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Visualization for Easier Recognition of Low-risk and Successful Passes in a Basketball Match

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Abstract

In order for a novice-player to improve the decision-making skill in basketball, s/he needs an ability to assess the game situation of every moment and select an appropriate movement for the succeeding future. In this study, the pressure fields obtained by calculation of the positioning metrics of all players on the court are used to assess the situation, and the values are used to find a low-risk and successful receiver for the pass thrown by the ball holder. We also propose and evaluate the prototype that visualizes the pressure fields as a VR-based simulator.

1 Introduction

Basketball is a team sport in which two teams of five players compete for points by shooting a ball at the opponent's goal in the shared court. In attacking basketball, dribbling and passing are often used to increase the probability of successful shooting. The objectives of these movements are, for example, getting closer to the goal or creating an advantageous situation where the defense cannot interfere. Nakagawa defines a good pass as a pass that is executed with an understanding of the game situation and appropriate judgment, which is an action performed regardless of the game situation [1]. In addition, team sports such as basketball are complex sports in a competition perspective, and regularities of play and universal strategy are difficult to find [2]. Therefore, novice-learners of this kind of sports begins learning the fundamentals of play. We focus on performing low-risk passes for a ball holder in offense because it is difficult for a novice basketball player to learn high risk but high return passes at first that are sometimes performed by an experienced player. This study aims to improve the critical thinking way of pass-judgment of novice basketball players using a simulator of virtual reality (VR). By using VR, we can learn under conditions that are similar to actual matches, regardless of weather, location, or other environmental factors in the physical world.

2 Related Works on Team Sports

In Takamatsu study, optimizing behavior could be mathematically determined by quantifying play based on information such in match data of skilled players and the movement speed of the players [3]. However, it cannot be identical to apply the optimized such model to the real game. There are other types of study that uses neural networks and other information technologies to predict the result of matches [4][5]. It contributes to the entire strategy but merely to each play.

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Tom Decroos's research addresses the problem of difficulty in automatically detecting tactics from data collected in professional soccer matches [6]. Because of the complexity of team sports such as soccer, tactical analysis is often performed by humans who are directly viewing video footage. Therefore, Tom Decroos states that automatic detection of performed tactics from match data can save time.

Losada's research involves the development of a system that allows data to be easily understood through visual representations [7]. The system intended for basketball aims to evaluate performance in a game.

The aforementioned research on quantifying play is not intended for novice basketball players. Therefore, in this study, we support learning by quantitatively determining and displaying the best passer for novice students from low-risk perspectives.

3 Low-risk Pass Learning Support

3.1 Definition of low-risk pass

As already noted, our goal is to support learning on easier seeking players who can pass a ball to another player with low risk in this study. Therefore, at first, let us discuss what a low-risk pass is. A low-risk pass is simply described a pass that has little risk of being cut off by an opposing team player. In order to avoid being cut off, there must be no defensive players in the path, and in this study, the path is a straight line connecting the ball carrier and the ball receiver. However, it does not matter who one passes to, as long as the opponent does not cut off the pass. Simply passing to another team-member far away from the goal because it is safe to do so will not lead to an effective attack and will not reach a goal. In other words, the objective of this research is not just to develop the selecting skill of an opponent who can be received the pass with low risk, but to get the skill of selecting an opponent who can score while minimizing the risk as much as possible.

The reason why we focus on low-risk passing in this research is that our target is a kind of novice players to be able to select an opponent with whom they can pass safely with low risk, because it is difficult for them to perform the same level of passing as an expert at beginning.

3.2 Low-risk pass decision learning support

This study uses a VR simulator that captures a bird's-eye view of a basketball court from above. The simulator used was developed by Takeuchi et al [8]. The simulator shows a circle with 10 players (offense and defense) and the ball. By dragging the circle, the player can move freely around the court.

