

Adaptive Sliding Mode Control based on the Fuzzy Theory for Food Processing Robot

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Abstract—Due to the large consumption and dispersed processing of food, therefore, the study of food processing robots have been widely concerned. The food processing robot control system is susceptible to the extreme dynamic characteristics and the influence of external disturbance parameters. Combining fuzzy theory with sliding mode control, Adaptive sliding mode control is proposed based on the theory of fuzzy, in order to improve control accuracy and stability. The simulation results show that compared with the conventional sliding mode control method, the control is not only the external disturbance and parameter perturbation with stronger adaptability and robustness, but also has fast dynamic response and good tracking performance.

Key words—Food processing; fuzzy theory; adaptive sliding mode control; robustness

I. INTRODUCTION

The construction industry as a pillar industry of the national economy has an very important role in the coordinated operation of the national economy. The rapid development of construction industry to strengthen the urban and rural infrastructure construction, promote the urbanization process, build a harmonious society and improve the efficiency of production in the whole society is of great significance[1]. As the pillar industry of national economy, the status of the construction industry in the national economy become to strengthen little by little, construction promoting the economic development is increasingly significant, there is a mutual influence, mutual promotion and mutual restriction relationship between them.

In recent years, with the continuous improvement of people's living standards, food safety problem get more and more attention of people. The latest achievements of the studies on the food safety continue to spring up. Based on the cloud computing, Miaochao Chen et al. set up a food safety tracking system in 2013. For controlling the food from the production, processing, packaging, circulation links, good results have been achieved. However, the establishment of the platform needs government to vigorously investment and regulation. For developing countries, it is relatively difficult. The platform is developed based on the Android system. The android system belongs to open system. Once being attacked by hackers, therefore, it is easy to modify the platform data recorded by the food. It has certain security hidden danger. On the other hand, because the food has big consumption and processing disperse, it is difficult to monitor the food safety. On the premise of saving

manpower, food processing robot can avoid the pollution of food processing. Therefore, for food processing research of the robot get more and more attention.

When food processing robot running in the processing of unstructured environment, due to the fuselage elastic deformation, parameter variations and external disturbances, it makes the established motion model highly nonlinear, strong coupling and uncertainty. It affects the control quality of the controller(1-2). So in the control system under the condition of uncertainty and unknown disturbance, it guarantees the stability of control system to realize tracking control. The practical application of tracked robot is particularly important. There is less food processing robot motion control method in the existing literature. Food processing robot and wheeled mobile robot has many similarities in kinematics model. Direct reference of wheeled robot control is difficult to meet the requirements of tracked robot precise control.

Sliding mode control is a kind of control method. The fundamental difference between with conventional control is the control discontinuity, which makes the system a "structure" changing with the switch characteristics. In this paper, the food processing robot fuzzy sliding mode control is proposed. The fuzzy theory is combined with sliding mode control. The total control is built by the equivalent control and switch control. The equivalent control of approximation control is designed. It adjusts the control parameters of the adaptive law and adjusts the output control in real time. It aims to make the control object along the designed "sliding mode" trajectory.

II. THE DESIGN OF SLIDING MODE CONTROLLER

The sliding surface is defined as

$$s = c[R(k) - x(k)] = 0 \quad (1)$$

The C conforms the stability condition of sliding mode

$$C = [C_1 C_2 \dots C_n], C_n = 1$$

Assume



$$x(k) \rightarrow x(k+1) \rightarrow x(k+2) \rightarrow x(k+3) \quad (2)$$

According to exponential reaching law

$$\begin{aligned} ds(k) &= -\varepsilon T \operatorname{sgn}(s(k)) - qTs(k), \\ \varepsilon &> 0, q > 0, 1 - qT > 0 \end{aligned} \quad (3)$$

So the sliding mode controller based on exponential approach law is as follows.

$$u(k) = (CB)^{-1}[C(R(k+1) - R(k)) - C(A-1)x(k) - ds(k)] \quad (4)$$

The system structure of double adaptive fuzzy sliding mode control is shown in Fig .1.

