Realization of Highly Realistic Broadcast that Includes the Eye Movements of Basketball Players

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Abstract: Sport spectatorship changes with the introduction of new technologies. There are many video editing methods in sports broadcasting, but it is more important to base video presentation on the characteristics of a specific sport. We examined the eye movements of basketball players and found. An essential relationship between their skill level and their eye movements in making successful shots. Analysis of eye movements during free throws revealed that a player was more likely to score if they focused on the support frame line on the backboard not only before the shot but even after releasing the ball. Overlaying reveals the movements of both players and their focus simultaneous analysis. Overlaying technology proved that spectators could watch a player's focus and body movement specifically at the same time. By recording with 4K video cameras, spectators could easily understand the directions of the players. Furthermore, we proved that the analysis of a player's eye movement in a play situation can be beneficial to the team. As a result of this study, the differences in court awareness during a play according to the skill levels of different players became apparent.

1 INTRODUCTION

Unfortunately, the International Olympic Committee and the Japanese government have decided to postpone the 2020 Tokyo Olympic and Paralympic Games until 2021 due to the global spread of the new corona virus (COVID-19). However, this happen might be an excellent opportunity to further develop techniques that convey the attractiveness of sports for the broadcast companies to spectators, including those watching TV as well as Internet-distributed (computers, smartphones, tablets, and so on) viewers.

A study of TV viewers concluded that most people would watch the 2020 Tokyo Olympic games on TV (92%), and that spectators will expect better and more realistic image quality (Saito, 2019). TV and Internet-distributed viewers seek more information and a more powerful experience than they would get in the stadium, such as through virtual reality (VR). Another author emphasized "a more realistic feeling" as a key phrase for the near future (Noma, 2002). In other words, growing numbers of spectators will watch sports on TV or the Internet as technology improves. The enjoyment of sports on T.V. or Internet-distributed content will be the new norm and will be increased more and more in the future.

Basketball is one of the sports where a group of people form a team and face each other in offense and defense, competing for points using individual and group tactics around a "single contested object."

According a textbook on basketball, one of the abilities players need is situational awareness (Japan Basketball Association, 2014). To improve their situational awareness, players need to broaden their peripheral vision. Basketball, players must be aware of valuable information and take appropriate action amid the rapid changes in their surroundings (Japan Basketball Association, 2014). Therefore, all players are always anticipating something, watching something, feeling something, thinking something, judging the ever-changing situation, and choosing when to try to score (Toyoda et al., 2016). In a previous study about a player's eye movements, the

[a] https://www.u-tokai.ac.jp/staff/detail/MDgwMDcw/MjA2MTU4
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[c] http://eyemove.g1.xrea.com/yamadalab_ENG.htm

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passer (usually a point guard) looks to the left and right, finds open player and, when passing, uses their eye mislead defenders (Sasaki et al., 1995).

Ryu et al. (2013), experimented with the roles of central and peripheral vision in expert decision making. The authors watched basketball scenarios on video (11 expert and less-skilled men's basketball players in each group) and, determined whether it was a correct decision for the ball carrier to pass, or to drive to the basket. The expert players responded faster than the less-skilled players. A similar study concluded that regular basketball players' latency of vergence divergence was shorter than that of non-regular basketball players (Kokubu et al., 2019). Those authors mentioned that players with more experience, were able to quickly initiate a gaze movement in the direction of depth.

A significant factor that determines the success or failure of a shot is the "quiet eye "(QE). QE is a characteristic eye behavior exhibited by experts during successful aiming movements, such as free-throws and darts. Vickers stated that good free-throw shooters spent more time looking at the ring before the start of the shot than when they were successful. Although the QE mean durations of the expert are 1000 ms (successful) and 800 ms (unsuccessful), those of the near-expert are less than 400 ms (successful) and more than 400ms (unsuccessful) in the study of (1996). Based on that study, university basketball team took QE training for two seasons. As a result, that team improved its who free-throw success rate from the first season to the second and also showed better results than the teams that did not do QE training (Harle et al., 2001).

