Fuzzy mathematics model-based soccer robot competition situation evaluation applied research

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ABSTRACT

With sports development, soccer robot also accordingly moves forward, especially for soccer robot competition situation evaluation correlated analysis and researches are more focused by lots of scholars. The paper just based on the thought, it introduces fuzzification thought into it, analyzes its main influence factors, and applies specific examples to make algorithms verification, it gets its competition result's matrix structure, so it proves soccer robot competition situation evaluation model plays an important role in improving soccer robot undertakings development.

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KEYWORDS

Competition situation evaluation;
Fuzzy mathematics;
Comprehensive evaluation;
Soccer robot;
Transformation matrix.

PREFACE

With social development, deep researches have been made on multiple intelligent system problems; the system has already become one of important artificial intelligence researching orientations, form which soccer robot development is using a kind of evaluation standard competition to propel to artificial intelligence and multiple intelligent system researching.

Among them, lots of scholars have made efforts, and got plentiful achievements, which provides beneficial conditions for scholars from all circles of society researching, and provides impetus for soccer robot development. Such as: Wang Bing in robot competition researches, he put forward that divided information fusion into three layers that were respectively decision layer, feature layer, data layer, it mainly used own party and opponent as well as players positions to calculate accelerated speed, speed, so it could predict that subsequently soccer robot player's trend and position change status, and he also proposed that soccer robot competition system was a battlefield information fusion system, its technical research could reference formers' information fusion system relative research achievements so that improved soccer robot intelligence level.

The paper on the basis of previous research result, it analyzes soccer robot fuzzy comprehensive evaluation influence factors, puts forward and discusses fuzzy evaluation algorithms that provides theoretical basis for soccer robot fuzzy comprehensive evaluation, in addition, it also introduces specific examples to make simulation, applies examples to prove that the model fuzzy comprehensive evaluation on soccer robot is exactly reasonable, so it proves the model has universalities.

FUZZY MATHEMATICS THEORY

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ESTABLISHMENTS

In nature, it has excessive unclear problems due to objective differences that are fuzziness problems, it is up to American automatic control expert that provided fuzzy set concept in 1965 and was the theoretical basis of fuzzy mathematical problems; For a normal set A, select any element x, $A \notin x$, or $x \in A$, it should select one of the two, we can promote feature function till fuzzy interval to be $[0,1]$, in normal set, it takes 1, 0 two values, so it can use function to express as:

$$A(x) = \begin{cases} 0 & x \notin A \\ 1 & x \in A \end{cases} \tag{1}$$

We let A to be fuzzy set, then A is a function set of x in $[0,1]$, and x is global value, if it takes A, B intersection, and sum set as well as A complementary set as fuzzy set, corresponding memberships are:

$$(A \vee B)(x) = \max(A(x), B(x)) \tag{2}$$

$$(A \wedge B)(x) = \min(A(x), B(x)) \tag{3}$$

$$A'(x) = 1 - A(x) \tag{4}$$

The model's intersection and sum can be applied into arbitrarily multiple models' sets.

Assume $n \times m$ and $m \times 1$ are respectively A and B fuzzy matrix forms, and then $C = AB$ is matrix of $n \times 1$, corresponding element is:

$$C_{ij} = \vee(a_{ik}{}^m \wedge b_{kj}) \tag{5}$$

In above formula $(i = 1, 2, \cdots, n; \ j = 1, 2, \cdots m)$, and $\wedge$" together with $\vee$" represent:

$$a \vee b = \max(a, b), \ a \wedge b = \min(a, b)$$

Define judgment object, it is individual variable affected by y pieces of factors, and its factor set is α, definition is:

$$\alpha = (\alpha_i, \alpha_i, \alpha_i, \cdots, \alpha_i) \tag{6}$$

And regulate

$$\alpha_i \ (i = 1,2,3,\cdots,y) \tag{7}$$

Due to each variable weight is different, for defined judgment grade, impact degree is also different, we assume that its weight allocation is a_i, and:

$$b_i = (b_1, b_2, b_3, \cdots b_y) \tag{8}$$

Among them:

$$b_i (i = 1, 2, 3, \cdots, y) \tag{9}$$

It is formula(2) weight value, according to common sense, we know $b_i \geq 0$ and $\sum\limits_{i=1}^{y} b_i = 1$.

