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Optimization Design of Mechanism Motion System Control Based on Simmechanics

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Abstract
Mechanism model is established by SimMechanics, CAD model is directly introduced into Simmechanics for modeling, Feedforward controller is established with the inverse kinematics provided by SimMechanics, A motor model is built with SimPowersystem, ideal drive and the actual motor drive is compared, Thereby the optimal design of system control is obtained.
Keywords: SIM MECHANICS, INVERSE KINEMATICS; FEEDFORWARD CONTROL

1. Introduction

Mechanism kinematics mainly study on relative motion of component: the displacement, velocity and acceleration change over time. The traditional analysis methods for mechanism kinematics mainly include graphic method and analytic method. Due to

the way in the past, most of the complex mechanical movement will be able to make the analytical locus, but it is difficult to calculate for the use of engineering design. Only could we use the graphical method to obtain the data which is rough and approximate. In recent years, with the development of the computer, we can use the complex locus to solve various motions of mechanism precisely.

MATLAB is an engineering application software which was developed by the American Mathworks company integrating scientific computing, data visualization and program design. Now it has become the essential computer aided analyzing software in engineering disciplines, it consists of main bag, MATLAB Simulink component and different function toolbox. Simulink has many advantages such as convenient intuitive of system modeling, Powerful function of simulation and visual analysis, which has been widely used in academic and industrial fields.

In this article, the Matlab SimMechanics toolbox is used for optimization analysis on mechanism motion control system.

2. Modeling of a mechanism

SimMechanics is a new toolbox of MATLAB7. 0, its main function is beforehand modeling, simulating and analyzing for the dynamic system of mechanism, before the formation of the actual system, we can correct timely, in order to reduce the modification time for system, achieve the purpose of efficient development. It implements modeling and simulation of the mechanical components, hinge constraint, sensors, drives and other components of, provides a set of modules in the Simulink environment, various modules of mechanism can be mapped in the ordinary Simulink window. and through connecting the testing and driving module which provided by himself with ordinary Simulink module, we can gain the simulation results of the whole system.

First defined the rigid body quality, centroid and moment of inertia in SimMechanics module, then defined the hinge of mechanism. Also can we establish connection of MATLAB and other drawing software (such as Pro/Engineer, Solidworks, etc.), import the model of mechanism into the module directly. Particular way is to build a new XML format file of the model which was built in Solidworks. SimMechanics module provides a simport physmod statements which can transform the format file into their own models. Open the model in MATLAB was shown in figure 1.

The part of the figure with green basic color are the four hinges of mechanism, the four parts of the circle is the four rigid bodies, the quality, centroid and moment of inertia of every rigid body should be defined total. In order to simulate the mechanism, added a motor and two sensors on the hinge 1, the two sensors were used to measure the angle and torque respectively.

3. Reverse modeling of dynamics

For the purpose of the inverse dynamics modeling is to feedforward control system, so here use kinetics to inverse derive the torque, but it does not need to establish a new model again, Only change the model input in the first section, this is, to change the input torque into motion input in the previous section, then the model will prompted you to enter the movement Angle, angular velocity and angular acceleration, the model will help to calculate required torque value to complete such movement. So here only change the input and output of the previous model, we have ob-

