Simulation Analysis of the Head Shot of a Virtual Football Player

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Abstract: Modeling simulation of virtual football players' head shot is the exact embodiment of the application of virtual human technology in football. Based on the importance of technical movements in football matches, this paper studies the dynamics modeling methods of football players based on sports biology, gives the characteristics of muscles and joints when provoking a positive head ball, decomposes the head shot action, creates the rigid body model of the football player, uses the skeleton model of the virtual football player to establish a simulation experiment, and introduces the genetic algorithm to plan the path before the shooting for the virtual football player, and obtains the best path of the shot. And the simulation results proves the effectiveness of the algorithm.

1. Introduction

Football is the most widely developed sport in the world. It is typical to take football as the object of study. Football players should be the focus of attention of researchers. Simulating the player's behavior is the common embodiment of virtual technology and football. Finding an effective offensive path is a prerequisite for shooting.

Research on the key movements of football players can provide support for football training. With the rapid development of computer technology, the need to use virtual people instead of humans for scientific research is increasingly great, which can provide efficient technical means for football research. The development of sports biology and other related disciplines has provided impetus for the virtual research of athletes. Virtual technology realizes the digitization of virtual human body by computer processing with the information of human morphology and biology. It is a precise mathematical description of the dynamic biological process of human beings. Virtual human technology has been widely used in virtual reality, sports and other fields. The path planning method of virtual football players studied in this paper can meet the needs of athletes' counter guard, providing a research method for further modeling on virtual football players' movement[1].

2. A review of related studies

2.1. Virtual human technology

The development of virtual human technology and robot technology provides a theoretical basis for virtual football players. Virtual human technology is a research hotspot at home and abroad in recent years. Its research scope includes geometric model, motion generation and control, advanced intelligent behavior. The geometric model of the virtual human includes the skeleton model and the entity model. The skeleton model represents the contour of the human body with a bar graph. The solid model represents the shape of the human body with a combination of basic voxels. The human body model represented by the solid shape is not realistic enough. The human body surface model divides the human body into several segments, and the connected segments are connected by smooth transition surfaces.

At present, a hierarchical representation method of virtual human is formed. The hierarchical model consists of a bone hierarchy and a skin hierarchy. The skeleton structure of the human body

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is represented by VRML and MPEG-4. Geometric modeling techniques are widely used in the representation of human muscles. At present, the behavior expression of virtual human is at the initial stage all over the world.

Virtual human technology is a comprehensive frontier discipline. At present, the final realization of virtual human technology faces many difficulties, and it is of great practical significance to explore it.

2.2. Research on the path planning in football courts

Football is a highly competitive confrontational project. The two sides launched a confrontation in order to kicking the ball into the opponent's goal. How athletes make shots is a path planning problem for football players on the court. Path planning mainly includes planning methods and the results of implementation. The environmental expression refers to how to express the real world environment reasonably as environmental information that can be utilized, and different planning methods can be formulated according to different environments.

The path planning method is first applied to the path planning problems introducing artificial intelligence method such as robot field and neural networks. Usually centralized methods are combined to implement path planning tasks. The artificial potential field method has the advantages of simple calculation method and considering the motion performance of the robot while at counter guard[2].

There are many research methods for path planning. Path planning based on static environment is relatively ripe. The global optimal path planning method is not very ripe. The path planning of virtual football players is one of the research contents of this paper.

3. Basic theories of head shot for virtual football players

3.1. Exercise Physiology Theory

Athletes' technical level directly affects the result of competition. Human movement is a research hotspot in this century. The research emphasis is on how to accurately measure various kinematic parameters. Researchers began to focus on exploring the intrinsic relationship between parameters, and the theoretical methods of exercise physiology theory began to emerge and have gradually been improved. This paper uses this method to model and analyze the head movement of football players.

The biomechanics of sports method consists of theoretical and experimental methods of exercise physiology. The difference is that the research object is the motion of an abstract mechanical model of human body. The conclusion of the study can reveal the intrinsic mechanism of motion.

The key to the theoretical method of biomechanics of sports is to establish a model of human motion mechanics. Man's will carries on various activities according to man's will through the nervous system. The human body system simulation research method and the application of rigid bodies system mechanics established a mechanical model to describe human motion.

