ILUR TRANSACTIONS ON SCIENCE AND ENGINEERING, Volume 2017 (2017), Article ID 20170901
ISSN 2414-6684

Global Visual 2VS2 Strategy Improvement on the Basis of Regional Division and Game Analysis

Wang Zhongwei, Wang Meijuan，Deng qiaoyu
(*College of Command Information Systems*, *PLA University of Science & Technology*, *Nanjing* 210007, *China*)

Abstract： With the vigorous development of information technology, electronic machinery, sensor control, artificial intelligence and other technologies, the development and application of robot has become a popular field of today's society. Based on this, all kinds of robot competitions have appeared. Over the past few years, our school has regularly participated in International Underwater Robot Competition. In order to find a more efficient algorithm, this paper seeks an effective strategy to improve the global visual 2VS2 project based on the International Underwater Robot Competition. First to the field of regional division, the competition venues were analyzed based on the threat degree of different regions. On this basis, this paper achieved strategy improvement. Also, a new algorithm to head the ball has been written. Practice has proved that the algorithm can effectively improve the combat capability of defense and offensive efficiency goals.

Keywords： MURobotSys platform, Regional game analysis, Algorithm for ball-pushing movement, Strategy

1 Introduction

With the rapid development of artificial intelligence technology, robot technology, which is supported by information technology, electronic machinery, sensor control and artificial intelligence, has been developing vigorously. Various kinds of robots competitions have appeared around the robot. International Water Robot Competition has been founded, with its project fine, high technology, widely-oriented advantages to attract the United States West Point, Tsinghua University, Peking University and other institutions involved. Among them, the representative of the global visual group competition is strongly favored because of its high technical challenges and its delight to watch.

The author takes the overall 2VS2 project as the research content, attempts to introduce the thought of modeling and game theory, and puts forward an effective strategy improvement scheme on the basis of theoretical analysis and design

2 Background

2.1 2VS2 Water Polo Rules

The overall visual water polo ball 2VS2 is currently used as the game environment[1], as shown in Figure 1. The game is divided into two parts. In the first half of the game, Robotic fish of team A and team B depart from the side of the goal line. The second half will be in exchange. If one kicks the ball into the goal, then re-kick the game. During the normal course of the competition, if the situation that whole body of the water ball crosses over the goal line occurs, the referee will whistle to determine the offensive side of the team to score goals, and for the "own goal" is regarded as the other goal. The result is determined by the number of goals. If the number of goals is the same, the game is tied. The team earned points in accordance with the following rules: 3 points for victory, 1 point for a draw, 0 point for failure. If the two teams gain the same points in the group match, the team rules are determined by the following rules: the number of goals for the team; the average number of goals per game; and the outcome of the match between two teams.

2.2 MURobotSys Platform

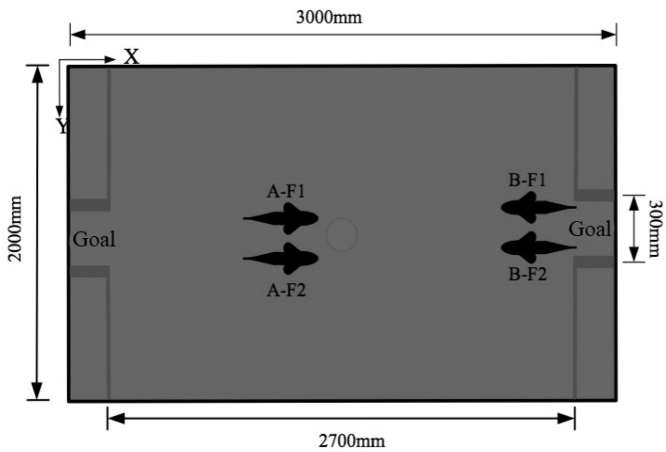

Figure 1 Site map

MURobotSys platform[2], namely multiple underwater robot system (MURS), using Microsoft Visual Studio 2010 SP1 development environment, with the use of C programming language development, can be used for a single team of control performances or multi-team of the same stage against the

ISSN 2414-6684

competition. It is a standard platform for the competition of the global visual group of the robot, including the robot software control platform, which is used to load the running game strategy, and the corresponding communication device and data acquisition and processing device.

