Issue 14 APR 2012

CRUSER · NEWS

Consortium for Robotics and Unmanned Systems Education and Research

FROM TECHNICAL TO ETHICAL...FROM CONCEPT GENERATION TO EXPERIMENTATION

Contents

Robots in the Roses is fast approaching! Mark your calendars now, and reserve the afternoon of Thursday 10 May to wander through the NPS Rose Garden. This research fair offers the CRUSER community of interest (COI) an opportunity to share research and educational opportunities in the areas of unmanned and robotic systems. Exhibitors from academia, industry, and the greater DoD will be on hand to share their work. This is an opportunity for NPS students to explore potential thesis research topics; and to inspire younger students to approach the study of science, technology, engineering and math (STEM) with zeal!

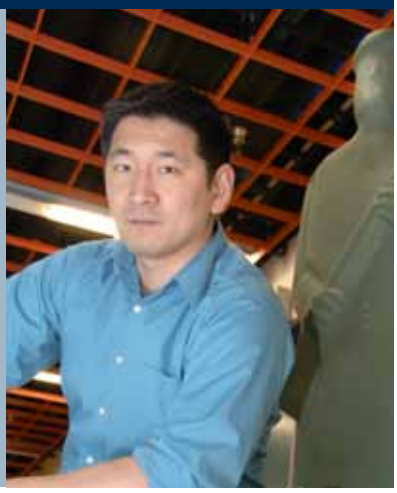
This year's Robots in the Roses Research Fair is scheduled to complete a series of concurrent UxS related events in Monterey. The inaugural CRUSER Technology Continuum integrated within the TENTH International Mine Warfare Technical Symposium will take place from 7-10 May at the Embassy Suites, just down the road from the NPS campus. NPS community members may attend these related events free of charge. Session topics for the CRUSER Technology Continuum include:

- Project MISSION: Maritime In Situ Sensing Inter-Operable Network
- Implementation of an Underwater Wireless Sensor Network in San Francisco Bay
- Mine Burial Expert System for Changing MIW Doctrine
- Channel Modeling and Time Delay Estimation for Clock Synchronization Among Seaweb Nodes
- Underwater Acoustic Sensor Network Demonstrator System
- Tailorable Remote Unmanned Combat Craft (TRUCC)
- Defeating Swarm UAV Threats with Aerial Battle Bots
- Autonomous System Support for Maritime Visit, Board, Search and Seizure Operations
- Emerging Applications of 4K Ultra-high Resolution Full Motion Video for Unmanned systems and Remote Sensing
- From "Unmanned" to True Autonomy

These events will both conclude by noon on Thursday, so exhibitors and visitors will have plenty of time to catch the shuttle bus over to the NPS Rose Garden!

See you at Robots in the Roses! cruser@nps.edu or cruser.nps.edu for more information

Director's Corner



The thriving and expanding robotics community is a testament to the impact of vibrant information sharing and open conversations, whether between government, academia, and industry partners, or across researchers and practitioners from diverse disciplines, or between education mentors and budding roboticists. Next month, CRUSER will host its 2nd Annual Robots in the Roses Research Fair, which is a signature venue for encouraging just such an exchange. Celebrating robotics research and education in its many colors and flavors, we welcome fellow robotics enthusiasts to this opportunity to spark new interactions or rekindle old ones, both at Robots in the Roses and beyond!

Dr Timothy H Chung
CRUSER Director Education and Research

The morality of lethal autonomous machines

by Capt. Emmanuel Goffi, French Air Force

Debates over the morality of the use of lethal autonomous machines in wars are growing amongst scholars. The main concern is to know whether it would be moral to design, build, and deploy machines with the capacity to decide autonomously to kill human beings. The perplexing issue here is the definition of autonomy.

Autonomy is often tackled through its technical meaning. According to Pfeifer and Scheier, "[a]utonomy means independence of control." Thus autonomy corresponds to the level of automation of the machine, up to full autonomy when "[t]he human is not involved in the decision-making process".[1] Robots remain dependent, however, on the computer software programs and the rules that guide them.

Ronald C. Arkin, a computer scientist at Georgia Tech, argues that machines can be more ethical than humans since, devoid of feelings, they can act rationally, according to these preprogrammed rules which alone govern their behavior.

