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The interception state algorithm of master_ robot soccer based on numerical analysis

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ABSTRACT

In this paper, it studies the ball interception problem of Master robot soccer, after the establishment of the motion model and state update equations of players and the football, uses the numerical analysis method to simulate the ball interception problems, and finally simplifies the numerical algorithms on this ball interception issue. The simplified numerical results show that the time needed to traverse all players is basically 0.02 milliseconds. The players in no-ball controlled state use the simplified analysis method to conduct overall test, and no obvious interception misjudgment appears. The no ball controllers need to accurately analyze the fastest interception time for both sides, and can use the complex numerical algorithms; And ball controllers have higher requirements of the ball interception analysis, so we use the simplified numerical algorithms, which do not affect the decision-making time and makes it easier to implement.

KEYWORDS

State update;
Speed attenuation;
Numerical analysis;
Robot.

INTRODUCTION

Artificial intelligence is an independent study discipline, which has begun since the nineteen fifties, and has been developing with the rapid development of automation information technology. Particularly with the development trend of taking the computer this powerful computing tools as supporting, the systematically research on artificial intelligent has made a series of achievements, from the single intelligent agent static problem solving in predictable environment by the "Deep Blue" series of computers, to the recent multi-agent dynamic problem solving in unpredictable environment, it has become a typical issue in artificial intelligence research. The characteristics of robot soccer that this paper studies is an extension field of the development of artificial intelligence. The soccer machine-machine confrontation and human - machine confrontation is a suitable platform for the study of the multi-agent theory. In order to reflect the reality of soccer race simulation, this paper discusses and studies the ball interception issues in Master robot soccer.

For the research of robot soccer many people have made efforts, it is these people's efforts that make the theory of the field more complete and has made a good-looking vision and realization principle for its development, including: Zhang Xiao-yong and Peng Jun from School of Information Science and Engineering of Central South University, in the " Realization of pass ball strategy in RoboCup", conducted research and analysis in collaboration and coordination of the multi-agent, discussed the two role-based and region-based passing decision-making methods, and their application in Yunlu Team (CSU_Yunlu) of Central South University, and won the second prize in RoboCup simulation group of 2003 China Robot Competition; Yu Lei, Wang Hao and Wang Cheng from Computer Science and Technology Department of Hefei University, in the " Studies on strategy of pass in RoboCup", put forward the concept of the convergence rate, formed the triple filter, which maintained the advantages of the original algorithm and simultaneously improved the convergence rate and the trust region radius, and given the corresponding algorithm, based on the SQP filter algorithm proposed the strategy algorithm of RoboCup ball passing, as RoboCup itself had a discrete features, this algorithm is different in implementation with SQP filter algorithm; Wei Xiao-ming, Zhang Xu from School of Computer Science and Engineering, Dalian Nationalities University, Yun Jian from E Institute of Shanghai Normal University and Wang Chun-xia from Modern Education Technology Center of Dalian Nationalities University, in the "Key tactics of intercepting the ball, processing or dribbling the ball and running in RoboCup", analyzed and studied the robot's interception, ball controlling, dribbling, passing, run and other five basic skills in the game and designed the appropriate strategy, the designed strategy proved the reliability through the game, which preferably met the needs of the game, the current team using these strategies has become a paradigm team and enter the final eight of the country, and obtained the qualifications to participate in the "World Cup" soccer robots in United States; Hong Bing-rong and Bo Xi-zhu from Computer Science Laboratory of Intelligent Robot of Harbin Institute of Technology, in the " Establishment of simulation system of robot football match strategy ", discussed the strategy necessary for robot soccer game and the machine computer simulation, first described the geometric modeling and dynamic modeling of robot soccer competition, followed by the proposed basic behavior and action simulation of the robot soccer, and finally discussed the race strategy of robot soccer and its computer simulation; Dai Hao and Li Xiao-jian from Mechanical and Electrical Engineering school of North China University of technology, in the "Establishment of simulation system of robot football match strategy ", discussed the needed race strategy for robot soccer simulation game, described the dynamic modeling of the robot football game, given the fundamental behavior and motion simulation of soccer robot, discussed the robot race strategy based on simulation platform.

