Defense Strategy of URWPgSim2d Simulation Platform's Survival Challenge

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Abstract. In order to protect the regular fish efficiently in half-time when being the defense side in the survival challenge project, the tactics of human basketball game are introduced, and the defense strategy of urwpgsim2d simulation platform's survival challenge is proposed, that is, the defensive strategy of the target defense based on the position of attacking fish. This paper first analyzes several problems appeared in the competition process, then, according to the rules and common problems of the competition, we formulated the survival strategies of No.2 and No.4 upper and lower double winding columns, as well as one-to-one defense of No.1 against No.3. In the process, the mathematical model of the common fish's avoiding and one-on-one protection is established. The results of a lot of experiments show that the strategy can avoid the attack of the other party effectively, improve the defense efficiency of our side, and provide reference for other counter games in the treatment of obstacles.

Keywords: 2d Simulation Fish, Survival Challenge Defense Strategy, Target Defense, Double Wound Column, One-To-One

1. Introduction
The 2D simulation competition platform of underwater robot provides a real-time simulation system [1], which can simulate the changes of underwater robot fish’s position and posture, movement state and the competition status of underwater obstacles [2]. The system structure of various kinematics control theories and collision detection theories of underwater simulation robot fish are tested, which can better promote the research and development of underwater robot technology [3]. The International Water Robot Competition takes bionic robot fish as the theme, in which Underwater Robot 2D Simulation Group Competition uses ontic software-simulated global-vision league underwater robot. The survival challenge is a confrontation project, which mainly studies attack and avoidance strategies. The author studies the defense project of survival challenge on the new platform of 2016urwpgsim2d simulation [4], and proposes a defensive strategy based on attacking fish position.

1.1. Introduction to Survival Challenge Project
There are six sub projects under the competition platform of 2D simulation group, which include both antagonistic projects such as the game of ball snatching, survival challenge, rapid rescue and non antagonistic projects such as water handling, synchronized swimming and obstacle cross-country. The survival challenge project is completed by two teams. Each team is divided into left and right fields, and project time is 10 minutes as stipulated by the organizing committee.

In the initial state, each team has 4 simulation machine fish, fish 1 is special, which plays the role of "catcher" in attack and "defender" in defense; fish 2, 3 and 4 are regular fish, which play the role of "dodger" in defense, and do not play in attack. In the first half, it’s the left side of the machine fish’ turn to attack, and the right side of the machine fish side’s turn to guard. In the second half, the offensive and defensive exchanges. The color of special machine fish is different and are numbered 1. [1] There are three square obstacles in the center of the site, which have a side length of 400 mm. The coordinates of the center points are divided into (0, 0), (0, 700), (0, -700) and are numbered 1, 2 and 3 respectively. Then the game begins. Once the attacking fish touch the dodger of the defending party with the body, the corresponding dodger will be eliminated. Therefore, the dodger shall avoid the attack of the attacking fish according to the corresponding defense strategy. When all the dodgers are eliminated, the game finishes, and the elimination time is taken as the evaluation standard.

2. Strategy Research and Analysis
When we are the defensive side, regular fish 2, 3 and 4 need to avoid the attack of the attacking fish. Because the maximum line speed of attacking fish and defensive fish (fish 1) is the same and is twice that of regular fish (fish 2, 3 and 4), and attacking fish must be able to touch the regular fish to eliminate it, so the best defense strategy should be studied from the obstacle and attacking fish position;

2.1. Error Analysis in the Past
According to the situation of the game and the relevant strategies, the most effective defense strategy is to use three regular fish to avoid the attacking fish via surrounding the obstacles, and the defensive fish should actively approach the attacking fish to interfere with the related actions of it. Therefore, we should mainly consider the main problems when the three fish surround the obstacles and overcome them when studying strategies.

2.1.1. Defensive fish actively defend but missed attacking fish. In the observation of the competition and code experiment, the following conditions will appear: if fish 1 of our side intercept the attacking fish at the beginning of the game, when the target of attacking fish is moved, it is very likely that our fish can not interfere the attacking fish anymore, which will make the body of the two special fish miss. After that, because the speed of the main fish on both sides is consistent, it will lead to the failure of catching attacking fish and effective defense in a period of time, which is the most common mistake of defensive fish when it attacks actively.

2.1.2. Mutual interference among regular fish. In the case of two fish on the same side of adjacent obstacles, two regular fish will turn in a slit at the same time in the face of attacking fish. In the process of turning, two fish will easily interfere with each other or even occur physical jump, which will bring opportunities to the attacking fish in the opposite side, so that it will lead to the elimination, as shown in Figure 1:
2.1.3. Interference between defensive fish and regular fish. When defending the attacking fish actively, the defensive fish may cause serious interference to the surrounding obstacles of the regular fish due to the fixed-point pursuit and interception of certain coordinates of the body of the attacking fish. In this situation, any one of the three fish has a great opportunity of facing physical jump, which will cause loophole in defense and bring great convenience to attacking fish, as shown in Figure 2:

![Figure 2. Interference of defensive fish on the column](image)

2.2. Strategy Design Ideas
According to the analysis of the common mistakes, we have found the corresponding solutions: let fish 2 and 4 surround obstacles 2 and 3 respectively to avoid, defensive fish 1 protects the regular fish 3 one-on-one, so that fish 1 can get close to fish 3 and block the attacking fish (taking use of the geometric characteristics of fish 1 and the rules of the competition, making fish 1 cross between the attacking fish and fish 3 as a physical obstacle). And our fish plan the escape route by judging the position of attacking fish. That is, the defensive strategy of the target defense based on the position of attacking fish.

