Issue 52 June 2015

From Technical to Ethical...From Concept Generation to Experimentation

Contents

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Robo-Ethics: Exploring Ethics of Unmanned Combat Systems

by Kenneth Stewart, NPS, kastewar@nps.edu

Students and faculty from the Naval Postgraduate School (NPS) and the U.S. Naval Academy (USNA) recently came together with teams of junior officers from U.S. Navy Third Fleet to discuss the ethics of unmanned systems for the 2015 iteration of the Robo-Ethics Continuing Education Series. This year's event was led via video teleconference by NPS Associate Professor Ray Buettner, April 14.

"We are interested in exploring the ethical boundaries of robotic systems … preparing tools to figure out what the future will be like," said Buettner.

But as student and faculty researchers wade into the at-times turbulent waters of unmanned systems, they are also exploring the many ethical considerations that autonomous combat systems present. "Should a machine be able to decide to kill, and if so, what does 'decide' mean?" Buettner asked assembled students and others joining via video teleconference from USNA and elsewhere. "The key concept to consider may be, 'where is the human relative to the selection of the target and the decision to engage,'" said Buettner. "Do we want discrimination authority granted to the human loop?"

Another area of concern being debated is the question of punishment and accountability. Researchers, ethicists and policy makers are asking questions like, 'Who do we hold accountable when a lethal autonomous system engages the wrong target?'

While it may seem counterintuitive to debate whether or not a human should be "in the decision loop," Buettner points to serious debates among ethicists as to whether or not humans or machines are more likely to make errors that cost human life.

Coincidentally, while Buettner and his group debated the ethics of unmanned systems, the United Nation's Convention on Certain Conventional Weapons (CCW) was meeting in Geneva to debate a proposed ban and moratorium on Lethal Autonomous Weapons Systems (LAWS).

Buettner believes that there is currently no need for a prohibition against lethal autonomous systems, noting that current law already adequately provides necessary safeguards in this area. He is referring in part to Directive 3000.09, which the DOD published in 2012 to provide guidance on the development of autonomous systems. The directive places a series of regulatory safeguards on autonomous systems development while simultaneously encouraging innovative thinking and development in the autonomous systems arena.

"So far, no country has declared an intent to deploy a totally autonomous lethal system that decides who to kill and when," Buettner noted. "Almost all fully autonomous systems are defensive."

Buettner also noted NPS Professor Wayne Hughes' views on the rapidly changing nature of autonomous systems. "The fundamental error in a debate over robotic development is to think that we have choice," quoted Buettner. "This world is coming, rapidly coming.

"We can say whatever we want, but our opponents are going to take advantage of these attributes," he continued. "That world is likely to be sprung upon us if we don't prepare ourselves."

NPS Assistant Professor Timothy Chung has long recognized the utility of research in this area. He is a pioneer in the area of unmanned aerial vehicle (UAV) swarms. "How do we take evolutionary changes in UAVs and use them to achieve revolutionary effects?" asked Chung.

In addition to exploring the ethics of unmanned combat systems, Buettner and Chung showcased ongoing CRUSER initiatives, many of which were born of student research. Current projects include the use of QR Codes in network-deprived environments and the feasibility of wireless underwater computer networks.

Director's Corner

Lyla Englehorn, CRUSER Director of Concept Generation

We are pleased to carry forward the Robo-Ethics Continuing Education Series (RECES). This conversation, started in the Pentagon conference room in January 2012 and continued annually, was moved forward in April 2015 by junior officers at NPS, THIRDFLEET, and USNA. We expect to distribute thoughtful analysis of their outcomes by midsummer. Finally, I am pleased to announce our next Warfare Innovation Workshop will work to advance the CNO's concept of electromagnetic maneuver warfare and leverage unmanned systems to enhance cross domain operations. Small teams of NPS officers, early career engineers from Navy labs and academic and industry partners, and fleet junior officers will propose technologies and employment concepts in scenario based discussions. Teams will brief their outcomes to sponsors, industry executives, and senior officers the final morning. These results will be disseminated to fleet commands, and will also start the fifth CRUSER Innovation Thread. *We are now accepting nominations of junior officers and early career engineers for the 2015 workshop:* ***Creating Asymmetric Warfighting Advantages, 21-24 September 2015.***

