DOI: 10.3969/j.issn.1003-501X.2017.05.009

Sliding model control of robot manipulator based on a novel switching function

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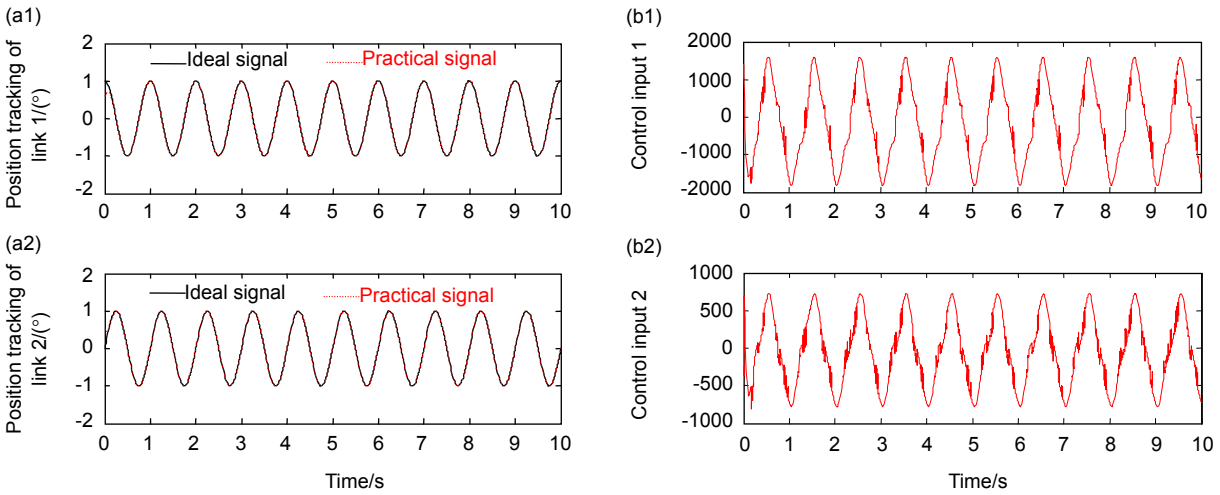

(a) Position tracking of link 1 and link 2. (b) Control input of link 1 and link 2.

Abstract: The high frequency chattering of the sliding model control system affects the control accuracy and increases energy consumption. It perhaps stimulates the uncertainty dynamics with the high frequency and causes the system instability. The control input discontinuity caused by the sign function is the main reason for the high frequency chattering in the sliding model control system. A novel switching function which replaces the sign function is presented in order to reduce high frequency chattering of the sliding model control. It is a special continuous power function in the neighborhood of the origin, which refrains from the high frequency chattering phenomena of the control input. When the absolute value of the error is smaller, the gain in the function is greater. When the absolute value of the error is greater, the gain in the function is smaller. Firstly, the dynamics mathematics model of multi-DOF serial robot manipulators with the parameters uncertainties and external disturbance is studied. Secondly, a multi-order sliding control law for robot manipulators with the novel switching function is constructed, and the asymptotic stability of the sliding model control system of robot manipulators is proved by using the Lyapunov function. Finally, the sine signal tracking simulation experiments of the sliding model control of 2-DOF robot manipulators with the novel switching function are conducted, which are compared with those of the sliding model control with the sign function. The desired angular position signal of link 1 and link 2 is q_{1d}=cos(2πt) and q_{2d}=sin(2πt) respectively. The maximum angular position tracking error of link 1 is 0.013° and that of link 2 is 0.0065° besides the original values. The maximum angular speed tracking error of link 1 is 0.46 °/s and that of link 2 is 0.45 °/s besides the original values. The experiment results illustrate that two links of robot manipulators obtain higher angular position tracking accuracy and speed tracking accuracy. Moreover, dynamic response of the control system is faster. The sliding model control system with the novel switching function reduces high frequency chattering effectively compared with the sliding model control system with the sign function. So the angular speed of two links has much less high frequency chattering. The novel switching function can reduce high frequency chattering phenomena of the sliding model control system which achieves better tracking performances. This switching function can be used on other sliding model control systems, for instance, the airborne electro-optical stabilized platform, numerical control machine and missile guidance, etc.

Keywords: switching function; sliding model control; robot manipulator; high frequency chattering; tracking accuracy

Citation: Zhou Tao, Wang Lei. Sliding model control of robot manipulator based on a novel switching function[J]. *Opto-Electronic Engineering*, 2017, **44**(5): 534-538.

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