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CRUSER • NEWS

Consortium for Robotics and Unmanned Systems Education and Research

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

Contents

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SEED/CRUSER Data Farming Mini-Workshop

by Susan Sanchez, NPS Operations Research Faculty, ssanchez@nps.edu

NPS's Simulation Experiments and Efficient Designs (SEED) Center for Data Farming hosted the first SEED/CRUSER Data Farming Mini-Workshop in November 2014. Faculty, visitors, and students from across NPS were involved.

- *Does your research involve making a simulation model of unmanned vehicles?*
- *Do you find yourself wishing you could quickly and easily explore a variety of "what-if" questions using your simulation?*
- *Are you curious about how simulation and experimentation might augment your CRUSER research?*

Consider attending the upcoming SEED/CRUSER Data Farming Workshops!

The SEED Center's mission is to help decision makers gain timely insights from their simulation models. Increasingly, the defense community is turning to simulation to explore the development of new capabilities and new tactics. These models tend to be extremely complex, with hundreds or even thousands of factors, and many sources of uncertainty. Data farming helps researchers understand the impact those factors and their intricate interactions have on model outcomes. Data farming is the process of using computational models to "grow" data via controlled experimentation, and then analyzing that data using statistical and visualization techniques to obtain insight. Effective data farming draws on state-of-the-art technologies including design and analysis of experiments, high-performance computing, and data mining analysis tools.

During the first SEED/CRUSER Data Farming Mini-Workshop, the SEED Center team guided participants through a mix of lecture, discussion, question formulation, and hands-on exploration of an agent-based simulation model that involved UAVs in maritime interdiction operations. We used MANA V (for Map Aware Non-uniform Automata, Vector Movement, developed by New Zealand's Defence Technology Agency) as the simulation platform for the demonstration. In this scenario, a Blue patrol vessel with two types of UAVs (surveillance and armed) seeks to detect and identify smugglers in the midst of a heavily trafficked strait.

After some "Data Farming 101" concepts and an overview of the scenario and experiment, workshop participants were asked to identify which of the UAV capabilities or characteristics they thought would be the most critical drivers of success. As is often the case with complex systems, plausible arguments could be made for the importance of a sizeable set of factors—and group members came up with a wide variety of answers. Based on those answers, we created a set of designed experiments in which we varied factors including the speeds, sensor ranges, endurance, and numbers of UAVs to see the effects these factors had on mission success. We then showed how the experiment results could be quickly used to provide quantitative answers to the question—and as is often the case, we discovered other interesting questions in the process.

The scenario and experiment used for this workshop were relatively simple, but illustrate how easy—and valuable—it is to "make your simulation model work for you!" Many SEED Center students from a variety of backgrounds—including Army, Navy, Marines, Air Force, and international allies—have successfully used data farming on agent-based or discrete-event simulation models to explore the potential impact unmanned vehicles can have in operational environments. They have investigated unmanned vehicles of many types—aerial, ground, surface, and underwater—for missions related to reconnaissance and surveillance, IED detection, mine detection, border security, asset protection, casualty evacuation, humanitarian logistics, and more. For additional information, visit our web pages at http://harvest.nps.edu.

Upcoming events:

- *Friday February 27, 2015: SEED/CRUSER Data Farming Mini-Workshop #2*
- *April 9-10, 2015 (right after the CRUSER Technical Continuum on April 7-8): SEED/CRUSER Data Farming Workshop #3 (limited number of participants)*

SEED/CRUSER Data Farming Mini-Workshop #1: Data Farming 101
Facilitators: Susan Sanchez, Paul Sanchez, and Steve Upton

Director's Corner

Steve Iatrou, CRUSER Director of Strategic Communication

The holidays must be over because there has been a lot happening in the CRUSER Community with much more on the horizon. This month's newsletter might best be titled "Nature Calls" because we're learning how to grow data through Data Farming; how to move across the sea-floor from horseshoe crabs (with some helpful hints from Archimedes); and we're helping SHARCs exploit wave generated energy. A great testament to the breadth and diversity of thought, imagination and ingenuity in our Community of Interest. I know you'll enjoy reading about these exploits in this newsletter but when you're done you'll want to take a deep breath because there's a lot happening in the next few months. Check the calendar for the upcoming Data Farming Mini-Workshop and (not-so-mini Workshop), Robo-Ethics, CRUSER TECHCON, Robots-in-the-Roses, Tech Expo, CRUSER Colloquium and of course our monthly meetings. It's certainly a great time to be a part of CRUSER.