In this paper, on the basis of previous studies, it studies the ball interception problem for Master robot soccer match, establishes the motion model and state update equation of the players and soccer according to the analysis of the ball interception problem, based on the ideology of the models and equations designs a numerical method to achieve the ball interception strategy, proposes simplification strategy for the numerical algorithm depending on the problems of whether need to turn around and strategic issues of turn around, and designs the simplified numerical and calculation methods.

THE PROBLEM OF THE INTERCEPTION AND THE MOTION MODEL

The problem of the interception

The action modules in Master robot Soccer Tournament include: positioning, speed up ball, the ball interception, dribbling and other underlying actions, which are called the individual technique of the intelligent agent.

Randomly place soccer and player on the football field, and respectively assign the initial velocity to the ball and the player, this process of how to catch up with football with the fastest speed for the players is called interception. The successful ball interception refers the distance between the football's and player's centroid positions is less than the kicked range kickable_area, and this kicked range is in formula (1) below:

Kickable_area = kickable_margin + ball_size + player_size **(1)**

Formula (1) expresses that only when the distance of player with the football is in range of kickable_margin, that the kicker can kick football. Because the football and player are both represented by a circle, and the distance between the object should be the position of the centroid. So when two particles are apart in kickable_area range, the kick command will only be executed by the simulation platform.

Establish the interception model, as shown in Figure 1:

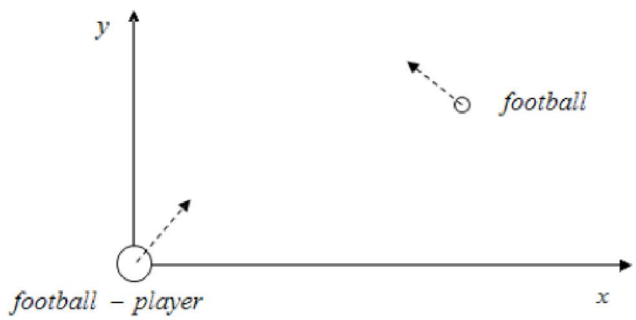

Figure 1 : The physical simulation schematic of the interception

In Figure 1, the intelligent agent's position is at the original point, the dashed arrows mean the initial velocities of the football and the player, and the player's body can have a different direction with its initial velocity.

Then the problem is proposed that how to track the trajectory of the football and arrange the basic operation command for the players, how many cycles it takes to successfully intercept the ball as soon as possible.

In the simulation platform, two mutually exclusive operation instructions as turning around and run cannot achieve simultaneously in a cycle, so the player does not appear curve movement on the pitch. From this the basic action of the ball interception-the realization of run is first turning around and then running. The key of successful interception is the lock of the target point, the goal point here is the ball interception point, and you need to solve the problem of problems analysis and action execution. The whole interception process is transformed into analyzing the ball's motion model and the fastest ball interception cycles and then calling the run actions to complete the implementation of the interception action.

For players in no-ball control state, we need to calculate the fastest interception cycles required of both sides and plan the decision-making module to determine whether to execute the interception movements. For players in ball control state, they need to search passing, dribbling and other action space. But the search is based on assumptions of different football speeds, and analyzing other players' fastest interception situation to determine the passing route and safety of dribbling speed. In this process the ball controllers will call the interception analysis functions more frequently, and it requires the interception analysis can reduce a calculation amount on the premise of ensuring the accuracy.

Motion model of the simulation platform

Player's run and his speed attenuation both will change his speed, so that the position of the player on the pitch changes. Speed attenuation is an inherent property of the player, run is generated by the dash commands of action interface, dash Power gives players new impetus; similarly in addition to its inherent properties of speed attenuation, the kick commands that outside players act on a soccer can give football new impetus, state updates are completed by mathematical operation, the speed update is as formula (2) below:

$$\left(u_x^{t+1}, u_y^{t+1}\right) = \left(v_x^t, v_y^t\right) + \left(a_x^t, a_y^t\right) \quad \textbf{(2)}$$