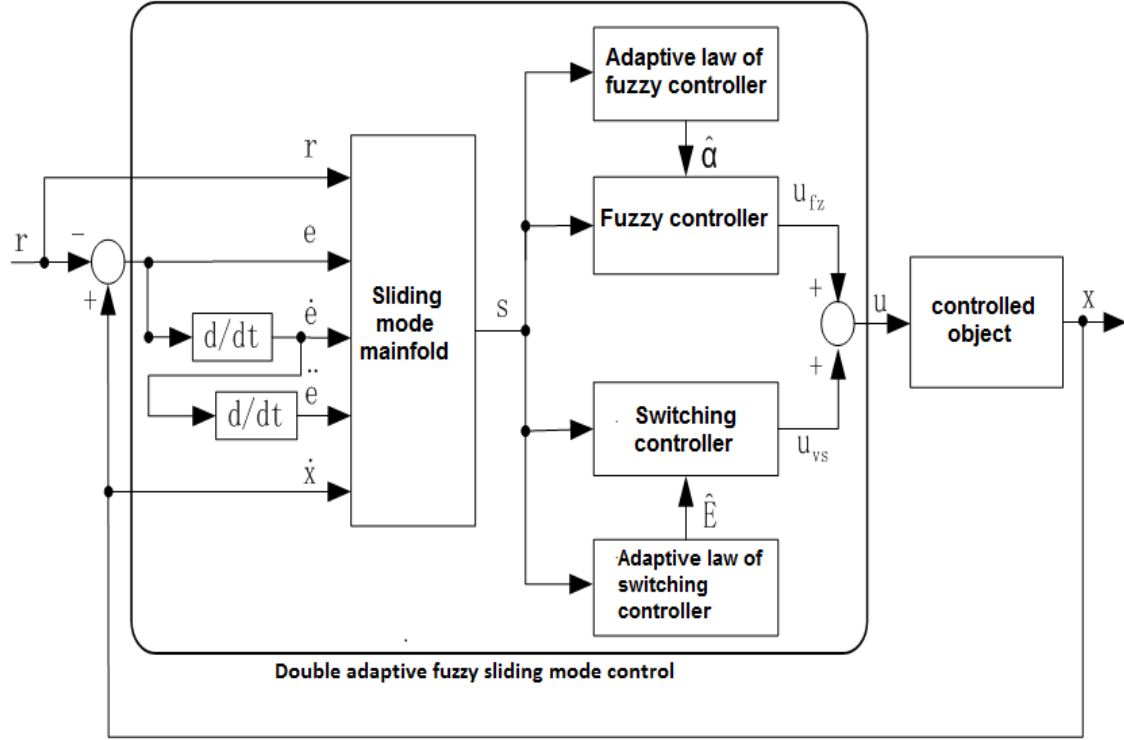


Figure 1. Double adaptive fuzzy sliding mode control system

III. STABILITY ANALYSIS

Define the Lyapunov function is:

$$V(k) = \frac{1}{2}[S(k)]^2 \quad (5)$$

So

$$\begin{aligned} V(k) &= \frac{1}{2}[S(k)]^2 \\ V(k+1) &= \frac{1}{2}[S(k+1)]^2 \\ V(k+1) - V(k) &= \frac{1}{2}[S(k+1)]^2 - \frac{1}{2}[S(k)]^2 \\ &= \frac{1}{2}\{[S(k+1) - S(k)][S(k+1) + S(k)]\} \end{aligned}$$

$$V(k) = \frac{1}{2}[S(k)]^2$$

$$V(k+1) = \frac{1}{2}[S(k+1)]^2$$

$$\begin{aligned} &\because [S(k+1) + S(k)]\text{sgn}(S(k)) \\ &= [-qTS(k) - \frac{|S(k)|}{2}T \tan \text{sig}(\|x\|)\text{sgn}(S(k))]\text{sgn}(S(k)) \\ &= -(q + 0.5 \tan \text{sig}(\|x\|))T|S(k)| < 0 \end{aligned} \quad (6)$$

$$\begin{aligned} &\because [S(k+1) - S(k)]\text{sgn}(S(k)) \\ &= (2 - qTS(k) - \frac{|S(k)|}{2}T \tan \text{sig}(\|x\|)\text{sgn}(S(k))]\text{sgn}(S(k)) \\ &= (2 - qT - 0.5T \tan \text{sig}(\|x\|))S(k) \\ &= (2 - qT - 0.5T)|S(k)| > 0 \end{aligned} \quad (7)$$

