ISSN : 0974 - 7435 Volume 10 Issue 6

BioTechnology
An Indian Journal

FULL PAPER

BTAIJ, 10(6), 2014 [1436-1441]

Soccer robot optimal tactics strategy research based on particle algorithm

Yongbing Chen[1]*, Geng Du[2]

[1]Institute of Physical Education, Wenshan University, Wenshan, (CHINA)

[2] Sports Training Department, Wuhan Institute of Physical Education, Wuhan, (CHINA)

ABSTRACT

Soccer robot is a kind of synthetic multi-agent that fuses information, artificial intelligence, image, computer and other relative information together, the paper just based on this, it researches soccer robot path strategic problems, establishes soccer robot motion model and particle algorithm optimization model, and finally it gets that the model plays a positive role in soccer robot path strategic problems.

KEYWORDS

Soccer robot;
Shortest path strategy;
Particle algorithm.

PREFACE

Regarding robot soccer aspect research, it was developed in the second half of 20th century, and continued to grow in subsequently development that got evolved in each field, meanwhile, soccer robot competitions were gradually increasing in all parts of the country. In soccer robot competition, whether it can win, the key relies on soccer robot degree of intelligence; it defines soccer robot motion and path according to field known information so that can arrive at destination at shortest time with shortest distance.

Regarding shortest path strategy problems soccer robot researching aspect, formers have already made many contributions, such as: Liu Zhao and others regarding soccer robot wins the competition in competition process, they proposed particle swarm optimization, and established a soccer robot motion selection set, judged which motions to be selected and ran by environment, and combined with particle swarm relative model commonly decided final motion and path planning.

The paper just on the basis of previous thoughts, it carries out soccer robot correlation research and analysis, in order to defeat opponent in the competition, it should arrive at destination at shortest time with shortest distance, so the shortest path strategy is the focus of research, by combining with control and dynamics correlation researches, then it proposes particle algorithm optimization model, and finally gets that the model is best choice, it will provide extremely beneficial conditions for soccer robot arriving at destination that builds foundation for soccer robot development.

SOCCER ROBOT MOVEMENT RESEARCH MODEL

Soccer robot kinematic model

Soccer robot is moving by two wheels rotating, if ground contacting point and wheel are rolling, then solve robot movement can according to rigid body mechanical structure, its formula is :

$$V_L = r \cdot \omega_L \quad V_R = r \cdot \omega_R \quad V = \frac{V_R + V_L}{2} \tag{1}$$

$$\omega = \frac{V_R - V_L}{L} \tag{2}$$

Distance between two wheels is using L to represent; soccer robot wheel radius is using r to express; soccer robot left and right wheel angular speed and linear speed are using ω_R、 ω_L to express, soccer robot mass center angular speed and linear speed are using ω and V to express; then, corresponding trolley motion configuration is as Figure 1.

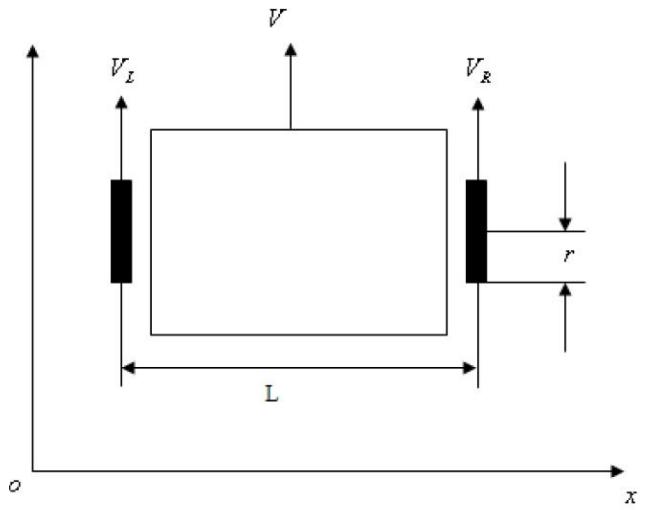

Figure 1: Soccer robot motion model

Let S to be soccer robot speed vector, then corresponding formula is:

$$S = \begin{bmatrix} V \\ \omega \end{bmatrix} = \begin{bmatrix} 1/2 & 1/2 \\ -1/L & 1/L \end{bmatrix} \begin{bmatrix} V_L \\ V_R \end{bmatrix} \tag{3}$$