In Formula (2) $\left(u_x^{t+1}, u_y^{t+1}\right)$ satisfies the formula (3):

$$\left(u_x^{t+1}, u_y^{t+1}\right) = \begin{cases} \left(u_x^{t+1}, u_y^{t+1}\right) & , \sqrt{\left(u_x^{t+1}\right)^2 + \left(u_y^{t+1}\right)^2} \le \text{speed\_max} \\ \left(\dfrac{u_x^{t+1}}{\text{speed\_max}}, \dfrac{u_y^{t+1}}{\text{speed\_max}}\right) & , \text{Otherwise} \end{cases} \quad \textbf{(3)}$$

The position update of the moving object is in the formula (4) below:

$$\left(p_x^{t+1}, p_y^{t+1}\right) = \left(p_x^t, p_y^t\right) + \left(u_x^{t+1}, u_y^{t+1}\right) \quad \textbf{(4)}$$

The inherent speed attenuation of the moving object is in the formula (5) below:

$$\left(v_x^{t+1}, v_y^{t+1}\right) = \text{decay} \times \left(u_x^{t+1}, u_y^{t+1}\right) \quad \textbf{(5)}$$

When a dynamic action of the cycle is completed, the dynamic is cleared represented by the formula (6):

$$\left(a_x^{t+1}, a_y^{t+1}\right) = (0,0) \quad \textbf{(6)}$$

Inherent speed attenuation parameters decay is controlled by the ball_decay and player_decay, the new impetus got by the moving objects can be calculated by the parameters of run command dash, ball kick instructions and power, as shown in the formula (7) below:

$$\left(a_x^t, a_y^t\right) = \text{Power} \times \text{power\_rate} \times \text{power\_rate} \times \left(\cos\left(\theta^t\right), \sin\left(\theta^t\right)\right) \quad \textbf{(7)}$$

In the Formula (7) the calculation method of θ^t is in the formula (8) below:

$$\theta^t = \theta_{\text{kicker}}^t + \text{Direction} \quad \textbf{(8)}$$

In order to reflect the uncertainty of football players and the football sport in the game, some noise interference is added to the movement of players and football in the simulation platform and interference situation is in the formula (9) below:

$$\left(u_x^{t+1}, u_y^{t+1}\right) = \left(v_x^t, v_y^t\right) + \left(a_x^t, a_y^t\right) + (\text{rand}, \text{rand}) \quad \textbf{(8)}$$

In Formula (9) rand is the random number of the attribute [-rmax, rmax], which is uniformly distributed, rmax is defined in the formula (10):

$$\text{r max} = \text{rand} \cdot \left|\left(v_x^t, v_y^t\right)\right| \quad \textbf{(10)}$$

THE INTERCEPTION NUMERICAL CALCULATION BY THE SIMULATION PLATFORM

The numerical calculation methods

Combining with the motion equations of football and players simultaneously can directly describe the interception problem; in the process of solving equations, high order equations will appear making it impossible to obtain analytical solutions, so for simulation platform the ball interception problem commonly adopts numerical algorithms.

Symbol description:

i : represents the sport cycles of soccer;

$\vec{\text{P}}\text{os}_\text{i}$: indicates the position of football after i cycles;

Cyc : represents the number of cycles;

acc_max : represents the maximum acceleration that the players can achieve in each cycle;

player_decay : indicates the inherent attenuation speed of the players;

Speed_max_ ab : means the maximum speed that players can reach;

kick_area : represents the target point.

With a given target point, the player has two possible options; one is to adjust the angle of the body properly, and then moves along a straight line, the other one is to move directly forward and reach the target point without adjusting the angle of the body. If you need to turn around first, the players' actual turning angle is subject to the initial velocity of the players and is decided by the formula (11):

$$\text{actual\_ang le} = \frac{\text{Moment}}{1.0 + \text{inertia\_mo ment} \times \text{player\_spe ed}} \quad \textbf{(11)}$$

The players may need maximum four cycles to complete 180 degree turn around, therefore we assume Moment is maximum 180 of the turn command parameters, inertia_moment takes maximum 10 of the heterogeneous type, the maximum speed and speed attenuation that affect the player's speed are 1.2 and 0.6. Based on this when need to turn the body by certain angles, it may take several cycles to complete the desired turn angle, so we use trial and error method for numerical attempt. Suppose that whether the player can achieve the goal point without the turn around, suppose that whether the player can achieve the goal point with one turn around, and so on, until he can reach the target point and to return the needed fastest cycles when reach the goal point.

