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Prediction based on basketball competition video athlete behaviors and on-line RBF neural network application

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ABSTRACT

The paper puts emphasis research on basketball competition athlete behaviors predicting, makes analysis of holding athletes' behaviors and shooting as well as other processes, proposes on-line RBF neural network model to predict basketball video's athlete behaviors, puts forward artificial potential fields to players in field position influence model, input athlete shooting, passing, dribbling and other motions into the model, and makes prediction by adjusting parameters, its result proves high precise of prediction.

KEYWORDS

Basketball video;
Behavior prediction;
Neural network;
Sport strategy.

INTRODUCTION

In recent years, with high technological development, obtain information ability by video has also being constantly improving; it makes contributions to relative fields development. The experts mention that it should bring video industry into sports field that will drive sports development, domestic scholars have ever proposed to introduce video relative techniques in sports training field, continuously shooting competition process will play positive roles in athletes and coaches' training, it not only helps them more intuitional understand shortcomings, but also points out direction to improve technical level abilities.

The paper just based on previous researches, it further makes analysis, the research will have important guiding significance in improving basketball players' competitive and technical levels aspects, and the model has widely prospects in sports video aspect.

BASKETBALL VIDEO'S ATHLETE PREDICTION MODEL ESTABLISHMENT

Two different coordinates' transformation

Players movement images in basketball field and

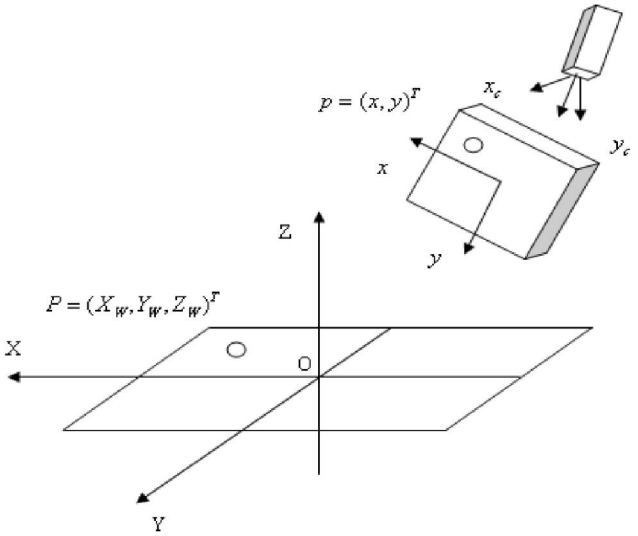

Figure 1: Schematic image coordinates relations with the world coordinate system

images in videos are not completely the same due to perspective projection and other problems' existing, therefore to solve the problem, it needs to establish true coordinate and video images' coordinate transformation model, two kinds of coordinates is as following Figure 1 show.

We let true coordinate system to be defined as world coordinate system, it has some connections with schematic image coordinate system, the connections totally include eight unknowns, in Figure 1 we assume $(x, y, 1)$ is p coordinate, the corresponding point is $(X_W, Y_W, 1)$, and then it has:

$$\begin{bmatrix} x \\ y \\ 1 \end{bmatrix} = \begin{bmatrix} r_1 & r_2 & r_3 \\ r_4 & r_5 & r_6 \\ r_7 & r_8 & r_9 \end{bmatrix} \begin{bmatrix} X_W \\ Y_W \\ 1 \end{bmatrix} \quad \textbf{(1)}$$

Let $r_9 = 0$, and then it has:

$$\begin{bmatrix} x_1 & y_1 & 1 & 0 & 0 & 0 & x_1X_{W_1} & y_1X_{W_1} \\ 0 & 0 & 0 & x_1 & y_1 & 1 & x_1Y_{W_1} & y_1Y_{W_1} \\ x_2 & y_2 & 1 & 0 & 0 & 0 & x_2X_{W_2} & y_2X_{W_2} \\ 0 & 0 & 0 & x_2 & y_2 & 1 & x_2Y_{W_2} & y_2Y_{W_2} \\ x_3 & y_3 & 1 & 0 & 0 & 0 & x_3X_{W_3} & y_3X_{W_3} \\ 0 & 0 & 0 & x_3 & y_3 & 1 & x_3Y_{W_3} & y_3Y_{W_3} \\ x_4 & y_4 & 1 & 0 & 0 & 0 & x_4X_{W_4} & x_4X_{W_4} \\ 0 & 0 & 0 & x_4 & y_4 & 0 & x_4Y_{W_4} & y_4Y_{W_4} \end{bmatrix} \times \begin{bmatrix} r_1 \\ r_2 \\ r_3 \\ r_4 \\ r_5 \\ r_6 \\ r_7 \\ r_8 \end{bmatrix} = \begin{bmatrix} X_{W_1} \\ Y_{W_1} \\ X_{W_2} \\ Y_{W_2} \\ X_{W_3} \\ Y_{W_3} \\ X_{W_4} \\ Y_{W_4} \end{bmatrix} \quad \textbf{(2)}$$

From above description, we can get eight unknowns should have corresponding four points so that can get mapping process, and can solve $r_i (i = 1, \cdots, 8)$.

Proposition and application based on artificial potential

In the later period of last century, foreign scholars put forward artificial potential fields, the method is simply converting target, barrier and robot and other people into one point, abstract artificial forces is proceeding with abstract by robot sports changes. Artificial potential field in moving objects positions function equation is:

$$W_{APF}(q) = W_{att}(q) + W_{rep}(q) \quad \textbf{(3)}$$

In above formula, attractive potential energy in the position of q is using $W_{APF}(q)$ to express, and rejective potential energy is expressed by $W_{rep}(q)$, moving object position is using q to express, and target position is using q_{goal} to express, definition about attractive potential energy is:

$$W_{att}(q) = \frac{1}{2} k_{att} \rho_{goal}^2(q) \quad \textbf{(4)}$$

In above formula, target Euclidean distance and moving object are expressed by, positively attractive gain coefficient is using k_{att} to express, besides, we can define attractive potential energy as:

$$F_{att} = -\nabla W_{att}(q) = -k_{att} \rho_{goal}(q) \nabla \rho_{goal}(q) = -k_{att}(q - q_{goal}) \quad \textbf{(5)}$$

And then corresponding repulsive potential energy is:

$$W_{rep}(q) = \begin{cases} \frac{1}{2} k_{rep} (\frac{1}{\rho(q)} - \frac{1}{\rho_0})^2, \rho(q) \le \rho_0 \\ 0, \rho \ge \rho_0 \end{cases} \quad \textbf{(6)}$$

In above formula, when moving objects suffered barriers resistance, the maximum influence degree threshold value is using ρ_0 to express, repulsive gain coefficient is using k_{rep} to express, and corresponding repulsive force formula is:

$$F_{att} = -\nabla W_{att}(q) = \begin{cases} k_{rep} (\frac{1}{\rho(q)} - \frac{1}{\rho_0}) \frac{1}{\rho^2(q)} \frac{q - q_{obstacle}}{\rho(q)} & , \rho(q) \le \rho_0 \\ 0 & \rho \ge \rho_0 \end{cases} \quad \textbf{(7)}$$

Therefore object suffered force is:

$$F(q) = F_{att}(q) + F_{rep}(q) \quad \textbf{(8)}$$

Research on artificial field application in basket-

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ball players' information quantity

By former introduction, we can know that in competition, it is one guard and multiple chasing players playing together, then we can assume that basketball field position is y, let present time to be t, and then its artificial potential information formula is :

$$W_{APF-i}^{t}(x) = W_{att-i}^{t}(x) + W_{rep-i}^{t}(x) \quad (9)$$

$$W_{att-i}^{t}(x) = \frac{1}{2} k_{att} \frac{1}{\rho_{goal}^{2}(x)} \quad (10)$$

Actual distance between opponent rim and player is using $\rho_{goal}(x)$ to express, when distance between rim and player is further, attractive potential will diminish, such position is bad for ace, on the contrary, it will more beneficial to ace. And to k_{att}, when the value is a negative value, it represents defensive ability, and when the value is a positive value, it represents ace ability.

