

Neural Network-Based Table Tennis Competition Technique and Tactics Diagnosis and Evaluation

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Abstract: Artificial intelligence technology has rapidly developed; it has already fused into all walks of life. The paper applies artificial intelligence knowledge to make diagnosis and evaluation on China men table tennis players' competition technical and tactics, the paper firstly briefly introduces artificial intelligence method and decision-making tree, rough set, artificial neural network, and then on the basis of artificial intelligence method and table tennis event knowledge to establish table tennis competition technique and tactics diagnosis evaluation indicator system, and make diagnosis on China men table tennis players' competition technique and tactics. Research gets that China men table tennis players should reduce push shot technical errors and improve forehand loop technique in technical aspect, while need to adopt more serve and attack as well as receive and control tactics in tactical aspect.

Keywords: Artificial intelligence, decision-making tree, neural network, table tennis, tactical diagnosis.

1. INTRODUCTION

Artificial intelligence initially was put forward in Dartmouth academy in 1956, after that, numerous scholars developed numerous theories and principles. Artificial intelligence involvement is very widely, to go in for artificial intelligence research, firstly is should understand computer knowledge, psychology, philosophy, and then it also should understand professional knowledge of researched specific problems. The paper applies artificial intelligence knowledge to research on China men table tennis event, in the hope of promoting China table tennis advancement [1].

For artificial intelligence technique, numerous predecessors have made great contributions, combined artificial intelligence with its located professional fields, perfectly promoted artificial intelligence technique. Among them, Li De-Yi in the article "network era artificial intelligence research and development" pointed out that it should utilize real life complex network small-world model and scale-free, take network topology as knowledge expression's a kind of new method, research on network topology evolution and network dynamics behaviours, and research on network intelligence [2]. And he pointed out that science development up to now, on one hand, it was highly differentiation, disciplines were constantly subdividing, new disciplines, new fields were constantly emerging [3]; on the other hand, it was highly fusion; more presented disciplines crossing and integrated tendency. The feature's performance in artificial intelligence research was particular [4].

Li Chuang in the article "Artificial intelligence principle-based test system", established genetic algorithm-based intelligent test system, which was used to solve the algorithm test questions models applied practical problems, and promoted artificial intelligence technological development. Liu Rui applied artificial intelligent algorithm into computer five in a row designing and implementation, which made great contributions to one of artificial intelligence research orientation- computer game [5].

On the basis of former researching on artificial intelligence, the paper combines artificial intelligent method with table tennis event, establishes table tennis competition technique and tactics diagnosis evaluation indicator system, and makes diagnosis on China men table tennis athletes' competition technique and tactics, and promotes artificial intelligence technological development and China table tennis levels improvements.

2. ARTIFICIAL INTELLIGENCE METHOD PRINCIPLE

Artificial intelligence refers to use artificial method to let computer to possess learning ability that is similar to people, and then implement intelligence similar to human in computer, let computer to be able to make independent discrimination, which makes correct decision-making for managers. Artificial intelligence gets involved in multiple kinds of researching fields; it has knowledge representation, machine learning (decision-making tree, rough set learning), experts system, artificial neural network and pattern recognition and others. Artificial intelligence is a science that involves quite widely, the paper mainly applies decision-making tree, rough set, artificial neural network knowledge under artificial intelligence, therefore for other parts in artificial intelligence, the paper will not further discuss.

