An Application Based on Spatial-Relationship to Basketball Defensive Strategies

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Abstract. This paper aims to develop a simulated system used for teaching and training basketball defensive strategies. Respectively, defensive strategies can be described within one method by editing video recorded from basketball games into desired clips for analysis and storing them into the database. In this paper, we used Spatial-Temporal Relationships to describe the local defensive movements by the basketball players in a game. The system will automatically capture tracks of defensive movements by the basketball players in the video clips, from which basketball coaches and players can learn various defensive strategies within the shortest period of time. The simulated system is expected to become a computerized educational aid to basketball teaching and training and to replace the unscientific and stereotyped system of basketball teaching and training.

1 Introduction

Basketball is an open sport. In this paper, we aim to develop a simulated system used for teaching and training basketball defensive strategies [1]. No matter whether on defense or offense, basketball players have to react according to their opponent's movements [2]. The success of a team depends on the degree of teamwork. A coach must have professional knowledge of basketball and he or she directly tells the players the training topics, from which the players can learn the key to successful defense. Therefore, the coach's pre-training preparation in collecting as well as sorting the information concerning the opponent teams, and how to oppose each tactic, plays an extremely important role in the field of basketball [3].

When it comes to basketball tactics, what we basically understand are no more than concepts of space, ball, and players (offensive as well as defensive). How to move? When to dribble? And when to pass the ball to teammates? If we can utilize a

T. Enokido et al. (Eds.): EUC Workshops 2005, LNCS 3823, pp. 180 – 188, 2005.

computer assisted teaching module, with theories of basketball tactics installed in the program, we are confident that the establishment of a simulated system concerning basketball tactics will facilitate the coach's preparation work. Figure 1 shows the overview of the system.

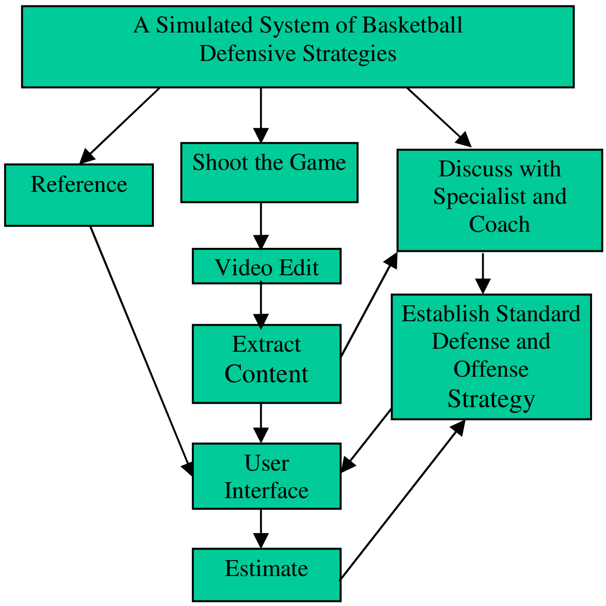

Fig. 1. The overview of system

2 Background

People in love with basketball would definitely know that a tactics-board is a white board on which marker pens or colored magnets are used to demonstrate specific tactics. Oftentimes, we see coaches draw the route or move the colored magnets to inform the players of the tactic message. Coaches have to express the tactics and draw the routes or move the colored magnets at the same time. The situation will go like this: Now, Position 1 dribbles the ball to the baseline, and meanwhile, Position 2 should…, and Position 3 needs to… Movements of the five players change accordingly, but coaches cannot draw five routes or move five magnets at the same time. Besides, the speed of each player and the position after the movement cannot be clearly displayed in terms of the relative space among the player, the teammates, and the ball. Those players who have a tacit understanding of the coaches' directions may quickly reach an agreement with the coaches; however, for newcomers or players who need time to accustom themselves to the situation, it would be totally different from the former.

The physical strength of a player is limited. Players are capable of experiencing a five to eight-hour training days. In addition to the tiresome training, a method with scientific basis to improve the players' abilities is needed. Nations with strong athletic programs such as the United States, Russia, and China all invest huge amounts of money in scientifically researching the most effective method to improve sports performance. However, the scientific research concerning psychology, physiology, or movement analysis, from either magazines or The Discovery Channel, emphasizes the importance of strengthening personal quality and sports performance. It is strange that, when compared to players of other Asian countries, Taiwanese basketball players have comparable strength, skills, conception, training duration, and training intensity. However, players seem not to be able to optimize their potential. The underlying factor behind this lies in the success rate of teamwork coordination and tactical execution.

