CHAPTER 7

CONCLUSIONS AND SUGGESTIONS FOR FUTURE RESEARCH

7.1 Conclusions

In this dissertation, we presented a specific simplex set, uniformly distributed simplex set, which is possessed of unit magnitude and uniformly distributed in the control space. By employing the uniformly distributed simplex set, the problems, which exist in the conventional simplex sliding-mode control (SSMC), could be solved in an efficient way. First, two approaches were proposed to easily obtain an appropriate uniformly distributed simplex set even the number of control inputs is more than three. Then, a novel design method, uniformly distributed simplex sliding-mode control (UDSSMC), was developed for multi-input systems suffering from matched disturbances. Based on the uniformly distributed simplex set, the developed UDSSMC could theoretically eliminate the upper-bound matched disturbances. Unlike the conventional SSMC, the magnitude of the UDSSMC algorithm can be explicitly determined to ensure the system trajectory could be forced to reach the sliding mode.

With use of some properties of the uniformly distributed simplex set, a checking vector was proposed to easily determine the sub-region where the current system trajectory stays. For the developed UDSSMC, it still inevitably confronts with the

chattering problem, which happens not only in the sliding mode but also in the approach mode. This dissertation proposed a novel smoothing strategy with two different schemes, which one applied in the approach mode and the other applied in sliding mode. By means of the new smoothing strategy, the chattering caused by the UDSSMC can be completely eliminated.

Although the matched disturbances could be suppressed by the UDSSMC, it must require the prior information concerning their upper bounds. To deal with this drawback, this dissertation proposed a novel design method of the UDSSMC combined with grey prediction. First, the past value of the matched disturbance was measured by utilizing an efficient way derived from the derivative of the sliding vector. Then, the grey prediction was used to forecast the current value of the matched disturbance. With use of grey prediction, the UDSSMC could eliminate the matched disturbance without any prior information related to their upper bounds. From simulation results, it demonstrates the usefulness of the UDSSMC combined with grey prediction.

In order to stretch the application for the UDSSMC, the UDSSMC was applied to deal with the position tracking control for robotic manipulators. By employing the uniformly distributed simplex set, the control algorithm was designed via the Lyapunov function. The developed UDSSMC algorithm could efficiently suppress the external disturbance and system uncertainties, which exist in robotic manipulators. Finally, a

two-link robotic manipulator as an example was simulated as an example to demonstrate the success of the proposed UDSSMC algorithm.

7.2 **Future Research**

Some directions for future study are recommended as below:

(1) Although the developed UDSSMC could efficiently tackle the multi-input system suffering from matched disturbances, the case of the systems with the system uncertainty $\Delta \boldsymbol{B}$ isn't discussed in this dissertation. Actually, the determination of the UDSSMC algorithm is based on the position of the sliding vector $\boldsymbol{\sigma}$. However, for the systems with the system uncertainty $\Delta \boldsymbol{B}$, it cannot accurately determine the location of the sliding vector $\boldsymbol{\sigma}$. Therefore, how to design the suitable control algorithm to deal with the systems with the uncertainty $\Delta \boldsymbol{B}$ is one of the future researches.

(2) Since the developed UDSSMC is possessed of simplicity and usefulness, it is suitable to extend the UDSSMC to deal with multi-input nonlinear systems.

(3) The characteristic of the PWM converter with three phase is similar to the simplex set with the case of m=2. Intuitively, the UDSSMC is appropriate to deal with the control of the PWM converter. Hence, how to design the suitable UDSSMC algorithm to tackle the control of the PWM converter is one of the future researches.