Computer Graphics Simulation of Robot Arm Configuration

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Abstract. The industry robot generally refers to the robot, which is used in the mechanical manufacturing industry, replacing the human to complete the mass and high request work. This thesis is based on the structure of 4-DOF SCARA robot arm and investigates the problem of the analysis and optimization of the structure of robot arm according to the requirement of system for the rapid response and smooth work.

Keywords: 4-DOF, SCARA Robot, Robot Arm

1. Introduction

With the rapid development of modern science and technology, robot technology has been widely used in various fields of manufacturing industrial. The main contents of this paper include the comparative analysis of different design schemes in the following aspects: joint design of planar articular robot, optimization of mechanical arm, overall dynamic optimization of robot through Analyze Software. Through the comparison and calculation of different kinds of motors, the joint drive mode, motor and reducer are selected.

2. Mechanical system design

The mechanical structure of industrial robot has three parts: body, arm, wrist and hand. The robot must have a base piece that is easy to install. In addition, this is the base of the industrial robot, which is often integrated into the body. For the study of robot in this subject, the fuselage design mainly considers the size, stability, and convenience of the placement of arms and arm-related components. Therefore, the fuselage is designed with the interior being hollow. The purpose of this design is to facilitate the placement of the servo motor of the first joint inside the base, and also to reduce the weight of the base and move the center of gravity downward.

It can be seen that the robot in the process of running requires the torque, moment of inertia of conform to the requirements of the mechanics from the existent laboratory experiments of the robot. In the absence of speed reducer in the movement process of the robot, it will have a certain amount of vibration,
the moment of inertia, the greater the vibration, the more obvious according to the principle of inertia matching. In order to choose the appropriate gear reducer to do more indirect drive, low torque in the robot with a speed reducer into a low speed and high torque drive is selected to solve the problem of inertia matching. In terms of the robot movement analysis, there the kinematic equation of attitude is as follows:

\[
T_4 = A_4 A_3 A_2 A_1 = \begin{bmatrix}
  n_x & o_x & a_x & p_x \\
  n_y & o_y & a_y & p_y \\
  n_z & o_z & a_z & p_z \\
  0 & 0 & 0 & 1
\end{bmatrix}
\]

(1)

Here \( T_i \) is the \( i \)th the position of the linkage with respect to the reference frame for checking \( T_e \). \( N, o, a, p \) is the length of parts. The pose matrix between the coordinate systems of two adjacent bars is as follows:

\[
A_i = \begin{bmatrix}
  c\theta_i & s\theta_i c\alpha_i & s\theta_i c\alpha_i & h_i c\theta_i \\
  s\theta_i & c\theta_i c\alpha_i & -c\theta_i c\alpha_i & h_i s\theta_i \\
  0 & s\alpha_i & c\alpha_i & d_i \\
  0 & 0 & 0 & 1
\end{bmatrix}
\]

(2)

Here \( A_i \) represents the position of the \( i \)th with respect to the \((i-1)\)th of the link. Among them, \( c\theta = \cos \theta, s\theta = \sin \theta, c\alpha = \cos \alpha, s\alpha = \sin \alpha \).

3. Virtual simulation and kinematic analysis of robot

Since the overall technology of intelligent robot has been very mature, it is possible to directly use the drawings of intelligent robot parts to model one by one in the software, and assemble all the parts into four main assemblies, including body and arm, arm and arm connection, arm and arm connection, and manipulator.

During the assembly of the intelligent robot, the virtual prototype model is assembled on the basis of the body. First, the base assembly is inserted as a fixed part, and then other assembly is inserted in turn according to the design principle from top to bottom. The effect diagram of the body and arm 3d model in the old environment is shown in the following figure 1.

![Figure 1. Assembly plan of performance and arm one](image-url)
4. Robot structure analysis

The application of the provided menu, function and command methods, as well as the combination of these methods in the finite element analysis of robot arms mainly includes the following stages:

(1) Preprocessing stage

There are two ways to create a geometric model, top-down and bottom-up, or you can import it from another file. For the robot arm and the three-dimensional model of the arm should be modeled in the middle and then imported into the middle for analysis. The main structural dimensions include the total length, the distance between the center hole at the left and right ends, the width and the thickness. The structural model is shown in the figure 2.

![Figure 2. The model of arm one](image)

(2) Set unit properties

Unit properties include unit types, unit options, real constants, material properties, and cross sections.

(3) Meshing

The grid division has the intelligent grid division and divides through the grid division tool. The mesh generation tool is used for the mesh generation of arms. According to the regular structure characteristics of the main structure of the arm, the tetrahedral mesh is used to divide the elements. The main purpose of the analysis of the arm is to observe whether the deformation of the arm at the right end of the arm meets our requirements under the conditions of applying pressure and bending moment. Therefore, for the convenience of analysis, the right end of the arm can be set as a solid body below (Figure.3).

![Figure 3. The mesh element of arm one](image)

(4) Finite element analysis of robot arm

Under the same conditions, two different design structures of arms are analyzed and compared to find the most reasonable design. In terms of the arm, it is necessary to install the nut in the middle, and the matching requirements between the nut and the lead screw are relatively strict. Therefore, when
the arm bears the pressure and torque at the right end, it must first ensure that the part of the nut in the middle has a small deformation and stress, and then the deformation at the right end to ensure the positioning accuracy of the robot. Two different design structures of the arm are divided into grids. After adding constraints and loads, please refer to the following figure 4 and figure 5.

![Figure 4. The mesh element one of arm one](image)

![Figure 5. The mesh element two of arm one](image)

From the result of the analysis, we can see that the deformation into stepped distribution is the biggest in the arm of the right end deformation. Most of them are stones. It can be seen from the two results are the maximum deformation of basic similarity in planar joint type robot motion accuracy within allowable limits. The arms of the deformation stay close to each other in the intermediate position of the two arms. This is accord with the requirement of the beginning of the design. Both designs meet the requirements from the contrast of the deformation.

5. Conclusion

The articular robot designed in this paper has the characteristics of light structure, quick response and harmonic mechanical transmission. The transmission of wave reducer, synchronous belt and lead screw nut is stable, reliable, high precision, low noise and high transmission torque point. The whole structure can be applied to mass production due to its low cost. In addition, this paper establishes the correct kinematic model. The positive and inverse solutions of the kinematic equations are obtained.

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