Such robots would remain wholly dependent on the software programs with which they are equipped, which means they would remain under external control at some degree. Furthermore, if one deliberately designs robots that are devoid of emotions or feelings, one would deprive them of any opportunity of acting with genuine moral autonomy.. This is because genuine moral or ethical behavior is not simply the application of relevant guiding rules, it is also (as psychologist like Piaget and Kohlberg argue) learning about "what is good and what is bad," and acting intentionally (including acting on intentions that are oriented towards achieving what is good, while resisting or avoiding acting on intentions that are malevolent).

Philosophers, including critics of the drive toward lethal autonomy (like Peter Asaro) claim that Kantian moral autonomy can be reached by warbots. But even so, it is unlikely that these "warbots" would be able to "think" on an abstract basis, or genuinely exercise true Kantian autonomy of the will (defined by the German philosopher, Immanuel Kant, as "the property of the will through which it is a law to itself").

Eventually it would be useful to work on the proper definition of autonomy, and specifically, to make a distinction between technical and moral autonomy. While it is feasible for robots to achieve various degrees of technical autonomy, there is no corresponding reason to demand that robots demonstrate moral autonomy. The latter is a conceptual misnomer when applied to machines, which are devoid of the intentionality and self-awareness that is the hallmark of moral judgments. It is obvious, by contrast that they will continue to increase their degree of technical autonomy – i.e., their ability to act independently of immediate or ongoing human control or oversight. These two, entirely different meanings of autonomy should not be allowed to confuse the debate about our attempts to design lethally-armed autonomous platforms for military purposes.

Emmanuel Goffi is a Ph.D. candidate (ABD) at the Institute of Political Studies (Science-Po) in Paris., and lectures on ethics and international relations in École de l'Air (Air Force Academy) of France.

[1] *Mary L. Cummings, Bruni, S., Mercier S. & Mitchell, P. J., "Automation Architecture for Single Operator, Multiple UAV Command and Control", The International C2 Journal, 1:2, 2007, pp. 1-24.*

Robotic Systems Joint Project Office (RS JPO) Unmanned Ground Vehicles Interoperability Profiles

The Robotic Systems Joint Project Office (RS JPO), who develops, fields and sustains Unmanned Ground Vehicles (UGVs) for the Army and USMC, recently published the first ever UGV Interoperability Profiles (IOP). IOP Version 0 establishes interoperable and modular hardware and software interfaces between UGV platforms, payloads (sensors, manipulators & emitters), radios, and controllers. This IOP defines the interfaces to be used on all future RS JPO managed systems. The RS JPO is currently leading a voluntary Working Integrated Product Team (WIPT) of government & industry representatives who are developing IOP Version 1, which will expand upon Version 0 and be published later this year. Full Press release at https://wiki.nps.edu/display/CRUSER/CRUSER+News+Articles

The published IOP Version 0 files are available at: http://www.rsjpo.army.mil/images/IOPv0.zip

Autonomy and "Machine Morality": A response to Captain Emmanuel Goffi

by George Lucas*

Captain Goffi, of the French Air Force Academy, helpfully focuses on a serious confusion that is currently obstructing robotics research and development: the general public's understandings (or rather, misunderstandings) of "autonomy" and "morality." His reflections on this matter, invoking philosophers like Immanuel Kant, and psychologists like Piaget, reflect the careful conceptual framework in which our French military allies have contextualized their own considerable achievements in military robotics (as evident in an impressive international robotics symposium and demonstration of integrated human-machine battlefield tactics conducted at the French Military Academy in Saint-Cyr just this past November).

On the one hand, eminent robotics experts like Ronald C. Arkin (Georgia Tech) have claimed that lethally-armed autonomous robots will eventually perform in the battlefield with as much or even more "humaneness," "ethics," and a higher degree of compliance with the international law of armed conflict (LOAC) than their human counterparts (Arkin, et al.: Proceedings of the IEEE 100, no. 3: 571-589; March, 2012). Arkin outlined his design for an "ethical governor" for unmanned platforms during his recent, CRUSER-sponsored lecture at NPS in early August, 2011.