Although there are many types of research into the eye movements of basketball players, most of them have been conducted in fast attack situations, such as two-on-one, or three-on-two, to prove their hypothesis. However, it is hard to have these "best situations" in real games. Therefore, we decided to conduct an experiment similar to the actual game and selected free-throws, one-on-one and two-on-two, on a limited quarter area of a basketball court. The reason for the space limitation is that, during practice, most players play on only one side of the half-court (a quarter) when playing one-on-one or two-on-two.

The purpose of this study was not to statistically analyze basketball skills to improve athletic performance but rather to identify new ways to represent those skills to new spectators.

2 EXPERIMENTAL METHOD

The experimental equipment included wireless eye-movement measurement devices and 4K video cameras. The wireless eye-movement measurement uses an external control system comprised of a video transmitter. A Bluetooth mouse was added to the TalkEye Lite system (Takei Science Instruments Co., Ltd.) using the corneal reflection method. This wireless device allows the subject to move freely. The researcher can check the measurement status from a remote location with a wireless monitor. If the calibration shifts due to an experimenter's hard movement, it can be readjusted remotely. Neither the experimental data recorded in the wireless eye movement measurement device nor the delay caused by the wireless transmission affects the measurement result. The device can be secured to the subject's head with a hook and loop fastener to prevent the eye-movement sensor from slipping during exercise (Sarugaku et al., 2020).

Two experiments were conducted at different places with different players. One of them was at the Takanawa Campus Area of Tokai University with four members of the Tokai University Takanawa Campus Basketball Club. Although these plays have an average of more than 6 years playing organized basketball, they have played for fun, not competitively; in other words, they are less-skilled players. On the other hand, the other experiment was conducted at Yokogoshi Athletic Center in Niigata city. The players belonged to the Apple Sports College Basketball Course, U23 of Niigata Albirex BB (Apple Sports College). They won the national basketball championship tournament in vocational school in 2018. The team members aim to be professional basketball players, so we consider them skilled players.

We recorded five scenarios:

1. Free throws
2. One-on-one (fixed camera)
3. Another one-on-one (tracking camera)
4. Two-on-two (Takanawa)
5. Two-on-two (Niigata)

We chose these five scenarios because we want to study eye movements and player actions in various scenarios that occur in basketball games.

3 EXPERIMENT

3.1 Free Throws

The experimenter shot a free throw from the free-throw line while wearing the wireless eye movement measurement device. Figure 1 shows the layout of the free-throw experiment. The eye movement measurement focused on before and right after shooting. Three video cameras were set up: one at the center circle, another at the end line, and the third on one of the sideline.

Figure 2 shows the scene of before and after the player shoots a free throw. The top of the image is the field-of-view image of the wireless eye-movement measurement devices that superimposes the movement of the line of sight, and the bottom three are from the three video cameras (The capital "C" is the camera number).

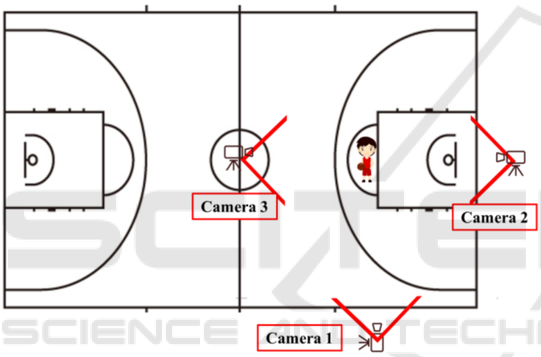

Figure 1: Layout of free throws.

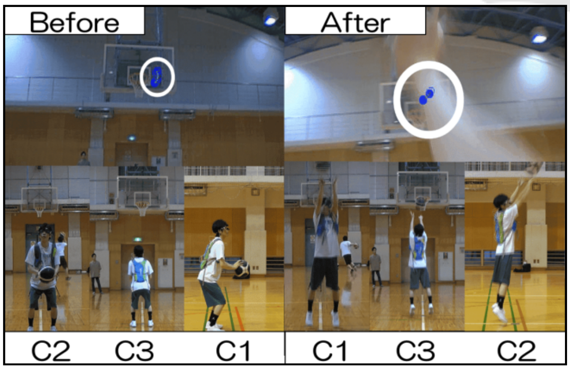

Figure 2: A scene of before and after the player shoots a free throw.

