

In this inaugural issue of the Student Corner Column, we interview Haijing Wang, a student first author of the paper titled “A Composite Control Framework of Safety Satisfaction and Uncertainties Compensation for Constrained Time-Varying Nonlinear MIMO Systems” published in the December 2023 issue of the IEEE Transactions on Systems, Man, and Cybernetics: Systems.

1. Please tell us a bit about your background and your research area.

*State constraints are prevalent in real-world systems but systematic design of feedback controllers that account for constraints remains challenging. Control barrier functions (CBFs) are an effective tool for establishing the safety of nonlinear systems. The CBFs provide a system-level certificate to guarantee a given set forward invariant relying on accurate models. However, there always exist unknown dynamics and sensor noises in practical systems. The model errors can degrade the performances of the CBF-based controllers such that the safety is no longer guaranteed. Therefore, there is strong motivation to study the CBF-based methods for constrained systems with uncertainties and unmeasured states.*

2. How did you become interested in your field?

*My field of study is control science and control engineering, and I selected this major as soon as I become an undergraduate student. The more that I learned about control engineering, the more excited I become about my chosen field. Especially, I had an opportunity of pursuing a doctorate in Robot sensing and control Engineering Research Center. Robotics relies heavily on electrical engineering and control theory. Finally, I became interested in safety control as it is very important in robotic research.*

3. What motivated you to join the IEEE SMC Society?

*The IEEE SMC Society can bring people together from all walks of life, which can give me the chance to meet people from outside my lab. The one common thread is a desire to connect with quality people. It can give me an inside track into what's happening in my research fields. And I think I can access people and information from experts who help me improving my research.*

4. What motivated you to publish in the IEEE Transactions on Systems, Man, and Cybernetics: Systems?

*The IEEE Transactions on Systems, Man, and Cybernetics: Systems is a top journal in the field of computer science. The scope includes the fields of systems engineering. And it includes a variety of systems engineering methods such as optimization, modeling and simulation. This paper proposes a unified control framework for time-varying nonlinear multiple-input-multiple-output (MIMO) systems with unknown dynamics and safe constraints. And simulations as well as experiments are conducted to verify the effectiveness of the proposed safety control schemes. Therefore, the paper is within the scope of the journal and can contribute the journal in nonlinear system control methods.*

5. What is the main innovation in your paper?

*An observer-based CBF/HoCBF framework, which combines ESO with the CBF/HoCBF, is constructed for the safety control of constrained MIMO time-varying nonlinear systems with unmeasured states and system uncertainties. In this framework, the unmeasured states and the compound system uncertainties can be estimated and compensated simultaneously by ESO, and the arbitrarily high relative-degree constraints can also be addressed to achieve the safety by the CBF/HoCBF-based methods. Especially, in this paper, 1) the safe set can be guaranteed forward invariant for uncertain nonlinear time-varying systems without accurate full-states information. 2) The constructed tightened safe set can be derived from the bounded estimated errors, and the set can be arbitrarily closed to the original safe set with fewer design parameters. 3) The proposed ESO-CBF/HoCBF-based controllers are not sensitive to the compound system uncertainties due to the model-free ESO, which can improve the robustness and reduce the conservatism of the CBF-based safety control methods.*

6. Where would you see yourself in 5-years' time career wise?

*In 5 years from now, I see myself progressing in the field I've been working in during the past five years. I find this field extremely interesting and I can see many challenges lying ahead which I am eager to approach. Therefore, most probably, I will become a scientific research worker.*



Haijing Wang received the B.S. degree in automation from Zhengzhou University, Zhengzhou, China, in 2010, and the M.S. degree in control science and engineering from Shandong University, Jinan, China, in 2014. She is currently pursuing the Ph.D. degree in control science and engineering with Zhengzhou University. Her current research interests include Lyapunov methods, constrained nonlinear systems, and safety control on robotics.