Surf Zone Robotic Platform Study

by Frederick E. Gaghan, Director of Program Development, Applied Research Associates Inc, fgaghan@ara.com

The near shore environment is one of the most dynamic and technically challenging for both man and machine. Significant research efforts have been conducted to investigate sea-floor crawling robots, but they usually involve "water-proofing" a standard ground robot and attempting to operate it underwater. These designs often experience difficulties in maintaining positional accuracy or operability due to the water flow and wave action.

Over the course of several months, ARA studied two key engineering concepts for the Strategic Environmental Research and Development Program (SERDP) that directly affect the ability of a robotic system to operate in the surf-zone; 1) platform hull shape and, 2) propulsion.

To address platform shape a study was completed of a horseshoe crab's carapace as a biomimetic representation for the hull shape of a robotic system (Figure 1). It was hypothesized that a hull shape based on a horseshoe crab would provide the appropriate balance between lift and drag, and allow hydrodynamic forces in the VSW/SZ to assist in the ability to station keep and maneuver without the need for excessive weight or a complex propulsion system to achieve platform stability and traction. The study focused on answering the following questions:

Figure 1 Baseline Model

Figure 2 – Baseline 3D Model

- Can a biomimetic hull design provide better stability in the dynamic wave conditions found in the VSW/SZ?
- Is the required scale of this hull design sufficient for carrying a usable payload and other system components?
- What are the maximum flow vectors for which the biomimetic hull can remain effective?
- What are the resultant forces from those maximum flow vectors?

Several biomimetic hulls were modeled and underwent simulated and empirical testing in a water channel. The empirical testing was used to validate the data obtained from the Computational Fluid Dynamics simulations used to identify a more effective hull shape.

To address locomotive factors a separate study was completed using an Archimedes screw drive as the mode of propulsion to assess platform traction and mobility (Figure 2). An Archimedes screw was chosen because of its ability to operate in various mediums with varying flow rates. It was hypothesized that an Archimedes screw with optimal geometry could provide the tractive force to propel a robotic system. Archimedes screw drives have been successfully used on larger underwater robots, such as those found in the deep sea mining industry, but it has not been widely applied to a robotic system in the near shore environment.

A test bed was designed to measure the speed, forces, and displacements created by an Archimedes screw interacting with various mediums. Several drive designs with different barrel diameters, flange heights, and flange depths were empirically tested to record efficacies in a range of mediums, including water, sand, and pebbles to answer the following questions:

- Can the Archimedes screw drive be scaled appropriately for a small to medium robotic system?
- What performance characteristics (speed, efficiency, tractive force) would this system provide?
- How will the system perform across a variety of medium?

Results of the two studies confirmed that is possible to design a biomimetic hull shape to improve stability and an optimized geometry for an Archimedes screw that would provide good tractive force on the aquatic floor in the dynamic wave conditions found in the VSW/SZ (Figure 3)

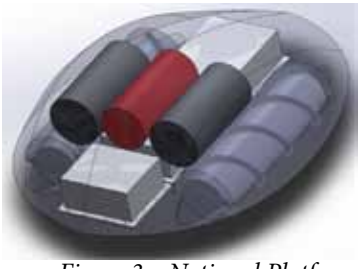


Figure 3 – Notional Platform Design

CRUSER Monthly Meetings

Mon 9 Mar, 1200-1250 (PST)

Mon 4 May, 1200-1250 (PDT)

details at: http://CRUSER.nps.edu

JIFX (*http://my.nps.edu/web/fx*)

11-15 May 2015 at Camp Roberts, CA

Fall Quarter Graduate's Research Recognized by Navy Oceanographer

by Kenneth Stewart, NPS Public Affairs Office

Naval Postgraduate School (NPS) student Lt. Cmdr. Kathryn "Kate" Hermsdorfer, graduating this Fall Quarter in the university's Meteorology and Physical Oceanography curricula (METOC), was recently recognized for academic excellence by Oceanographer of the Navy, Rear Adm. Jonathan W. White, for work that she is conducting at NPS on unmanned vehicles.

