CPS Week 2013 Tutorial

Experimenting For Everyone With a Hexacopter: Getting Practical Data for your Research

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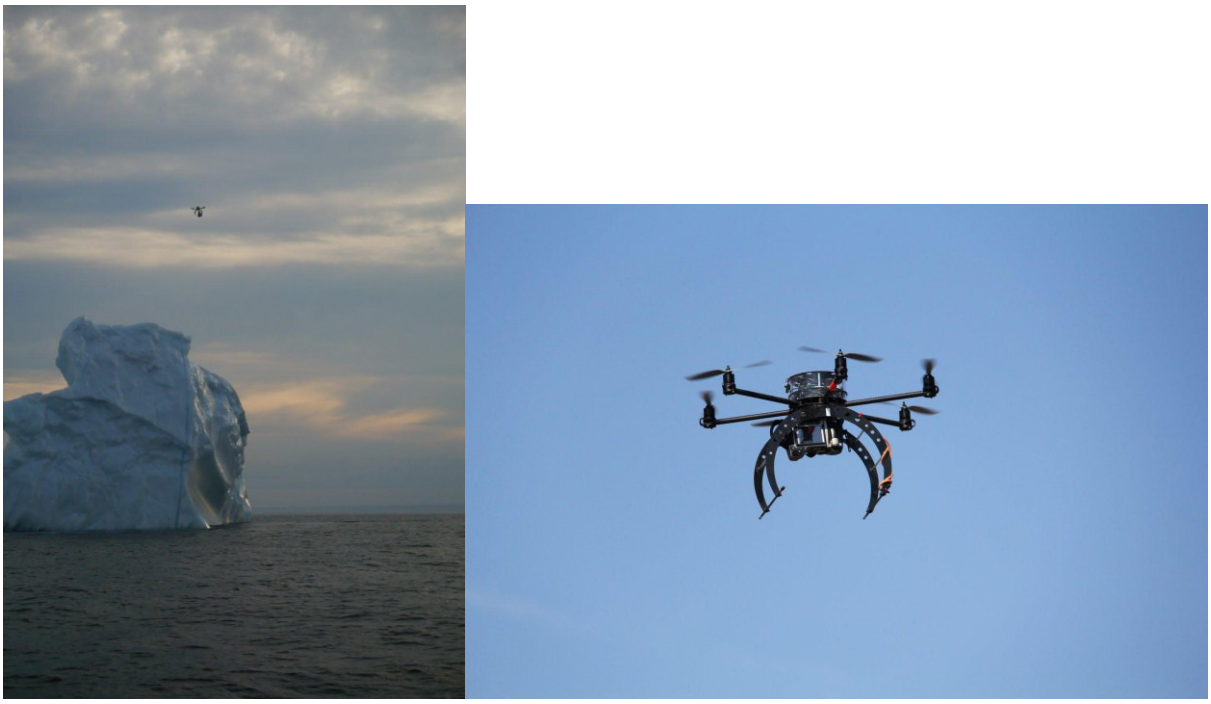
Abstract:

Empirical research in embedded systems is lagging behind the accomplishments in theory and methodology. One reason for this is that it is difficult to create a convincing case study with the diverse expertise required, the tools needed, and the time demanded. The other reason is the difficulty to maintain such a case study across the ever changing environment of students graduating and new students arriving.

To address this problem, and help our community move forward, we will present our approach to remote experimentation. The system provides access to a well-maintained, high-fidelity hardware-in-the-loop simulation of a flight-validated hexacopter with an autopilot. The whole system has already received the Special Flight Operations Certificate (SFOC) and was used during several missions such as sensor deployment on icebergs, terrain mapping, and structural integrity checks.



The system is easily accessible to remote users, and in active use for research and teaching. Users will be able to connect through a remote connection and gain access to the system. Several scenarios are available which mimic different flight conditions and flight paths. The platform supports research from the operating system up to arbitrary application software and thus enables case studies on software/system design, modeling, programming, validation, and verification, as well as robotic operations, mission planning, and simultaneous localization and mapping.

Proposed outline:

1 Welcome
2 Motivation: The need for a research platform
3 What is an experiment
4 The research platform overview
5 The hexacopter, software components, and its dynamics
6 The programming interface
7 Example case study
8 Closing and discussion

Organizers:

Peiyi Chen received his MASc. degree in Mechanical Engineering and BASc. degree in Computer Engineering from the University of Waterloo. He has over three years of experience in developing unmanned aerial vehicles (UAV), and has worked extensively with many notable

UAV platforms including the Aeryon Scout, MikroKopter, and ARDrone. His research interests include system modeling, estimation and control algorithms, motion planning, sensor integration, and embedded system development. He is currently a member of the Waterloo Autonomous Vehicles (WAVE) Lab and the Real-time Embedded Systems Lab (RESL) at the University of Waterloo.

Sebastian Fischmeister is an Assistant Professor in the Department of Electrical and Computer Engineering at the University of Waterloo, Canada. He received his MASc in Computer Science at the Vienna University of Technology, Austria, and his Ph.D. degree at the University of Salzburg, Austria. He worked as a research associate at the University of Pennsylvania, USA, until 2008, and is currently the head of the Embedded Software Group (ESG) at the University of Waterloo. His preferred application areas are distributed embedded real-time systems in the automotive systems and medical devices domains.

Thomas Reidemeister received his BASc in 2006 and his Dipl.-Ing.-Inf. degree in 2007 from the Otto-von-Guericke University in Magdeburg, Germany in Computer Systems in Engineering (Ingenieurinformatik). In 2012, he obtained his PhD degree from the University of Waterloo in Electrical and Computer Engineering. Thomas has done research in automating electro-magnetic interference (EMI) measurements at the Fraunhofer Institute for Factory Automation (IFF) and the University of Magdeburg. He has worked in IBM on fault diagnosis in enterprise software systems and cloud computing infrastructure services. Thomas worked as a consultant for embedded system design and development at the Engenuity corporation in Canada. Currently, Thomas is a research associate in the Real-time Embedded Systems Lab (RESL) at the University of Waterloo. His interests include applied research in performance benchmarking, safety-critical systems, and hardware in-the-loop testing.

Yassir Rizwan recieved his BASc and MASc degree in Mechatronics Engineering (with Honours) from the University of Waterloo in 2009. Yassir's research during his Masters included high performance UAVs and onboard real-time systems. He was also the President of the Waterloo Aerial Robotics Group, a student design team that focuses on the development of UAVs for local and international competitions. He has extensive experience working with autonomous aircraft (both fixed wing and rotary) including systems integration, sensor design and nonlinear control systems. He is currently a member of the Waterloo Autonomous Vehicles (WAVE) Lab and the Real-time Embedded Systems Lab (RESL) at the University of Waterloo.

Steven Waslander, Assistant Professor, Department of Mechanical and Mechatronics Engineering, University of Waterloo. Dr. Waslander is an expert in the automation and control of aerial vehicles. He was one of the two creators of the Stanford Testbed of Autonomous Rotorcraft for Multi-Agent Control, the first outdoor capable quadrotor testbed developed from 2002-2008. He works closely with Aeryon Labs on the estimation and control of quadrotors for industry, and has numerous projects in aerial and ground vehicle perception, localization, mapping, planning and control. His estimation and control methods have been incorporated into the hexacopter autopilot, and work is ongoing to incorporate vision based online mapping for operation in GPS denied environments.

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