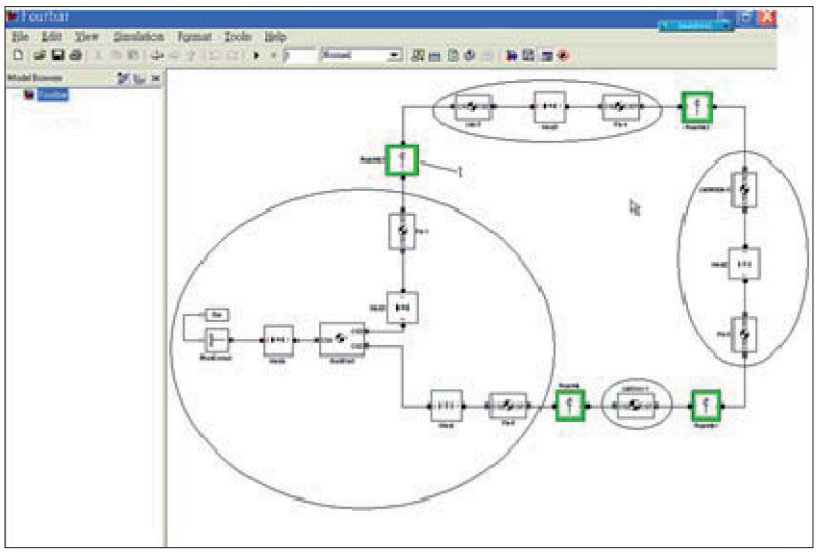


Figure 1. Model of four bar linkage established in SimMechanics

tained feedforward control model which was constructed by the inverse kinematics at once, as shown in figure 2.

In figure 2 we input three parameters of motion Angle, angular velocity and angular acceleration in the model, at first we only input Angle to look at the torque output while the angle changes, as shown in figure 3.

From the figure 3, it can be seen that at the beginning of the movement is coincided better, but later we found there's no way to achieve an coincided degree of motion relying on such a feedforward control, so we join recycling control on the basis of it in next section.

4. linearize the system and join recycling control

The model joined with recycling control was shown in figure 4. An Angle feedback circuit and a PID controller were joined in figure 4, the feedforward control and recycling control worked together on the mechanism. On the design of the controller, using the traditional method of trajectory, we can adjust the controller from watching the variation of system parameters, and can even use optimization methods to help adjusting the controller.

Now simulate iInput of the angle in the second section again, the results of simulation was shown in figure 5. we found that by using feedforward control and recycling control combination, the error of the movement in the second half was reduced while the system has only feedforward control, but from the result of simulation, the error has still a growing trend, does not be adjusted very well.

In order to reduce the error much more, using the function provided in simlink to linearize the system, through adjusting PID, the corresponding results can be obtained. fill these results into the original model, simulated again and the results was shown in figure 6. we found that the error reduced much, the value of the error is within 10-3 on the whole.

5. The driving model added a motor

The simulation process ahead is using the ideal driving conditions in SimMechnics, in order to make

