Application of Three-Dimensional Animation in Mechanical Control Mechanism

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Abstract. With the development of the times and the advancement of science and technology, the development of 3D animation has gradually been applied in various fields. In the field of mechanical control, three-dimensional animation has gradually become a very important application. In the actual application process, the use of three-dimensional animation effects cannot be applied in the field of mechanical control only by imagination. It must be applied in practice from the perspective of mechanical control. Analyze from its own stability and external factors to realize its application value. The purpose of this paper is to study the application of 3D animation in mechanical control mechanism. This article will take mechanical control as an entry point to discuss the application of three-dimensional animation in its mechanism. The research is carried out from two aspects. The first is the application of the robot arm. Based on the kinematic path planning of the shortest time priority strategy, the shorter the motion time of the robot arm, the faster the speed, and the vibration is more difficult to avoid. This is the vibration of the flexible arm. Improve its work efficiency, lay the foundation for more complex path planning problems; create conditions for lighter and faster robotic arm applications. The second is the application of the mechanical foot. The proposed ankle joint control strategy based on the lateral and forward cycle matching can be combined with the forward plane walking control strategy under the stable initial gait of the robot to realize the human-like virtual prototype of the biped robot. Dynamic walking for analysis. Experimental investigations have shown that in the process of normal walking, there is a dynamic swing process and a static support process. The swing process refers to the lifting of the foot to move forward or backward, and the supporting process refers to the immobilization of one foot to the other. One fulcrum on each foot allows it to move forwards and backwards. Among them, the dynamic swing process accounts for 40% of the whole process, and the static support process accounts for 60%. In general, based on these data, the three-dimensional robotic arm and three-dimensional robotic foot can be better studied.

Keywords: 3D Animation, Mechanical Control, Mechanical Arm, Mechanical Foot
1. Introduction
With the development of the times and the advancement of science and technology, the development
of 3D animation has gradually been applied in various fields [1-2]. In the field of mechanical control,
three-dimensional animation has gradually become a very important application [3-4]. In the actual
application process, the use of three-dimensional animation effects cannot be applied to the field of
mechanical control only by imagination [5]. It must be applied in practice from the perspective of
mechanical control [6]. Analyze from its own stability and external factors to realize its application
value [7-8].
In the research on the application of three-dimensional animation in mechanical control
mechanism, many domestic and foreign scholars have studied it and achieved good results. For
example, the passive dynamic walking theory proposed by Rozario can make biped robots without
active control and in the case of energy driving, it can make full use of its own dynamic characteristics
(such as gravity, etc.) to stably walk down the slope [9]. Cortez developed a three-dimensional
autonomous walking robot and a running robot based on the theory of semi-dynamic walking by
introducing drives in the hip and ankle joints, gradually transforming from the bipedal robot's two-
dimensional planar walking to the three-dimensional actual walking [10].
This article will take mechanical control as an entry point to discuss the application of three-
dimensional animation in its mechanism. The research is carried out from two aspects. The first is the
application of the robot arm. Based on the kinematic path planning of the shortest time priority
strategy, the shorter the motion time of the robot arm, the faster the speed, and the vibration is more
difficult to avoid. This is the vibration of the flexible arm. Improve its work efficiency, lay the
foundation for more complex path planning problems; create conditions for lighter and faster robotic
arm applications. The second is the application of the mechanical foot. The proposed ankle joint
control strategy based on the lateral and forward cycle matching can be combined with the forward
plane walking control strategy under the stable initial gait of the robot to realize the human-like virtual
prototype of the biped robot. Dynamic walking for analysis.

2. Application Research of 3D Animation in Mechanical Control Mechanism

2.1. 3D Animation Simulation Robotic Arm
(1) Establishment and import of geometric model of mechanical arm
Using PARASOLID as the core of solid modeling, it provides a large number of parts graphics
library, and the modeling work is fast. For some simple institutions, it can be directly established in
the ADAMS/View module. However, for some mechanical systems with more complex models, the
modeling function of the ADAMS/View module itself cannot quickly establish a system model, so
ADAMS provides an interface for external model data, and you can use professional modeling
software to first establish a solid model. Such as PRO/E, SOLIDWORKS, CATIA, etc., and then
import it into ADAMS. Since the end effector of the RBT-4S01S robot is a pneumatic gripper, the
state of the gripper does not affect the path planning of this paper, so here The modeling was
simplified accordingly, and the opening and closing functions of the claws were removed, but the
space occupied by the claws was still reflected in the model. After the model is imported into
ADAMS, the system unit needs to be set. In order to prevent errors in the subsequent simulation, the
material of the robot arm must be defined. Here, the material is selected as steel, and an obstacle needs
to be added.

