行政院國家科學委員會專題研究計畫　成果報告

資訊化之籃球運動攻守戰術教學與訓練系統(I)

計畫類別：個別型計畫
計畫編號：NSC93-2413-H-032-013-
執行期間：93 年 08 月 01 日至 94 年 07 月 31 日
執行單位：淡江大學體育室

計畫主持人：覃素莉
共同主持人：相子元，洪啟舜
計畫參與人員：黃俊宏、謝枚芳

報告類型：精簡報告

處理方式：本計畫可公開查詢

中　華　民　國 94 年 10 月 30 日

行政院國家科學委員會補助專題研究計畫 ■成果報告

資訊化之籃球運動攻守戰術教學與訓練系統(I)

計畫類別：■ 個別型計畫　□ 整合型計畫
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計畫主持人：　覃素莉 淡江大學體育室 副教授
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執行單位：淡江大學 體育室

中　華　民　國　94　年　10　月　30　日

中文摘要

我們的研究計畫目的在於發展一套籃球模擬戰術系統，這套系統核心在於利用電腦軟體將比賽所拍攝下來的錄影帶，剪輯出需要分析的片段，再將影像套入電腦程式中，程式會自動抓出進攻或防守球員的移動軌跡，如此，教練及球員可在最短的時間了解影帶中的戰術變化。除此之外，教練可利用另一套軟體，將正確的攻守反應戰術作一定位，由球員選擇防守的位置及移動路線，藉此評估該球員對該戰術的認知程度。本計畫的發展方向主要在於學術的研究及籃球攻防戰術之標準模式的評估分析，除希望可做為教育訓練的輔助工具外，希望能將資訊科學化的訓練替代土法煉鋼的方式，因此本系統的完成除了對於學術上有一份貢獻外，更是體育與科技結合最佳表現。

關鍵詞：資訊化、攻守戰術、籃球教學系統、籃球訓練系統

英文摘要

The present study aims to develop a simulated system used for teaching and training basketball offensive and defensive strategies. By editing video tapes recorded from live basketball games into desired clips for analysis and storing them into the program, the program will automatically capture tracks of offensive and defensive moves by the basketball players in the video clips, from which basketball coaches and players learn various offensive and defensive strategies within the shortest time. In addition, coaches can, by using another program to position correct offensive and defensive reactions, evaluate players' understanding towards specific tactics from their chosen defensive positions and moves. The direction of the present study focuses on the academic research and the evaluation and analysis of a typical model of basketball offense and defense. 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. Therefore, the completion of the simulated system is not only a contribution to the academic research but also a successful connection between sport and technology.

keywords：a simulated system, strategy, basketball teaching system, basketball training system

前言:

球隊的打法選擇，關係到球隊的勝負，教練指示的打法就是要贏球，如果球隊的實力和對手是 7-3 波，一般來說用體能或是個人技術來應戰就可以取勝，但接近 6-4 波或是 5-5 波的狀況，則需要戰術來製造更多的機會。所謂戰術，分別應用在防守及進攻上，根據不同的目的令其具有不同的意義，條件在於全隊共同遵守一個特定的打法，所衍生出的動作及技術表現。但要瞭解對方的戰術並予以突破，必須在賽前做很多功課，包括敵情資料的收集，正確的目標設定，以及我方戰術的演練，然而現在是一個資訊化的時代，教練用經驗傳陳，土法煉鋼，已不敷使用，球員不見得願意接受教練耐心且長時間的指導，但是教練若具有更多的技能，必能博得球員的尊崇，於是這套系統的產生可解決教練收集敵情及處理資料的程序變得簡單，球員對本隊戰術瞭解也能縮短時間，是謂好事一樁。

報告內容:

1. Introduction

This project aims to develop a simulated system used for teaching and training basketball defensive strategies[1][2][3] in the first year. 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 project, we used Spatial-Temporal Relationships[4] 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.

In the first year of this project, we study and focus on defensive strategies and the organized and results of the project as show as follow. The next Section presents the method for capturing the moving objects and defining the spatial relationship. Section 3 describes the Experimentation and Result. Finally conclusions and future work are drawn in Section 4.

