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CRUSER · NEWS

Consortium for Robotics and Unmanned Systems Education and Research

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

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CRUSER Hosts TechCon 2014

By MC2 Chablis J. Torrence, NPS Public Affairs

CRUSER's NPS Technical Continuum (TechCon) provides NPS Students and Faculty an opportunity to explore selected concepts in support of CRUSER's current innovation thread, "Distributing Future Naval Air and Surface Forces." Concepts were selected during the September 2013 Warfare Innovation Workshop.

CRUSER Deputy Director, Dr. Timothy Chung, offered the TechCon 2014 opening presentation at the fourth annual TechCon which featured twenty-two presentations by NPS Faculty and Students over two days.

LCDR Vincent Naccarato, a Systems Engineering Analysis student, presents his capstone project team's effort on Future Naval Air Operations

"[The TechCon] concept is not so much about the specifics of getting a robot into the sky to do battle, as it is about the concepts that the conference will generate to allow us to go out and explore," said Chung.

Robots in the Roses Brings TechCon 2014 to a Close

By MCSN Michael Ehrlich, NPS Public Affairs

Assistant Professor Timothy Chung (below) with NPS' Department of Systems Engineering describes advances in Unmanned Aerial Vehicle (UAV) research to a group of children during the 4th annual Robots in the Roses Research Fair. Robots in the Roses concluded CRUSER's 4th annual Technical Continuum.

"Robotics is a field that is on an accelerated growth schedule," said Chung. "It is changing dramatically year by year because it isn't a single discipline that is working on a particular project."

"Whether it's a decision support tool to help determine where to send UAVs to search; a diver assist robot that can pull an operator out of the water allowing for safer operations, or a remotely operated vehicle that can help with harbor security, all of these arenas and more are where NPS can deliver to the Navy immediately," continued Chung.

Robots in the Roses is NPS's contribution to National Robotics Week. It provides an interesting opportunity for local community members to interact with NPS students, faculty and staff and it provides a platform to showcase advances in robotics through activities and demonstrations. There are also activities especially for K-12 students, this year featuring the opportunity to pilot a sea perch ROV and fly a tethered quad rotor. Four local high school robotics teams brought their robots and drove them around interacting with attendees.

"When the Secretary of the Navy and the Under Secretary of the Navy told NPS to establish CRUSER, the point was to develop a culture around robotics systems and to help incorporate them into our DNA," said CRUSER Director Dr. Ray Buettner. "Robots in the Roses is a way for us to share new information across campus and to get future supporters engaged and involved."

Director's Corner

Steve Iatrou, CRUSER Director of Strategic Communication

Robo-Ethics! TechCon! Robots in the Roses! What a great string of events and what an interesting snapshot of our community. These three gatherings showed us the diversity, curiosity and brilliance that represent the CRUSER community. It wasn't just the panelists and presenters that instilled this awe but the participants, the audiences, and anyone who just happened to stop by and ask about what we were up to. They were all genuinely interested in what CRUSER had to offer. It really hit home when I had the opportunity to talk with two high school students at Robots in the Roses, one a senior eager to get to college and study programming, the other a freshman already interested in a career in aeronautics. You, the CRUSER community, are the ones who help these young men and women chase and catch their dreams and the more there are of us, the more of them we can reach! Spread the word…join CRUSER!

Multi-Function Electronic Warfare System of Systems

By Bob Marshall, bob.marshall@torchtechnologies.com

The US Army is undertaking development of a new Program of Record, the Multi-Function Electronic Warfare (MFEW) System of Systems. MFEW is one leg of the Army's Integrated Electronic Warfare System (IEWS) Capability triad. The remaining two are: 1) the Electronic Warfare Planning and Management Tool (EWPMT) suite for use by Brigade and higher-echelon Electronic Warfare Officers (EWOs) to plan, synchronize, and execute EW Activities as well as to conduct Electromagnetic Spectrum Management, and 2) integrated Defensive Electronic Attack (DEA) systems to satisfy enduring force protection requirements. This integrated EW capability set of offensive electronic attack (OEA) and DEA systems and tools will dramatically improve a land force's ability to seize, retain, and exploit the advantage within the electromagnetic spectrum (EMS). These systems are being designed to provide an organic EW effects capability not subject to theater-level EA systems shortfalls to the Brigade Combat Team (a combined arms close combat unit commanded by an O-6). The endstate will be an overwhelming advantage delivered at the tactical level. Displaced and distributed units will be able to deny, degrade or disrupt the enemy's ability to conduct C2 and targeting and facilitate optimal effects by integrating electronic attack, electronic protect (EP), and electronic warfare support (ES) functions, without experiencing "frequency fratricide".