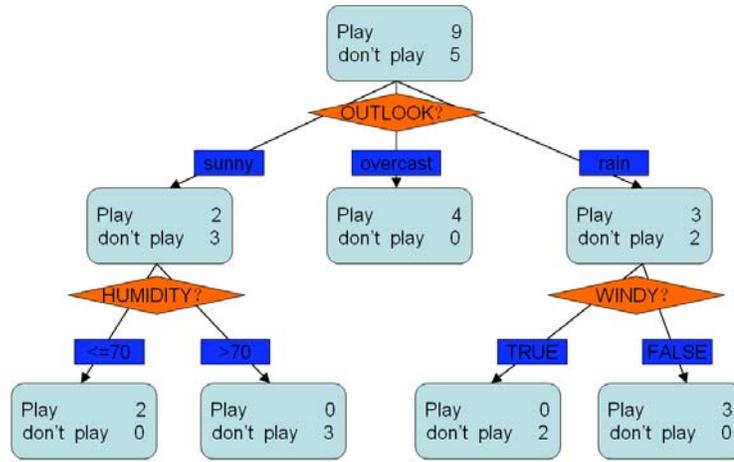


Fig. (1). Decision-making tree.

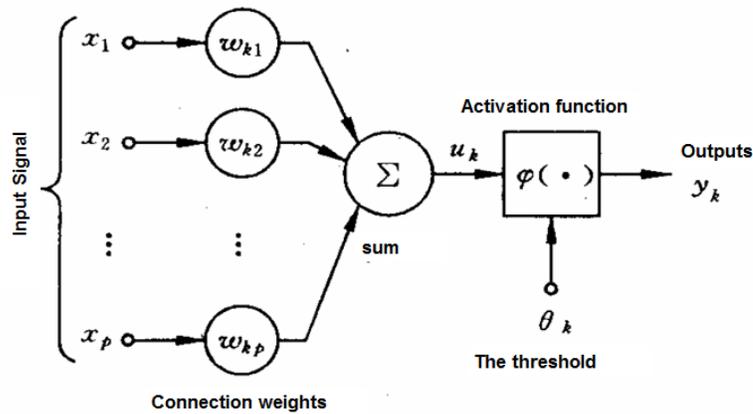


Fig. (2). Artificial neural network basic cell's nerve cell model.

3. DECISION-MAKING TREE, ROUGH SET, ARTIFICIAL NEURAL NETWORK

(1) Decision-making tree: it refers to a kind of method on the condition of each case occurrence probability is known, by constructing decision-making tree, it solves probability of its net present value expectation being larger and equal to zero, so that evaluates risks, judge its feasibility. It is probability analysis applied a kind of graphic method, because strategy branches formed graphics quite similar to a tree trunk, therefore it is called decision tree.

Apply decision-making tree method to judge feasibility, it mainly divides into three steps: 1 draw decision-making tree. 2 calculate expectation value. 3 define decision-making scheme. As Fig. (1) shows.

Decision-making tree is easy to implement, during learning and using process, people don't need to understand many background knowledge, only need to be able to learn decision-making tree expressed significance. For decision-making tree, it can get good efficiency result on large-scale data source in relative short time, and is easier to evaluation on model by static testing.

(2) Rough set: Rough set is a mathematical tool that processes uncertainty and inconsistency. Its thought is to

remain unchanged classification capacity, providing problems description, maximum advantage is no need to provide any experience information outside analysis; rough set has been widely applied in decision-making support, control engineering and other fields. In rough set theory, if attribute set A is composed of decision-making attribute set D and condition attribute set C , and $C \cup D = A$, $C \cap D = \phi$, then it calls S decision-making table. As formula (1) shows:

$$S = (U, C \cup D) \tag{1}$$

(3) Artificial neural network: Artificial neural network is a kind of abstract mathematical model that reflects human brain structure and functions, since it was proposed in 1943, by above 60 years' unsmooth development; artificial neural network correlation theory has already developed into a kind of inter-discipline that gets involved in mathematics, physics, computer and neurobiology. It has been widely used in intelligent control, image processing, pattern recognition, communication, robot and numerous fields. The paper only discusses most basic network model and applies it into sports events.

As artificial neural network basic cell's nerve cell model, it mainly has three basic elements, as Fig. (2) shows.

(1) A group connection: weights in connection represent connected intensity; weight is positive that is activation, is negative that is suppression. (2) A summation cell: solve each connection input signal weighted sum. (3) A nonlinear activation function: and restrict nerve cell output range into certain range, which plays mapping roles.

