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Collision system model research of volleyball robot based on Matlab simulation

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ABSTRACT

This paper analyzes the movement condition of each object in the Volleyball robot competition process, and finds that the core part of volleyball robot simulation system is the movement model of individual object and the model of interaction between objects. If the model selected in the simulation system is good, it will help the efficient operation of the system. This paper mainly studies the static models and dynamic models of the system, by analyzing the motion condition of volleyball players to establish a two-wheel-style car motion model, analyzes the volleyball movement to establish a projectile model of the simulation ball, and analyzes the collision situation between objects to establish the collision model between car and small ball. This paper analyzes and builds the system model, at the same time; it uses the model and algorithm to simulate the moving trajectory of the system ball with Matlab software, and provides a theoretical basis for the development of robots and volleyball career.

KEYWORDS

Dynamic model;
Projectile motion;
Collision;
Matlab simulation.

INTRODUCTION

In the research of artificial intelligence, as early as in the 1940s the goal was suggested to use a computer to chess with human; after 50 years of efforts, research on logical thinking and game and the development of high-performance computers has achieved a leap. In May 1996, IBM computer Deep Blue beat world chess champion Kashia Palou Fu, and realized the dream of researchers for 50 years. It can be seen that the machine can overcome human genius in certain areas, then as another challenging topic in artificial intelligence robot has rapid progress with the development of technology.

Currently, the international robot soccer has been very good development. Robot simulation system based on many kinds of ball games have emerged, many people have made efforts on the research of ball games' robot simulation technology, and the results of their research provide a good theoretical basis for the development of robotics and sports analysis technology.

In recent years, multi-agent system (Multi-Agent System) rises in the field of intelligent robots, the main content of the study is that how a multi-robot can co-operate with each other and co-operation to achieve a goal in a variety of adverse environmental conditions.

Robot soccer strategy simulation is relatively mature, and gets a good application. This paper analyzes the process of actual volleyball game, respectively sets up static and dynamic models for individual object's movement conditions in the game, and uses the model algorithm of robots volleyball system software simulate volleyball trajectory in Matlab in order to promote the development of robotics and volleyball career.

THE MATHEMATICAL MODEL IN THE SIMULATION SYSTEM

For the simulation of volleyball robot system, on the one hand need simulation for each object's static model, where static model includes the size, shape, mass and other physical properties; on the other hand also need to simulate the dynamic model of the object, starting the dynamic model includes speed, acceleration, collision and other sports attributes. The following the static model will be summarized as geometry model, because geometry is relatively simple, this article takes the brief form and focuses on the dynamic model of the volleyball robot system.

Geometric model

In volleyball robot simulation system the robot car will be defined as a two-dimensional square, mark out the team member on the surface of the square; volleyball is defined as a circle, and the centroid of car body and the ball is its geometric center; site design is planned in accordance with the proportion of the actual venue shown in Figure 1.

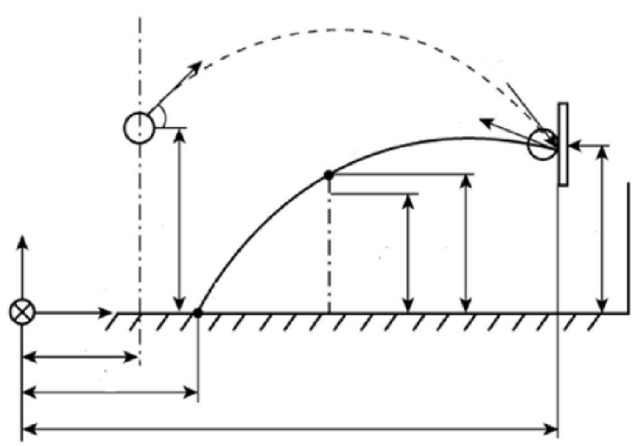

Figure 1 : The simulation system geometric model of volleyball robot

The car body motion model of volleyball robot

The movement of the volleyball robot body is divided into two steps, one is judgment, two is the movement. Through the ball's landed zone to determine which car body moves and how the body moves, then move according to the judgment result. The motion of volleyball robot car is based on the speed control of the left and right two wheels of the vehicle body, by transmitting the speed control command to the robot left and right wheels to adjust the speed and direction of its movement, so that it can move according to the established target point. The vehicle's motion model is shown in Figure 2.