Therefore, the purpose of the present study aims to establish a simulated system used for teaching and training basketball defensive tactics. With the facilitation of the system, the players not only have a more profound understanding of the tactics but also maintain a clearer concept in executing the tactics, without the coaches' repeating explanations.

The remainder of the paper is organized as follows. The next Section presents the method for capturing the moving objects and defining the spatial relationship. Section 4 describes the Experimentation and Result. Finally conclusions and future work are drawn in Section 5.

3 Capture the Moving Objects and Define the Spatial Relationships

Tracking objects in an image sequence has been discussed in many papers [4] [5] [6]. The method we used to track objects is similar as in [7]. However, [7] treats two or more objects as one object when they may move too close to each other. In our system, we discriminate objects as individuals, and use the colors of sportswear to distinguish one team from the other. Then, we extract the trajectories and movements of the players from the video which is recorded from an overhead view as shown in figure 2. The purpose of doing so is to avoid the heavy collision of players brushing past one another. In analyzing a sequence of players, players are represented by using silhouette images. In this paper, we used Spatial-Temporal Relationships [8] to describe the local defensive movements by the basketball players in a game, since each silhouette image needs to be assigned a unique number initially, as it will help us to conveniently identify the spatial relationship between each object. According to figure 3, we can define the 12 spatial relationships between each defensive player. The spatial relationship can be appropriately applied to basketball defensive strategy. Then, we reconstruct a spatial relationships table which represents a unique ID number for each spatial relationship as shown in table 1.

Here we only consider 12 spatial relationships. We do not consider the relationship for example: "A is up right side of B and close to B" due to object A and object B are too close and are the team partner. In this paper, spatial relationships are used to evaluate defensive strategies such as "2-3 local defensive"、"3-2 local

Fig. 2. To Film the basketball game with an overhead view

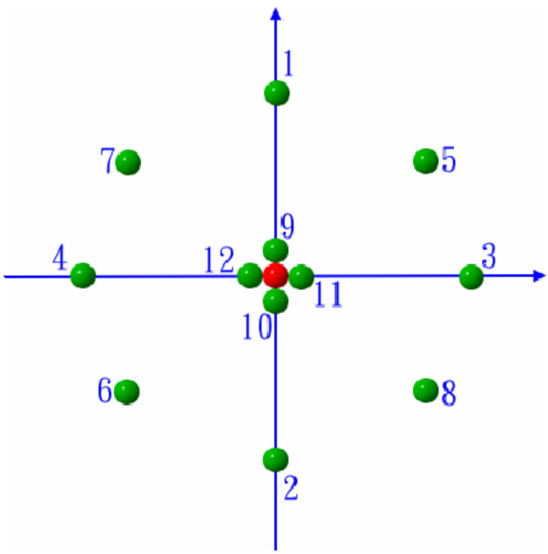

Fig. 3. The distribution of 12 spatial relationships

defensive" or "2-1-2 local defensive". Figure 4 shows the topologies of these defensive strategies and they would be the standard defensive strategies which are stored in the database. In figure 5, there exist six objects A、B、C、D、E and F. A-E are players and F is the basketball stand which plays a role as benchmark. Generally, the topology for a defensive strategy does not vary dramatically in an image sequence, since a team enforces a defensive strategy with certainty. Different relationships have their own ID number and the relationship sets can be represented by the matrix for each frame, since different defensive strategies have different spatial relationships. As shown as the topology in figure 5, the spatial relationships can be represented by the 6X6 *SP* matrix as follow:

$$
\begin{array}{c} \\ SP_i^j = \end{array}
\begin{array}{c}
\begin{array}{cccccc} A & B & C & D & E & F \end{array} \\
\left| \begin{array}{cccccc}
0 & 4 & 5 & 7 & 1 & 7 \\
0 & 0 & 5 & 7 & 5 & 1 \\
0 & 0 & 0 & 4 & 7 & 7 \\
0 & 0 & 0 & 0 & 5 & 5 \\
0 & 0 & 0 & 0 & 0 & 4 \\
0 & 0 & 0 & 0 & 0 & 0
\end{array} \right|
\end{array}
\begin{array}{c} \\ A \\ B \\ C \\ D \\ E \\ F \end{array}
$$

This matrix represents the spatial relationship for the i^{th} frame of video clip *j*. For our system, we have *n SP* matrix, since we choose *n* frames from every chip equally. The set of *SP* matrix can be represented as follows.