Since the support system in this study is offering a preliminary learning support for novice basketball players to be able to pass the ball like skilled players, it does not consider tactics such as cutting and screening. The designing issue has been presented in a domestic workshop [9]. Further, the reader should note that the system is developed using only information such as the positional relationship between the passer and the defense and the position of the goal, which are different from what a skilled player would think of as an area in which a pass can be made.

4 System Design and Development

4.1 Team pressure area

At first, we describe the concept and mathematical definition of team pressure field (TP) on which this research tackles to support learners [10]. However, in order to describe the TP, the word "individual pressure field (IP)" is required, so it is necessary to describe the IP at first. The formula for the IP of "player *i*" is defined as follows.

$$IP_i\,(x, y, r) \;=\; \exp\,(\frac{-(L/r)^2}{2}) \qquad (1)$$

The IP has a formal definition of the fact that the closer a player gets to a position, the less likely it is that another player will break through. Figure 1 illustrates the IP. In this study, the basketball court is divided into sections of 0.25 square meters in length and width, and the values of the IPs are obtained for each of the areas.

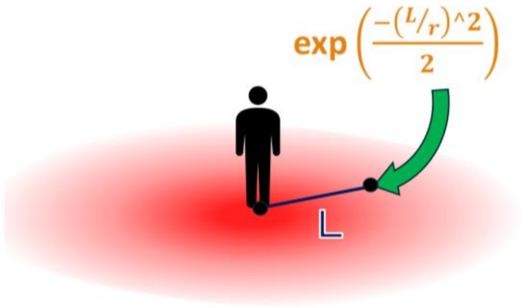

Table showing values for individual pressure fields (r = 1.2)

Value of L (meter)	Value of individual pressure field
1	0.707
2	0.249
3	0.043
4	0.003

Figure 1: Concept of IP (converted from [9])

The values of the IPs obtained in this way are added together for the number of team members to obtain the TP. In the case of basketball, it is the sum of the values of the IPs of the five players. The system can automatically calculate those of the offensive and defensive players, respectively. The formula for TP is as follows. *N* indicates the number of players on the team, *N*=5.

$$TP(x, y, r) \;=\; \sum_{i=1}^{N} IP_i(x, y, r) \qquad (2)$$

4.2 Distance to Goal Factors

In this research, we find the coordinates of the goal on the court and define a pass as an attack that can lead to a score the closer it is to the goal's coordinates. For this reason, we process the values of the TP that we obtain for each of the gridded areas in such a way that the closer the distance from the goal becomes, the larger the value becomes. However, in this study, we do not consider the scoring weight difference inside and outside the 3-point line, but in the future, we would like to consider introducing a weighting function that implements this perspective.

4.3 Factors depending on the position of the defense

In Chapter 3, we defined a risked pass as one that is likely to be cut off when the defense is in a straight line between the ball carrier and the receiver thereof who receives the pass. In this support system, this is expressed by increasing the value of the TP on the defender's side in the area where the likelihood of a pass being cut off is high.

4.4 Indication of low-risk pass areas and optimal pass partners

The low-risk pass safety area is determined by subtracting the TP of the defense from the TP of the offense. Larger values indicate safer passes, which are colored green and implemented on the simulator. The low-risk pass region is also depicted with a color gradient, with larger values being brighter and darker, and smaller values being darker and lighter. The optimal pass partner is determined based on the value of the low-risk pass safety region, which is highlighted by surrounding the corresponding player with a yellow circle.

5 Experimental Use

5.1 Experiment organization

This chapter describes the details of the experiment using the developed prototype system. The subjects of the experiment were 30 novices of basketball without much basketball experience, all of whom were male. Subjects ranged in age from 19 to 25, and 26 had experience in sports other than basketball. As for the definition of novice basketball players, in Yano's research dealing with learning support for novice players using the similar simulator as in this study, subjects who had belonged to club activities for about more than one year during their elementary or high school years were treated as experienced players [11]. Therefore, subjects who had been a member of a basketball club for less than one year were considered to be novice basketball players.

