A System for Practicing Ball/Strike Judgment in VR Environment

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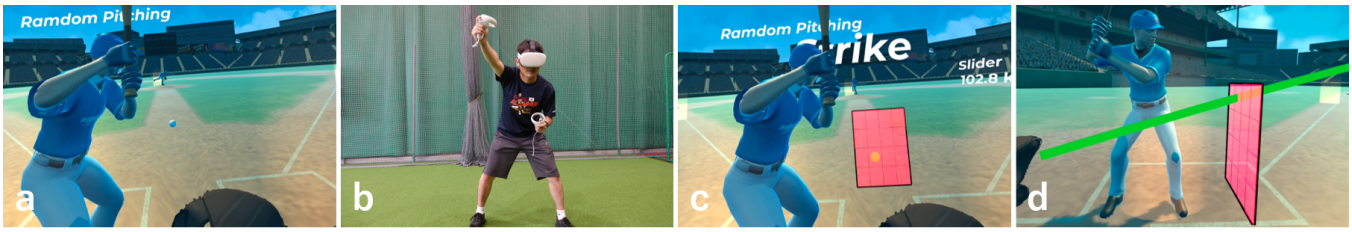

Figure 1: Overview of our system. The user observes a pitched ball (a) and performs ball/strike judgment (b). The system provides feedback whether the judgment is correct or not (c). The user can review pitches with trajectory visualization (d).

ABSTRACT

The purpose of this study is to develop an easy-to-use ball/strike judgment practice system for inexperienced baseball umpires. The main idea is to provide a practice environment in a Virtual Reality (VR) space. With our system, users observe a pitched ball, perform ball/strike judgment, and review their judgment in a VR space. Since the whole process is completed in VR, users can practice the judgments without preparing a pitcher and catcher. A user investigation in which participants practiced with our system and judged balls thrown by a pitching machine was conducted. The participants responded positively when asked about the usefulness of our system.

CCS CONCEPTS

• **Human-centered computing** → User studies; • **Computing methodologies** → **Virtual reality**.

KEYWORDS

Virtual Reality, Ball/Strike judgment training, baseball.

ACM Reference Format:
Kentaro Yanase, Shunji Muto, Kyohei Masuko, Tomoyuki Nagami, and Takashi Ijiri. 2021. A System for Practicing Ball/Strike Judgment in VR Environment. In *27th ACM Symposium on Virtual Reality Software and Technology (VRST '21), December 8–10, 2021, Osaka, Japan.* ACM, New York, NY, USA, 2 pages. https://doi.org/10.1145/3489849.3489931

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VRST '21, December 8–10, 2021, Osaka, Japan

ACM ISBN 978-1-4503-9092-7/21/12.
https://doi.org/10.1145/3489849.3489931

1 INTRODUCTION

The home plate umpire in baseball assesses whether a pitched ball is a ball or strike. This ball/strike judgment is challenging, especially for inexperienced umpires in amateur baseball games, because an umpire may only watch pitches from a limited position behind the catcher. Constant practice is necessary to improve the skill of the ball/strike judgment. However, this judgment practice necessitates the preparation of numerous items, including a pitcher, catcher, field, and protective gears. Furthermore, the ball/strike judgment practice poses risks of injury since a trainee watches balls flying at high speeds up close.

Many researchers have created virtual reality (VR) systems to aid in the efficient training of many sports and dances, such as golf [1], skiing [2], and dancing [3]. VR spaces are used in this system to visualize the user's or skilled players' motions. Various VR-based systems have been proposed and have resulted in effective sports training environments. The majority of these methods, however, are aimed at the players, with only a few focusing on the referees.

2 PROPOSED METHOD

The objective of this study is to provide an easy-to-use ball/strike judgment practice system for inexperienced umpires. Our key concept is to create a practice environment in a VR space. A user observes a pitched ball, decides whether it is ball or strike, and then reviews their judgment in a VR space (Figure 1). The user can practice judgment alone without preparing a pitcher and catcher and without the risk of being hit by balls since all activities are completed in a VR space. In addition, it is possible to observe the same ball multiple times.

Figure 1 summarizes our system. A three-dimensional (3D) pitcher and a catcher model are placed on a baseball field (Figure 1a). The user performs a practice in this VR space. After observing a ball, the user judges by using a VR controller (Figure 1b); when it is ball or strike, the user lowers or raises the controller and presses the button, respectively. After a judgment, the system promptly delivers feedback whether it was correct or not (Figure 1c).