P represents soccer robot position, then corresponding formula is:

$$P = [x, y]^T \tag{4}$$

P_o represents soccer robot posture, then corresponding formula is:

$$P_o = [x, y, \theta]^T \tag{5}$$

And let soccer robot left and right wheel speed vector to be defined as $V_A = [V_L, V_R]$ for expressing, then:

$$S = \begin{bmatrix} 1/2 & 1/2 \\ -1/L & 1/L \end{bmatrix} V_A \tag{6}$$

By the above formula, we can get soccer robot left and right speed vector and angular speed as well as linear speed mutual transformational relations, so it can control whole soccer robot by above any one factor.

By above formula, we can get:

$$P = \begin{bmatrix} x \\ y \\ \theta \end{bmatrix} = \begin{bmatrix} \cos\theta & 0 \\ \sin\theta & 0 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} V \\ \omega \end{bmatrix} \tag{7}$$

Furthermore, it can calculate:

$$P = \begin{bmatrix} x \\ y \\ \theta \end{bmatrix} = \begin{bmatrix} \cos\theta/2 & \cos\theta/2 \\ \sin\theta/2 & \sin\theta/2 \\ -1/L & 1/L \end{bmatrix} \begin{bmatrix} V_L \\ V_R \end{bmatrix} \tag{8}$$

After making discretization on above formula, we can get:

$$\begin{cases} x_t = x_{t-1} + V_{t-1}\Delta t \cos\theta_{t-1} \\ y_t = y_{t-1} + V_{t-1}\Delta t \sin\theta_{t-1} \\ \theta_t = \theta_{t-1} + \omega_{t-1}\Delta t \end{cases} \tag{9}$$

Therefore, we can deduce soccer robot motion coordinate definition is:

$$\begin{cases} x_t = x_{t-1} + V_{t-1}\Delta t \\ y_t = y_{t-1} \\ \theta_t = \theta_{t-1} + \omega_{t-1}\Delta t \end{cases} \tag{10}$$

$$\begin{cases} x_t = x_{t-1} \\ y_t = y_{t-1} + V_{t-1}\Delta t \\ \theta_t = \theta_{t-1} + \omega_{t-1}\Delta t \end{cases} \tag{11}$$

On above, sampling period can be expressed as Δt; t-1 moment soccer robot mass center angular speed and linear speed can be expressed as ω_{t-1}, V_{t-1}, soccer robot motion state at t-1and t moment can be expressed as θ_{t-1} x_{t-1}, y_{t-1} and θ_t x_t, y_t.

By kinematic rigid body formula, we can get soccer robot kinematic curvature radius is:

FULL PAPER

$$\rho = \frac{L(V_R + V_L)}{2(V_R - V_L)} \quad (12)$$

By above formula, we can calculate mass center, and combine with above solved period, then it can solve threshold and corresponding next period coordinate is:

$$P_{t-1} = P_{t-1} + sign(\omega) \cdot \rho \begin{bmatrix} \sin\theta_t - \sin\theta_{t-1} \\ \cos\theta_t - \cos\theta_{t-1} \end{bmatrix} \quad (13)$$

Soccer robot competition motion function correlation analysis

(1) Soccer robot fixed target location motion analysis

Soccer robot, if it can achieve simultaneous turn in motion process, then it can arrive at correct and fast motion, its corresponding formula can be expressed as:

$$(V_R - V_L) \cdot \Delta t = K\theta \quad (14)$$

$$(V_R + V_L)/2 \cdot \Delta t = f(d) \quad (15)$$

In above formula, distance between soccer robot and target point is d ; Target direction angle and soccer robot direction angle balance is using θ to express.