(2) Impose constraints and drive
After the previous work is completed, constraints and drivers need to be added to the model to
prepare for simulation. First, it is necessary to add a fixed pair to the stage, the arm base and the
obstacle, which are static during the simulation process, and then add a rotating pair between the arm
base and the connecting rod 1, the connecting rod 1 and the connecting rod 2, . And then add a
translation pair between the connecting rod 2 and the lifting connecting rod 3, so that the constraint is
added. Then add a rotary drive to the rotating pair 1 and the rotating pair 2, and add a linear drive to
the translation pair. At this point, a three-degree-of-freedom mechanical arm is formed, and there are three drives on it. At this point, the work before the system simulation is basically completed. At this time, you can use the self-check command to check whether the model has errors.

3) Simulation of obstacle avoidance movement of manipulator

The purpose of manipulator simulation here is to check whether the previously planned path is correct and feasible. Therefore, the various parameters of the system during simulation must be the same as the previous ones, such as the size of the manipulator model, the position and size of obstacles, and the application of each joint. The law of motion of the drive and the initial state of each joint. After the above work is completed, the simulation can be started. During the simulation process, use the pause function of the simulation tool to pause the simulation at the required position. The intercepted state of each time period can be seen from the figure, the robot is in the movement process. In this process, obstacles can be avoided smoothly, so that the planned trajectory is correct and effective.

2.2. 3D Animation Simulation of Mechanical Foot

1) Forward walking control strategy

The process of human walking forward can be divided into four states: the swing stage before the knee joint of the swing leg is locked; the moment when the knee joint of the swing leg collides and locks; the swing back stage of the swing leg reflects the passive dynamic walking characteristics of the robot; the foot collides with the ground State switching, complete a gait cycle. The mechanical foot is a hybrid dynamics model, which includes a limited continuous motion state and discrete collision switching states. The finite state machine (FSM) is a mathematical model that describes the state of finite motion modes and the transitions and actions between these states. The state transition diagram is used to model the dynamic behavior of the system and perform visual analysis. Therefore, the finite state machine can be used for the research of the stable walking control strategy of the biped walking robot. Based on the principle of passive dynamics, the planar realization of the passive walking gait of a biped walking robot needs to introduce drive control in the form of gravity, that is, to compensate for the loss of potential energy in passive walking. In addition, considering that humans mainly rely on the thigh driving moment of the hip joint during walking, the forward walking control moment of the biped walking robot is applied to the rotation joint of the thigh and the hip joint.

2) Lateral control strategy

The walking cycle of the mechanical foot is formed alternately between the two-foot support period and the one-foot support period, and the one-foot support period occupies 70% of the entire walking cycle. However, the actual three-dimensional mechanical foot will deviate to the side of the swing leg due to the gravity of the center of mass during the one-foot support period, resulting in unstable lateral movement. Therefore, the actual mechanical foot prototype needs lateral control torque to compensate the centroid effect to achieve lateral controllability. For the ADAMS virtual prototype of a mechanical foot with a linkage upper body, when a torque is applied to the lateral rotation joint of the mechanical foot ankle, it can be seen from the phase diagram of the lateral angle of the mechanical foot and the lateral change of the center of mass that the mechanical foot is from a static state after two cycles, the limit cycle can be stabilized under the action of lateral torque (the end of the discontinuity is the discontinuous collision switch caused by the collision of the mechanical foot with the ground), and the center of mass of the mechanical foot also periodically swings in the lateral direction. Therefore, applying a lateral moment to the ankle joint of the mechanical foot can realize the control of the lateral movement of the mechanical foot.