2.3 Game Theory

Game theory is to consider the game in a competitive or confrontational nature, taking the various strategies that the opponent may use into account, using the existing game information to find the best coping strategy of one's own way and realize the maximization of the target benefit. The game is mainly composed of three basic elements [3]: First, the decision-making subject, which can also be called the participants or player. According to the number of players, the game can be divided into two-person game and multi-player game; The second is the given information structure, which is mainly embodied in the strategic set of players and the action space, also known as the strategy set; The third one is the utility, also known as the gain and loss or payment function, which is the goal that all players strives for. The gains and losses of each member are related not only to the strategy chosen by the people themselves, but also to a set of strategies that are determined by the population. Players, strategy set and the utility form the basic elements of the game.

A complete game theory model needs to be described from five aspects: G = {P, A, S, I, U}. P corresponds to the persons, namely the game participants, also known as the decision-making body. They need to be able to independently assume the responsibility of the game process, and make independent decisions to achieve the ultimate effectiveness of their own game; A is the set of all strategies and actions that may be adopted or can be used by the players; S is the process of the game, that is the order the game needs to be followed; I is the game information, namely, all the game players information that will affect the final result of the game; U is the ultimate goal of the game, and it is the final game goal pursued by all the players, and any party wants the ultimate benefit of one's own as much as possible.

The corresponding game method of the model is the Nash equilibrium game, in which the strategy of all people is optimal for each other.

3 Analysis and Design

3.1 Designing Ideas

For the game in the global visual water polo 2VS2 game project, the competition platform provide some basic heading-ball algorithm[4] for the contestants. Some problems have revealed through the pre-game test, such as the inefficient goal, endless loop, misjudgment and so on. The main design ideas of the author are prsented as follows. First, to regionally model competition venue to determine the threat extent of different regions; and then to introduce the game theory, develop a specific algorithm strategy for different regions and modify the original platform algorithm. This can make use of theoretical decision-making instead of the original algorithm of human intervention, thus simplifying the complexity of the code to improve operational efficiency.

3.2 Regional Modeling

According to the cumulative experience of the game, when the water polo is in front of the goal, the threat is greater than the threat if the polo is on both sides of the goal, and the distance between the ball and the goal will also affect the extent of its threat to the goal; Therefore, the author analyzes the pool area from different angles through pool area division and modeling and the theoretical analysis of different regional offensive positions on the threat of the goal level, and then to develop appropriate strategies to provide a reasonable and reliable basis.

During the race, the performance of the machine fish and the distance from which to the target goal will determine the probability of the goal; therefore, when the two influencing factors are determined, in the process of machine fish's attacking goal, the water polo on the goal line of the placement will become relatively regular. Through the simulation test, we can see that the placement distribution is a one-dimensional normal distribution [5], which can be modeled and analyzed.

The author simplifies the goal as a straight line, in the straight line area where the goal of the distribution of water poles points, that is, a goal hit rate. You can find the goal hit rate and the goal of the target location has a high relativity. However, in reality, because the machine fish can choose the goal target, we need to traverse all the points on the goal line, and then get a shot point's threat to the goal

ILUR TRANSACTIONS ON SCIENCE AND ENGINEERING, Volume 2017 (2017), Article ID 20170901
ISSN 2414-6684

through hit rate points. The attack zone is divided according to the size of the threat. In order to facilitate the analysis and take the actual situation of the game into account, the author made the following assumptions:

1) Due to the smaller ball, we set the ball speed of 100 mm/s without considering the impact of the ball on the speed after the fish hits the ball;

2) In the ideal state, we consider that the basic performance of the machine fish is the same, or little difference;

3) In the condition of the standard pool: length-3000 mm; width-2000 mm; goal width-300 mm;

4) The machine hits the ball only in the opponent near the goal of the half, assuming that the halftime for the effective hit area.

First, we set up the coordinate system as shown in Figure 2, namely that the center point of the goal is the origin O, the water surface is xOy surface.