2.3. Strategy Implementation Process
2.3.1. Mathematical model of target defense around column of fish 2 and 4. At the beginning, taking use of TeamsRef [(1 + teamid)%2.fisher[0].Polygonvertices[0].Z to prejudge the attacking route of attacking fish. At the same time, fish 2 and 4 go to different points to start winding the column according to corresponding situations. In order to prevent the occurrence of physical jump, we take 8 points around the obstacle as the target point of the column winding. Take obstacle 2 as an example, the point position principle is shown in Figure 3. Point 2, 4, 6 and 8 are the middle and the docking points of the winding column. It is found that when the following points are taken, the regular fish can conduct the winding column around the obstacles without physical jump; similarly, the fixed point of obstacle 3 is shown in Figure 3.
Taking the obstacle coordinate as the reference point, the coordinate value of the relevant reference coordinate around is calculated (i is the obstacle number):

\[
\begin{align*}
\text{Dest1.X} &= 0 + 500 \times \cos(\pi/4); \\
\text{Dest1.Y} &= 0; \\
\text{Dest1.Z} &= -700 - 500 \times \sin(\pi/4); \\
\text{Dest2.X} &= 0; \\
\text{Dest2.Y} &= 0; \\
\text{Dest2.Z} &= -700 - 400; \\
\end{align*}
\]

The corresponding coordinate value can be obtained by axisymmetry.

After the middle points in the process of winding column are set, the corresponding escape route is planned by judging the position and posture of the attacking fish. The program diagram is shown in Figure 4.

**Figure 4.** Program block diagram of fish around column marking evasion

2.3.2. One-to-one target defense avoidance mathematical model. In the one-to-one protection part, the body of defensive fish appears as a baffle via the program, and the best position to form one-to-one protection is determined according to the attacking route of attacking fish. Then, a state will formed, in which the defensive fish crosses between the attacking fish and fish 3, and fish 3 stands against the body of the defensive fish. When the attacking fish get to attack, no matter which side it chooses, both
defensive fish and regular fish will make corresponding adjustments, and finally form a slow rotation state [5]. The schematic diagram is shown in Figure 5 and Figure 6.

![Figure 5. Principle of forming initial state route](image)

Figure 5. Principle of forming initial state route

After the formation of defensive fish to protect the regular fish, it also evades according to the position and posture of attacking fish. The program diagram is shown in Figure 7:

![Figure 6. Schematic diagram of rotary protection](image)

Figure 6. Schematic diagram of rotary protection

3. The Effect of the Defensive Strategy of the Target Defense based on the Position and Posture of Attacking Fish
3.1. Actual Effect of Target Defense Avoidance Around the Column
In the absence of defensive fish interfering with attacking fish, we test the effect of indirect fixed-point round column by chasing a fish around the column. When winding the column in one direction and there is no interference from other fish, the fish can hold on to half court without physical jump. What’s more, in the one-way pursuit of attacking fish, the regular fish can not be eliminated quickly, and the minimum time of holding is 1 minute 57 seconds.

3.2. Actual Effect of One-To-One Target Defense Avoidance
After realizing the actual program, the initial state is shown on the left side of Figure 8. After a period of adjustment and the influence of "water flow" [6], the following conditions will appear. As shown in the right side of Figure 8, because it is in the rotating state, attacking fish will not be able to eliminate regular fish for a period of time;

![Figure 8. One-to-one protection](image)

After testing the procedure of one-to-one target defense, some experimental data are shown in Table 1 below (5 minutes is half-time for the defensive side):

| Number | Time/min | Number | Time/min |
|--------|----------|--------|----------|
| 1      | 3:45     | 6      | 3:53     |
| 2      | 3:42     | 7      | 5:00     |
| 3      | 5:00     | 8      | 4:33     |
| 4      | 3:53     | 9      | 4:17     |
| 5      | 5:00     | 10     | 5:00     |

Through the statistics of the experimental data from 50 experiments, the probability of persistence time is obtained, as shown in Figure 9.

![Figure 9. Probability diagram of one-to-one effective defense time](image)
Among them, the probability of holding on to the whole half time (5 minutes) by one-to-one target defense is 0.18. Compared with the defense time of traditional three-winding column, the algorithm of one-to-one target defense has been improved significantly, and the results are different due to the difference in the algorithm of three-winding column. The minimum time of this algorithm is 2 minutes and its stability is more than that of the three-winding column.

4. Conclusion
In the verification of this strategy, it is found that this strategy can timely avoid the common problem of all the three regular fish rotating around the obstacle in the past, and taking the middle target point strategy has well solved the problem of physical jump, which means the probability of physical jump in the process of surrounding the column is greatly reduced [7]. But for the range of winding column, we have not achieved the goal of being close to wind around, and the surrounding radius has not yet reached the optimum. If the state of three fish rotating together changes, the relative initial state will increase the probability of elimination [8]. In addition, because the stability of one-to-one target defense is limited by the site, once a part of our fish body contacts the boundary, there will be a great chance of physical jump. But, anyway, compared with the traditional three-winding column strategy, our strategy is more stable, and the degree of change will decrease with the optimization of the program.

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