2.3. Description Method of Mechanical Deformation

1) Hypothetical modal method

It uses a finite linear group sum of hypothetical modal vibrations to approximately describe the vibration of an elastic body, and its vibration displacement can be described in the following form:
\[ y(x,t) = \sum_{i=1}^{n} \phi_i(x) q_i(t) \]  

(1)

(2) Virtual constraint thinking

The process of imposing virtual constraints is mainly realized through zero dynamic control strategy. For the discrete subsystems in the variable-dimensional hybrid dynamic system, the virtual constraints of the system are taken as:

\[ h(p) = Hq_c - h^d \theta(q) \]  

(2)

Among them, \( Hq_c \) represents the driving joints that impose virtual constraints; \( h^d(\theta(q)) \) the functional relationship \( \theta(q) \) that the joints that impose virtual constraints are synchronized with is specified, that is, the stable desired trajectory of each joint.

3. Experimental Research on the Application of Three-Dimensional Animation in Mechanical Control Mechanism

3.1 Subjects

With the rapid development of computers, three-dimensional animation has gradually become an important application in the field of mechanical control. In the actual application process, the use of three-dimensional animation effects cannot be applied in the field of mechanical control only by imagination. First, it must be applied in practice from the perspective of mechanical control. This article takes the three-dimensional mechanical arm and the three-dimensional mechanical foot as the object for research, analyzes its own stability and external factors, and realizes its application value.

3.2 Experimental Method

Taking human joint motion as the main reference material, by analyzing the angles of various types of activities of the main joints on the arms and legs, and then studying the research data of other researchers on the three-dimensional robotic arm and the three-dimensional robotic foot, we can get the results.

3.3 Data Collection

Analyze by measuring the angle of movement of the main joints on the arms and legs of the human body. Use the data combined with three-dimensional animation for mechanical control applications.

4. Application Experimental Research Analysis of 3D Animation in Mechanical Control Mechanism

4.1 Arm Motion Analysis

The control of the manipulator is generally carried out through its joint control, and the planned result still needs to be solved by inverse kinematics. Because the conversion process is relatively complicated, it is difficult to meet the real-time requirements of the manipulator. The experimental results are shown in Table 1:

| Type of activity | Angle value |
|------------------|-------------|
| Buckling         | 0~150       |
| Stretch          | 0~10        |
| Pronation        | 0~80        |
| Supination       | 0~80        |

Table 1. Range of movement of the elbow joint
Figure 1. Range of movement of the elbow joint

As shown in Figure 1, when planning a path, all the joint values are planned. Generally speaking, the difference between pronation and supination is not large, the angle value is 0 to 80, and the extension angle value is 0 to 10. According to these data, Can better research the robotic arm.

4.2 Analysis of Lower Limb Movement

When walking, the movement of the lower limbs is mainly driven by the hip bones to move the femur, tibia and foot bones relative to each other. The hip bone and the femur are connected by a hip joint, the knee joint connects the femur and tibia, and the ankle joint connects the tibia and foot bone. The movement of each joint of the lower limbs mainly includes flexion and extension movements, the main ranges are, abduction, internal rotation, internal rotation, and external rotation. The experimental results are shown in Table 2:

Table2. Hip range of motion

| Type of activity | Angle value |
|------------------|-------------|
| Bend            | 0~135       |
| Stretch         | 0~120       |
| Outreach        | 0~35        |
| Adduction       | 0~25        |
| Spin            | 0~45        |
| Spinout         | 0~45        |

Figure2. Hip range of motion

As shown in Figure 2, in the normal walking process, there is a dynamic swing process and a static support process. The swing process refers to the lifting of the foot to move forward or backward, and
the supporting process refers to the immobilization of one foot. A fulcrum on the other foot allows it to move forwards and backwards. Among them, the dynamic swing process accounts for 40% of the whole process, and the static support process accounts for 60%.

5. Conclusions
This paper selects the application of three-dimensional animation in mechanical control mechanism as the research object, and focuses on how to make it better in mechanical control. The preliminary discussion and analysis of three-dimensional animation in the simulation of mechanical control are carried out, and the three-dimensional Related knowledge of manipulator arm and three-dimensional mechanical foot, and then design the vibration trajectory that meets the first-order mode of the flexible arm with zero residual vibration, and proposes ankle joint lateral torque compensation control and lateral control based on the lateral and forward period matching control strategy. Towards a stable control method. In order to improve the stability and efficiency of the motion of the mechanical foot. The research of 3D mechanical foot and 3D mechanical arm should not only consider the stability of its own control mechanism, but also the anti-disturbance adaptability to the external environment. Really exert its application value in the real society.

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