Our system has three modes: random pitching mode, preset pitching mode, and review mode. The user can choose any of them by the VR controller. In the random pitching mode, the system pitches a ball with randomly selected parameters (see below for detail). The user practices judging various balls with this mode. In the preset pitching mode, the system pitches balls with parameters predefined by the user. This mode is useful for practicing judgments of specific balls. In the review mode, the system replays the balls pitched in the two modes above. The system also visualizes trajectories of the balls (Figure 1d). The user can move around the field to check the balls from different viewpoints.

A plate umpire observes a pitched ball from slightly behind the catcher and between the catcher and the batter. This positioning is called "the slot." Our system indicates a green marker to support the user to get into the slot position (Figure 2a). The user positions their chin on this marker when observing the ball. Figure 1a indicates the visibility of the scene observed from the slot position. We computed a ball trajectory with a simple model in our current implementation, $\mathbf{x}(t) = \mathbf{x}_0 + \mathbf{v}_0 t + \frac{1}{2}(\mathbf{g} + \mathbf{f})t^2$, where t denotes time, $\mathbf{x}_0$ denotes the release position, $\mathbf{v}_0$ presents the initial velocity, and $\mathbf{g}$ and $\mathbf{f}$ are accelerations generated by gravity and spin, respectively. We prepare four different balls, such as fastball, curve, slider, and screw by tuning $\mathbf{f}$ and the magnitude of $\mathbf{v}_0$. We introduced randomness to these parameters to generate a variation. Our system considers 6×6 cells around the strike zone as in Figure 2b and throws a ball that passes through the center of the target cell by tuning the orientation of $\mathbf{v}_0$.

3 EVALUATION AND DISCUSSION

To verify the effectiveness of our system, we conducted a user investigation. In the study, each participant performed (1) a prior judgment task, (2) practice with our system, and (3) a posterior judgment task. In the prior and posterior judgments, a participant judged 32 balls (16 fastballs and 16 curves) thrown by a pitching machine. To avoid balls that were too easy to judge, we positioned the machine to target the lower left or right corner of the strike zone. In the practice step, a participant initially judged 50 balls and then reviewed all balls using our system. In this practice step, we provided low fastballs and curves. After the three steps, a participant responded to questions.

Five undergrad students participated in the study; four of the five have played baseball, and all five had no experience of a plate umpire. Figure 3 summarizes the accuracy of the prior and posterior judgment tasks. We did not find a significant variation in the accuracies of the prior and posterior tasks. One reason for this outcome is that the practice step with our system was too short. User study done for a longer duration remains as our future work. The participants were asked several questions. One of them was; "Do you feel your judgment skill improved by using the VR judgment practice system?." All participants responded "yes" to this question. Some additional positive comments were obtained, such as "I could understand the boundaries of the strike zone" and "I could learn the correct positioning of the plate umpire."

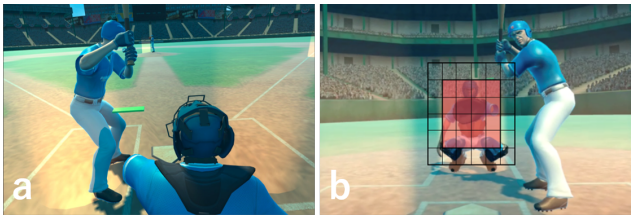

Figure 2: (a) Green marker represents the umpire's face position. (b) The system throws a ball to one of the 6×6 cells.

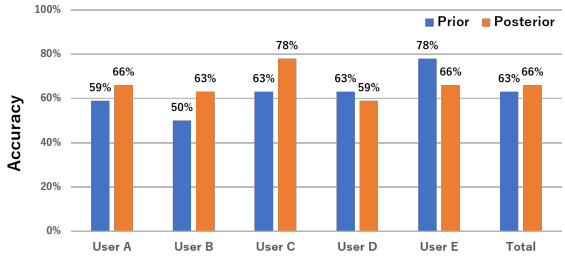

Figure 3: Accuracy of the prior and posterior judgment tasks.

4 CONCLUSION

A ball/strike judgment practice system using VR technology has been proposed in this study. The user can observe various pitched balls and practice judgment in a VR space with the proposed system. A user study was conducted to evaluate our system. In the user study, the participants responded positively to the questions on the usefulness of our system. However, no significant gain was observed in ball/strike judgment accuracy after practice with our system. Our future work includes animating the batter and the catcher to improve the reality of the scene. We also would like to introduce a function to provide balls that were pitched in real-world professional games.

ACKNOWLEDGMENTS

We thank all the persons who participated in the user study.

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