(2) Unchanged speed soccer robot kinematics analysis

If soccer robot wants to make unchanged speed motion, then set two wheels speed as fixed values, corresponding formula is:

$$V = V_L = V_R \quad (16)$$

(3) Soccer robot spinning kinematics analysis

By controlling soccer robot two wheels rotational speed, it can realize itself surrounding spinning, which also means wheels speed sizes are equal but directions are actually opposite, corresponding formula is:

$$V = V_L = -V_R \quad (17)$$

And in general, soccer robot always realizes itself spinning in motion process, so above formula is not suitable, therefore we introduces two wheels rotational speeds inconsistency formula that:

$$V_L = K \quad V_R = V_L + K_2 \quad (18)$$

To sum up, in order to let soccer robot change direction while moving in motion process, so that it can arrive at destination at shortest time, so the paper according to above mentioned motion function, it further makes optimization, and gets formula as:

$$f(d) = 1/(1 + e^{-Kd}) - 0.5 \quad (19)$$

By above formula, we can see whether it can accurate arrive at destination is up to k to control.

STRATEGIC SOCCER ROBOT PATH AND PARTICLE IMMUNE ALGORITHMS APPLICATION

The paper tries to strengthen soccer robot and look for optimal path ability one method by combining fast information processed immune algorithms with particle swarm simple fast convergent algorithm.

Regarding soccer robot path correlation research

In order to solve soccer robot shortest path problem, the paper introduces immune particle swarm to answer, from which path coding is indispensible, and path coding is as following Figure 2 show:

In searched path region, it can be expressed as:

$$L_j = \{A_{j0}, A_{j1}, A_{j2}, \cdots, A_{ji}, \ldots A_{jn-1} A_{jn}\} \quad (20)$$

Among them, it divides horizontal coordinate into n portions, after connecting all points together, let end point to be A_{jn} and starting point to be A_{j0} 's, A_j and, $j = 1, 2, \cdots, m$, $i = 0, 1, 2, \cdots, n$,, so it can express these points in coordinate systemit, gets:

$$L_j = \{(x_{j0}, y_{j0}), (x_{j1}, y_{j1}), (x_{j2}, y_{j2}), \cdots,$$

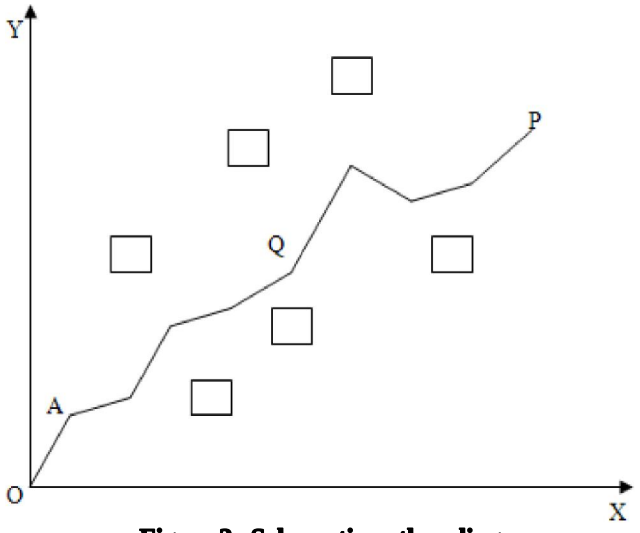

Figure 2 : Schematic path coding

$(x_{ji,}, y_{ji}), \cdots, (x_{jn-1}, y_{jn-1}), (x_{jn}, y_{jn})\}$ (21)

When end pint and starting point coordinates are known, it can be expressed as $(x_{ji,}, y_{ji})$ point is A_{ji} in coordinate system, so we can see a regarding $\{x_{j0}, x_{j1}, x_{j2}, \cdots, x_{ji}, \cdots, x_{jn-1}, x_{jn}\}$ arithmetic sequence, in formula $i = 0,1,2,\cdots,n$; $b = DIST / n$, $DIST$ and $x_{ji} = i \cdot b$, and segment OD length is path end point and starting point horizontal coordinates' distance, so we can simplify code about path, the result is:

$$L_j = \{0, y_{j1}, y_{j2}, \cdots, y_{ji}, \cdots, y_{jn-1}, a\} \quad (22)$$

In above formula, target point in vertical coordinate axis coordinate is a, and $i = 0,1,2,\cdots,n-10$

Based on above process, we can get that after converting two dimensions into one dimension is not only beneficial to function's calculation but also simplify path coding.