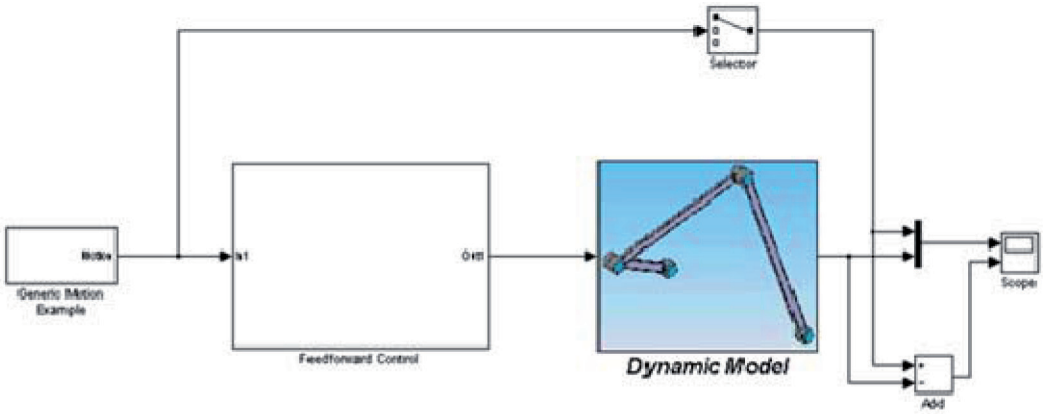


Figure 2. Simulation model of mechanism under the feedforward control

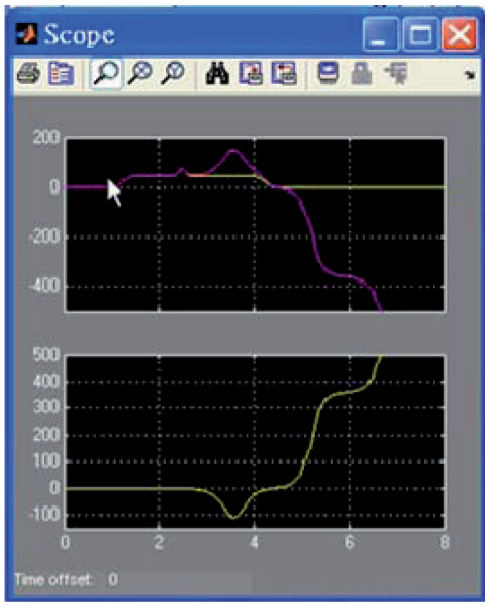


Figure 3. The situation of the output after inputting angle control

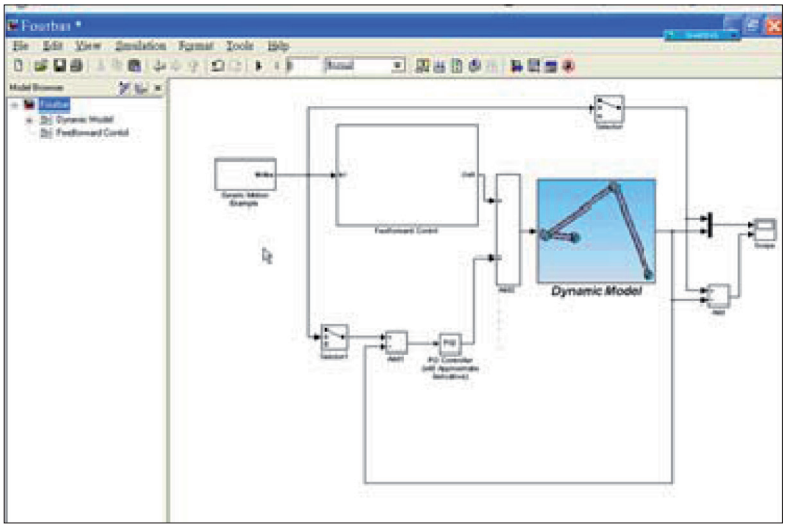


Figure 4. The model after joining recycling control

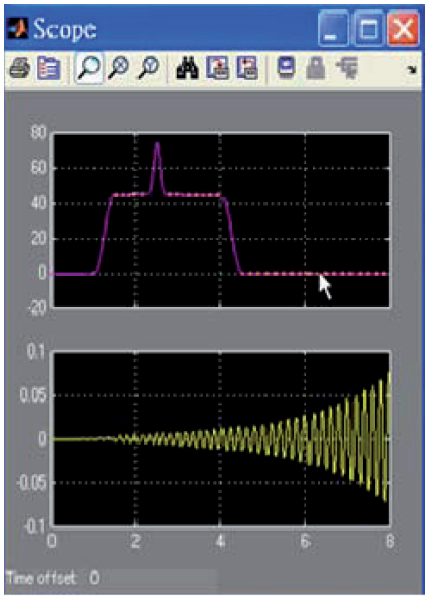


Figure 5. The situation of output after joining recycling control

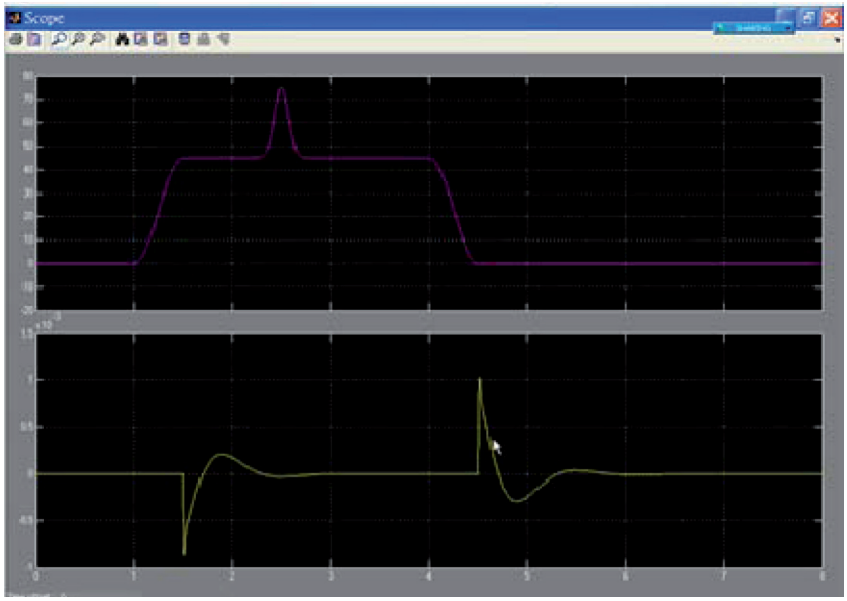


Figure 6. The situation of output after adjustment

the simulation effect better close to the actual system, replace the ideal drive with motor drive, simulated once more, the result is shown in figure 7. By adding PWM switching model, so we can see the torque was the yellow part in figure 8 (a), there is a high speed switch was shown in figure 8(b). It can be seen from the figure 7 that the errors relative to figure 6 has increased, the value is within the range of ±0.18 mm. Through the results we can make the right assessment, determine whether such an error in line is suitable for the actual situation needs.

6. Conclusion