In Figure 2, R means rotation radius, $\Delta\alpha$ means the central angle of the vehicle body rotation in time Δt, the point O means the initial position of the vehicle body at time t, the point O' means the position of the vehicle body at time $t+\Delta t$.

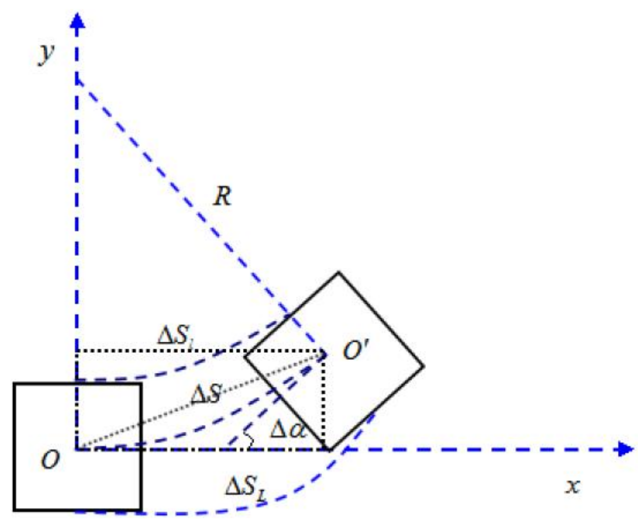

Figure 2 : The movement model schematic diagram of volleyball robot body

Assuming there is no slip between the wheel and the ground and the car body moves in the horizontal plane, then the vehicle centroid moves from point O to point O' at time Δt shown in Figure 2. Assuming that the position of the vehicle body is represented by (x, y, α) at time t, the position at time $t+\Delta t$ can represented by $(x + \Delta x, y + \Delta y, \alpha + \Delta\alpha)$, ΔS_r, ΔS_L respectively represent the movement distance of the two wheels during the movement process, L means the distance between the two wheels of the vehicle body.

The rotation radius can be calculated by the for-

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mula (1):

$$R = \frac{\Delta S}{\Delta \alpha} \quad (1)$$

The car centroid movement distance can be calculated by the formula (2):

$$\Delta S = \frac{\Delta S_l + \Delta S_L}{2} \quad (2)$$

The rotation central angle of the car body can be calculated by the formula (3):

$$\Delta \alpha = \frac{\Delta S_L - \Delta S_l}{L} \quad (3)$$

The displacement of the car centroid in the *x* axial direction and the *y* axial direction can be obtained by the formula (4):

$$\begin{cases} \Delta x = |OO'|\cos\left(\alpha + \frac{\Delta\alpha}{2}\right) = 2R\sin\left(\frac{\Delta\alpha}{2}\right)\cos\left(\alpha + \frac{\Delta\alpha}{2}\right) \\ \Delta y = |OO'|\sin\left(\alpha + \frac{\Delta\alpha}{2}\right) = 2R\sin\left(\frac{\Delta\alpha}{2}\right)\sin\left(\alpha + \frac{\Delta\alpha}{2}\right) \end{cases} \quad (4)$$

When the car body is in linear motion, there is the relation in the formula (5):

$$\begin{cases} \Delta\alpha = 0, \sin\left(\frac{\alpha}{2}\right) \sim \frac{\alpha}{2} \\ \Delta x = \Delta S\cos\alpha, \Delta y = \Delta S\sin\alpha \end{cases} \quad (5)$$

In the data collection process of the car, if the sampling time is set short enough, you can draw the movement very similar to the ideal model. Through the position change of the car body in time Δt, and then accumulates it, the position of the body in the global coordinates can be obtained.