Algorithm optimization model

Due to soccer robot competition process gets involved in multiple factors, particle swarm algorithm cannot meet its demand to some extent, it will generate final result as partial optimal problem, to make up the shortcoming, the paper introduces concentration controlled immune algorithm to optimize algorithm structural function.

Optimize and standardize particle swarm algorithm

In $V_i = (v_{i1}, v_{i2}, \cdots, v_{in})$ as particle speed standard particle swarm optimization algorithm, now use $X_i = (x_{i1}, x_{i2}, x_{i3}, \cdots x_{in})$ to express particle's position, use $P_{best_i} = (P_{best_{i1}}, P_{best_{i2}}, \cdots, P_{best_{in}})$ to express current the i particle searched best position, then the whole particle swarm best position can be expressed as:

$$G_{best_i} = (G_{best_{i1}}, G_{best_{i2}}, \cdots, G_{best_{in}}) \quad (23)$$

So particle swarm evolution formula is:

$$V_i = \omega \times V_i + c_1 \times rand() \times (P_{best_i} - X_i) +$$

$$c_2 \times rand() \times (G_{best_i} - X_i) \quad (24)$$

$$X_i = X_i + V_i \quad (25)$$

Algorithm correlation parameters research

In order to balance convergent speed and precise, it needs to select a proper inertia factor that is original speed to this moment speed one kind of influence factor, combines with the paper features, we can express the factor by following formula:

$$\omega = \omega_{\max} - \frac{\omega_{\max} - \omega_{\min}}{D_{\max}} \times d \quad (26)$$

Maximum iteration time is expressed by $D_{\max}$, according to previous experience, we can take value as $\omega_{\max}$ =0.9, $\omega_{\min}$ =0.4, now iteration times can use d to express, maximum weight then can be expressed as $\omega_{\max}$, then corresponding minimum weight can be expressed as $\omega_{\min}$. Besides, we can express each item weight that used to count acceleration as c_1, c_2, according to previous experience and textual features, it can let:

$c_1 = 1.4, c_2 = 1.4$

Regarding objective function shortest path length, we can express it as:

$$fit_1 = \sum_{i=1}^{n} \sqrt{(x_{ji} - x_{ji-1})^2 + (y_{ji} - y_{ji-1})^2} \quad (27)$$

In above formula (x_{ji}, y_{ji}) refers to path j corresponding the i point coordinate.

In order to let soccer robot stays away from barrier in competition process, we can establish corresponding model, its formula is:

$$OB_S^-(i) = \min\left\{0, \left[\sqrt{(x_{ji} - x_k)^2 + (y_{ji} - y_k)^2} - 2r\right]\right\} \quad (28)$$

In above formula, k value is $1, 2, 3, \cdots, q$

Combine with above relative algorithms to establish particle swarm optimization flow, regarding particle swarm algorithm's concrete steps are as following Figure 3 show:

ALGORITHMS PARAMETERS AND PROCESS IMPLEMENTATION RESULT

By above statement, combine the algorithm with Matlab and relative parameters selection problem,