In addition, it also needs a threshold value θ_k . Above effects can express by mathematical formula:

$$u_k = \sum_{j=1}^p w_{kj} \cdot x_j \tag{2}$$

$$v_k = u_k - \theta_k \tag{3}$$

$$y_k = \varphi(v_k) \tag{4}$$

In formula (2-4), x_1, x_2, \dots, x_p is input signal, $w_{k1}, w_{k2}, \dots, w_{kp}$ is nerve cell K weight, u_k is linear combination result, θ_k is threshold value, $\varphi(\cdot)$ is activation function, y_k is output of nerve cell k . If increase one dimension to input dimension number, then it can include θ_k , according to formula (5):

$$u_k = \sum_{j=1}^p w_{kj} x_j, y_k = \varphi(u_k) \tag{5}$$

Here add a new connection, its input is $x_0 = -1$ (or $+1$), weight is $w_{k0} = \theta_k$ (or b_k), as following Fig. (3) shows.

Activation function $\varphi(\cdot)$ can have following ways.

Threshold value function:

$$\varphi(v) = \begin{cases} 1, & v \geq 0 \\ 0, & v < 0 \end{cases} \tag{6}$$

That is step function. Now output y_k is:

$$y(k) = \begin{cases} 1, & v_k \geq 0 \\ 0, & v_k < 0 \end{cases} \tag{7}$$

Among them, $v_k = \sum_{j=1}^p w_{kj} x_j - \theta_k$.

Piecewise linear function:

$$\phi(v) = \begin{cases} 1, & v \geq 1 \\ \frac{1}{2}(1+v), & -1 < v < 1 \\ 0, & v \leq -1 \end{cases} \tag{8}$$

Sigmoid function:

Most common function form is:

$$\phi(v) = \frac{1}{1 + \exp(-\alpha v)} \tag{9}$$

In formula (9), parameter $\alpha > 0$ can control its slope. Another kind is hyperbolic tangent function as formula (10) shows:

$$\phi(v) = \tanh\left(\frac{v}{2}\right) = \frac{1 - \exp(-v)}{1 + \exp(-v)} \tag{10}$$

The kind of function has progressive and smoothness and monotony.

4. COMPETITION TECHNIQUE AND TACTICS EVALUATION SYSTEM ESTABLISHMENT

Technique system construction: By competition video analysis, it can find that loop technique, flick technique, deep technique, drop shot technique and push shot technique are most applied techniques in competition, five techniques sum average utilization rate is 86%, from which loop technique utilization rate is 26.7% that utilization rate is highest. In view that loop technique has larger differences between forehand and backhand, divides it into forehand loop and backhand loop two types, it can get indicator system as following Table 1 shows.

For Table 1, combine with technique applied mass definition, it can get technique system operation indicator as Table 2 shows.

Tactics system construction: According to table tennis tactical behaviours and competition time series combinative methods, the paper can establish tactics system. According to competition time series, it can be divided into attack and service stage, receive and attack stage, and stalemate phase. According to tactical behaviours, it can be divided into attack, defence, control and equilibrium four types. Combine

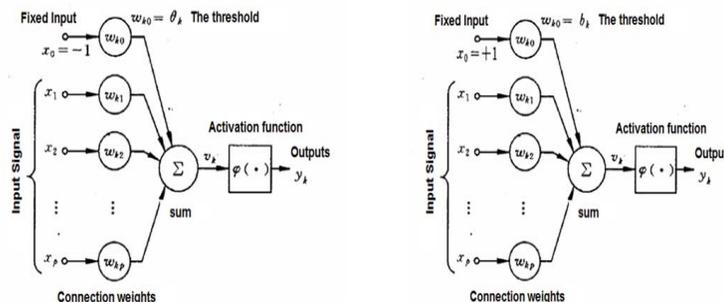


Fig. (3). Nerve cell model under newly increased connection.

above competition time series with tactical behaviours, it can get tactics system and competition time series graph as Table 3 shows.