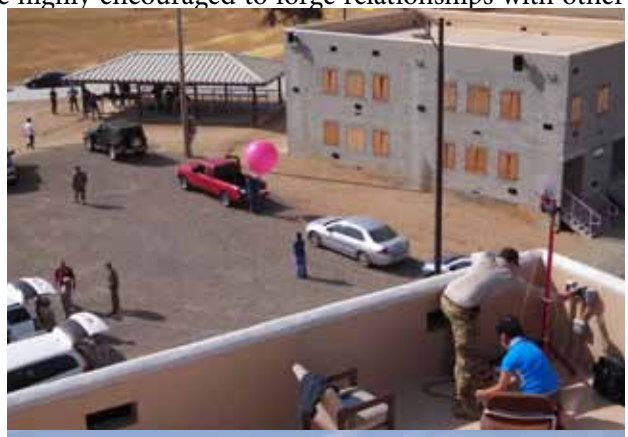
Joint Interagency Field Experimentation (JIFX)

by Tristan Allen, tmallen@nps.edu

Hosted by the Naval Postgraduate School on a quarterly basis, the Joint Interagency Field Experimentation (JIFX) event provides a unique venue opportunity for emerging technology experimentation in a field environment. In order to create a multi-institutional, semi-structured learning environment, JIFX hosts organizations from the federal government, academia, private industry, state/local governments, and non-profits where emphasis is on raw experimentation and end user feedback. JIFX is not designed as an acquisition activity, trade show, or demonstration venue.

Experiments of interest are identified on the event's Request for Information (RFI) document. The RFI outlines the types of experimentation that are important to the event's government stakeholders. If accepted to attend a JIFX event, experimenters can expect to receive feedback from these government stakeholders as well as end user feedback from uniformed units who have expertise in the area of research. Additionally, experimenters are highly encouraged to forge relationships with other participating experiments and seek to develop experiments ad hoc. These concepts are captured in JIFX's 5 fundamental tenants:

1. Austere by Design: We provide the basics: space to work, an airstrip, bathrooms, and basic communications infrastructure. It's up to you to bring everything else you need.
2. Collaboration is Expected: Collaboration often results in unexpected and positive results. You are required to collaborate within your ability. (Proprietary, CLASSIFIED, ITARS, EARS, etc. information provide the only exceptions.)
3. Bounded, Not Controlled: We create a safe, secure, and legal sandbox in which products grow and new ideas flourish.
4. Inclusive by Default: Everyone is welcome to the event; good ideas come from everywhere.
5. Develop. Now.: We are immediate. We do not put off development until next week. We expect development activity at the event, in real time.



The next JIFX event is 10-14 August 2015 and experiment Proposals are due no later than 2 July 2015.

Additional events are scheduled for 2-6 November 2015, February 2016, and May 2016. For more information on the upcoming events and for information on how to participate, please visit the JIFX website: **www.nps.edu/fx**.

Short articles (up to 500 words) for CRUSER News are always welcome submit to: cruser@nps.edu

Next CRUSER Monthly Meeting

Mon 13 Jul, 1200-1250 (PDT) details at http://CRUSER.nps.edu

ARSENL Team Breaks Record for Number of Autonomous Aircraft in Large-Scale Live-Fly Field Experiments

by Mike Clement, NPS Advanced Robotic Systems Engineering Laboratory, mrclemen@nps.edu

The NPS Advanced Robotic Systems Engineering Laboratory (ARSENL) team broke the known record for simultaneously flying autonomous aircraft during a recent field test at Camp Roberts, California. The team successfully flew 20 autonomous planes, nearly doubling its own record of 12 aircraft set in February and doubling previously known records for fixed-wing aircraft set by a team at EPFL in Switzerland in 2010[1]. This test further represents an important milestone on the way to the team's ultimate goal of having two teams of 50 aircraft compete in an aerial capture-the-flag style competition called Aerial Combat Swarms, as envisioned by Dr. Timothy Chung, the principal investigator for the project[2].