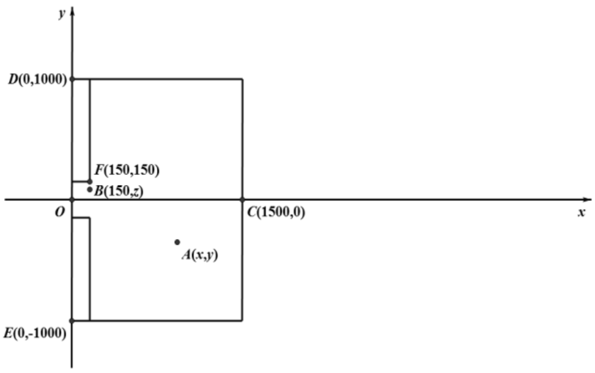

Figure 2 Plane Cartesian coordinate system

The definitions of symbols in Figure 2 and the following formulas are given in Table 1.

Table 1 Symbol description

Letters	Meaning explanation
Ω	The line where the goal is is above the surface of the water
D	The distance between a goal on the pool above the water line
$A(x,y)$	The point in the pool，(x.y) is its coordinates
$B(150,y)$	The point on the goal (150,y) is its coordinates
$P(x,y;150,y_1)$	From the pool in the A(x,y) point of the goal B(150,y) hit the ball, hit the probability of the goal
$D(x,y)$	The midpoint (x,y) of the pool on the threat of the goal
k	The basic performance of the machine fish A relative indicator
d	The distance between the point A in the pool and the point B on the goal

Based on the above analysis, it is assumed that when the robot fish can shoot from point to the goal, the water ball will obey the one-dimensional normal distribution at the drop point of the goal line.

The probability density function is:

$$f(\mathrm{y}) = \frac{1}{\sigma\sqrt{2\pi}} e^{\frac{-(\mathrm{y}-\mu)^2}{2\sigma^2}} \quad (\mathrm{y} \in \Omega) \tag{1}$$

Where the variance σ is inversely proportional to the performance k and is proportional to the distance d between the shooting point $A(x_0, y_0)$ and the target point $B(150, y_1)$. Thus, σ can be determined with formula $\sigma = \frac{d}{k}$.

Among them,

$$\mathrm{d} = \sqrt{(\mathrm{y}_0 - \mathrm{y}_1)^2 + (\mathrm{x}_0 - 150)^2} \tag{2}$$

Noting that in the density function of Eq. (1), there is no limit to the variable y, but in practice, the ball can only fall within the water pool, that's to say, $-1000 \le y \le 1000$. Therefore, the author defines:

$$p_D = (\mathrm{x}_0, \mathrm{y}_0; 150, \mathrm{y}_1) = \int_D f(\mathrm{y})\,\mathrm{dy} \tag{3}$$

$$p_\Omega = (\mathrm{x}_0, \mathrm{y}_0; 150, \mathrm{y}_1) = \int_\Omega f(\mathrm{y})\,\mathrm{dy} \tag{4}$$

and the ratio of the above two is the probability of the hitting goal:

$$p = (\mathrm{x}_0, \mathrm{y}_0; 150, \mathrm{y}_1) = \frac{\int_D f(\mathrm{y})\,\mathrm{dy}}{\int_\Omega f(\mathrm{y})\,\mathrm{dy}} \tag{5}$$

Integrate with the probability of the goal within the range of goal's span D and define it as the threat degree of a random $A(x_0, y_0)$ for the goal, that is,

$$D(\mathrm{x}_0, \mathrm{y}_0) = \int_D (\mathrm{x}_0, \mathrm{y}_0; 150, \mathrm{y}_1)\,\mathrm{dy}_1 \tag{6}$$

Above all, for any point $A(x, y)$ in the pool, the threat degree of the goal is

$$D(\mathrm{x}, \mathrm{y}) = \int_D (\mathrm{x}_0, \mathrm{y}_0; 150, \mathrm{y}_1)\,\mathrm{dy}_1 \tag{7}$$

among them,

$$p(\mathrm{x}_0,\mathrm{y}_0;150,\mathrm{y}_1)=\frac{p_D(\mathrm{x}_0,\mathrm{y}_0;150,\mathrm{y}_1)}{p_\Omega(\mathrm{x}_0,\mathrm{y}_0;150,\mathrm{y}_1)} \quad (8)$$

$$\mathrm{d}=\sqrt{(\mathrm{y}_0-\mathrm{y}_1)^2+(\mathrm{x}_0-150)^2} \quad (9)$$

The author considered using the numerical integration method to solve and it needs to determine the robot fish's basic performance k . Through the calculation, when $k=10$, the model can be solved and the threat degrees of random shooting points in the pool can be figured out. According to all the threat degrees, the threat degree curve can be made with MATLAB software, as shown in Figure 3.