At first initialize with player stealing and shooting abilities that are α , β, so when one party ball is stolen by another party, it will update according to following equation, its equation is as following:

$$k_{rep-B_i} = k_{rep-B_i} + \gamma \text{ , } \eta_d \le k_{rep-B_i} \le \theta_d \quad (11)$$

If above equation is false, and then it has:

$$k_{rep-B_i} = k_{rep-B_i} - \gamma, \quad (12)$$

So, we can regulate whether equation is true or false so that decide whether it steals ball or not, and can apply following formula:

$$k_{rep-A_i} = k_{rep-A_i} + \gamma \text{ , } \eta_d \le k_{rep-A_i} \le \theta_d \quad (13)$$

$$k_{rep-A_i} = k_{rep-A_i} - \gamma \text{ , } \eta_d \le k_{rep-A_i} \le \theta_d \quad (14)$$

If player shots and it can accord following formula:

$$k_{att-carrier} = k_{att-carrier} + \tau \text{ , } \eta_a \le k_{att-carrier} \le \theta_a \quad (15)$$

And if it fails in shooting, and it can have:

$$k_{att-carrier} = k_{att-carrier} - \tau, \quad (16)$$

Among them, player every time ability decreasing value or increasing value is γ and τ, player shooting ability upper limit value and lower limit value are respectively using θ_a and η_a to express, lower limit value and upper limit value of players' abilities to fight for ball lower limit value and upper limit value are respectively η_d and θ_d .

APPLY NEURAL NETWORK TO PREDICT BASKETBALL PLAYERS' BEHAVIORS

In basketball competition process, every athlete running trajectory is a kind of very complicated process; therefore the paper selects a kind of special way to make prediction that is on-line RBF neural network.

RBF neural network theory composition

In prediction field, neural network is a kind of higher application, from which the most important one belongs to forward neural network and that RBF neural network belongs to it, the model is composed of three forms that are output layer, input layer and hidden layer these three forms, its structure is as Figure 2 show:

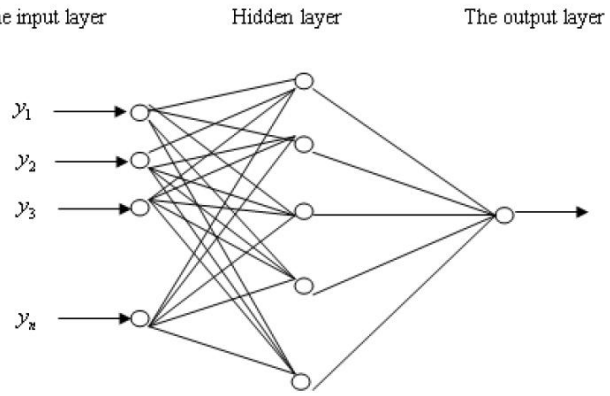

Figure 2 : The basic structure of RBF neural network

Though they have no connections, their nerve cells are mutual correlated. From input to output, it experienced non-linear and linear two processes, and the function of hidden layer is the total sum of linear weighting forms. In RBF neural network model, there are many kinds of hidden layer forms, from which the major ones have three kinds, that:

$$\varphi(r) = \exp\left(-\frac{r^2}{2\sigma^2}\right), \sigma \ge 0, r \in R \quad (17)$$

$$\varphi(r) = \frac{1}{(r^2 + b^2)^{1/2}}, b \ge 0, r \in R \quad (18)$$

$$\varphi(r) = (r^2 + b^2)^{1/2}, \quad (19)$$

Above are respectively Gaussian, inverse quadratic and multiquadrics these three kind of functions forms,

but exactly applying to the paper can select to use the first type, and then the type exact expression is:

$$\varphi(r) = \exp(-\| x - c_k \|/\sigma_k^2), k = 1, 2, \cdots, K \quad (20)$$

x and c_k radial distance can use above formula $\| x - c_k \|$ to express, hidden nerve cell radial basis function width is using k pieces of σ_k to express, l dimensions input vector is represented by x, and then it has x same dimension vector c_k. Corresponding output form can be expressed as:

$$\hat{y} = f(x) = w_0 + \sum_{k=1}^{K} w_k \exp(-\| x - c_k \|^2/\sigma_k^2) \quad (21)$$

Output layer and hidden layer weight values can be expressed as $w_k (k = 1, \cdots, K)$, and the deviation is w_0.