Simulation model of volleyball movement

The volleyball movement with no collisions is generally approximate projectile motion. In the simulation system assume the ball only suffers gravity, and the motion model is shown in Figure 3.

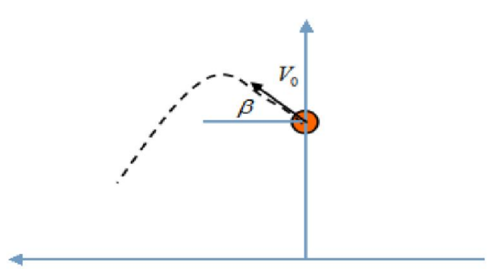

Figure 3 : Schematic model of the ball's movement

When the ball only suffers the gravity and the ball has the initial velocity V_0 shown in Figure 3, then the movement of the ball is a projectile motion, and the centroid coordinate ($x(t)$, $y(t)$) of the ball changes with time shown in formula (6):

$$\begin{cases} x(t) = V_0 \cos\beta \cdot t \\ y(t) = h_0 + V_0 \sin\beta \cdot t - \frac{1}{2}gt^2 \end{cases} \quad (6)$$

In Formula (6), h_0 represents the height from the initial position of the small ball to the ground in Figure 3, when the sampling interval of the ball's position data is Δt, the centroid coordinate of the small ball at time $t + \Delta t$ is shown in the formula (7):

$$\begin{cases} x(t+\Delta t) = V_0 \cos\beta \cdot (t+\Delta t) \\ y(t+\Delta t) = h_0 + V_0 \sin\beta \cdot (t+\Delta t) - \frac{1}{2}g(t+\Delta t)^2 \end{cases} \quad (7)$$

Combine formula (6) and (7) we have the relation in formula (8):

$$\begin{cases} \frac{x(t+\Delta t) - x(t)}{\Delta t} = V_0 \cos\beta \\ \frac{y(t+\Delta t) - y(t)}{\Delta t} = V_0 \sin\beta - gt - \frac{1}{2}g\Delta t \end{cases} \quad (8)$$

When the $\Delta t \to 0$ in the formula (8), there is $\frac{y(t+\Delta t) - y(t)}{\Delta t} \to (V_0 \sin\beta - gt)$; use the $\frac{x(t+\Delta t) - x(t)}{\Delta t}$ and $\frac{y(t+\Delta t) - y(t)}{\Delta t}$ in the formula (8) to represent the ball's velocity in the *x* axial direction and the *y* axial direction.

Through the samples of the ball's centroid coordinates, according to the formula (8) the speed of the ball can be obtained at any time.

Collision model

In this system, the collision condition is divided into four categories: The first one is the small ball collides with the net or pillar, the second one is small ball collides with the robot car, the third one is small ball collides with the ground, and the fourth one is the collisions between robot cars. Since the first one and the third one belongs to the collisions between the small balls and the static things, which is simple and this text does not repeat, this paper focuses on collisions between the ball and the robot car and collisions between the robot trolleys.

The collision process between the robot and the small ball meets the momentum conservation of collision system, and the collide situation is shown in Figure 4.

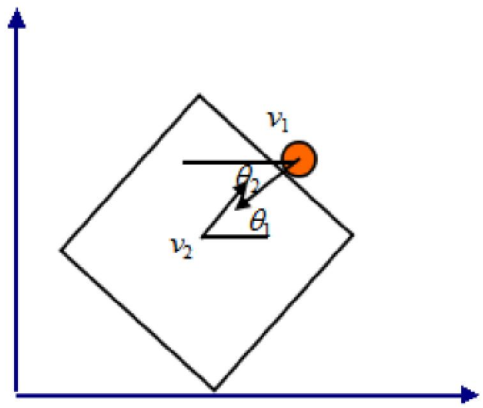

Figure 4 : The collision schematic diagram between the trolley and small ball

According to the momentum conservation in the horizontal and vertical directions, we can draw separate momentary speed of the two; formula (9) shows the component speed both in the horizontal direction and the vertical direction before the collision:

$$\begin{cases} \mathbf{v}_{1,//} = \mathbf{v}_1 \cos\theta_2, \mathbf{v}_{1,\perp} = \mathbf{v}_1 \sin\theta_2 \\ \mathbf{v}_{2,//} = \mathbf{v}_2 \cos\theta_1, \mathbf{v}_{2,\perp} = \mathbf{v}_2 \sin\theta_1 \end{cases} \quad (9)$$