For the former case, the following equation can be obtained:

$$\begin{aligned}
& V(k+1) - V(k) \\
&= \frac{1}{2} \{ [(S(k+1)) - S(k)) \operatorname{sgn}(S(k))] \\
& [S(k+1) + S(k)) \operatorname{sgn}(S(k))] \} \\
&\therefore V(k+1) - V(k) < 0 \\
&\therefore V(k+1) < V(k)
\end{aligned}
\tag{8}$$

Therefore, the adaptive sliding mode control system is stable.

IV. NUMERICAL SIMULATION

In order to verify the validity of the algorithm, the food processing robot is studied by numerical simulation using MATLAB (omitted parameters), the simulation results shown in Fig .2 to Fig .7.

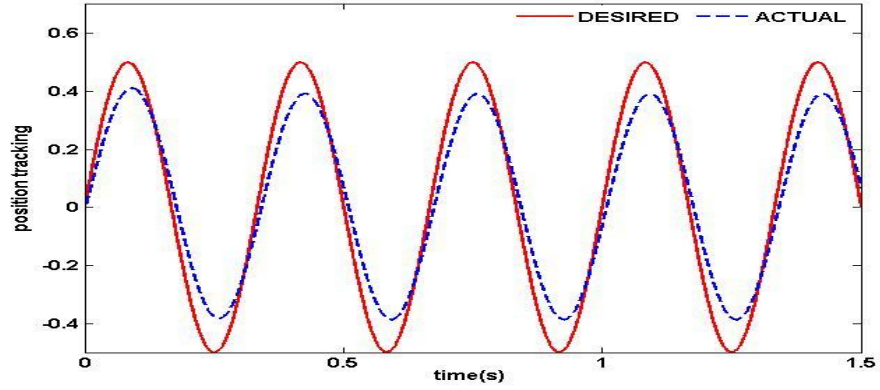


Figure 2. Traditional sliding mode position tracking

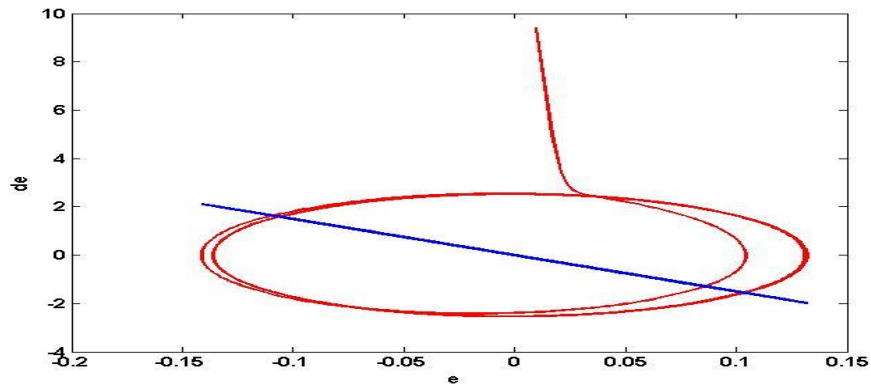


Figure 3. Traditional sliding mode trajectories