If every factor b_i includes n pieces of sub factors, its factor set is

$$\alpha_i = (\alpha_{i,1}, \alpha_{i,2}, \alpha_{i,3}, \cdots, \alpha_{i,n}) \tag{10}$$

Then corresponding weight value is:

$$b_i = (b_{i,1}, b_{i,2}, b_{i,3}, \cdots b_{i,n}) \tag{11}$$

To $\alpha_{i,j}$ weight value b_i, according to common sense, it is clear that $b_{i,j} \geq 0$ and $\sum\limits_{j=1}^{n} b_{i,j} = 1$

Establish an evaluation indicator set as:

$$g = (g_1, g_2, g_3, \cdots, g_s) \tag{12}$$

Corresponding evaluation objects can be divided into s pieces of different grades, here, we let $g_1, g_2, g_3, \cdots, g_s$ to be each merit goodness from high to low, such as excellent, good, qualified, and unqualified so on.

Regarding evaluation indicators' defining and selecting

By carefully researching on football field, it can select evaluation indicator factors as: current competition balance time and scores, the two sides dribbling speed, the two sides' sports directions, player position, ball speed, ball sports direction and ball position so on.

Research on field information fuzzification process

Due to football field form is the result common decided by multiple factors, it needs to establish and adopt fuzzification method to research, if football competition attack time is in right half, then it can use formula:

$$\begin{cases} Object.x = BOUND\_RIGHT - Object.x; \\ Object.y = Object.y; \\ Object.\theta = \pi - Object.\theta \end{cases}$$

Above formula can be used to transform, from which $BOUND\_RIGHT$ as the length of football field, *Object*

FULL PAPER

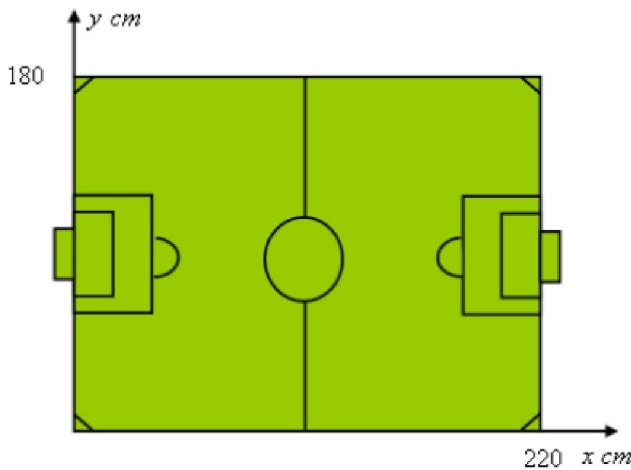is an coordinate that includes ball, robot two sides and field as following Figure 1show:

Figure 1 : Stadium graph

In order to control the degree of control $flag$, set its initial value as 0, for $flag$ we takes three values that are respectively 1, -1, 0, if opponent is weak, then $flag = 1$; if own party is weak, then $flag = -1$, if the two have no big differences, then $flag = 0$, other value $flag$ is a constant.

Let b_0 to express opponent used time, b_h then express own party used time, so here own party ratio is:$\alpha_h = \dfrac{b_h}{b_h + b_0} \times 100\%$

Then control degree corresponding membership function is expressed as:

$$flag = \begin{cases} -1, & \alpha \geq 60\% \\ 1, & \alpha < 40\% \\ 0, & 40\% \leq \alpha < 60\% \end{cases} \quad (13)$$

In robot football field, the same as people, it also has all-out attack(1-0-4: four forwards), Stress attack(1-1-3: one rear guard, three forwards), all-out defense(1-4-0: four rear guards), stress defense (1-3-1: one forward, three rear guards)as well as attack and defense balance (1-2-2: two forwards, two rear guards) such five battle formations, and during competition period, football robot transform formations according to control degree, scores and other factors, if it is in final stage of competition, then formation defining is based on scores.

