数学与系统科学研究院学术报告

报告题目： Nonlinear Output Tracking Control by Trajectory Linearization
Part 1: Theory and Case Study

报 告 人：Dr. J. Jim Zhu, Avionics Engineering Center, School of Electrical Engineering and Computer Science, Ohio University

时间地点：2008 年 1 月 3 日上午 10:00—11:00，思源楼 712

摘要： In this talk we present a nonlinear output tracking control technique called trajectory linearization control (TLC). The TLC method is based on Lyapunov's notion of stability of a nominal trajectory, where a nominal control is applied in an open-loop fashion to put the system output in the vicinity of the commanded nominal trajectory, and a closed-loop tracking error regulator is designed to stabilize the time-varying tracking error dynamics by linearization along the nominal trajectory. The method is applicable to nonminimum phase nonlinear plants, and has distinct advantages over many other nonlinear control methods. As an example, complete design of a TLC tracking controller and trajectory linearization observer (TLO) will be presented for an unstable, nonminimum phase, stiff nonlinear plant with fast tracking trajectories. The nominal control is computed by nonlinear pseudo-inverse using nonlinear coordinate transformation and back-stepping stabilization, and trajectory stabilization is achieved using linear time-varying (LTV) PD-eigenstructure assignment. Robustness of the TLC-TLO system to regular and singular perturbations will also be discussed. Simulation case studies show that significant improvement in tracking performance, robustness and disturbance rejection over the classical (prior to 1995) and modern (since 1995) gain scheduled controllers can be achieved using rational combinations of nonlinear and LTV control techniques. The TLC method has been applied to the ascent and entry flight controller design for Reusable Launch Vehicle, hypersonic vehicle longitudinal flight control, 6DOF flight control of a Vertical Take-Off and Landing (VTOL) aircraft, a mobile robot with omni-directional wheels, and active control of vortex flow over a delta-wing. These applications will be discussed in an accompanying talk.

报告人简介及联系方式:

Dr. Jianchao Zhu's main research area and contribution is in time-varying linear systems theory and nonlinear control system design, with a focus on advanced flight control systems and autonomous flight management systems for aerospace vehicles funded over the past 12 years by AFOSR, AFRL and NASA MSFC. In particular, he developed during his Ph. D. research a Differential Algebraic Spectral Theory (DAST) that generalizes the important concept of eigenvalues and eigenvectors for Linear Time-Invariant (LTI) system to Linear Time-Varying (LTV) systems. Based on the DAST, he

advanced the Trajectory Linearization Control (TLC) and Trajectory Linearization Observer (TLO) techniques, which have successfully been applied to Reusable Launch Vehicle (RLV) and Unmanned Aerial Vehicle (UAV) flight control, aerodynamic flow control and mobile robot control applications.

To date he has published more than 100 papers in refereed journals and conference proceedings. In the past 16 years, he has been a PI or Co-PI on research funded over $6M by NSF, AFOSR, NASA, and ARMY SSDC. Since he joined OU in 2000, he led a 4-university team as the PI of a $4.4M research contract from NASA/MSFC in 2001 on Autocommander–an autonomous supervisory flight control system with integrated guidance and control for the Second-Generation Reusable Launch Vehicle (2GRLV) under the Space Launch Initiative (SLI) Program (with an additional $5M pending Cycle II contract that did not proceed due to SLI Program cancellation by NASA). As the 2GRLV Program transitioned into the Orbital Space Plane (OSP) Program in 2003, Dr. Zhu was subcontracted by Lockheed Martin to perform flight control system design for their OSP vehicle until that program was canceled by NASA. In 2004, he was awarded an $800K subcontract from Boeing's $32M contract with NASA on autonomous flight control for Boeing's planetary landing vehicle for NASA's Human and Robotics Technology (H&RT) Program (Boeing's contract was soon cancelled along with all 80 H&RT contracts by NASA Headquarters). Dr. Zhu was a Co-PI of another multi-university research on active flow control supported by a $400K grant from the Dayton Area Graduate Studies Institute and the Air Force Research Laboratory (DAGSI/AFRL) from 2002-2004, and was awarded a National Research Council/Air Force Office of Scientific Research Summer Faculty Fellowship for 2002 on active flow control research. He is currently funded by DAGSI/AFRL $150K for 3 years to investigate flight control systems for a conceptual hypersonic sramjet aircraft, and a $150K from AFRL on a conceptual study of Robotic Aerial Transformer.

Dr. Zhu received the NSF Research Initiation Award in 1991. He was an AFOSR Summer Faculty Associate in 1995, a NASA Summer Research Fellow in 1999, and a National Research Council Summer Research Fellow in 2002. Dr. Zhu is a Senior Member of IEEE and a Senior Member of AIAA. He was a Technical Associate Editor of the Control Systems Magazine from 1996-1997, an Associate Editor of the IEEE Control System Society (CSS) Conference Editorial Board (CEB) from 1994-1997. He was the 34th CDC Program Committee Vice-Chairman for Short Papers, and the General Chair for the 28th IEEE Southeastern Symposium on System Theory (SSST). He was the Chairman/Editor of the IEEE CSS CEB and a member of the IEEE CSS Conference Activities Board from 1998-2001, and an Elected Member of the IEEE CSS Board of Governors from 2001-2003.

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