Starting from modeling of mechanism by using SimMechanics, It can greatly simplify the modeling work that the CAD model is directly imported, with the help of inverse kinematics provided in SimMechanics can quickly build a feedforward controller, then a motor model is set up fast by the SimPowersystem. here we can compare the ideal drive with the actual motor drive, and make the right evaluation on the system, determine whether such an error in line is fit for the actual situation, Compared with other dynamic analysis simulation method realized by programming or completely using Simulink, SimMechanics makes mechanism system simulation problem can be easily solved which the original look very complicated, and

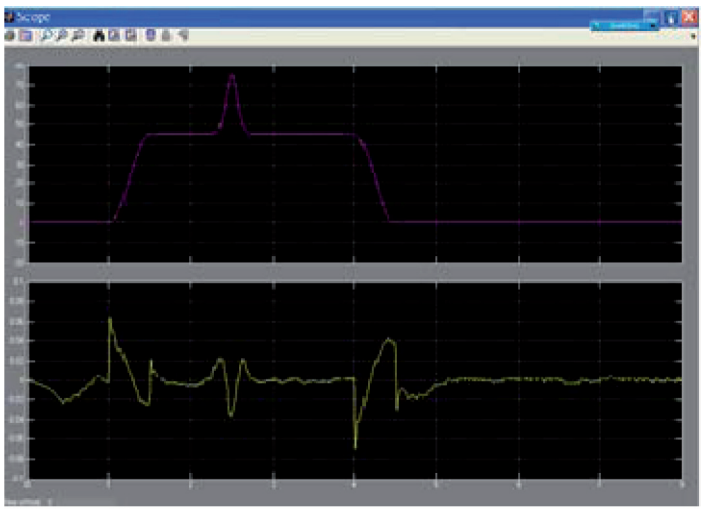
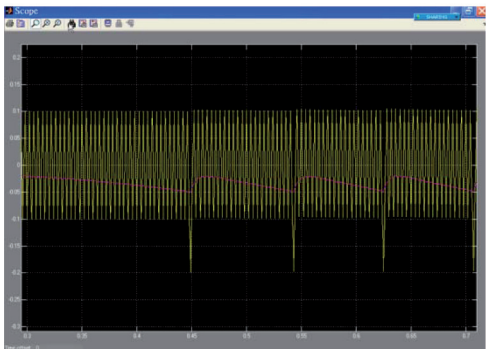


Figure 7. The output after added motor driving

(a)



(b)

Figure 8. The changes of torque after switching with the PWN

an animation of virtual reality can be beautiful demostrated. It has the advantages of convenient intuitive for system modeling, powerful function on simulation, automatic analysis on model, and so on. without needing programming, we can analyze the movement of the mechanical system very well, provide a powerful and convenient tool for mechanical system modeling and simulation.

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