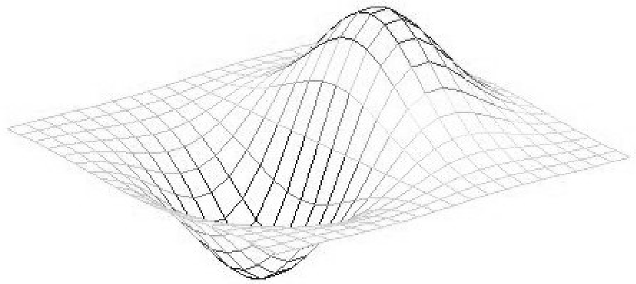

Figure 3 Threat degree distribution map

From the above figure, we can conclude that the central area of the pool which is just opposite to the goal causes the largest threat to the goal. With the expansion to both sides, the degree of threat gradually reduced and it nearly approaches zero in the both edge parts. As the competition is confrontational, the site can be divided into two symmetric parts according to the venue center line. Considering that the performance of the opponent's robot fish and the shooting point selection also satisfy the above modeling analysis; therefore, the area where the threat degree is negative in the above figure can be classified as a dangerous area of the goal and protected.

3.3 Game Analysis

In the water polo 2VS2 competition, because the water polo position changes at any time and both sides have two robot fishes, the selection of strategy should take the location of the water polo, the location of robot fish and the strategy of attack and defense used by both sides into account; Therefore, the author made regional division according to the threat degrees from game modeling result analysis; giving priority to the threat degrees of water polo and robot fish's locations' to the goal. The results are shown in Figure 4.

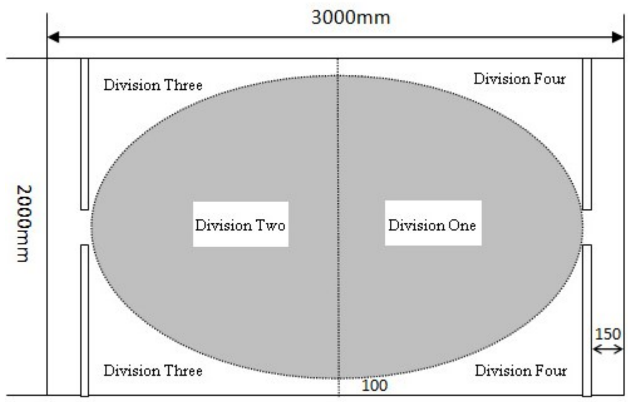

Figure 4 Area map

In the above figure, area 1 and area 2 correspond exactly to the area where the degree of threat is higher in the above modeling results, and the distance between the upper line and the field edge is exactly equal to the 100 mm, the diameter of the ball. Supposing that we are the left half, opponents is for the right half, area 1 should be our main offensive area, area 2 is for the opponent, that is, our main defense area. Area 3 and area 4 are divided into upper and lower parts, respectively corresponding to our secondary defense area and secondary offensive area.

4 Strategy Optimization and Implementation

4.1 Strategy Optimization Analysis

For area 1, the location of robot fish is a severe threat to the goal and is conducive to our attack on the opponent's goal. Therefore,the robot fish heading-ball algorithm can be used in this area. If the robot fish is located between the water polo and the goal, it primarily needs to adjust the position, use the way of coiling up or down, maneuver to the extension line of the polo and the goal, and then head the ball into the goal. If the robot fish is located on the extension line of the water polo and the goal, you can directly hit the ball into the goal.

For area 2, because of the symmetry of the game, we need to adopt a positive defensive strategy, otherwise it is easy to generate "own ball"; therefore, our fish needs to head the polo out of the area in the first place, making it away from our goal, and reduce the threat degree to the goal. We can use the right-up or left-up way to head the polo and make the ball into area 3.

Area 3 is our secondary defense area. Due to the limitation of robot fish's direction-turning performance, the area is easy to form the dead end of

ISSN 2414-6684

the goal. Therefore, we need to maintain this adverse state for the opponent and seek opportunities to transform passivity into initiative.