For decision-making tree, rough set, artificial neural network researches, combine artificial neural network method with decision-making tree, rough set to make improvement, it can reasonable distinguish table tennis technique and tactics application effects under different competitive states, so that carries on effective technique and tactics diagnosis.

By improved artificial neural network algorithm, and combine with computer technology as well as table tennis technique, analyze China excellent men table tennis players competition video, it can get men technical scoring rate competitive efficiency value as Table 4 shows.

By Table 4, it is clear each technical indicator importance, from which maximum efficiency value is loop technique's forehand loop-backhand, Forehand loop-forehand, forehand loop-mid-way, efficiency values respectively occupies 15.37%, 14.03%, 11.62%.

Table 1. Table tennis competition technical system.

| First grade indicator (technique) | Second grade indicator (drop point) |
|-----------------------------------|---|
| Service | Short shot Semi-introduced long shot |
| Forehand loop | Forehand long shot Mid-way long shot Backhand long shot |
| Backhand loop | Forehand long shot Mid-way long shot Backhand long shot |
| Flick | Forehand Mid-way Backhand |
| Deep | Forehand long shot Mid-way long shot Backhand long shot |
| Drop shot | Forehand short shot Forehand semi-introduced |
| Push shot | Forehand long shot Mid-way long shot Backhand long shot |

Table 2. Technique system operation indicator.

| No. | Indicator | No. | Indicator | No. | Indicator |
|-----|--|-----|---|-----|---|
| 1 | Service-Short shot scoring rate | 19 | Backhand loop-backhand long shot utilization rate | 37 | Drop shot-Forehand semi-introduced scoring rate |
| 2 | Service-Short shot utilization rate | 20 | Backhand loop-error rate | 38 | Drop short-Forehand semi-introduced utilization rate |
| 3 | Service- semi-introduced scoring rate | 21 | Flick- forehand scoring rate | 39 | Drop short- Mid-way short shot scoring rate |
| 4 | Service- semi-introduced utilization rate | 22 | Flick- forehand utilization rate | 40 | Drop short- Mid-way short shot utilization rate |
| 5 | Service- Long shot scoring rate | 23 | Flick- Mid-way scoring rate | 41 | Drop short- Mid-way semi-introduced scoring rate |
| 6 | Service- Long shot utilization rate | 24 | Flick- Mid-way utilization rate | 42 | Drop short- mid-way short shot utilization rate |
| 7 | Forehand loop- Forehand long shot scoring rate | 25 | Flick- backhand scoring rate | 43 | Drop short- Backhand short shot scoring rate |
| 8 | Forehand loop- Forehand long shot utilization rate | 26 | Flick- backhand utilization rate | 44 | Drop short- Backhand short shot utilization rate |
| 9 | Forehand loop- Mid-way long shot scoring rate | 27 | Flick- error rate | 45 | Drop short- backhand semi-introduced scoring rate |
| 10 | Forehand loop- Mid-way long short utilization rate | 28 | Deep- Forehand long shot scoring rate | 46 | Drop short- Backhand semi-introduced utilization rate |
| 11 | Forehand loop- backhand long shot scoring rate | 29 | Deep- forehand long shot utilization rate | 47 | Drop short- error rate |

Table 2. Contd...