We next describe the flow of this experiment. Figure 2 illustrates the flow of the experiment. In this experiment, 30 subjects were divided into Groups A, B, and C, with 10 subjects in each. The division was done randomly, regardless of their experience in sports other than basketball or their scores in the pretest. The duration of the experiment was standardized at 5 minutes for each group.

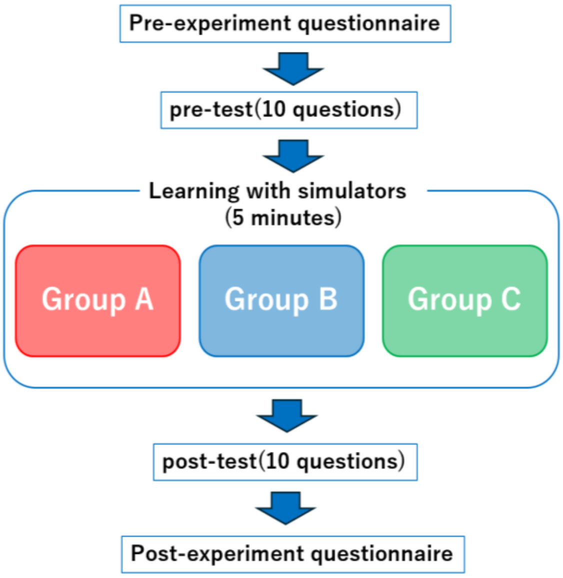

Figure 2: Experiment Flow

5.1.1 Experimental details of Group A

Group A is the control group and learns without the supporting function. In other words, learning by trial and error is conducted by running the simulator under the self-direction for five minutes.

5.1.2 Experimental details of Group B

Group B learned about low-risk passing opponents by having the participants move their offensive and defensive positions for five minutes. Subjects were instructed only on how to operate the simulator and that the yellow circle was the optimal pass partner, and then the experiment was conducted.

5.1.3 Experimental details of Group C

Group C learned by operating the simulator with fully implementation of all the supporting functions in this study for five minutes. Unlike Group B, we gave a brief explanation of the support system to Group C before the 5-minutes experiment. First, we explained to the subject the TP on which this research support system was based on. In other words, the subject was asked to look at the TP on the offensive side and the TP on the defensive side. The explanation was limited to the simple explanation that the closer the team has been to the player, the larger the value became, and did not include an in-depth explanation of the TP equation or how it was implemented on the simulator. Next, we explained that the difference between the two TPs indicated in green the areas where low-risk passes could be made. We also explained that the yellow circle indicates the optimal player for the pass, but we did not tell the subjects how to calculate it, as in Group B. Finally, images of the simulators handled by the subjects in the Group A, B, and C experiments are shown in Figure 3.

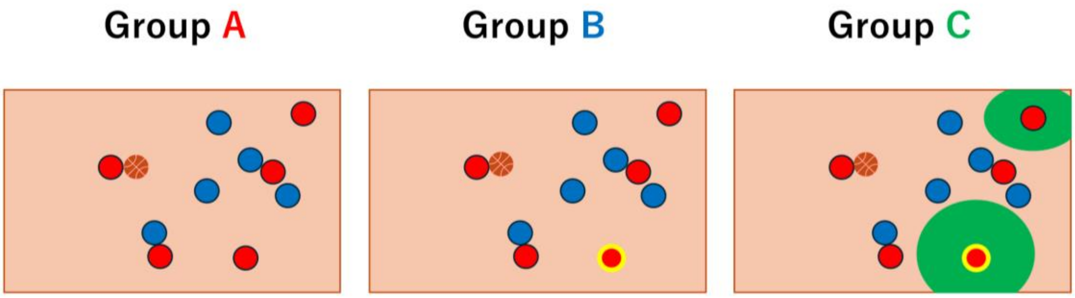

Figure 3: Images of simulators for each group

5.2 Configuration of Pre/Post test

This section describes the evaluation methods for the pre-test and post-test. Both the pre-test and the post-test consisted of 10 questions, and we prepared all the questions differently for the pre-test and the post-test. The order of the questions was fixed, and all 30 subjects were required to answer the same questions.