On the afternoon of May 15th, the team launched 20 lightweight autonomous aircraft using a bungee-driven catapult launcher. The aircraft used are flying wings made of Styrofoam and outfitted with hobby-grade components. Each plane is also equipped with an autopilot that can perform waypoint-based navigation and a secondary computer that communicates with other aircraft as well as ground systems, and coordinates cooperative flight.

In this experiment, once launched, each plane autonomously flew to an assigned position in one of two vertical "stacks," with a small altitude offset from its neighbors. The planes were then split into two "sub-swarms" and each was commanded to begin a follow-the-leader behavior. Two aircraft designated themselves as leaders based on relative altitude, one per sub-swarm, and began flying along a pre-programmed course. All remaining aircraft immediately started following their respective leaders based on shared awareness of each other's positions. The followers used no a priori knowledge of the leaders' intended courses. Finally, each aircraft was commanded to land autonomously.

The ARSENL team performing the test comprised Dr. Timothy Chung, Mr. Michael Day, Mrs. Marianna Jones, Mr. Mike Clement, and LT Ryan Beall. ARSENL team members not present that day were Dr. Kevin Jones and Dr. Duane Davis. Also joining the team during the week of testing were ONR reservists CDR Robert Been and CDR Randall Bice, and Mr. Joseph Utschig (NPS) and Dr. John Reeder (SPAWAR Pacific).

From a research and development perspective, these aircraft provide a viable solution for exploring autonomous fixed-wing aerial vehicles at large scales. Using primarily commercial off-the-shelf hardware and open-source software, each vehicle costs approximately $1,000 in parts. Most of the custom parts, such as mounting brackets and landing skids, are 3D printed, further reducing manufacturing costs and allowing for iterative improvements to the aircraft design.

Even more interestingly for the DoD, this test represents a distinct shift in personnel requirements for operating uninhabited aerial systems (UAS). Most currently fielded UAS require one, if not several, humans to maintain and operate each aircraft. By contrast, this 20 aircraft test was conducted by eight personnel in total, spanning a mission commander who oversaw the experiment, only two operators for aircraft and swarm actions who commanded the swarm in the air, four flight technicians who conducted preparations, takeoff, and recovery operations, and a safety pilot for potential manual intervention during takeoff or landing.

Getting to 20 planes in the air, especially with a small team, posed a number of significant challenges. For instance, the entire concept of "controlling" a plane had to be rethought. It is not tenable to have a committed safety pilot with a Remote Control (RC) transmitter in hand for each plane, nor is it feasible to have a committed Ground Control Station (GCS) operator per plane. During this test, two human operators oversaw all 20 planes in the air. One person was the "UAV Operator," monitoring all aircraft health and status. Should any plane have had a critically low battery or a sensor failure, the UAV Operator could detect the problem and either remediate or land that plane. The second person was the "Swarm Operator;" this person actually commanded the entire swarm, or individual sub-swarms. The Swarm Operator could assign individual planes to a sub-swarm and command sub-swarms with "tasks," such as leader-following behavior or traversing a path in the air. Both of these roles required rethinking traditional single-aircraft ground control software, and designing tools that helped to visualize many planes' position and status and quickly alert operators if something was wrong.

Over the coming months, the team plans to continue to increase the number of planes aloft from 20 to 50 and beyond.