$$SP^j = \{SP_1, SP_2, ..., SP_i, ...SP_n\}$$

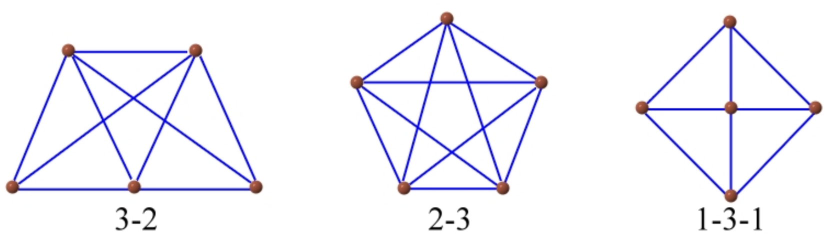

Fig. 4. Three topologies of defensive strategy

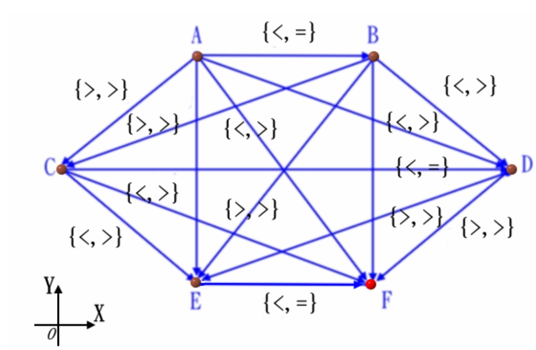

Fig. 5. The topology of defensive based on spatial relationship

We could calculate the similarity among different defensive clips. The distance *dist* between *SP* matrixes of each frames of different clip is obtained according to table 2.

$$dist_{(i)} = SP_i^j \Leftrightarrow SP_i^k \quad 1 \le i \le n \tag{1}$$

$$SP_i^j : The\ spatial\ matrix\ of\ i^{th}\ frame\ of\ clip\ j$$
$$SP_i^k : The\ spatial\ matrix\ of\ i^{th}\ frame\ of\ clip\ k$$

For example, if

$$SP_i^k = \begin{array}{c} \begin{array}{cccccc} A & B & C & D & E & F \end{array} \\ \left|\begin{array}{cccccc} 0 & 4 & 5 & 2 & 1 & 10 \\ 0 & 0 & 5 & 7 & 5 & 1 \\ 0 & 0 & 0 & 4 & 7 & 2 \\ 0 & 0 & 0 & 0 & 5 & 5 \\ 0 & 0 & 0 & 0 & 0 & 4 \\ 0 & 0 & 0 & 0 & 0 & 0 \end{array}\right| \begin{array}{c} A \\ B \\ C \\ D \\ E \\ F \end{array} \end{array}$$

Then *dist(i)* between SP_i^j and SP_i^k is

$$\begin{aligned} dist_{(i)} &= (0+0+9+0+4) \\ &+ (0+0+0+0) \\ &+ (0+0+9) \\ &+ (0+0) \\ &+ (0) = 22 \end{aligned}$$

Table 1. 12 spatial relationships

ID	Relationships	Judgments(X, Y)
1	A is on the top of B	(=, >)
2	A is under of B	(=, <)
3	A is right side of B	(>, =)
4	A is left side of B	(<, =)
5	A is up right side of B	(>, >)
6	A is up left side of B	(<, <)
7	A is bottom left side of B	(<, >)
8	A is bottom right side of B	(>, <)
9	A is on the top of B and close to B	(=, m)
10	A is under of B and close to B	(=, mi)
11	A is right side of B and close to B	(mi, =)
12	A is left side of B and close to B	(m, =)

Table 2. The distance between each spatial relationships

ID	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1	0	6	6	6	3	9	3	9	5	1	5	5
2	6	0	6	6	9	3	9	3	1	5	5	5
3	6	6	0	6	3	9	9	3	5	5	1	5
4	6	6	6	0	9	3	3	9	5	5	5	1
5	3	9	3	9	0	12	6	6	8	4	4	8
6	9	3	9	3	12	0	6	6	4	8	8	4
7	3	9	9	3	6	6	0	12	8	4	8	4
8	9	3	3	9	6	6	12	0	8	4	4	8
9	5	1	5	5	8	4	8	8	0	4	4	4
10	1	5	5	5	4	8	4	4	4	0	4	4
11	5	5	1	5	4	8	8	4	4	4	0	4
12	5	5	5	1	8	4	4	8	4	4	4	0

