SMC eNewsletter's Student Corner Column (March 2025 Issue)

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In this issue of the Student Corner Column, we interview Abdelhakim Amer, co-author of the paper "Adaptive Robust Control Integrated with Gaussian Processes for Quadrotors: Enhanced Accuracy, Fault Tolerance and Anti-Disturbance" published in IEEE Transactions on Systems, Man, and Cybernetics: Systems, DOI: 10.1109/TSMC.2025.3539707, 2025.

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

My name is Abdelhakim Amer, an Industrial PhD student at Aarhus University and EIVA A/S. My research focuses on learning-based optimal control with applications in autonomous underwater vehicles and drones. I investigate how machine learning and optimization techniques can enhance control, planning, and dynamics modelling in uncertain environments. I hold a Master's in High-Tech Mechatronics Systems from TU Delft and a Bachelor's in Mechanical Engineering. Additionally, I have been a visiting scholar at DFKI and the University of Paderborn, where I worked on underwater robotics.

2. How did you become interested in your field?

My interest in robotics and control systems was sparked during my undergraduate studies in Mechanical Engineering, where I specialized in mechatronics and numerical methods. A course on micro aerial vehicle navigation at TU Delft sparked my interest in autonomous systems. This led me to join the AIR Lab at Aarhus University, where I worked on a project on autonomous wind turbine inspection using aerial vehicles. These experiences deepened my interest in learning-based control and real-world robotic applications, which now drive my PhD research in AI-driven control for autonomous vehicles.

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

The IEEE SMC Society offers a unique platform for interdisciplinary research at the intersection of systems science, cybernetics, and machine learning. Given my focus on learning-based optimal control and autonomous systems, the society aligns perfectly with my research interests. It fosters collaboration between academia and industry, enabling researchers to address real-world challenges. Additionally, its high-impact conferences and journals, including IEEE Transactions on Systems, Man, and Cybernetics, provide excellent opportunities to share innovative research and engage with the broader robotics and control community.

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

IEEE Transactions on Systems, Man, and Cybernetics: Systems is a prestigious journal dedicated to fundamental and applied research in intelligent and autonomous systems. Given our work integrating Gaussian Processes (GPs) with adaptive robust control for quadrotors, it was an ideal venue to reach researchers focused on control, machine learning, and robotics. The journal's rigorous review process and extensive readership ensured that our contributions would be widely recognized, making it a fitting platform to impact the field of intelligent control and autonomous systems.

5. What is the main innovation in your paper titled "Adaptive Robust Control Integrated with Gaussian Processes for Quadrotors: Enhanced Accuracy, Fault Tolerance and Anti-Disturbance" and its importance to IEEE Transactions on Systems, Man, and Cybernetics: Systems?

The main innovation in our work is the integration GPs with Adaptive Robust Control (ARC) to address uncertainties in quadrotors. We propose a hierarchical approach that combines parameter adaptation for parametric uncertainties and GP for nonparametric uncertainties, enabling real-time compensation for unknown nonlinear disturbances. Additionally, we introduce a detailed actuator model for targeted fault estimation and compensation, improving fault tolerance without the need for fault diagnosis. Furthermore, a GP-based robust feedback mechanism enhances uncertainty mitigation, delivering superior performance compared to classical robust control methods. This approach also demonstrates better disturbance rejection and trajectory tracking, even in the presence of actuator faults and propeller failures, offering a novel solution to critical challenges in autonomous systems.

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

In five years, I see myself working at the intersection of academia and industry, focusing on bridging the gap between theory and practice in robotics. As I am nearing the completion of my PhD, my goal is to apply advanced control and data-driven techniques to tackle real-world industrial challenges. I aim to bring robotics into industrial applications, leveraging cutting-edge research to create practical, impactful solutions. By contributing to the scientific community through continued publications, mentoring students, and participating in international collaborations, I will focus on driving innovation in autonomous systems while ensuring that research findings are translated into practical solutions for industry.

Biography:

Abdelhakim Amer (Graduate Student Member, IEEE) received the B.Sc. degree (with Distinction) in mechanical engineering from the American University in Cairo, New Cairo, Egypt, in 2018, and the M.Sc. degree in mechanical engineering from TU Delft, Delft, The Netherlands, in 2021, respectively. He is currently pursuing the Ph.D. degree in robotics and AI with with the Artificial Intelligence in Robotics Lab, Aarhus University, Aarhus, Denmark, in collaboration with EIVA A/S. His research interests include learning-based optimal control and machine learning, with applications to robotics and autonomous systems.