Minimum resources allocation network model's prediction model to basketball player behaviors

Minimum resources allocation neural network is a kind of algorithm that proceeding with hidden layer deleting, parameters adjustment and introducing new hidden layer, basic steps are:

① For input layer, after inputting x_i, then it has:

$$e_{rms}^i = \sqrt{\sum_{j=i-(M-1)}^{i} \frac{\| e_j \|^2}{M}} \quad (22)$$

$$\hat{y}_i = f(x_i) = w_0 + \sum_{k=1}^{K} w_k \varphi_k(x_i) \quad (23)$$

$$d_i = \min_{1 \le k \le K} \| x_i - c_k \| \quad (24)$$

$$\delta_i = \max\left\{\gamma^i \delta_{\max}, \delta_{\min}\right\} \quad (25)$$

$$e_i = y_i - \hat{y}_i \quad (26)$$

$$\varphi_k(x_i) = \exp(-\frac{1}{\sigma_k^2} \| x - c_k \|^2), k = 1, 2, \cdots, K \quad (27)$$

In above formula, damping coefficient $0 \le \gamma \le 1$ to express, and input data minimum and maximum distance are respectively using $\delta_{\min}$ and $\delta_{\max}$ to express, let hidden layer center closest distance x_i to be d_i.

② If $e_{ms}^t > s, d_i > \sigma_i, |e_i| > \varepsilon$, and then it can add a new hidden layer in neural network and get corresponding parameters are:

$$w_{K+1} = e_i \quad (28)$$

$$c_{K+1} = x_i \quad (29)$$

$$\sigma_{K+1} = Kd_i \quad (30)$$

The above condition is $K = k + 1$, and then hidden layer corresponding width can be expressed as K.

③ If above assumption is false, then we can change parameters, that:

$$v_i = v_{i-1} + K_i e_i \quad (31)$$

$$K_{i(z \times n_y)} = P_{i-1} C_i \left[R_i + C_i^T P_{i-1} C_i \right]^{-1} \quad (32)$$

$$P_i = \left[I_{z \times z} - K_i C_i^T \right] P_{i-1} + q_0 I_{z \times z} \quad (30)$$

In above formula, after the i samples entering into network, parameters state measuring parameter can use $v_i = \left[w_0^i, w_1^i, c_1^i, \sigma_1^i, \cdots, w_k^i, c_k^i, \sigma_k^i \right]^T$ to represent. $K_{i(z \times n_y)}$ Corresponding gain matrix is:

$$K_{i(z \times n_y)} = P_{i-1} C_i \left[R_i + C_i^T P_{i-1} C_i \right]^{-1} \quad (31)$$

By above formula, measuring parameters variance matrix can use R_i to express, and can let number of parameters use $z = n_y + K \times (l + n_y + 1)$ to express, number of nerve cell output nodes can use n_y to express, parameter vector v_i $f(x)$ can also be $C_i = \nabla_v f(x_i)$ form or other one, the form has:

$$C_i = \left[I, \varphi_1(x_i) I, \varphi_1(x_i)(2w_1/\sigma_1^2)(x_i - c_1) \right] \quad (32)$$

$$\varphi_1(x_i)(2w_1/\sigma_1^3) \| x_i - c_1 \|^2, \cdots, \quad (33)$$

$$\varphi_K(x_i) I, \varphi_K(x_i)(2w_K/\sigma_K^2)(x_i - c_K)^T \quad (32)$$

$$\varphi_K(x_i)(2w_K/\sigma_K^3) \| x_i - c_K \|^2]^T \quad (33)$$

And updated matrix is using output error covariance matrix P_i to express, as following formula show:

$$P_i = [I_{z \times z} - K_i C_i^T] P_{i-1} + q_0 I_{z \times z} \quad (34)$$

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Random steps are using q_0 to express, and unit matrix is using $I_{z\times z}$ to express, and then newly added column and line are respectively:

$$P_i = \begin{pmatrix} P_{i-1} & 0 \\ 0 & p_0 I_{z1\times z1} \end{pmatrix} \quad (35)$$