The PM-EW Office at Aberdeen Proving Grounds, Aberdeen MD is in charge of the MFEW program. MFEW is a weapon system of systems consisting of ground (mounted, dismounted, and fixed site) and airborne assets that will provide OEA, DEA, and ES functions. The Army wishes to implement levels of interoperability that will benefit multiple DoD services on the battlefields of the future, so US forces may request and receive EW support when MFEW is present in their theater of operations. As a result of the numerous counter radio controlled IED fielding programs over the past decade, current ground-based DEA capabilities are quite robust. Thus, as articulated in the current MFEW Capabilities Development Document, priority is being placed on the development of an airborne electronic attack (AEA) system, referred to as "MFEW-Air". The ground and airborne systems will be controlled by the unit's EWO through a common, secure network. Potential MFEW-Air platforms include both manned rotary wing and Class III and IV UAVs.

Integrating an active EW payload on today's sophisticated, avionics and software dependent platforms presents no small challenge. Numerous studies are being undertaken to identify technical risk areas for both the payload and the candidate platforms (e.g., platform space, weight, power, and cooling; electromagnetic interference; antenna design; information assurance and encryption; C2 data link management; aircraft performance impacts; etc.). They will also ensure that the techniques and technologies are operationally suitable for future warfighters, theaters, and threats. Findings will ultimately guide the strategy for technology development, leading up to a Milestone B decision.

PM-EW seeks input to the MFEW SoS technology, its network architecture, and air/ground concepts of operation. NPS students who wish to contribute to this effort via thesis research, and faculty researchers interested in the development and application of this cutting edge EW system are encouraged to contact Mr. Fran Orzech, Chief, Technical Management Division , PM EW, at francis.t.orzech.civ@mail.mil.

Hyperspectral Imaging by Headwall Photonics

by Christopher Van Veen, www.headwallphotonics.com, information@headwallphotonics.com

Hyperspectral imaging, long favored for military ISR (intelligence, surveillance, reconnaissance) missions, is finding a home aboard commercial UAVs doing important work within the 'remote sensing' domain. These include precision agriculture, environmental research, mining and minerals, pollution analysis, and petroleum exploration. Costs are more affordable, instruments are smaller and lighter, and the resulting data is more actionable and useful to the scientific research community.

Fundamentally, hyperspectral imaging is favored over 'multispectral' imaging because it delivers a steady stream of data-rich spectral information with complete spectral and spatial resolution for every pixel within the field of view. By comparison, multispectral sensors are limited to a handful of bands, with 'gaps' between those bands. For a research scientist, this can mean missing valuable data upon which important decisions (planting or harvesting, for example) need to be made. Figure 1 shows the essence of a 'pushbroom' hyperspectral sensor that collects spectral and spatial data for everything it sees within the field of view. Spectral data is depicted by λ (or Z), spatial is identified by X, and Y represents the collection of this information (at very fast frame rates) over time (Y).

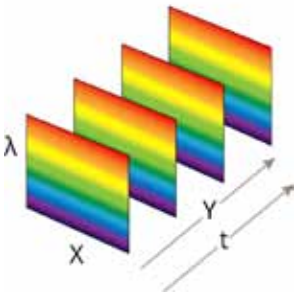

Figure 1: A pushbroom imager collects complete spectral and spatial data over time, for every pixel within the field of view. This is the essential difference between multispectral and hyperspectral

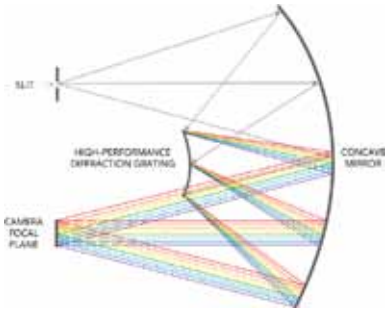

Figure 2: All-reflective, concentric imager using high-performance diffraction grating and concave mirrors yields an elegant, simple, and high-performance hyperspectral sensor.

Resultant datacubes can be several gigabytes in size, which means that an overall application-specific solution needs to factor the design, size and weight of the sensor, but also the necessary data storage and management elements that are also onboard.

The favored all-reflective design for airborne hyperspectral imagers uses concentric mirrors and an aberration-corrected diffraction grating as shown in Figure 2. Aberration correction is an important attribute because it eliminates the unwanted effects known as keystone and smile, which can yield distorted image data…especially off to the edges. When image data is guaranteed to be accurate off to the edges, the sensor can have a very tall image slit. A taller (wider) slit means the UAV or aircraft can be more efficient in flying over the ground. This can mean one pass over an orchard rather than three, for example. As UAVs often have limited flight duration and battery life, flight efficiency is key.

There are several other advantages to adopting the all-reflective design approach. First is that aberration-corrected gratings themselves can be exceptionally small and with very precise groove profiles. Headwall, for example, makes all-original gratings rather than replicates from a master. This guarantees uniform hyperspectral imaging performance across all instruments for a given design. By their nature, replicated gratings cannot exactly equal the performance specification of the original master. Small gratings mean small instruments, which favor the payload restrictions of today's class of hand-launched UAVs favored by researchers. All-reflective, aberration-corrected designs are by nature very simple, and thus relatively impervious to the rigors of airborne use. There are no moving parts, the gratings are temperature insensitive, signal-to-noise is exceptionally high, field of view is very wide, and spatial and spectral resolution are both very high. They also eliminate chromatic aberration for excellent focus over the entire spectral range. Also, the amount of stray light is greatly minimized, meaning better photometric accuracy for darker targets such as vegetation, soils, and minerals. An illustration of Headwall's Micro-Hyperspec airborne sensor (Figure 3) shows that a hyperspectral sensor comprises a spectrograph, a focal plane array (fpa), and a fore-optic lens.