And the similarity ***SoD(Similarity of Defensive)*** between two defensive clips *j* and *k* is shown as followed:

$$SoD = \frac{1}{\frac{1}{n}\sum_{i=1}^{n} dist_{(i)}} = \frac{1}{\frac{1}{n}\sum_{i=1}^{n} (SP_i^j \Leftrightarrow SP_i^k)} \tag{2}$$

According the value of *SoD*, we could find similar defensive strategies in the database. The system supports a GUI to display the active similar defensive shot. This mechanism helps coaches to find the standard defensive technique for teaching and they could learn the usage frequency of the defensive strategy by the opponent.

4 Experimentation and Result

In our system, we need camera installation and proper clip editing, since we will just evaluate the defensive strategies. We should pre-edit the video and cut out the suitable clips that we want. The average time period of each clip is 20 seconds. However, the number of frames is probably different among clips which would impede comparison between defensive strategies. To solve this problem, we should choose enough average frames to make sure each clip would have an equal or close on number of frames. The figure shows the GUI and the results of a query. We experimented with a desktop PC of Pentium-4 3.0 GHz. In this system, we marked the goals first before we extracted the locations of the players as shown in the video in the figure 6. The upper right side of figure 6 shows the defensive location of the players. After extracting the locations, the system would record the spatial relationships of every frame in the database. And we can query for the similarity of defensive strategies from the database. Presently, our database has 361 specimens. We still collect and film basketball games for expanding the number of specimens to be stored in the database.

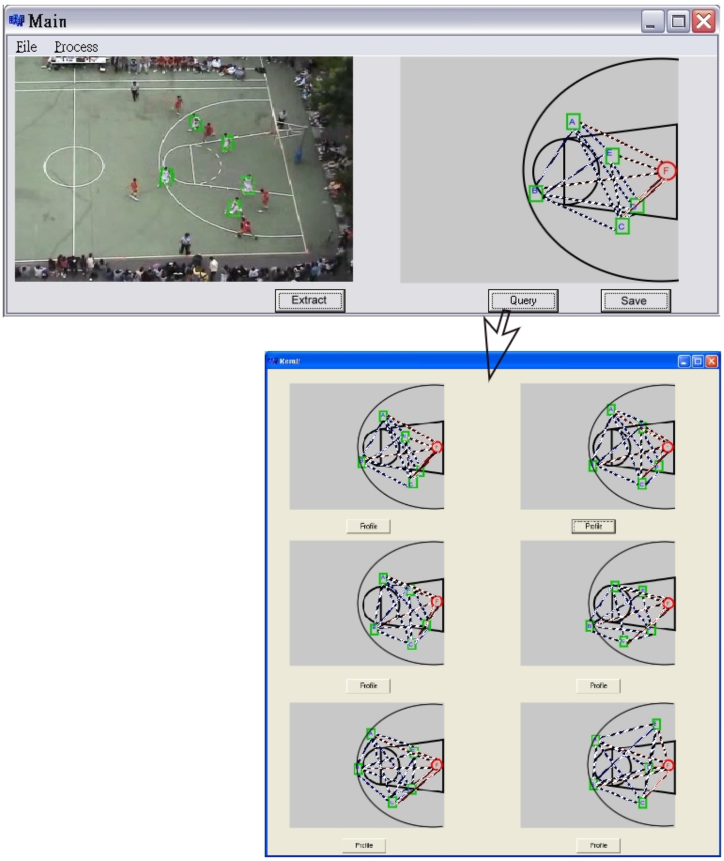

Fig. 6. The GUI and query results

5 Conclusion and Future Work

In this paper, we track objects moving in basketball game video sequence and record the locations of the defensive players. After extracting the locations, we used Spatial

Relationships to define the relationships between players for evaluating basketball defensive strategies. The system could retrieve the similar defensive strategies efficiently. It will help coaches and players to learn how they carried out the tactics via continuous frames. The coaches could teach players to learn various defensive strategies within the shortest time through the system and without using a white board on which marker pens or colored magnets are used to demonstrate specific tactics. The next work we will proceed to analyze is offensive tactics. A ball game includes offense and defense both which are crucial to win or lose. In addition, coaches can, by using another program to position correct defensive reactions, evaluate players' understanding towards specific tactics from their chosen defensive positions and moves.

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