X3D-Based Robot Kinematics Simulation

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ABSTRACT

This paper introduces the related technology in the design of robot virtual prototype. Research is mainly focused on the virtual prototype of the mechanism design, kinematics simulation, control logic and main problems of prototype performance analysis, and try to use X3D technology to realize virtual prototype model of the robot. It is verifies the effectiveness of X3D technology in robot virtual prototype design. The key to realize the robot mechanism design, kinematics simulation, several aspects such as the logic control. But the design of the robot system is a comprehensive mechanical mechanisms, kinematics, dynamics, graphics, artificial intelligence, concurrent engineering, and simulation project of multiple disciplines such as advanced manufacturing technology. The design of the robot system includes dynamic analysis, static analysis, speed, trajectory control, sensor fusion, artificial intelligence analysis, and other technology. The comprehensive realization of multidisciplinary various restrictive factors is to achieve a feasible, effective and ideal robot virtual prototype model of the key problems. Further use X3D technology to add various related techniques to achieve X3D virtual prototype model, the design of robot system, the development of industrial robot has important practical significance.

Keywords: Kinematics, Robot, Simulation, Virtual Prototype, X3D

POSTURE MATHEMATICAL MODEL

Denavit and Hartenberg in “ASME Journal of Applied Mechanics” published a paper. They use the paper to representation and modeling for the robot, and deduced the equation of motion, this has become a current of robots and robot motion modeling standard. Denavi Hartenberg (DH) model of the robot modeling connecting rods and joints of a very simple method, the robot can be used in any configuration, regardless of the structure of the robot how to order and complexity in any coordinate transformation, such as rectangular, cylindrical coordinate, spherical coordinates, the ruler Angle coordinate and twisted coordinates, etc., DH model can be represent. In addition, it can also be used for the rotating chain robot, SCARA robot or any possible joints and connecting rod combination. DH model assumes that the robot is composed of a series of joints and connecting rod. These joints may be sliding (linear) or rotation (rotation), they can be placed in any order and

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in any plane. The length of the connecting rod can be arbitrary (including zero), it can attack distorted or curved, may also at any plane. So any set of joints and connecting rod can constitute a said we want to modeling of the robot (Xu, Hong Zhong, & Xu, 2004).

Using DH modeling, the first specify a reference coordinate system for each joint, and then determined from a joint to the next step, to conduct a joint transform namely from a joint coordinate system to the next joint coordinate system transformation. Joints from base to top, and then from the first joint until the last of all joints transformation, from the total transformation matrix of the robot (Koren, 1985).

Specifies the coordinate system for each joint of the steps are as follows (Yi, 2007):

1. For each joint use z axis for represent. For rotary joints, z positive direction according to the rules of right hand rotation direction of the axis. For smooth joints, z axis is the direction of motion along a straight line. In each case, the z axis of the joints (as well as the local reference coordinate system) of the joint of the subscript for \( n-1 \). For example the number \( n+1 \) of joint z axis is \( z_n \). This is the simple rule allows us to quickly define all the joints of the shaft. For rotary joints. For the rotation of the z axis (Angle) is the joint variables. For sliding joints, along the z axis of the connecting rod length is joint variables represent as \( d \).

2. Most of the joint does not necessarily parallel or intersecting in reality (Jing Jun, 2008). As a result, the z axis is usually a slash, but there is always a shortest distance and vertical line; It is orthogonal to the arbitrary two diagonal lines. Usually in vertical direction is defined on the x axis of local reference frame. Adjacent joints between the common normal don’t intersect or collinear, therefore, the position of two adjacent coordinate system origin may also not in the same place. In order for all the joints specified x axis.

3. If two joint z axis parallel, between them there are many common normal lines. At this time can be selected from the previous joint the common normal of collinear any a common normal, can simplify the model to do so.

4. If it is the intersection of two adjacent joint z axis, so between them, there is no common normal (or perpendicular distance is zero). At this moment can be perpendicular to the axis of the two constitutes a straight line is defined as the x axis plane. In other words, the common normal is perpendicular to the contains two axis plane straight line, it is equivalent to choose the direction of the cross product of two z axis as the x axis. This method can simplify the model.

Transform a coordinate system to the next one, can use the steps in turn:

1. Pivot with \( z_n \) axis, it makes \( x_n \) and \( x_{n+1} \) parallel to each other, because \( a_n \) and \( a_{n+0} \) is perpendicular to the \( z_n \) axis, so the pivot, make them parallel (and coplanar).

2. Along the \( z_n \) axis shift distance \( d_{n+1} \), making \( x_n \) and \( x_{n+1} \) collinear. Because \( x_n \) and \( x_{n+1} \) parallel and perpendicular to \( z_n \), move along \( z_n \) can make them overlap each other.

3. Translation \( a_{n+1} \) distance along the \( x_n \) axis, \( x_n \) and \( x_{n+1} \), the overlap of the origin point. While two reference coordinate system are at the same location.

4. The pivoting \( z_n \) axis, makes the \( z_n \) and the \( z_{n+1} \) alignment. Coordinate system \( n \) and \( n + 1 \) is exactly the same. At this point, we finish from a transformation of coordinate system to the next.

According to the above steps, you can achieve all adjacent coordinate system transformation. From the ground reference frame, can convert it to the robot body, then the first joint, the second joint, the third joint. Use right by said four movement four matrix transformation matrix A, will be given matrix A said the four movement in turn. Because all of the trans-
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