The questions were based on a screenshot of the simulator showing 10 offensive and defensive players and ball placement just before a pass was made, from which the player is asked to select the first and second best players to pass.

The scoring system for the questions was to award 10 points for the first player whose pass was suitable and who selected the correct answer, and 5 points for the second player whose pass was suitable and who selected the correct answer.

5.3 Resulting score

The mean scores of the pre-test and post-test for each group and the difference in scores between the two tests are shown in Table 1.

Table 1: Difference in scores between the two tests

	Group A	Group B	Group C
pre-test	57.0	54.0	55.0
post-test	54.5	67.5	64.0
difference in score	−2.5	13.5	9.0

The mean difference between the total pre- and post-test scores for Group A is −2.5 points, a slight drop. In comparison, the mean difference between the two tests for Groups B and C increased by 13.5 and 9.0 points, respectively, with the largest increase in Group B's score. When we tested the results using a one-way analysis of variance against the results, we found $p = 0.1317 (\geq 0.05)$, which did not confirm a significant difference.

The average score for each question in the post-test is then shown in Table 2.

Table 2: Comparison of scores by question

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Group A	7.5	10	1	1	3	10	4	7.5	8.5	2
Group B	8	8.5	6	6	5	7	8	8.5	6	4.5
Group C	9	9	4.5	3.5	3.5	8	8	6.5	8.5	3.5

Table 2 shows that Groups B and C scored higher than Group A in Question 3, Question 4, and Question 7 of the post-test, In other words, with regard to these issues, the support system in this study was able to improve the level of understanding. When we looked for commonalities among questions 3, 4, and 7, all of which had a positive effect on learning with the support system, we found that all three questions involved a pass to a player positioned closed to the three-point line. The players who received the passes were commonly located at a distance from the defense. Based on this factor, we speculate that this support system was effective in learning to select players who are capable of shooting the three-pointer.

5.4 Results of the Survey

We present the results of the survey we administered after the post-test. All surveys were conducted on a 5-point scale with 5 being the highest rating. When all groups were asked if they felt they were better able to make appropriate low-risk path decisions for basketball, Groups A, B, and C responded 2.9, 4.0, and 3.9, respectively. The results show that the experimental group with the support system was better able to make low-risk path decisions in basketball. However, when asked if they thought they could make use of this knowledge when actually playing basketball, the scores for Group A, Group B, and Group C were 3.4, 4.0, and 3.7, respectively, showing no significant differences.

5.5 Discussion

Here we discuss the fact that the results of Group B were slightly better than those of Group C, although there is little difference between the results of Group B and C. We consider that the reason for this result is that the support system in Group C may have given too much information to the subjects even though they were less experienced. In the Group C system, a green area was displayed for all players except the player holding the ball, and subjects were given information on the four players' areas and the yellow circle altogether. In comparison, in Group B, subjects were given information on only one best player with a yellow circle. In other words, because Group C, unlike Group B, is a support system that requires consideration of each individual offensive player, it may have given too much information and made the players think too much when solving the post-test to intuitively select the optimal pass partner.

6 Conclusion

The purpose of this study was to support the improvement of low-risk passing judgment among novice basketball players. We evaluated the effectiveness of the system by displaying areas on the simulator where low-risk passes could be made and having the subjects manipulate them.

The results of the experiment confirmed that the support system was able to improve scores in several problems and was particularly effective in selecting players who could aim for the there-pointer.

However, the applicable situations were limited. Therefore, we believe that by incorporating factors such as player direction and prior actions, the support system will be able to respond to a wider range of situations.

Acknowledgement

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