3.2 One-on-One (Fixed Camera)

In this experiment, two players participated in one-on-one play in which each was on offense and defense three times. Figure 3 shows the layout with fixed cameras. The players each wore a wireless eye movement measurement device, and three fixed video cameras were set up at the center circle, end line, and sideline of the court. The upper part of Fig. 4 shows the eye movements on the field-of-view images of both the offensive and defensive players. The bottom part of Fig. 4 shows the three different images from the three video cameras recorded at the different angles. By viewing the action from these three video cameras, spectators will be able to understand the players' movements easily, such as the location of each player, the timing of the dribbling, the shooting, and so on.

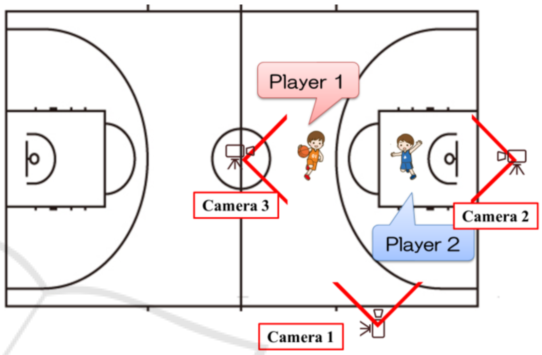

Figure 3: Layout of one-on-one (fixed camera).

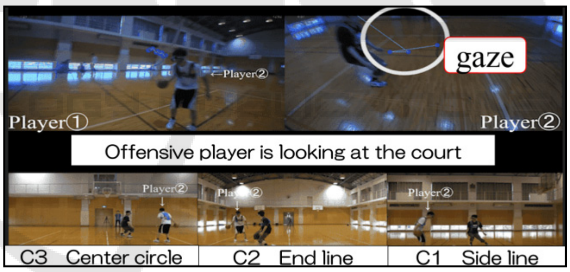

Figure 4: Eye and body movement of two players.

3.3 One-on-One (Tracking Camera)

In the second experiment of one-on-one, each video camera tracked each player. Figure 5 shows the layout of this experiment. Three video cameras were set up: one at the center circle and one on each sideline. Camera 1 followed the offensive player, camera 2 followed the defensive player, and camera 3 recorded half of the court. The upper part of Fig. 6 shows eye movements of both the offensive and defensive players.

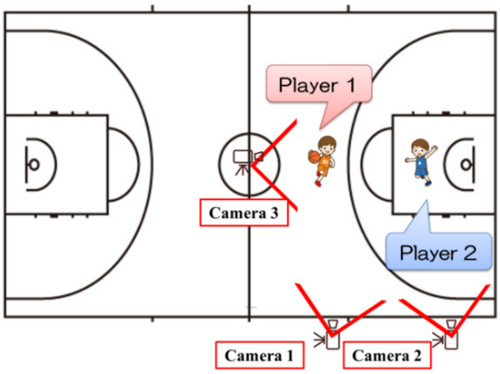

Figure 5: Layout of one-on-one (tracking camera).

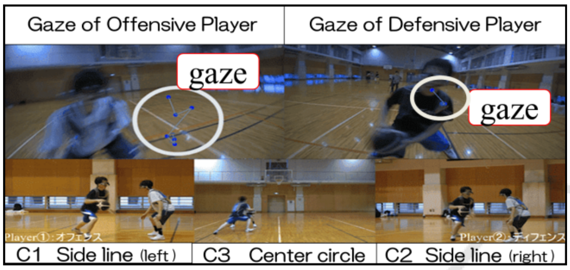

Figure 6: Eye and body movement of two players.

3.4 Two-on-Two (Takanawa)

In this experiment, offense and defense alternated, starting with a pass from a person off the court to one of the two players.

Figure 7 shows the layout of two-on-two experiment at Takanawa. Two of the players, one offensive and one defensive player, wore a wireless eye movement measurement device, and three cameras were set up: one at the center circle (camera 1) and one on each sideline (cameras 2 and 3). All three cameras were fixed. Figs.8 and 9 show the eye movements of both the offensive and defensive players.