3.2. Head skill of football players

In football matches, football players have the ability to catch, kick, and head. In the restricted area, the offensive side has to be severely restricted by breaking the defense line. And the head attack can exceed the ground attack limit. This paper takes the head movement as an example to analyze the technical characteristics of athletes' movements.

The head refer to use head to complete the batting action. The type of heading technique is mainly distinguished by the position of the head when heading the ball. In each technique, it can be divided into situ jumping and jumping according to the warm-ups before heading. According to direction of the ball coming, it can be divided into heading forward, backward and on both sides. There are many kinds of head movements. In this paper, we take the forward heading with two feet jumping as an example to analyze and study.

After the feet are off the ground, the movement is to bend the knees, stretch the torso, and the

arms extend horizontally across the longitudinal axis of the joint. The series of muscle movements after the suspension can reduce the deficiency of multiple joints in the heading stage, which can be regarded as the kinetic dynamic setting of the root formation[3].

3.3. Skeleton model of virtual football players

The human body is a complex system. To simulate real human motion, all joint data needs to be provided to first create a three-dimensional human body model. The human body can be framed from three levels: skeleton, muscle and skin. Motion control is closely linked to the skeleton model. The human body is a collection of rigid bodies connected by joint points. The upper arms and the trunks are connected by the shoulder joint. Simplifying human motion into human skeleton motion, a three-dimensional human skeleton model can be obtained. The line segment between the joints represents the cylinder block. The human skeleton can be regarded as a rigid bodies system. In this paper, the simplified human body skeleton model is used to simulate the football head shot action.

4. Modeling of head shot movement of football players

The head plays an important role in the football game. A dynamic model of the football player should be established. The main points of head-kick in situ jump are knees bending, feet kicking hard to jump, stretching abdomen and stretching chest at the phase of body ascension, eyes watching the coming ball, swinging forward the upper body when the ball runs to the forehead, swing explosively the neck, swinging forward legs, bending knees and ankles to land. The head movement can be divided into a squatting phase, a take-off phase, a suspension phase, a heading phase, a falling phase and a buffering phase.

The sports biomechanics analysis method describes human motion through mathematical models. The simulation of complex movements of the human body is quite difficult. Trying to choose a human body model with a small number of rigid bodies is an important step to solve the problem. The football player is simplified into a four-rigid structure with light rods representing the head, torso, and legs.

The process of frontal heading in situ jump is decomposed into knee bending, jumping, hypsokinesis, hitting and landing. Take the quality corresponding to the head, torso, legs, connecting parts to the neck, hips and knees. Set the height of the center of gravity of the body from the ground be y and the initial value of the coordinates in the X direction be 0.

The in-situ jump action is that the big and small legs fully act on the athlete through the ground force to complete the jump action. Assuming the torso and head maintaining the same posture. When jumping, the leg muscles gradually change to a straight line under the action of the moment. Let Mk be constant during the jump process, θ=0 and the constraint release condition F=0, when leaving the ground, the θ=0 can be used to obtain the speed of the athletes leaving the ground: y=2[$\frac{Mk\theta 40}{m4} - gl4(t - \cos\theta 40)]^{\frac{1}{2}}$ Athletes jump in suspension is a up throw motion. The velocity of motion is y=y0-gt2/2. When the athlete jumps to the highest point, there are hitting and landing movements[4].

The hypsokinesis process is from state I to state II. The muscles of the neck, hips and knees produce rotational moments. The torso and thigh are affected by the moment at both ends in rotation. The working moments of muscles at N, W, and K are Mn, Mw, and Mk. And 1, 2, 3 and 4 meet the law of conservation of momentum. The intramuscular moment in the hypsokinesis process accelerates first. Assuming that the magnitude of the moment remains unchanged, the final results of the hypsokinesis process make the velocities of 1, 2, 3 and 4 be zero.

The forward swing process is from state III to IV. Each part of the body starts from the last position of the hypsokinesis to lean forward to the hitting position. The model of the hypsokinesis process can be used. The speed of each part of the body reaches the maximum.

When hitting the ball, the mass is mb, the flying speed in the opposite direction is vb, the head speed after hitting the ball is 0, and the total torque of head action is MH=F(t). l1-Mn. And taking

F(t) be a fixed value, the angular velocity of 1, 2, 3 and 4 can be calculated by using the angular velocity calculation method.