The spectral ranges that remote sensing experts care most about will determine the choice of focal plane array and camera. Scientists know from using spectral libraries where they need to be; hyperspectral sensors are up to the task as long as the correct detector technology is chosen. In the VNIR range (380-1000nm silicon-based designs are favored. In the Extended VNIR (550-1700nm) and NIR (900-1700nm) ranges the detectors are typically InGaAs. Finally, In the SWIR range (950-2500nm) detectors can be either InSb or MCT, but the cost will be correspondingly higher since the coverage range is so broad.

System integration is a very important step that Headwall is able to offer customers, who often mistakenly believe that an off-the-shelf sensor and an off-the-shelf UAV will happily coexist. Payload issues (weight and balance), flight duration, orthorectification of collected

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Figure 3: Headwall's Micro-Hyperspec sensor is designed for airborne applications where low weight and small size are key requirements. The all-reflective concentric design provides high spatial and spectral resolution, high SNR, low stray light, and aberration-corrected imaging.

Figure 4: Whether the UAV platform is a multi-rotor copter or a fixed-wing design, it is crucial to manage the integration of all hardware and software. Headwall has begun offering turnkey airborne packages that include the UAV, sensor, LiDAR, GPS, and application software.

Robo Ethics 2014 Takes the Debate to the Naval Commander

By Javier Chagoya, NPS Public Affairs

A diverse panel of leading thinkers in the field of ethics and robotic systems, led by NPS Department of Defense Analysis Assistant Professor Dr. Bradley Strawser, shown above center, participate in the Robo Ethics 2014 debate in San Diego, Calif., March 24.

NPS students, along with students and faculty from the Naval Academy and personnel from the Naval Surface Warfare Center in Panama City, Fla. also participated in the debate via live video-teleconference (VTC).

"The diversity of backgrounds, experiences and disciplines on the panel was great … Having that breadth of insight across channels was an excellent way to convey the many difficulties and ethical conundrums a future commander will face with this newly-emerging technology," said Strawser.

Panelists were asked to envision a futuristic scenario where an escalating series of events leads to war. Newly-appointed Senior Advisor for Military Professionalism Rear Adm. Peg Klein participated via VTC from Washington, D.C. Klein was asked to weigh the need to deploy unmanned and manned systems during the notional crisis, while audience members also weighed in and contributed questions and insights into the scenario.

US Navy Photo by Javier Chagoya:
Dr Tim Chung, Dr BJ Strawser Robo-Ethics panelists

Strawser, who has written extensively on the ethical implications of unmanned systems, discussed the continue need to debate morality in relation to robotic systems.

"The future of robotics technology and unmanned systems complicates the moral decisions future commanders will have to make on several orders of magnitude. Asking these tough question today, will help prepare our future leaders tomorrow," said Strawser.

CRUSER Librarian Corner

United States Air Force RPA Vector: Vision and Enabling Concepts 2013–2038
http://www.af.mil/Portals/1/documents/news/USAFRPAVectorVisionandEnablingConcepts2013-2038.pdf

Sustaining the U.S. Lead in Unmanned Systems: Military and Homeland Considerations through 2025
http://csis.org/files/publication/140227_Brannen_UnmannedSystems_Web.pdf

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data, and connectivity considerations all need to be managed. An airborne solution needs to be optimized for the airframe, whether it is a multi-rotor VTOL UAV or a fixed-wing design. Here, Headwall is playing an enabling role by packaging everything as a turnkey offering (Figure 4).

Often, remote-sensing specialists will want to carry more than just a hyperspectral payload. LiDAR is also desired, as are onboard GPS/INU capabilities. The overall goal of this combined solution is to provide a very complete and precise array of hyperspectral data that is true to the actual features on the ground. Collecting the data is the first step, but processing and analyzing it also needs to happen…either in real-time or post-flight. A small, lightweight computer needs to be matched and suitably connected to the sensor so that everything is secure and balanced on the airframe. The computer provided with Headwall's airborne hyperspectral systems is very small and light and is loaded with Hyperspec III software, which manages many of these processing and analysis routines quickly and efficiently with low power draw. Headwall also makes a Google-map-enabled polygon tool available so that users can define the sensor operating parameters based on precise GPS coordinates. Soon, the computer will be onboard the sensor itself, leading to an even smaller, lighter, and more efficient package.

Short articles of 500 words for CRUSER News are always welcome - cruser@nps.edu

- Unmanned Systems/Robotics research
- New Program/Systems/Projects
- Other aspect of Unmanned Systems/Robotics

CRUSER Monthly Meetings

Mon 12 May, 1200-1250 (PST)
Mon 23 June, 1200-1250 (PST)
Root 242, VTC, or dial-in 831-656-6681
contact us at cruser@nps.edu for the passcode