[1] Hauert, S., Leven, S., Zufferey, J.C., and Floreano, D. (2010, October 10) The Swarming Micro Air Vehicle Network (SMAVNET) Project . Retrieved from http://lis.epfl.ch/smavs

[2] Chung, T.H., Jones, K.D., Day, M.A., Jones, M., and Clement, M. 50 VS. 50 by 2015: Swarm Vs. Swarm UAV Live-Fly Competition at the Naval Postgraduate School. AUVSI North America, Washington, D.C., August 12-15, 2013

STUDENT CORNER

Student: LT Andrew Thompson, USN

Title: Evaluating the Combined UUV Efforts in a Large-Scale Mine Warfare Environment

Curriculum: Operations Research

Link to Completed Thesis: https://calhoun.nps.edu/handle/10945/45263

Abstract:
The current surface mine countermeasures (MCM) fleet is aging, yet there are no viable systems to replace it. The U.S. Navy requires an improved minehunting platform, and unmanned underwater vehicles (UUVs) can meet that need. In order to attain enough UUVs and operators to make these missions successful, the United States must rely on the participation of allies to provide these assets. This study assesses the key decision factors in mine clearance operations using UUVs of differing capabilities. It uses a discrete-event simulation to model the performance of UUVs in a large-scale MCM operation. Data is generated using a state-of-the- art design of experiments and analyzed to find the best tasking plan for the scenario. The results show that with proper tasking, UUVs with lesser ability levels can be used appropriately and still produce acceptable levels of mine clearance, usually more quickly than a smaller cadre of highly capable vehicles. This study finds UUV altitude, track spacing, number of passes, and search speed to be decision factors that influence minehunting results, while track spacing, number of passes, search speed, and resupply are influential factors that effect mission completion times.

NASA Cohosts Forum on Managing Expanding Unmanned Aerial System Traffic

POC: Dr Parimal Kopardekar, NASA Ames Research Center, Parimal.H.Kopardekar@nasa.gov

NASA and the Silicon Valley chapter of the Association of Unmanned Vehicle Systems International (AUVSI) are partnering to cosponsor the 2015 Unmanned Aerial Systems (UAS) Traffic Management Convention: A New Era in Aviation, July 28-30, at NASA's Ames Research Center in Moffett Field, California.

Convention speakers include NASA and Federal Aviation Administration executives, as well as industry thought leaders, innovators and stakeholders. Exhibits and flight demonstrations will feature the latest developments in unmanned aerial systems technology and how it will impact the future of low-altitude flight.

"As technology continues to revolutionize aeronautics, we are seeing an increased need to highlight the growing potential that lies in the use of unmanned aerial systems at low altitudes," said Jaiwon Shin, associate administrator of NASA's Aeronautics Research Mission Directorate in Washington. "Today, we see the need to establish a safe low altitude unmanned aerial traffic management system. Bringing together a broad spectrum of people interested in UAS technology will help us develop a well-coordinated plan that will guide us in the future."

Participants will include representatives from the UAS community, agriculture, film and other industries, conventional aviation, government and academia. Attendees will discuss the latest developments in unmanned aerial systems technology, solutions for privacy concerns and issues, safety and security, and the future impact of low-altitude flight on the emerging business sector. Sessions and demonstrations will examine the crossover between research, development and air traffic management, and highlight the latest issues, advancements and opportunities in the aviation industry.

"This convention affords a wonderful opportunity for UAS companies to meet and partner with users and government agencies," said Jesse Kallman, president of the Silicon Valley Chapter of AUVSI and director of Business Development and Regulatory Affairs at Airware. "As all areas of low-altitude use of unmanned aerial vehicles are explored, the convention will create new opportunities for collaboration among next generation aerial systems companies."

To register as an attendee or as media, or to request exhibit space: http://www.svc-auvsi.org/attendee-information/

For information about NASA's aeronautics programs, visit: http://aeronautics.nasa.gov

Librarian's Corner

Buchanan, Allen and Robert O. Keohane. "Toward a Drone Accountability Regime." Ethics & International Affairs 29, no. 1 (2015): 15-37.
http://wws.princeton.edu/system/files/research/documents/Toward%20a%20Drone%20Accountability%20Regime.pdf

Public Continues to Back U.S. Drone Attack [Pew Survey]
http://www.people-press.org/2015/05/28/public-continues-to-back-u-s-drone-attacks/