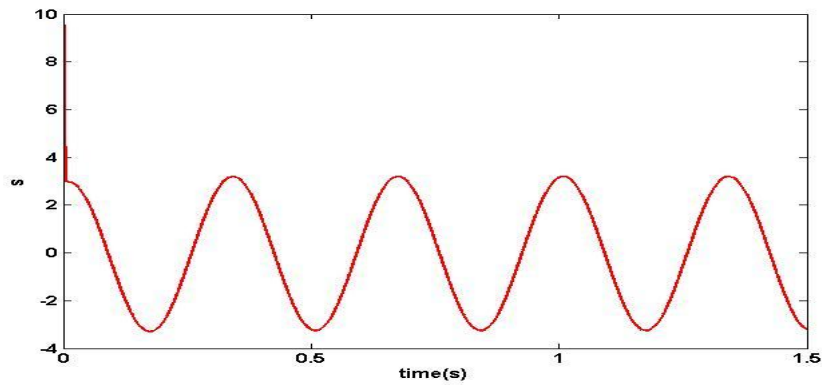


Figure 4. Traditional sliding sliding surface

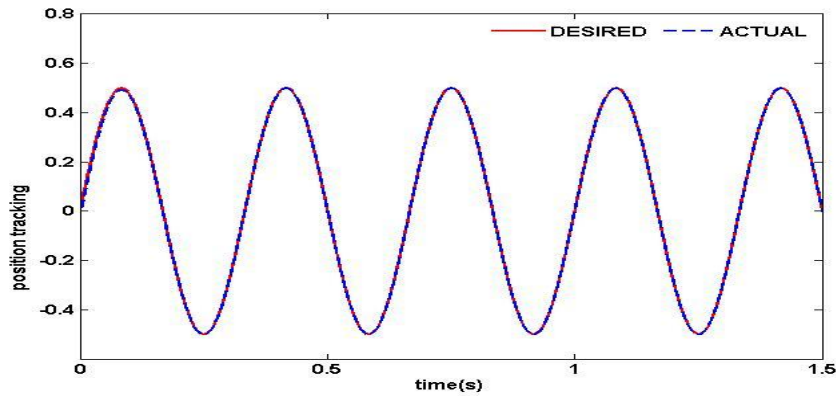


Figure 5. Adaptive Sliding Mode sliding position tracking

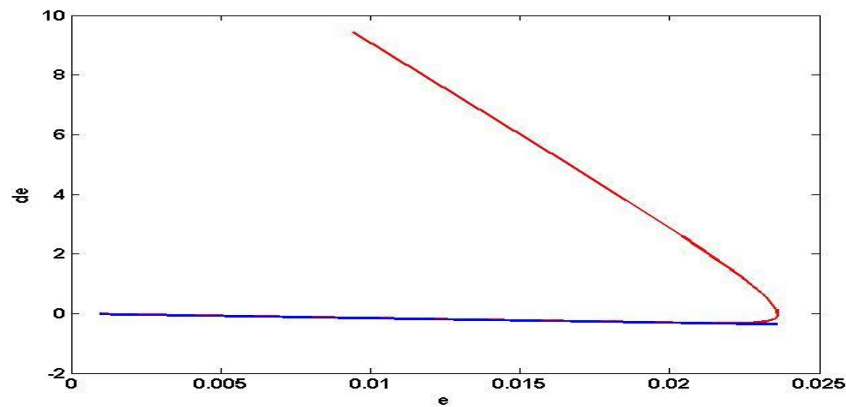


Figure 6. Adaptive Sliding Mode sliding phase trajectory

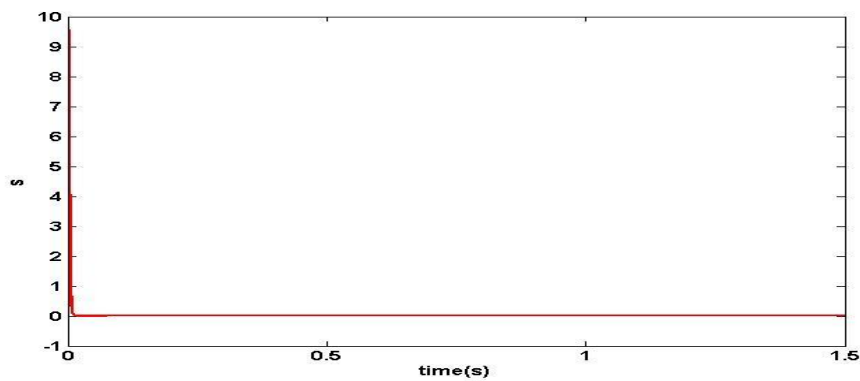


Figure 7. Adaptive Sliding Mode sliding surface

V. CONCLUSION

The above simulation results shows that the paper designed the food processing robot is adopted adaptive sliding mode control. It is not easily affected by the extreme dynamic parameters and external disturbance. The food processing robot has a good stability, quickness and resistance to disturbance. So it has high project application values.

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