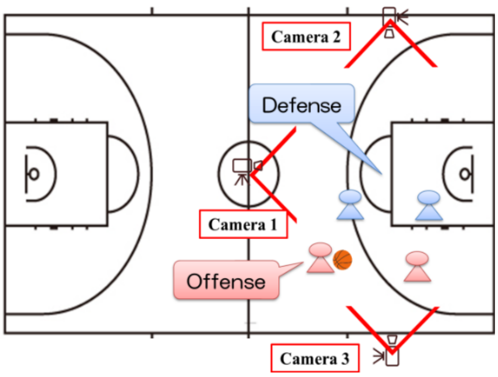

Figure 7: Layout of two-on-two (Takanawa).

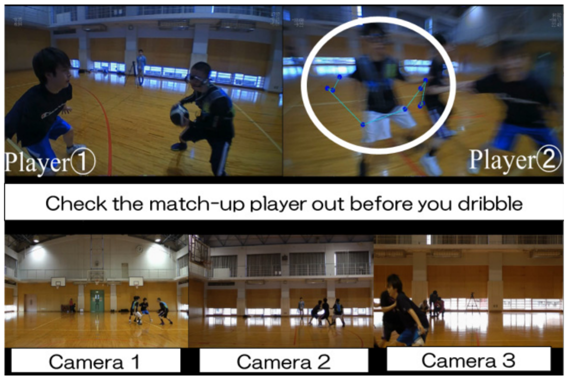

Figure 8: A scene of two-on-two with eye movement (Takanawa).

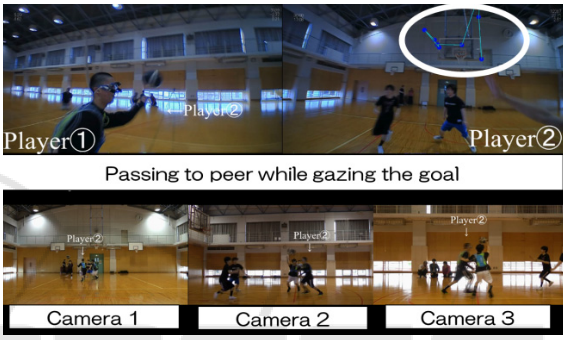

Figure 9: A scene of two-on-two with eye movement (Takanawa).

3.5 Two-on-Two (Niigata)

In this experiment, offense and defense alternated, starting with a pass from a person off the court to one of the two players on offense, as in Takanawa's experiment.

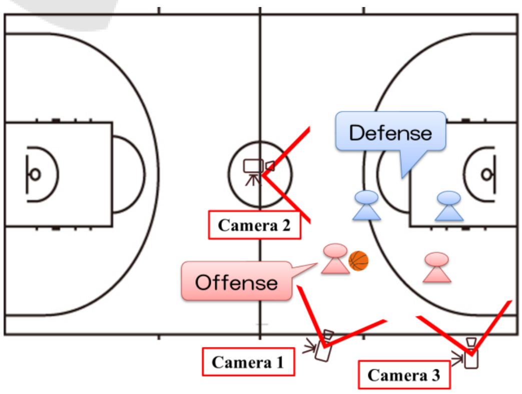

Figure10: Layout of two-on-two (Niigata).

Figure 11: A scene of two-on-two with eye movement (Niigata).

Figure 12: A scene of two-on-two with eye movement (Niigata).

Figure 10 shows the layout of the two-on-two at Niigata. Two of the players, an offensive player and a defensive player, wore a wireless eye movement measurement device, and three cameras were set up: one at the center circle (camera 2) and one on each sideline (cameras 1 and 3). Camera 3 tracked one offensive player while (cameras 1 and 2 were fixed). The upper parts of Figs.11 and 12 show the eye movements of the offensive and defensive players.

4 RESULTS

4.1 Free Throws

The player scored four goals out of ten free throws. The results show that the focal point is around the support frame line on the backboard before a shoot (Figs. 13 and 14). When a free throw is successful, the focal point almost the same from before to after shooting (Fig. 13). On the other hand, when a shot is unsuccessful, a player's focus moved after the ball was released (Fig. 14). This indicates that it is important to focus on a specific area constantly.