Football robot competition evaluation system construction

According to establish time factors, and combined ratio as well as control degree integration, it established football robot competition first grade evaluation system factor set, uses events driven mode to improve decision-making system efficiency as following Figure 2 show:
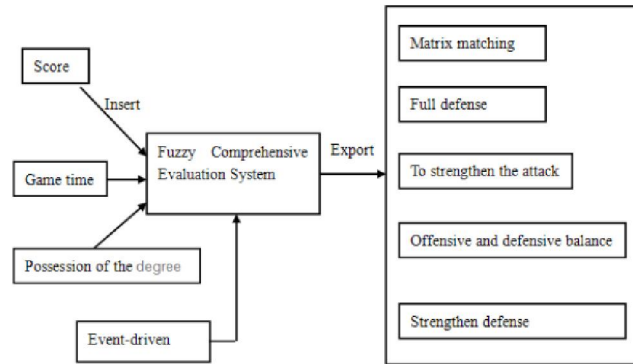

Figure 2 : Evaluation model based on event-driven

Let(1) g_1, g_2, g_3, respectively express control degree, competition time, scores that construct comprehensive evaluation system factor set,

That:

$$g = (g_1, g_2, g_3) \quad (14)$$

(2) $\alpha_1, \alpha_2, \alpha_3, \alpha_4, \alpha_5$ respectively represent strengthen defense, strengthen attack, attack and defense balance, all-out attack, all-out defense these types, so that it constructs single factor fuzzy mapping set, that:

$$f : g \mapsto \alpha, g_i \big| \mapsto f(g_i) \Leftrightarrow (\alpha_1, \alpha_2, \alpha_3, \alpha_4, \alpha_5) \quad (15)$$

Among them, $\alpha_{ij}(i = 1, 2, 3, j = 1, 2, 3, 4, 5)$, fuzzy evaluation set corresponds to factor g is $f(g_i)$. In order to define correct fuzzy mapping, make corresponding processing with g_1, g_2, g_3, and carry out grade classification problem.

Football robot competition time classified problem

Football robot competition time is even distributed, each have 5min in first and second half, we let $\Box t \Box t$ to represent competition time, current competition already proceeded time t_c , so competition ratio:

$$\Box t = \dfrac{t_c}{10} \times 100\% \quad (16)$$

TABLE 1 : Time factor membership

Grade	u_1	u_2	u_3	u_4	u_5
$\Delta t \in [0, 0.3]$	0.00	0.10	0.90	0.80	0.20
$\Delta t \in [0.3, 0.6]$	0.10	0.20	0.50	0.80	0.50
$\Delta t \in [0.6, 0.8]$	0.20	0.40	0.70	0.60	0.60
$\Delta t \in [0.8, 0.9]$	0.30	0.40	0.60	0.80	0.80
$\Delta t \in [0.9, 1.0]$	1.00	1.00	0.10	0.40	0.40

TABLE 2 : Control degree membership

grade	u_1	u_2	u_3	u_4	u_5
Flag=0	0.10	0.50	0.80	0.90	0.20
Flag=1	0.30	0.60	0.70	0.80	0.30
Flag=2	0.40	0.60	0.80	0.70	0.40

Then α corresponding membership evaluation set is as following TABLE 1 show:

Football robot competition control degree factors classified problems

By previous stated control degree function problems, according to investigation, expert experience and mathematical statistics, it makes correlation analysis and gets relative α evaluation set membership classification, as following TABLE 2 show:

Football robot competition scores classified problems

Assume that the paper discussed interval is integer value in [-10, 10], opponent score s_0, own party score s_h, then the two side score g difference is $\Box s = s_h - s_0$, according to investigation, expert experience and mathematical statistics, it makes correlation analysis and gets relative g classification, as following TABLE 3 show:

FOOTBALL ROBOT COMPETITION COMPREHENSIVE EVALUATION TRANSFORMATION MATRIX PROBLEMS

Define fuzzy evaluation matrix process is a matrix r that integrates the above three fuzzy evaluation together, that:

TABLE 3 : Score grade factor membership

Grade	u_1	u_2	u_3	u_4	u_5
$\Delta s = 0$	0.00	1.00	0.00	0.80	0.10
$\Delta s \in [-2, -1]$	0.00	0.80	0.40	1.00	0.20
$\Delta s \in [-5, -3]$	0.00	1.00	0.10	0.80	0.10
$\Delta s \in [-10, -6]$	0.10	0.20	0.80	1.00	0.20
$\Delta s \in [1, 2]$	0.20	0.40	0.60	0.80	0.50
$\Delta s \in [3, 5]$	0.40	0.20	0.60	0.40	0.80
$\Delta s \in [6, 10]$	1.00	0.00	0.20	0.10	0.60

$$r = \begin{bmatrix} f(g_1) \\ f(g_2) \\ f(g_3) \end{bmatrix} = \begin{bmatrix} r_{11} & r_{12} & r_{13} & r_{14} & r_{15} \\ r_{21} & r_{22} & r_{23} & r_{24} & r_{25} \\ r_{31} & r_{32} & r_{33} & r_{34} & r_{35} \end{bmatrix} \quad (17)$$

According to investigation, expert experience and mathematical statistics, as well as combine with weights defining method adoption, it districts time factor, control degree and scores allocation the three weights as:

$$b = (b_1, b_2, b_3) = (0.5, 0.3, 0.2) \quad (18)$$

By matrix compositional operation, it can get its corresponding evaluation result,

That:

$$c = b * r = (b_1, b_2, b_3, \cdots b_y) * (r_1, r_2, r_3, \cdots, r_y)^T$$
$$= (c_1, c_2, c_3, \cdots, c_y) \quad (19)$$

Above formula c is fuzzy evaluation vector, make

TABLE 4 : Weight and membership allocation

Factor	u_1	u_2	u_3	u_4	u_5	Weight ϖi
v_1	0.00	0.80	0.40	1.00	0.20	0.50
v_2	0.20	0.80	0.60	0.80	0.40	0.30
v_3	0.00	0.20	0.60	0.80	0.50	0.20
Evaluation result C	0.06	0.68	0.44	0.90	0.32	

FULL PAPER

normalization processing with above evaluation result, and then select maximum membership c_j $(j = 1, 2, \cdots 5)$ that is final football robot competition fuzzy comprehensive evaluation result.

FUZZY COMPREHENSIVE EVALUATION SPECIFIC APPLICATION

For above evaluation process, the paper assumes that when opponent current competition score is:0:1, there is one minute left before first half ending, so our party is backward, and corresponding control degree is $flag = -1$, now weight distribution is as following TABLE 4 show:

Make corresponding fuzzy transformation of above formula assumed weight set b, after computation handling, it can get corresponding result $c = [0.05, 0.67, 0.45, 0.91, 0.31]$, make corresponding normalization processing with the result, and then according to membership corresponding principles, it can get final comprehensive evaluation result is output formation α_2, so now it should strengthen attack, and attack way is the form of one rear guard, three forwards,

that: $1 - 1 - 3$.

USE SIMULATION MODEL TO VERIFY

The paper adopts $FIRA$ provided simulation platform to make simulation on football robot, firstly it should establish coordinate system that applies material object and simulation system transformation equation:

$$\begin{bmatrix} x_0 \\ y_0 \end{bmatrix} = \begin{bmatrix} x_1 - 6.8117 \\ y_1 - 6.373 \end{bmatrix} \times 2.53 \qquad (20)$$

In above formula y_1, y_0, x_1, x_0 represents simulation horizontal and vertical coordinate axis, for adopting above evaluation model or not, it uses two forwards, two rear guards ($1 - 2 - 2$) strategy to make comparison, above totally proceeds with 5matches, their result is as following TABLE 5 show:

The two sides respectively make analysis of multiple evaluation with and without comprehensive evaluation model, use two forwards and two rear guards (1-2-2)strategy to make comparison, similarly proceed with 5 competitions, their result is as following TABLE 6show:

By above two TABLE 5 and TABLE 6, we can

TABLE 5 : Test one competition result

Session	Number of goal	Pitch time %	Number of shooting times	Control degree%	Free throw times	Winning session
1	3:1	56.30:43.550	9:6	45.50:54.40	8:5	Win: defeat
2	2:1	55.40:44.70	8:5	47.5052.30	9:7	Win: defeat
3	1:1	54.40:45.50	5:3	52.5047.50	4:6	Draw: Draw
4	2:1	51.50:48.50	7:5	44.5055.60	6:5	Win: defeat
5	3:2	53.50:46.50	10:7	48.3051.80	10:7	Win: defeat
Total	11:5	54.30:45.70	39:26	47.6052.40	37:30	4win1draw

TABLE 6 : Test two competition result

Session	Number of goal	Pitch time %	Number of shooting times	Control degree%	Free throw times	Winning session
1	3:0	55.50:44.50	10:3	42.50:57.50	8:4	Win: defeat
2	4:1	54.60:45.40	9:3	43.60:56.40	9:5	Win: defeat
3	2:0	56.50:43.50	8:2	41.60:58.40	7:5	Win: defeat
4	5:2	58.50:41.50	11:5	46.50:53.50	10:6	Win: defeat
5	3:1	53.50:46.50	10:4	44.50:55.50	8:5	Win: defeat
Total	17:4	55.72:44.30	48:17	43.75:56.30	42:25	5win

FULL PAPER

get that to football robot situation evaluation, multiple grades form is obviously higher than first grade form, which is because multiple grades evaluation integrates all kinds of complicated factors, and improves football robot corresponding strategy allocation effects.

CONCLUSION

(1) The paper introduces football robot competition situation evaluation system, and introduces fuzzy mathematical concept and correlation algorithms, uses membership to make correlation evaluation, which provides systematic theory support for football robot competition sports development and provides impetus for its development.

(2) In the paper's models, the most important is weight allocation, as long as based on different football robot correlation indexes weights, it can comprehensive evaluate different football robot competition forms problems, so the model has universalities.

(3) Though the paper data has some constraints, in football robot competition situation analysis problems, apply fuzzy mathematics method and start from multiple aspects development, so that provide fast path for football robot competition situation research aspects.

(4) In the model verification process, establish multiple indicators more highlights the model's superiority by comparing to previous models.

REFERENCES

[1] Alireza Fadaei Tehrani, Ali Mohammad Doosthosseini, Hamid Reza Moballegh, Peiman Amini, Mohammad Mehdi DaneshPanah; A New Odometry System to Reduce Asymmetric Errors for Omnidirectional Mobile Robots. Robo Cup, 600-610 **(2003)**.

[2] R.E.Kalman; A New Approach to Linear Filtering and Prediction Problems. Transaction of the ASME - Journal of Basic Engineering, **82**, 35-45 **(1960)**.

[3] Carlos F.Marques, Pedro U.Lima; A Localization Method for a Soccer Robot Using a Vision- Based Omni- Directional Sensor. RoboCup 2000, 96-107.

[4] S.Thrun, D.Fox, W.Burgard, F.Dellaert; Robust Monte Carlo localization for mobile robots. Artificial Intelligence Journal, **128**, 99- 41 **(2001)**.

[5] Kan Li-Ping; Evaluation on Technical data of Free Kick in Impose Fine Region in Football Game. Bulletin of Sport Science & Technology, **19(3)**, 19-20 **(2011)**.

[6] Zheng Wei; On the Training of Football Shooting. Sport Science and Technology, **3**, 23-26, 33 **(2000)**.

[7] Yang Jilin et al.; Research on shooting in the 17th World Cup football semi-finals. Journal of Shandong Physical Education Institute, **18(3)**, 51-53 **(2002)**.

[8] Wang Xin; Analysis on the best region of shoot. Journal of Nanjing Institute of Physical Education, **16(5)**, 96-97 **(2002)**.

[9] Zhang Ji, Xiang; A Study on Effect of Application of the Skills of Side-to-middle Court Passing of Chinese Football Team. Journal of Hubei Sports Science, **21(1)**, 74-75, 79 **(2002)**.

[10] Li Ning, Zhou Jiandong; Statistical Analysis of Goals at 19th FIFA World Cup. Journal of Jilin Institute of Physical Education, **27(3)**, 45-47 **(2011)**.