At the opposite extreme, the Irish computer scientist, Noel Sharkey (University of Sheffield, U.K.) has criticized the U.S. in particular for its relentless and (in his view) wholly unreflective drive toward greater machine autonomy on precisely the opposite grounds. Ever more complex software designs for attaining increasingly sophisticated machine autonomy, Sharkey warns, will have unstable, unpredictable, and likely disastrous consequences for their human operators. Sharkey has co-founded an international consortium, the "International Committee for Robot Arms Control" (ICRAC) in order to seek international regulation of unmanned systems.

Proponents of increased machine autonomy may be complicating the issues unnecessarily, however, by invoking spurious concepts like machine "morality" and "ethical" governors, and erroneously describing autonomous combat weapon systems as making "moral decisions and judgments" that will be "more ethical" and even "more humane" than their human counterparts. Critics for their part needlessly worry about "killer robots" run amok, the (theological?) inappropriateness of machines "making decisions to kill humans," or the lack of meaningful accountability for resulting "war crimes" that might consequently be committed. They appear to envision cyborgs (like "the Terminator"), or the infamous intelligent computer, "HAL" (from Arthur C. Clarke's science fiction novel, 2001: A Space Odyssey) in command on the bridge of a nuclear submarine, or "R2D2" and "C3PO," fully weaponized and roaming the mountains of southern Afghanistan, but unable to distinguish (without human supervision) between an enemy insurgent and a local shepherd.

Goffi gently reminds us that both extremes are, frankly, preposterous. The "autonomy" requisite for moral decision-making is something quite distinct from "technical autonomy," which merely involves unmanned systems performing in complex environments without the need for continuous human oversight. In the latter sense, a Cruise missile and my iRobot "Roomba" vacuum cleaner are both "autonomous," in that they perform their assigned missions, including encountering and responding to obstacles, problems, and unforeseen circumstances with minimal human oversight. But the missile does not unilaterally change its mission en route, or re-program its targeting objectives (let alone does it raise "moral objections" about the appropriateness of targets), any more than my Roomba "decides" whether or not it is necessary or appropriate to shoot an intruder! We neither need nor desire our autonomous machines to make those kinds of moral judgments. It is sufficient that they function as "finite state" autonomous platforms, circumscribing their decision-making and problem-solving to highly scripted mission environments.

Ever greater degrees of technical autonomy within such scripted environments are desirable in order to increase the efficiency and "force multiplier" effects of using unmanned systems in our overall force mix. But they cannot (nor do we wish to attempt to enable them to) "behave ethically." We intend, instead, for them to be safe and reliable in their functioning and to perform their assigned missions effectively, including strictly following mission parameters that comply with the laws of armed conflict (just as human combatants do). Invoking "ethics," in lieu of strict compliance with the law (a far simpler domain of behavior to engineer), simply confuses the objectives of robotics research.

Policy guidance on future unmanned systems in the final draft stages from the Office of the U.S. Secretary of Defense, for example, will likely follow Captain Goffi's distinctions regarding autonomy. The chief distinction made is between "fully autonomous" unmanned systems and systems that exhibit various degrees of "semi-autonomy." DoD policy will specify lethal kinetic force may be integrated only, at most, with semi-autonomous platforms, involving set mission scripts and with executive oversight by human operators. Fully autonomous systems will be armed at most with non-lethal weapons and employ principally evasive action as protection. Fully autonomous systems will not be designed or approved to undertake independent target identification and mission execution.

Discussing the future of "moral machines" (the title of a recent book by Yale University philosopher, Wendell Wallach) is provocative, and has a certain cachet, to be sure. But what we seek is something much more modest, and far more feasible: machines that reliably carry out the missions that human operators assign to them, following programmed instructions that comply with the restrictions of LOAC, while performing those missions without the need for constant human oversight. Captain Goffi's thoughtful commentary reminds us of these distinctions, and enables us to get clear about what is desirable and achievable within the scope of current defense research and development.

*George Lucas is Professor of Ethics and Public Policy at NPS, and holds the Distinguished Chair in Ethics at the U.S. Naval Academy. A member of the CRUSER consortium, he is also co-founder and co-director of the "Consortium for Emerging Technologies, Military Operations, and National Security" (CEMONS), headquartered at Arizona State University.

