Quasi-linear Systems with Spacecraft Control Applications

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ABSTRACT

This world really behaves in a nonlinear fashion. Nonlinear systems really govern the dynamical behaviors of most of the practical systems in the world.

Whenever possible, nonlinear system technique is preferred to realized control of a nonlinear system, since it usually guarantee the global stability of the closed-loop system, and hence allows the system to be operated within a wide working range. However, existing nonlinear control approaches are limited and each one is only applicable to a special type of nonlinear systems.

An alternative way in tackling control of nonlinear systems is through linearization. Linear system techniques are popular and have wide applications in various fields, because linear systems theories and techniques are relatively mature, simple and universal. Yet they only guarantee local stability, and are only applicable to those systems which have narrow operating ranges.

Is there an approach which combines the advantages of both the linear and nonlinear approaches? The answer is positive.

Quasi-linear systems are linear in form, but nonlinear in nature. Many nonlinear systems can be represented in quasi-linear forms. Quasi-linear system techniques can often give results which are superior to those given by both pure nonlinear system techniques and linear system techniques.

In this talk, a brief introduction to the direct parametric design approaches for quasi-linear systems is given. It is shown with several types of quasi-linear systems that the approaches have the following advantages:

- result in constant linear closed-loop systems with desired eigenstructuure although the open-loop systems are highly nonlinear;
- provide complete degrees of freedom which can be further utilized to achieve additional system properties.

These advantages are demonstrated with certain spacecraft control applications, including space rendezvous control and spacecraft attitude control.

Guang-Ren Duan received his BSc degree in Applied Mathematics, and both his MSc and PhD degrees in Control Systems Theory. From 1989 to 1991, he was a post-doctoral researcher at Harbin Institute of Technology, where he became full professor of control systems theory in 1991. He visited the University of Hull, the University of Sheffield, and also the Queen's University of Belfast, UK, from December 1996 to October 2002. He was selected by the Cheung Kong Scholars Program of the Chinese government in August 2000, and elected in 2005 leader of a Cheung Kong Scholar Innovative Team sponsored by the Chinese Ministry of Education, and elected in 2009 leader of an Innovative Research Group sponsored by NSFC. He is the founder and currently the Director of the Center for Control Theory and Guidance Technology at Harbin Institute of Technology, and also Member of the Science and Technology committee of the Chinese Ministry of Education, Vice President of the Control Theory and Applications Committee, Chinese Association of Automation, and Associate Editors of a few international journals.

Prof. Duan is the winner of the 4th Chinese National Youth Award of Science and Technology, the winner of two Chinese National Awards of Natural Sciences, and also winner of the Over-century Talents Program of the Chinese Ministry of Education, and that of the Distinguished Young Scholars Program of NSFC (Natural Science Foundation of China). His main research interests include parametric robust control systems design, LMI-based control systems, descriptor systems, spacecraft control and magnetic bearing systems. He is the author and co-author of 5 books and over 270 SCI indexed publications, with more than 50 appeared in IEEE Transactions.