By above formula function relationship, we can get: initial estimation is sample data x_i and y_i covariance corresponded parameter that uses p_0 to express, newly added hidden layer node introduction and newly added number of parameters $z_1 = l + n_y + 1$ is using z_1 to express.

Regarding basketball player catching prediction model

If predicted that it is passing, then carry out next prediction that : catching people, in general, he will select nearest player, but it should also consider whether it is beneficial to ace or not, so in certain range, if it has k pieces of basketball players, then to the i player, his beneficial degree can be expressed as:

$$\varpi_i = w_1 \times U_{APF_i} + w_2 \times \frac{1}{d_{ci}^2}; w_1 + w_2 = 1 \quad (36)$$

In above formula, factor weight is respectively w_1 and w_2, representative actual distance between teammate i and holding player c is using $d_{carrier-i}$ to express.

TABLE 1 : Experiment data table

Session	Number of shooting scenes	Number of passing scenes	Number of dribbling scenes
Session 1	42	51	54
Session 2	43	48	33
Session 3	40	49	34
Session 4	46	52	38
Session 5	38	44	31
Session 6	49	47	40
Session 7	45	59	30
Session 8	16	61	35
Session 9	50	45	37
Session 10	52	54	40

MODEL APPLICATION AND ANALYSIS

To verify the paper athlete prediction behaviors, we collect recent years' basketball competition videos highlights, according to these videos as input data, make statistics of these videos stealing and shooting numbers so that to define basketball players' stealing and shooting abilities, we assume here stealing ability set as 3, and shooting ability set as 5, corresponding upper limit values are respectively 4 and 24, both lower limit values are 1, and $\tau and \gamma$ set values are also 1ÿin experiment, we defined weight ω_1、 ω_2 values are 0.26and 0.74, in testing phase, we select 20 competitions, we make changing by a kind of artificial way, after chang-

TABLE 2 : Traditional predication result table

Session	Shooting	Passing	Dribbling
Session 1	88	76	95
Session 2	89	79	91
Session 3	86	75	86
Session 4	91	74	88
Session 5	92	81	94
Session 6	70	83	92
Session 7	82	75	96
Session 8	86	71	91
Session 9	87	75	93
Session 10	88	82	95
Average accuracy rate	86.1	74.8	92.4

TABLE 3 : On-line neural network prediction

Session	Shooting	Passing	Dribbling
Session 1	80	73	*88*
Session 2	79	66	*85*
Session 3	85	71	*84*
Session 4	77	69	*82*
Session 5	84	67	*91*
Session 6	82	77	*93*
Session 7	78	71	*86*
Session 8	71	75	*87*
Session 9	82	79	*85*
Session 10	84	72	*83*
Average accuracy rate	*82.3*	*70.6*	*86.4*

ing, make concrete analysis, the analysis is as following TABLE 1 show:

According to above TABLE 1, we can predict above selected 20 competition videos clips' basketball players' holding staff movement process, prediction result is as following TABLE 2 show:

By above TABLE 3, we can see on-line neural network prediction is more accurate than traditional one, average accurate prediction all are above 85%, but in view of another aspect, passing accuracy rate is not so high, it mainly because the paper researches on holding movement form, and to passing, it still needs to learn catching players' running status.

CONCLUSIONS

By the paper final result, we can conclude that on-line neural network prediction model relative to traditional one, it has higher accuracy in each aspect prediction, which mainly because on-line typed neural network prediction constant adjusts whole algorithm structure with competition players' sports status, and computational speed is fast, efficiency is high, the algorithm is still effective to football and other sports events, so it has higher widely abilities, and can better fit for era development.

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