2 Capture the moving objects and define the spatial relationships

Tracking objects in an image sequence has been discussed in many papers [5] [6] [7]. The method we used to track objects is similar as in [8]. However, [8] 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 1. 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 project, 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 2, 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.

Fig. 1. To Film the basketball game with an overhead view

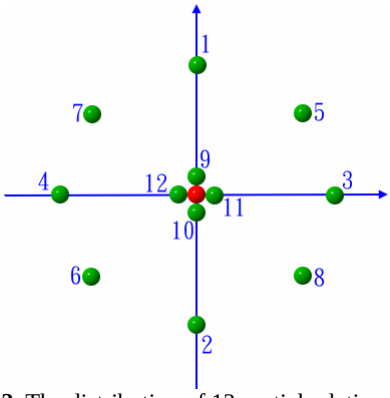

Fig. 2. The distribution of 12 spatial relationships

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. For this system, spatial relationships are used to evaluate defensive strategies such as “2-3 local defensive”、”3-2 local defensive” or “2-1-2 local defensive”. Figure 3 shows the topologies of these defensive strategies and they would be the standard defensive strategies which are stored in the database. In figure 4, 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 4, the spatial relationships can be represented by the 6X6 *SP* matrix as follow:

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

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.

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

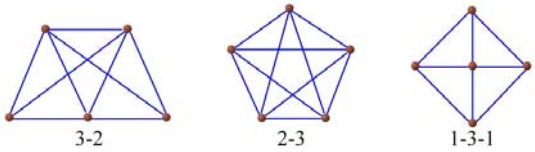

Fig. 3. Three topologies of defensive strategy

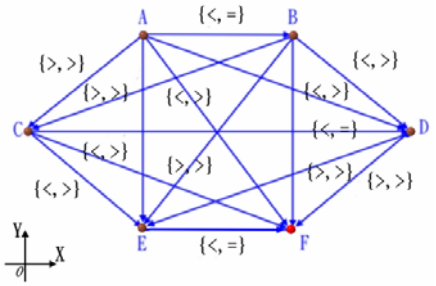

Fig.4. The topology of defensive based on spatial relationship

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.

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

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:

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

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.

3. 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 5. The upper right side of figure 5 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.

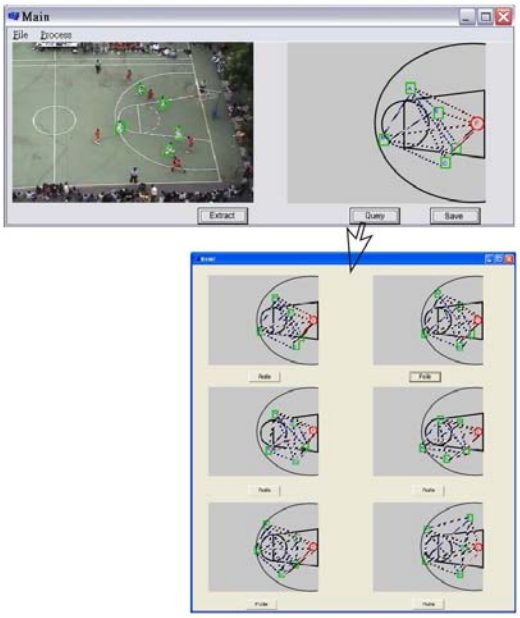

Fig.5. The GUI and query results

4. Conclusion and Future work

In our system, 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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計畫成果自評:

目前本計畫在籃球防守部分研究成果已將寫成論文並投稿到 International Symposium on Ubiquitous Intelligence and Smart Worlds(UISW2005)且已被接受，此國際研討會即將於 2005/12/06~2005/12/07 期間在日本九州舉辦，計畫參與人員將於十二月初出國參加並發表論文，會議論文評審委員均對於此篇論文給予肯定，其中一委員認為此研究論文在其所審之所有稿件中是最有趣的，給予了我們所有計畫參與人員莫大之鼓勵與肯定，而不枉這一年來的努力，讓我們在體育與科技的研究方向之路上能更加堅持與努力，本研究之第二年計畫目前也獲國科會計畫審查委員之青睞予以通過，計畫參與團隊也努力在計畫上研究，希望在計畫期限內展現更優良更有供獻之成果。