Although the players adopted various shooting forms, this experiment proved that focusing on a specific point without moving the eyes during shooting is one of the most important factors for players.

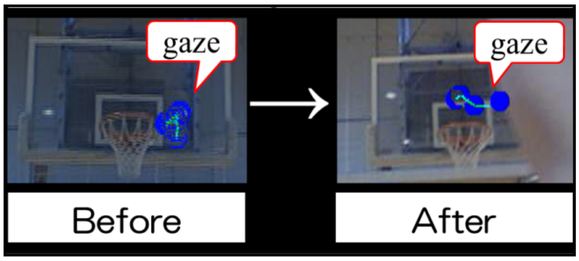

Figure 13: The focal point of before and after (successful shot).

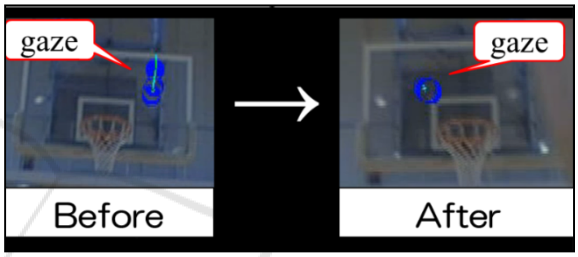

Figure 14: The focal point of before and after (unsuccessful shot).

4.2 One-on-One (Fixed Camera)

This one-on-one fixed camera recording method can show both body movements and eye movements at the same time. For example, Fig. 4 shows the offensive player (Player 2) looking at the floor right before he started to dribble (circle 5 in the figure). Video camera 1 (sideline) proved this movement, such as the downward movement of the player's head. This is because the offensive player checked the feet of the defensive player and tried to pull out while dribbling.

4.3 One-on-One (Tracking Camera)

The aim of this one-on-one tracking experiment was to clarify the movement of each player to a much greater extent than the experiment with a one-on-one fixed camera. We assumed that the offensive player looked for a moment at his intended route before he started to dribble (Fig. 6). However, there are some considerations about this eye movement. Although some people may think it is to decide whether to attack immediately, this eye movement may instead have been a feint. The tracking recording method will be able to clarify the player's intent. The two video cameras are tracking the respective players. These tracking cameras reveal what the offensive player and the defensive player are trying to do.

In this tracking method, the spectators can watch the players' eye movements as well as their body movements specifically at the same time. In other words, this tracking system can show spectators the characteristics of various playing styles.

4.4 Two-on-Two (Takanawa)

The offensive player looked for a moment at his intended route before he started to dribble. This is the same as the result of the one-on-one (tracking camera) experiment. Also, most of the offensive players' eyes were on the defensive player (Fig. 8) and the goal even when the player passed to his teammate (Fig. 9).

4.5 Two-on-Two (Niigata)

Based on the result of the Takanawa two-on-two experiment, the predicted result of the Niigata experiment was that the offensive player would focus on his opponent or in the direction of his teammate while dribbling. However, the result of Niigata experiment was that the offensive player looked for a moment at his opponent when receiving the ball and then started to dribble (Fig. 11). After that, the offensive player was always looking at his teammate while dribbling (Fig. 12).

5 DISCUSSION

First, the purpose of this study was not to statistically analyze basketball skills to improve athletic performance but rather to identify new ways to present those skills to new spectators. Although people need to accept a new way of life until the COVID-19 pandemic is over, this is an opportune time to adopt new ways to spectate. More and more, people will watch various sports on TV or on the Internet. What these spectators desire is quality and reality, as well as more information. The various eye-tracking studies have investigated the important relationship between athletic performance and eye movements to pass or take a successful shot. Especially, sports involving a ball and a goal demand quick decisions and instant transitions from defense to offense compared to other kinds of sports. By revealing the eye and body movements of players, it becomes clear to spectators what they are looking at, what they are paying attention to, and when and where they are feinting. Therefore, both tracking and fixed video recordings are necessary to achieve spectators' desires. The tracking recording watches an individual player who has the ball, and the fixed recording is to understand what the other players are doing.