For area 4, with the same restrictions of robot fish's hardware, if directly using head to hit the polo, it is easy to put the polo into the dead ends. So, the author proposed attacking approach method with a swing-tail-style. As the swing will form a wave, we can utilize the flow energy of water wave, drive the polo to the location where the threat extent to the goal is high and then organize an effective attack.

4.2 Strategy Algorithm Implementation

On the basis of the theoretical analysis results, we use Visual Studio for programming test, and the main algorithm code framework is shown in Figure 5.

```
b_pt=m_goalinfo.GetBallPoint();
i=judge(b_pt);   //The judge () function is used to determine which area the ball is in
BOOL CStrategy::Strategy1(CFishAction m_action[],CFishInfo m_FishInfo[],CBallInfo
&m_goalinfo,OBSTAINFO m_obst[],CHANNEL m_Channel[])
{
    j=judge(b_pt,f_pt1,f_pt2);
    switch(j)
    {
        case 1:CStrategy::Strategy11(CFishAction m_action[],CFishInfo
        m_FishInfo[],CBallInfo&m_goalinfo,OBSTAINFO m_obst[],CHANNEL m_Channel[]);
        //The attack strategy of main area
        case 2:CStrategy::Strategy12(CFishAction m_action[],CFishInfo
        m_FishInfo[],CBallInfo&m_goalinfo,OBSTAINFO m_obst[],CHANNEL m_Channel[]);
        //The attack strategy of secondary area
        case 3:CStrategy::Strategy13(CFishAction m_action[],CFishInfo
        m_FishInfo[],CBallInfo&m_goalinfo,OBSTAINFO m_obst[],CHANNEL m_Channel[]);
        //The defense strategy of main area
        case 4:CStrategy::Strategy21(CFishAction m_action[],CFishInfo
        m_FishInfo[],CBallInfo&m_goalinfo,OBSTAINFO m_obst[],CHANNEL m_Channel[]);
        //The defense strategy of secondary area
        case 5:CStrategy::Strategy22(CFishAction m_action[],CFishInfo
        m_FishInfo[],CBallInfo&m_goalinfo,OBSTAINFO m_obst[],CHANNEL m_Channel[]);
        //The strategy of interfering with adversary
    }
}
```

Figure 5 The Main algorithm code framework

4.3 The Experiment Results

Comparing the optimized code with the original one, it is easy to find that the new algorithm is more efficient than the original one. The test data is shown in Table 2.

Table 2 Test results

The number of goals on both sides	Opponent 1		Opponent 2		
	Group 1	Group 2	Group 3	Group 4	Group 5
Before improving code	(0，0)	(0，1)	(1，1)	(0，0)	(1，0)
After improving code	(1，1)	(1，0)	(2，1)	(2，0)	(1，0)

5 Conclusion

Through accumulating and summarizing the experience of the teams, the author introduces the modeling idea into the process of programming algorithm's implementation. Based on the existing software / hardware foundation, and through regional modeling division for the competition venues, the author provides theoretical basis for the competition's decision making. And then we can solve practical problems through the game theory, determine different regional competition strategy, achieve programming and optimize test. Under the same conditions, this strategy can take strategic attack or defense in a more flexible and effective way. In the following robot competitions, the research results were successfully applied by some college teams, and relevant practice results have verified the correctness of the strategy.

The author's research is more to find winning strategies from the general point of view, not fully considering about all the possible strategies that opponents may chooser (for example, the use of only one fish game and other special factors may have impact of one's own strategy), and these strategies will be improved in the follow-up steps.

Reference

[1] 2015 International Underwater Robot Competition Global Vision Group Competition Project and Rules [M]. International Federation of Water Robots, 2015: 15-17.

[2] Peking University. Robot Water Polo Competition Project Promotion Book [M]. Beijing: Peking University, 2009: 1-5.

[3] Guo peng, Yang xiaoqin. Game Theory and Nash Equilibrium [M]. Journal of Natural Science of Harbin Normal University, 2006: 25-26.

[4] Tao jin, Kong feng, Xie guangming. Methods of Machine Fountain Ball Based on Action Decision [J]. Ordnance Industry Automation, 2010, 29 (11): 70-73.

[5] Zhang xinjian. Brief analysis of the relationship between one-dimensional normal distribution and two-dimensional normal distribution [M]. Journal of Information Engineering, 1996: 54-56.