Research on Design and Implementation of Computer 3D Table Tennis Simulation Animation

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Abstract. Table tennis is China's national ball, which leads to education and teaching is particularly important. In the daily teaching of table tennis technical movements, it is difficult for coaches to achieve one-to-one training mode. At the same time, due to the different foundation of students, it is difficult for coaches to teach students in accordance with their aptitude. At the same time, based on the objective factors such as the angle and position of table tennis, the coach's judgment may be biased, which leads to the realization of 3D table tennis simulation animation based on computer. Through 3D table tennis simulation animation, we can not only improve the shortcomings of traditional table tennis teaching, but also make table tennis teaching more modern. Therefore, this paper first analyzes the movement principle of table tennis. Then, this paper designs the visual servo control system, which can better watch the entity training. Finally, this paper proposes the implementation method.

Keywords: Computer, Table Tennis, Motion Simulation Animation

1. Introduction
In the modern table tennis competition, people pay more attention to the factors such as speed, rotation and strength, which is also the place people pay attention to. At the same time, through the five elements of speed, rotation, strength, landing point and arc, athletes can better compete. Table tennis, as a national sport in China, has been loved by the public. However, the teaching system of 3D table tennis simulation animation in China is still relatively scarce, which leads to many table tennis fans can’t self-study training¹. Therefore, education and teaching is particularly important. It is difficult to ensure that the students learn the movements in a standardized way, which is difficult to allow students to understand the characteristics of movements from various angles. Therefore, the development of three-dimensional table tennis simulation animation is of great significance, which will help coaches to teach students in detail². Through the image, video technology, communication can better analyze each student's table tennis technology, which will be more convenient and fast to improve their tactical level. By enhancing students' confidence, we can promote the development of domestic table tennis³.

2. The movement principle of table tennis
2.1. Rotation types of table tennis
In the process of movement, the movement state of table tennis is different, including movement speed, rotation speed, etc., which requires us to decompose the size and direction of rotation speed in detail. Table tennis rotation can be simply divided into six forms, such as left spin, side spin, up spin, down spin, clockwise spin and reverse spin, as shown in Figure 1[4].

![Figure 1. Rotation types of table tennis.](image)

2.2. Magnus effect
In the movement of a ball, the orbit of the rotating ball of table tennis is curved in the process of movement, which is called Magnus effect. In the process of rotating ball, the ball will be affected by force because of rotation, which will make the actual trajectory of the ball deviate from the original track[5]. In 1852, Magnus studied the Magnus effect of a rotating cylinder. When the fluid passes under the rotating ball, the rotating speed direction of the ball is opposite to that of the fluid. At the same time, the viscosity of the sphere surface will reduce the fluid velocity, which will increase the fluid velocity. According to Bernoulli equation. When the pressure below the ball is greater than the pressure above, the ball will be subject to upward force[6]. The magnitude and direction of the force are Magnus forces, as shown in Figure 2.

![Figure 2. Magnus effect.](image)
2.3. Force analysis of table tennis
In the process of movement, table tennis will be affected by gravity, buoyancy, resistance and Magnus force. The gravity is related to the weight of table tennis, and the direction is vertical downward. The size of buoyancy is related to the volume of table tennis ball, and the direction of force is opposite to gravity. The resistance is related to the speed of table tennis, which is opposite to the speed direction of table tennis. Magnus force is related to rotation speed and motion speed. In this paper, the force diagram of table tennis is analyzed by under spin and side spin, as shown in Figure 3.

![Figure 3. Force analysis of table tennis.](image)

3. Construction of equation model

3.1. Mathematical equation
In this paper, a three-dimensional rectangular coordinate system is established, which is consistent with $x, y, z$. The initial velocity of the ball is set as $v_0$. $\phi$ as the axis of rotation, as shown in Figure 4.

![Figure 4. Table tennis space rectangular coordinate system.](image)

According to Newton's theorem, a nonlinear differential equation is obtained, as shown in Formula 1.
\[
\begin{align*}
\frac{dx}{dt} &= v_x \\
\frac{dy}{dt} &= v_y \\
\frac{dz}{dt} &= v_z \\
\frac{dx}{dt} &= -\frac{1}{2} C_D \rho A v_y v_x + \frac{1}{2} C_L \rho A v_y (v_x \sin \phi - v_y \cos \phi) \\
\frac{dy}{dt} &= -\frac{1}{2} C_D \rho A v_y v_y + \frac{1}{2} C_L \rho A v_y v_x \cos \phi \\
\frac{dz}{dt} &= -\frac{1}{2} C_D \rho A v_y v_z - \frac{1}{2} C_L \rho A v_y v_x \sin \phi - mg 
\end{align*}
\]

Finally, the formula of initial position is obtained, as shown in formula 2.

\[
\begin{align*}
\frac{dx}{dt} &= v_0 \cos \theta \cos \beta \\
\frac{dy}{dt} &= v_0 \cos \theta \sin \beta \\
\frac{dz}{dt} &= v_0 \sin \theta 
\end{align*}
\]

3.2. Visual servo control system

In order to compare the mathematical model calculation, this paper developed a visual servo control system, which can better determine the position of table tennis. This paper based on the visual servo control system of table tennis robot, to accurately control the strength and position of serve. The control structure of the robot is shown in Figure 5.

![Figure 5. Visual servo control system.](image)

4. Computer implementation

4.1. Composition of online learning environment
Based on the online learning environment, this paper develops three subsystems, including online learning support system, teaching behavior management system and learning resource management system, as shown in Figure 6.

![Composition of online learning environment](image)

**Figure 6.** Composition of online learning environment.

### 4.2. Play animation frame by frame

And it is very important for the advanced students to combine the skills. Computer animation technology can realize the frame by frame playback, frame by frame playback and normal play of technical action animation through interactive buttons. By watching the frame by frame animation, the college can easily press and hold the left key of direction to achieve continuous frame by frame playback. To play one by one, students can press the space bar to play normally. The main process is shown in Figure 7.

![Play animation frame by frame](image)

**Figure 7.** Play animation frame by frame.

### 5. Conclusion

By using Adobe Flash professional CS programming software, we can establish the system database, which will help to implement the system. The system can provide a tool for teachers to analyze students' movements accurately and precisely, which will make the evaluation of teachers more objective and fair.

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