| No. | Indicator | No. | Indicator | No. | Indicator |
|-----|--|-----|---|-----|---|
| 12 | Forehand loop- backhand long shot utilization rate | 30 | Deep- Mid-way scoring rate | 48 | Push shot- Forehand scoring rate |
| 13 | Forehand loop- error rate | 31 | Deep- Mid-way long shot utilization rate | 49 | Push shot- Forehand long short utilization rate |
| 14 | Backhand loop- Forehand long short scoring rate | 32 | Deep- Backhand long shot scoring rate | 50 | Push shot- Mid-way scoring rate |
| 15 | Backhand loop- Forehand long shot utilization rate | 33 | Deep- backhand long shot utilization rate | 51 | Push shot- Mid-way long shot utilization rate |
| 16 | Backhand loop- Mid-way scoring rate | 34 | Deep- error rate | 52 | Push shot- backhand long shot scoring rate |
| 17 | Backhand loop- Mid-way long shot utilization rate | 35 | Drop shot- Forehand short shot scoring rate | 53 | Push shot- backhand long shot utilization rate |
| 18 | Backhand loop- backhand long shot scoring rate | 36 | Drop shot- Forehand short shot utilization rate | 54 | Push shot- error rate |

Table 3. Tactics system operation indicator.

| No. | Indicator | No. | Indicator | No. | Indicator |
|-----|-----------------------------------|-----|-------------------------------------|-----|---------------------------------------|
| 1 | Service- Attacking scoring rate | 8 | Stalemate- attack scoring rate | 15 | Receive- attacking scoring rate |
| 2 | Service- control scoring rate | 9 | Stalemate- control scoring rate | 16 | Receive- control utilization rate |
| 3 | Service- Defense scoring rate | 10 | Stalemate- Defense scoring rate | 17 | Receive- Defense utilization rate |
| 4 | Receive- Attacking scoring rate | 11 | Stalemate- Equilibrium scoring rate | 18 | Receive- Equilibrium utilization rate |
| 5 | Receive- control scoring rate | 12 | Service- attacking scoring rate | 19 | Stalemate- attack utilization rate |
| 6 | Receive- Defense scoring rate | 13 | Service- Control scoring rate | 20 | Stalemate- Control utilization rate |
| 7 | Receive- Equilibrium scoring rate | 14 | Service- defense scoring rate | 21 | Stalemate- defense utilization rate |

Table 4. Men technical scoring rate competitive efficiency value (%).

| Technical indicator | Efficiency value | Technical indicator | Efficiency value | Technical indicator | Efficiency value |
|------------------------------------|------------------|-----------------------------------|------------------|------------------------------------|------------------|
| Service-short shot | 4.1 | Service-semi-introduced | 6.38 | Service-long shot | 2.39 |
| Forehand loop-Forehand | 14.03 | Forehand loop-mid-way | 11.62 | Forehand loop-Backhand | 15.37 |
| Backhand loop-Backhand | 3.01 | Backhand loop-mid-way | 2.27 | Backhand loop-Backhand | 8.46 |
| Flick-Forehand | 1.08 | Flick-mid-way | 0.23 | Flick-Backhand | 1.49 |
| Deep-Forehand | 2.87 | Deep-mid-way | 3.36 | Deep-Backhand | 5.11 |
| Drop shot-Forehand short shot | 1.3 | Drop shot-mid-way short shot | 0.7 | Drop shot-Backhand short shot | 1.07 |
| Drop shot-Forehand semi-introduced | 3.02 | Drop shot-mid-way semi-introduced | 2.95 | Drop shot-Backhand semi-introduced | 0.97 |
| Push shot-Forehand | 8.09 | Push shot-mid-way | 1.93 | Push shot-Backhand | 2.95 |

5. COMPUTATIONAL RESULTS AND COMPARISONS

The paper applies artificial intelligence method principle into table tennis technique and tactics research, makes good improvements on artificial neural network model and perfect

combines it with table tennis technique and tactics; for table tennis event, it establishes tactics system and technique system, which plays guiding role in table tennis training orientations; combines with tactics evaluation system and technique evaluation system, analyzes China men table tennis athletes'

technique and tactics, and can know that loop techniques' forehand loop-backhand, Forehand loop-forehand, forehand loop-mid-way have highest scoring efficiency; Athletes' most important tactics are service and attack as well as receive and control.

CONFLICT OF INTEREST

The author confirms that this article content has no conflict of interest.

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