STUDENT CORNER

Student: Michael A. Hurban, Lieutenant, United States Navy

Title: ADAPTIVE THROTTLE CONTROL FOR THE SEAFOX UNMANNED SURFACE VESSEL

Abstract: The operational objective of the research was to develop and implement in hardware a controller that enables a high speed autonomous surface vessel (USV) to follow a given speed command regardless of the variation in sea state or the load modifications due to variable mission requirements. This adaptive ability of the ship to adjust itself to a new and probably rapidly changing operational environment allows novel tactical missions of single and multiple USVs to be performed without human supervision.

To achieve the objective, the research utilized modern adaptive control techniques to design a speed following controller for the highly nonlinear dynamics of SeaFox USV. This vehicle operates in displacement mode at low speeds and planing mode at high speeds, but exhibits a rapid, speed-dependent transition between the modes. First, experimental data was gathered to characterize these three distinct regimes and the inherent nonlinear phenomena. Then, system identification was conducted to develop a mathematical model that represented the USV's speed dynamics. After model development, three controllers were designed: classical Proportional-Integral-Derivative (PID), nonlinear Model Reference Adaptive (MRAC) and L1 Adaptive controllers. Comparative study determined the best control algorithm for controlling USV speed in the presence of inherent, highly non-linear dynamics and operational disturbances. Extensive simulation and rigorous analysis also provided a basis for objective verification of the achievable robustness and performance characteristics. Finally, the PID and MRAC speed controllers have been implemented on the SeaFox USV and tested in sea-trials in Monterey Bay, with the L1 Adaptive controller scheduled for testing later this month. Conducting sea trials under natural conditions demonstrates the advantages and limitations of these different control architectures. The work was initiated and supported by the faculty and researchers of the NPS Center for Autonomous Vehicle Research (CAVR).

Army Regularly Conducts Prototype Experiments on Robots

by LTC Anthony S. Cruz, TRADOC, Army Capabilities Integration Center, Joint and Army Experimentation Division

Robots have continuously proven their worth in Iraq and Afghanistan, primarily in roles of Counter-Improvised Explosive Device (C-IED) for the Small Unmanned Ground Vehicle (SUGV) or Intelligence, Surveillance, and Reconnaissance (ISR) and aerial strike missions for the Unmanned Aerial Vehicles (UAV). The Army is looking to improve upon those capabilities while experimenting on other suitable roles that leverage the inherent strength of the unmanned system. The Army Expeditionary Warrior Experiment (AEWE), the Army's premier live-prototyping event held annually at Fort Benning, GA, is a major learning venue for both concept and materiel development in support of the small tactical unit.

The AEWE, which generally looks at prototype systems (not just exclusively for robots) with Technology Readiness Levels of 5-7, fosters an environment where it's acceptable to fail. Vendors can bring their solutions, put them in the hands of soldiers in operational settings against a live force, and then receive direct feedback from the users and a formal evaluation from the Army Test and Evaluation Command. Industry can then take this analytical rigor to make improvements to their systems and come to back to follow-on events or proceed to formal test and evaluation events such as the Network Integration Evaluation at Fort Bliss.

During last year's AEWE Spiral G, several unmanned systems were put through their paces with a company-sized experimental force (EXFOR). The Small UAV and UGVs combined with Unattended Ground Sensors conducted different offensive and defensive mission sets looking at aspects such as collaborative communication technology, autonomous control and modular design.

An experimental Robotics Section was created to evaluate the mission command implications of centralizing control of robotics systems in a tactical unit. On one particular mission, a KMAX helicopter, using way-point control, conducted an aerial resupply drop to the EXFOR, which had maneuvered from their forward operating base to the landing zones. Mule UGVs, in a "follow-me" mode, were used to retrieve the supply pallets while being supported by a network of ground and air sensors that provided situational awareness down to the individual soldier level.

The upcoming Spiral H in February 2013 will again look at promising robotics solutions that address Army capability gaps. The VIP Day is scheduled for February 27 with the Open House on February 28. **If you would like to participate or would like more information on the AEWE please contact jason.g.rakocy.ctr@mail.mil**

Librarian's Corner

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