1. Structure of the Screen Archery System

The screen archery system proposed in this study is a studio-like system that uses a VR archery shooter. It is necessary to understand the system structure first to understand its execution method. Figure 6 shows the structural diagram of the screen archery system using the VR shooter.

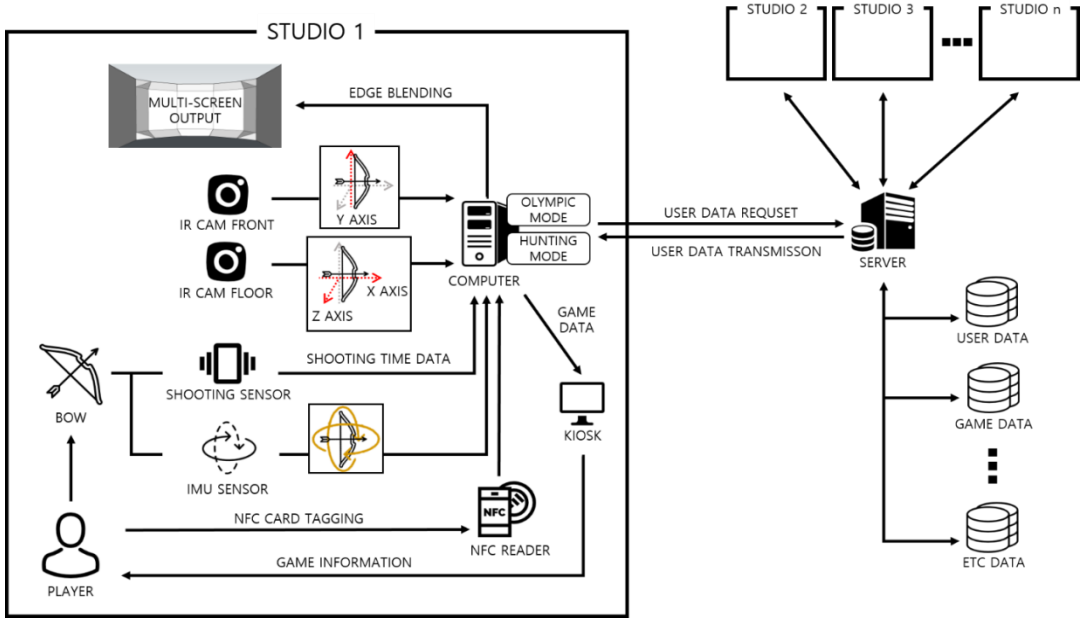

Figure 6: Structural diagram of the screen archery system using the VR shooter

The proposed screen archery system aims to secure the login data of the player before starting the game using an NFC card to load and store the player's game data and extend the system for networked multi-player in the future. The login data of each player includes their user ID and previous game data. Once the player shoots an arrow mounted with the VR shooter after their login through the login process, the shooting sensor and IMU sensor generate the location information value of the arrow. The location value of the arrow is additionally generated through the IR cameras installed at the bottom and in front of the player, and the arrow information shot in the running game is reflected and displayed. The realistic feeling of the images displayed in the multi-screen was raised to enable high-level alternative experiences for players by applying edge blending technology in consideration of the screen sports characteristics. Screen sports are mostly group-based experiences, so data about game progress information is provided through the front screen and kiosk.

4.2. Screen Archery Content And Execution

Two types of content were developed for screen archery virtual sports experiences. One was an Olympic mode that implemented an archery field used in a real Olympic event and the other was a hunting mode that enables the alternative experience of hunting using arrows. Figure 7 shows examples of the developed content for screen archery; (a) shows the Olympic mode display and (b) shows the hunting mode display.

Figure 7: Examples of the content for screen archery; (a) the Olympic mode and (b) the hunting mode

The Olympic mode aims to design content such that players can feel as if they were playing in the place where the event occurred. It can be experienced by one to four players at a time and calculates game score and player's ranking automatically without additional experts, in contrast with existing indoor archery experiences. There are some differences in calculating the score depending on the game and event chosen. However, the rules of the real space game were followed for the convenience of the game. Figure 8 shows the Olympic mode running display as an example of the implemented screen archery system.

Figure 8: Example of execution of the implemented screen archery system

The hunting mode aims to imitate hunting behaviors using arrows in nature. However, it did not use moving animals or humans as a target in existing hunting contents. Rather, this study developed content that targets the animal model with the target mark used in real archery exercises. This was because the purpose of the content development was to include fun factors of an archery experience while having a similar experience to animal hunting rather than to imitate hunting animals itself. The feeling of realism was provided by the act of shooting and the usage of a nature environment video so that field archery occurs in a real hunting archery field provided through the screen for players.

The two implemented types of the game are content for the screen archery system experience and can be installed in various experience spaces, such as an indoor archery field, archery experience field, or VR experience field. Since safety is guaranteed with the VR archery shooter, the age range of players is very wide and spans from young children to the elderly. In addition, since the methodology is similar to actual archery equipment, professional archery posture can be trained using this system. This study verified that asporting experience can be provided by utilizing complex content that enables alternative experiences and fuses real and virtual spaces.

5. Conclusions

This study verified the possibility of creating interactive screen sports content development that is diverse and realistic for a VR archery shooter through the proposed screen archery studio and ensured that the contents were applicable to the system. In contrast with the equipment for other games, which often include protective devices on arrowheads, making them different from the real arrows used in archery, the VR archery shooter can use realistic arrows to provide alternative experiences that are similar to real archery. Many considerations should be taken to use realistic equipment to obtain a similar experience as actual sports when engaging in screen sports. Although the provided content is currently limited to Olympic and hunting modes only, more active screen archery content will be developed, such as moving archery targets, which will be a future study goal.

Acknowledgment

This work was supported by the Institute for Information &Communications Technology Promotion(IITP) grant funded by the Korea government(MSIT) (No.20170006810012002, Screen Archery Solution based on Hybrid Reality and No.B01901620330004003, Non environment sensitive Face Detection Core Technology Development).

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