FULL PAPER

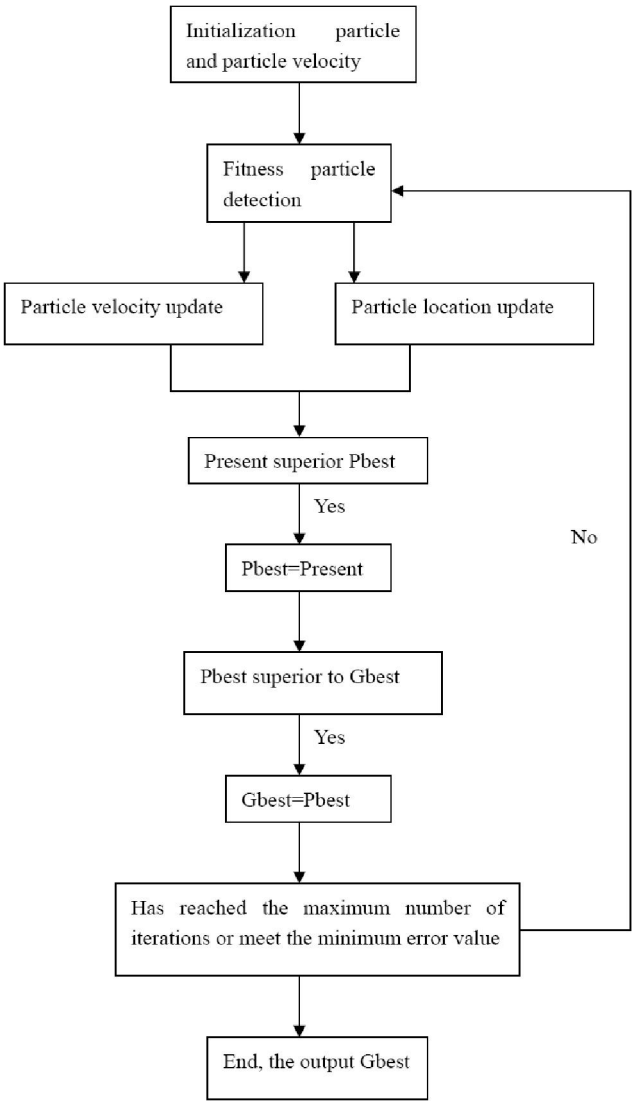

Figure 3 : Particle swarm optimization in progress

let $n = 22$ to represent searched space dimension, $m = 250$ represents particle swarm number in the beginning, starting point starts from origin, use $D_{\max} = 600$ to represent maximum iteration time, it can use (100,100) to express moving to final one point, and can take step distance $b = 5$, then we can get TABLE 1.

TABLE 1 : Two different algorithms' running results

Running time	1	2	3	4	5
Particle swarm algorithm	241.97	193.05	158.34	174.62	165.54
Particle swarm immune algorithm	151.20	151.41	151.28	155.94	151.74
Running time	6	7	8	9	10
Particle swarm algorithm	189.58	161.56	164.44	178.47	206.29
Particle swarm immune algorithm	149.76	151.14	151.16	152.20	151.58

By calculation, we can get regarding particle swarm algorithm average value is198.99, and particle swarm immune algorithm running result is 151.09.

CONCLUSIONS

The paper solves about soccer robot shortest path arriving at destination problem by establishing soccer robot dynamics model and particle algorithm correlation research model. By establishing soccer robot dynamics model, it solves that shortest path way to arrive at destination in each motion process is moving and meanwhile changing directions, to further optimize path problem, it introduces particle algorithm model, after researching, it combines particle algorithm with immune ability to optimize the algorithm, finally it gets that algorithm after optimizing convergence is obvious stronger than that before optimizing by running program, so the algorithm is more beneficial for soccer robot destination reaching way.

REFERENCES

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

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

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

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

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

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

[7] Li Bo, Xie Jun; Comparative Analysis on the Temporal and Spatial Characteristics of Offense and

Defense Conversion between Men and Women's Football——Taking 2010FIFA Men and 2011 Women Football World Cup as Example[J]. China Sport Science and Technology, **48(2)**, 40-44 **(2012)**.

[8] Gao Bin, Zhang Quan-ning; Comparative Study of Technical Characteristics at Shooting Area in Men''''s Handball Matches among China, Japan and Korea[J]. Journal of Beijing Sport University, **24(4)**, 561-563 **(2001)**.

[9] Liu Fei-zhen, Zeng Bo-si; A statistical analysis of goals scored by the last 16 teams in European Championship Cup Football Games 2005-2006[J]. Journal of Physical Education, **13(5)**, 108-109 **(2006)**.

[10] Wang Gang; Analysis on Goals in Women's Football Competitions of the Third World Cup[J]. Journal of Shanghai Physical Education Institute, **24(1)**, 73-75 **(2000)**.

[11] Jin Chuan jiang, Long Jun; Research on Goals during European Football Championship in 2000[J]. Journal of Beijing Sport University, **25(2)**, 281-283 **(2002)**.