The numerical calculation method of the ball is as follows:

The initialized interception point is $\vec{\text{U}}\text{nknown}$, the interception cycle is MAX_NUMBER;

Initialize $i = 0$;

While ($i <$ MAX_NUMBER)

Computing the position $\vec{\text{P}}\text{os}_\text{i}$ of the football after i cycles and the position $\vec{\text{P}}\text{os}_{\text{i+1}}$ of the football after $i+1$ cycles;

Calculate the time Cyc required for the players to reach $\vec{\text{P}}\text{os}_\text{i}$;

if $\text{Cyc} \le \text{i}$ or $\left|\vec{\text{P}}\text{os}_\text{i} - \vec{\text{P}}\text{os}_{\text{i+1}}\right| \le 0.001$

Suppose the interception point is $\vec{\text{P}}\text{os}_\text{i}$, the interception point number is $\text{Max}(i, \text{Cyc})$; break Jump out of the loop;

end if

$i++$;

end while

Based on the above analysis, in the relative coordinate system as shown in Figure 1, the factors that need to be considered include the player's initial velocity, the position of football, the initial velocity of football, acc_max, player_decay, Speed_max_ ab and interia_mo ment a total of eleven-dimensional inputs, adding the fourteen factors of player's position and body orientation that can determine the relative coordinate system can give an accurate analysis of the ball interception.

The simplified numerical analysis method

A complete interception exist fourteen influencing factors. Since it is considerably complex to integrate the initial error trial method into the whole interception problem, which affects the startup time of the numerical algorithms, if the startup time is much less than the total interception time, then it can be simplified as the consideration of the start-up procedure of the players, that is also a simplification of the time needed for the players to reach a certain point.

The simplified numerical analysis method of the interception problem by the simulation platform is as follows:

Assuming that the target point is $\vec{P}osTo$;

Assuming the player's own position is $\vec{P}osFrom$, and can achieve the maximum speed $Speed\_max\_ab$;

The Cycles that players need: $Cyc = \frac{|\vec{P}osTo - \vec{P}osFrom|}{speed\_max\_ab}$;

Suppose ray Rad1: the starting point is $\vec{P}osFrom$, the direction is the player's body orientation;

Suppose ray Rad2: the starting point is $\vec{P}osFrom$, and goes through $\vec{P}osTo$;

if (the distance of $\vec{P}osTo$ to the ray Rad1 is greater than kickble_area)

Calculate the angle of two rays Rad1 and Rad2, denoted by θ;

if (The player can complete turnaround by in a cycle)

$Cyc = +1$;

else

$Cyc = +2$;

end if

end if

Return

The time needed to traverse all players using a simple numerical algorithm is basically 0.02 milliseconds. The author uses the simplified analysis method to conduct overall test for players in no-ball controlled state, and no obvious interception misjudgment appears. Therefore the ball interception action is divided into the corresponding function of ball controllers and no ball controllers, respectively. The no ball controllers need to accurately analyze the fastest interception time for the two sides, and can use the complex numerical algorithms. And ball controllers have higher requirements of the ball interception analysis, so we use the simplified numerical algorithm. Of course, we can also use complex numerical algorithms for certain situations, and these do not affect the decision-making time.

CONCLUSIONS

Passing and shooting embodies the cooperation and confrontation in robot soccer games, but a combination of the two is on the basis of the ball interception. In this paper, it establishes the motion model and state update equation of the players and soccer under Master_robot simulation platform, and designs the numerical methods according to the model and the equations; it describes the computational complexity of the ball interception problem for a variety of situations, and proposes a simplified numerical method; The numerical experiments demonstrate that the designed algorithm can be well implemented in the programming software, is a general numerical analysis program, and can be applied in the rest of the field.

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