Second, the results of free-throw experiments proved the importance of QE, such as gaze fixation. However, QE is one of the factors involved in making a successful shot. To acquire the effects of QE, it is first necessary to set up a training period for the acquisition of movements before implementing the QE training. (Mizusaki et al., 2013). According to the basketball textbook mentioned above, players who learn to shoot and to move correctly during their developmental years will grow into great shooters as they develop. And the position of the ball during free-throw shooting changes as the muscular develops (2014).

Third, the differences in eye movements were expressed between two different players during two-on-two, such as looking at the opponent or the goal and glancing at a teammate. Based on this experimental result, it is difficult to decide whether these differences are attributable to the player's skill level. However, if cooperation among the players on team is essential for scoring points, then the players of Niigata could read the movements of their teammates, check the situation instantly, and decide where to attack easily by understanding the situation. In other words, cooperation enables players to score points. It is often thought that having a good scorer (point getter) is an advantage, but in reality, a team with a good balance of players is better for winning than a team with a single standout player.

Fourth, the basketball textbook maintains that passing requires a much higher level of judgment than shooting or dribbling. It is an important skill that supports team play and must be based on communication between teammates, but also on anticipation of defensive moves. The textbook shows that the keys to offense are to keep the face up, keep the vision wide, and be ready to react to the ball or to the movement of teammates at any time. On the other hand, the keys to defense are to keep the face up and both the ball and the opponent in sight. Here, "keep the face up" or "keep the vision wide" refers to peripheral vision (2014). In the experiment, although the eye movement camera of the offensive player always captures the Niigata teammate, the Takanawa player's camera does not. And, Takanawa player's camera shows the floor and goal sometimes. This result proved that skilled players demonstrate "keep the face up" and "keep the vision wide" as usual in their practice time (Japan Basketball Association, 2014).

Next, Yaita et al. (2014) mentioned that play involving post players has a lot to do with their ability to compete and their ability to make situational judgments. They need to be trained to understand how to make good situational judgments in play involving or related to post players. At least, the passer and the post player should wear eye movement measurement devices to clarify this situation. And, by putting different pictures on one screen on the same timeline (Figs. 5, 7, 9, and 10), the peripheral vision and eye contact of both the passer and the post player can be revealed. If all the players in the court wear the devices and record 4K video cameras from 360 degrees, all the players' eye and body movements will be evident.

Finally, although we could gather real experimental data from activity similar to a real game rather than from experiments in the lab or limited play performance situations, there will be more movement or more players involved in a real game. We limited the play performance area to a quarter of a basketball court for the one-on-one and two-on-two experiments. This is because the purpose of this research is not to analyze basketball skills to improve athletic performance, but rather to introduce to spectators the allure of basketball, such as players' decision making and make quick transitions.

6 SUMMARY

We approached a new method of recording performance videos by using a wireless eye movement measurement device and 4K video and then measured the eye movement of basketball players during free throws, one-on-one (fixed and tracking), and two-on-two play in order to identify new ways to present the game to new spectators. The results show the following: 1) focusing steadily on a specific point during shooting is one of the important factors in free throws; 2) in the one-on-one experiments, a fixed camera can capture both body and eye movements at the same time; 3) spectators can watch a player's eye and body movements specifically at the same time by one-on-one tracking camera method; and 4) eye movements during play are completely different for expert players than for less-skilled players. Although passing is not an individual play or skill, a passer always needs a receiver. In other words, basketball is not only about individual skills but about teamwork.

The use of wireless eye movement measurement devices and 4K technology allows us to watch the body movements of players from different angles and to simultaneously watch their eye movements in high resolution. As a result, eye movements can be observed and measured outside of the lab, i.e., on a court, where players can move freely. In other words, a wireless eye movement measurement device leads to experiments that are similar to real games. These techniques enable us to watch players move at dizzying speed over a relatively small area and thus to show the skills of basketball players. This study can be extended to reveal the secrets of skill development and spectators' observation points. At the same time, the concerted visual and body movement movements of players were investigated to determine the processing mechanisms in the brains of superior athletes. The results of this study are applicable not only to sports but also to the analysis of human behavior and the importance of concerted action between vision and body movement.

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