In Formula (9), $v_{1,//}$, $v_{1,\perp}$ respectively means the component speed both in the horizontal direction and the vertical direction of the ball before the collision, $v_{2,//}$, $v_{2,\perp}$ respectively means the component speed both in the horizontal direction and the vertical direction of the robot car before the collision. In the case of no energy loss it satisfies the formula (10):

$$\begin{cases} \mathbf{Mv}_{2,//} - \mathbf{mv}_{1,//} = \mathbf{Mv}'_{2,//} + \mathbf{mv}'_{1,//} \\ \mathbf{Mv}_{2,\perp} - \mathbf{mv}_{1,\perp} = \mathbf{Mv}'_{2,\perp} + \mathbf{mv}'_{1,\perp} \\ \mathbf{Mv}_2^2 + \mathbf{mv}_1^2 = \mathbf{Mv}_2'^2 + \mathbf{mmv}_1'^2 \\ \mathbf{v}_1'^2 = \mathbf{v}_{1,//}'^2 + \mathbf{v}_{1,\perp}'^2, \mathbf{v}_2'^2 = \mathbf{v}_{2,//}'^2 + \mathbf{v}_{2,\perp}'^2 \end{cases} \quad (10)$$

In Formula (10), $\mathbf{v}'_{1,//}, \mathbf{v}'_{1,\perp}$ respectively means the component speed both in the horizontal direction and the vertical direction of the ball after the collision, $\mathbf{v}'_{2,//}, \mathbf{v}'_{2,\perp}$ respectively means the component speed both in the horizontal direction and the vertical direction of the robot car after the collision, and $\mathbf{v}'_1, \mathbf{v}'_2$ respectively means the speed of the ball and the robot car after the collision.

The collision between robot cars in the simulation system means the collision condition between volleyball players, they are generally not concerned about the collision intensity between the staff, but only interested in whether there are collisions between players. In practical systems the car body is a wheel cube with relatively heavy mass. After the collision situation of two cubes it is more complex and has greater randomness, so this will be simplified to judge whether there are two objects overlapped in one cycle. The overlapping part is the collision point. According to experience two robots collision in the simulation playing field is summarized as the situation in Figure 5.

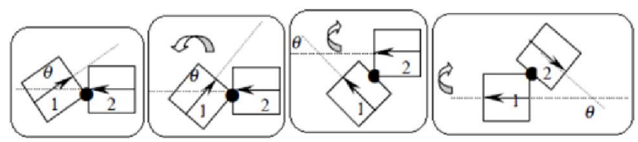

Figure 5 : Schematic diagram of collisions between robots

VOLLEYBALL MOVEMENT TRAJECTORY SIMULATION

When initial velocity of the ball is 30m / s, the initial height is 1.8m, and the elevation angle is 15 degrees, in the case that the ball does not collide with any object, the simulation trajectory is shown in Figure 6:

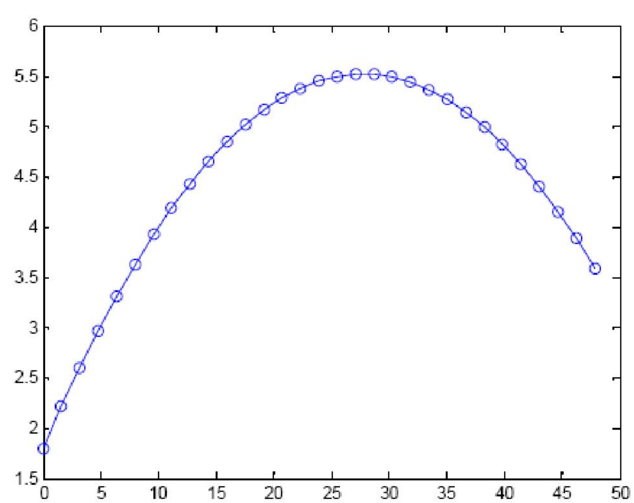

Figure 6 : Trajectory simulation schematic diagram of volleyball serve process

CONCLUSIONS

1) This paper conducted research on the model for the volleyball robot system, put forward the concept of the geometric model and the dynamic model ; the analysis of the model shows the arguments in this article are operable;
2) The model in this paper well reflects the scene of actual volleyball competition, is instructive for volleyball training;
3) the movement model of the volleyball car is not only easy to implement in observation and control technology, is also relatively easy to implement in the computer operation;
4) the movement of the volleyball is seen as projectile motion which only suffers gravity; although not considering air resistance and other factors, but it can also reflect the relatively complete movement of volleyball, and has a reduced effect on the complexity and operand of the model;
5) In the collision model study, in order to approach actual movement, it built momentum and energy conservation equations of the collision system, and used Matlab software to simulate the moving trajectory of the volleyball serve process.

REFERENCES

[1] Bing Zhang, Yan Feng; The special quality evaluation of the triple jump and the differential equation model of long jump mechanics based on gray correlation analysis. International Journal of Applied Mathematics and Statistics, **40(10)**, 136-143 **(2013)**.

[2] Cai Cui; Application of mathematical model for simulation of 100-meter race. International Journal of Applied Mathematics and Statistics, **42(12)**, 309-316 **(2013)**.

[3] Dai Hao, Li Xiao-Jian; The simulation system design and modeling of robot soccer competition strategy. Journal of North China University of Technology, **16(1)**, 25-29 **(2004)**.

[4] Haibin Wang, Shuye Yang; An analysis of hurdle performance prediction based on mechanical analysis and gray prediction model. International Journal of Applied Mathematics and Statistics, **39(9)**, 243-250 **(2013)**.

[5] Hong Bing-Rong; Research on purpose and meaning of robot soccer and its development prospects in our country's. Research Report of Harbin Institute of Technology, 15-35 **(1999)**.

[6] Hongwei Yang; Evaluation model of physical fitness of young tennis athletes based on AHP-TOPSIS comprehensive evaluation. International Journal of Applied Mathematics and Statistics, **39(9)**, 188-195 **(2013)**.

[7] Li Shi, Cheng Jiang, Sun Zeng-Qi; The structure design and implementation of Tsinghua robot soccer team. Journal of Tsinghua University (Science and Technology), **7**, 94-97 **(2001)**.

[8] Li Shi, Xu Xu-Ming, Ye Zhen, Sun Zeng-Qi; Server model of robot soccer simulation game. Acta Simulata Systematica Sinica, **2**, 138-141 **(2000)**.

[9] Rui Qing, Hu Zhog-Wu; Simulation research of table tennis orbit prediction learning with LWR. Robot, **20(5)**, 373-377 **(1998)**.

[10] Shang You, Xu Yu-Ru, Pang Yong Jie; Learning algorithms research of Autonomous underwater robot global path planning based on case. Robot, **20(6)**, 427-432 **(1998)**.

[11] Yang Fei, Liu Zheng Shi; Several typical motion analysis of wheeled round volleyball smart car. Mechanical Engineering & Automation, **1(1)**, 130-131 **(2008)**.

[12] Yan Hai; Research and implementation of simulation robot soccer competition system. Natural Science Journal of Harbin Normal University, **21(3)**, 58-62 **(2005)**.

[13] Zhang Yan-Pei, Lv Tian-Sheng, Song Li-Bo; The volleyball robot motion planning and support vector regression implementation based on case learning. Journal of Shanghai Jiaotong University, **40(3)**, 461-465 **(2006)**.