

Intelligent systems

This year brought a boom in autonomy, particularly for micro air vehicles (MAVs) and other UAVs. The University of Illinois at Urbana-Champaign's Aerospace Robotics and Control Lab developed a bird-like MAV that can make a precise perched landing on a small target or human hand. This MAV lacks a vertical tail for lateral-directional control and stability, using wing morphing for flight control and steering. The flapping wings are inherently articulated, eliminating the need for traditional control actuators. Autonomous control algorithms were developed to bring the MAV close to the hand, after which a traditional pitch-up achieves the deceleration and perched landing. The use of wing articulation is significant in developing bird-like flapping-wing MAVs capable of effective, agile flight even while gliding (<http://www.youtube.com/watch?v=2QqTcQ1BxIs>).

The University of Cincinnati finesses the collaborative assignment of tasks to multiple UAVs by using intelligent systems to solve problems under realistic conditions, including limited communication, minimum turn radius, visibility constraints, and scenario uncertainty. A market-based solution exhibited versatility to various cost functions and adaptability to scenario changes, while being near-optimal, computationally efficient, and scalable. Another scalable, fast, and near-optimal solution, based on a 'cluster-first, route-second' heuristic, tackles the UAV routing problem with limited communication ranges. This work advances the state of the art in terms of optimality, computational cost, and scalability (<http://most-aero.uc.edu/>).

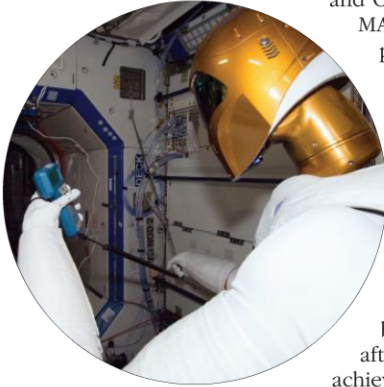
The Michigan Autonomous Aerial Vehicles (MAAV) team earned first place in the International Aerial Robotics Competition. The contest required teams to build an autonomous aerial vehicle that could enter and navigate an unknown building, follow Arabic signs to a particular room, find and retrieve a flash drive, deploy a decoy, and egress in under 10 minutes without being spotted by cameras or laser trip wires. MAAV deployed a custom quad-rotor equipped with two laser range scanners for

navigation and obstacle avoidance. The vehicle autonomously entered the course, explored and mapped the entire interior, exited safely, and landed outside (<http://maav.engin.umich.edu>).

NASA Johnson's Robonaut 2 (R2) is a humanoid robot that can be teleoperated using partial self-contained autonomy or operate fully autonomously using techniques learned in advance via machine learning. On March 14, astronaut Dan Burbank handed R2 an airflow meter and a measurement wand while ground personnel controlled the robot as it steadily manipulated the wand to collect data. R2 uses tools without needing special interfaces to perform tasks such as reading data meters, acting as a sort of avatar for ground personnel. This experiment is the first step in the robot's relieving the crew and, eventually, giving them more time for science and exploration.

The autonomous systems (AS) project, led by NASA Ames, is developing software for system operation automation. AS technology will help astronauts make more decisions without the assistance of people on the ground, providing software for automatic diagnosis of failures in a spacecraft or other system, and software to automate the execution of sequences of actions at the discretion of human operators. In June, AS software increased coordination capability while decreasing workload under varying operational scenarios, time delays, and levels of crew autonomy during the autonomous mission operations experiment in the Deep Space Habitat at Johnson (http://www.nasa.gov/centers/ames/cct/technology/stp/gamechanging/autonomous_systems.html).

As increasingly capable autonomous systems pervade our lives, advances that enable more rigorous verification are vital. IKOS is a new generation of static analysis tools from the NASA Ames Intelligent Systems Division, Carnegie Mellon University, and SGT. IKOS achieved approximately 2% false positives on a suite of flight control systems written in C and C++. This represents a significant advance in the state of the art, in terms of both precision and analysis time (from hours or days for the most precise commercial analyzers to seconds or minutes for IKOS). Though it is particularly efficient on embedded code, IKOS also demonstrates broader applicability than previous analyzers for general C programs. ▲



R2 can carry out many chores on the station, freeing up astronauts' time.

by **Kristin Yvonne Rozier**