There is a horizontal projectile motion in which the final velocity is the initial velocity when considering the overall action of the batting $\begin{cases} x(t) = x0 + vkt \\ y(t) = y0 - gt^2/2 \end{cases}$ VC++6.0 programming tool is used to simulate the virtual athletes' in-situ jump front head shot. The front head shot process of in-situ jumping is simulated. When football is approaching, jump up, lean back, keep hitting inertia, and finally land.

5. Path planning for virtual football players

Football is a highly competitive and confrontational project. The two sides struggle to achieve the goal of not allowing the ball to enter their own goal. How the athlete is inserted into the effective shooting position is the path planning problem for the athlete on the court. The traditional methods of path planning include grid method, potential field method, topological method and geometric method. The grid method is currently a widely studied path planning method. If there is no obstacle in the range of a certain grid, it is a free grid. The grid constitutes a connected map, searching the path from the initial grid to the target grid, and expressing it with the grid number. The grid number is converted to the actual coordinates of the space and moves along this path.

The basic idea of the topological method is to construct an artificial potential field that interacts with the gravitational field at the target location, looking for a collision-free path. The specific method is to first create a potential field U in the robot motion space, which is the superposition of the gravitational part and the repulsive part, and move mobile robot toward the target point along the direction of the resultant potential field force. The gravitational potential field has a large range of action, and the area far from the obstacle is not affected by the obstacle repulsive potential field. The advantage of the potential field method is that the structure is simple and it is convenient for in-time control of the bottom layer. The dynamic motion performance of the robot is considered in the motion planning. The planned path is smoother and safer. However, the shortcoming is the local optimization method will not consider whether the path is optimal. The unreasonable mathematical equation of potential field tends to produce local extreme points. A common phenomenon is that a certain point stops and cannot reach the target point. The potential field angle will change greatly due to the position change of the robot.

Genetic algorithm is an adaptive global optimization and improved search algorithm for simulating the formation of biological genetic processes. It originated from the research on natural and artificial adaptive systems in the 1960s. In the 1980s, the basic framework of genetic algorithms was formed. The first step of the genetic algorithm is to use the appropriate coding form to represent the problem with a string when the algorithm is implemented. The string length is fixed. The coding methods commonly used in genetic algorithms mainly include binary methods and real number coding methods.

The virtual football players are divided into obstacle avoidance players and obstacle players. Each virtual player has a safety radius R, the starting point is S, and the search scope of obstacle avoidance player is determined to be long L and width L/2. Treat players as obstacle players. There is a limited collection of obstacle players in the court. O={OB1,…OBq} q is the number of obstacle players within the search scope.

Taking the path point as a collection. Assuming that the starting point S and the target G are known. The line segment SG is equally divided into m to obtain VL1, ... VLm, and each vertical line has n points. There are mxn path points.VL1(x(j), y(j)) represents the jth point of the ith vertical line. For a fixed fitness function, the length of the code directly determines the online calculation time. Simplify the two-dimensional coding path to one-dimensional coding. Path points can be represented by one-dimensional variables. The initial population size generated randomly is 50.

Through the genetic algorithm, the virtual football player can avoid the interception of the opponent player and complete the virtual player's offensive shooting process. The traditional and

intelligent methods are used to analyze the path planning. Individuals adopt one-dimensional floating-point coding, setting adaptive functions from the perspective of dynamic obstacle avoidance, and using crossover and mutation genetic algorithm to optimize the path. The effectiveness of the algorithm is proved by simulation experiments.

6. Conclusion

The modeling of virtual football players' head shot and the application of sports biomechanics to football performance are analyzed. This paper studies the mechanics modeling analysis and path planning of virtual players, and summarizes the research status of virtual human technology and virtual football player motion modeling simulation. The mechanics modeling method of football players in sports biology method is analyzed, and the characteristics of muscle movement when jumping front head shot are given. The head shot of football players is decomposed. VC++6.0 is used a programming tool to realize the simulation of the virtual football player's jumping head shot movements. In this paper, the modeling and simulation of virtual football players' head shot movements are studied, and there are still many problems need to be further studied.

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