"I am working with the Sensor Hosting Autonomous Remote Craft (SHARC) Wave Glider," said Hermsdorfer.

The SHARC Wave Glider, created by Liquid Robotics, is an unmanned watercraft powered by the energy generated through the natural swelling of waves on the ocean's surface. These craft can be deployed for long periods of time, and are equipped with a variety of sensors and communications packages that allow operators to monitor their progress as they propel across the sea gathering data, which is wirelessly transmitted to control centers on the coast.

The SHARC Wave Glider is interesting to Navy meteorologists because of its persistence, and resilience. It can operate in hurricane conditions, and unlike other commercial buoy systems, it can be remotely moved from one area of interest to another and remain on the water for long periods of time.

"We are excited with this particular Wave Glider, because we have the ability to steer the craft by controlling it through an iridium network," Hermsdorfer explained.

Hermsdorfer worked with a small team of engineers and meteorologists to evaluate the SHARC's sensing capabilities and then to develop a sensor better suited to naval meteorological operations.

"SHARC comes with a weather sensor, my first step was to evaluate the commercial sensor and the data it collects. We then developed and integrated a suite of off-the-shelf sensors that better suit our needs," said Hermsdorfer. "I worked primarily on evaluating the sensors, while the team focused on the mechanics of incorporating the off-the-shelf sensors to the craft."

Hermsdorfer's work also caught the attention of the Space and Naval Warfare Systems Command (SPAWAR). SPAWAR offered Hermsdorfer a fellowship and a $10,000 grant to further her research in conjunction with a SPAWAR mentor.

"[The fellowship] really serves two purposes … It feeds my research and it gives me a better understanding of SPAWAR so that I can better support things that they are looking at as well," said Hermsdorfer.

Hermsdorfer will continue to rely upon the lessons she learned at NPS as she branches out and applies her graduate education to naval challenges.

"NPS has been invaluable … One of the things that everyone says, but you do not really appreciate until you go through the process, is that NPS helps you to develop a problem-solving thought process," stressed Hermsdorfer. "By conducting my research and working my experiments, I have been able to develop a set of problem-solving skills that I will rely upon in the future."

But Hermsdorfer will need more than just problem solving to be succesful in the academically-challenging worlds of meteorology and oceanography. She will need to draw upon her course work and the relationships that she has developed within the METOC community.

"I earned a master's in meteorology and oceanography, the specific subject matter of my degree is directly applicable to what I will be doing at my next and future duty stations," said Hermsdorfer "From now on out, I will be working in the meteorology and oceanography fields and applying this knowledge directly."

Hermsdorfer will not have far to travel after graduation to put her education to the test. She has been assigned to serve as the operations officer at Monterey's Fleet Numerical Meteorology and Oceanography Center (FNMOC) located just a short drive from the NPS campus.

"FNMOC does numerical forecasting, and I took both forecasting and numerical modeling courses here at NPS," noted Hermsdorfer. "When you are able to tie subjects like these to the operational requirements demanded by your profession, you can really see how an NPS degree is critical."

ONR Naval Future Force Science & Technology EXPO

CRUSER had a booth in the EXPO Hall during the ONR Naval Future Force Science & Technology EXPO, held 4-5 Feb in Washington DC. This opportunity allowed us to connect with several CRUSER members (thanks for stopping by to introduce yourselves) and to share the CRUSER Community of Interest with many more attendees. With each new member the community of interest grows stronger as the potential for collaboration increases and the collective knowledge of the community increases. Lyla Englehorn, CRUSER Director of Concept Generation pictured in the booth.

STUDENT CORNER

Student: LT Blake M. Wanier, USN

Title: A Modular Simulation Framework For Assessing Swarm Search Models

Curriculum: Undersea Warfare/Operations Analysis

Link to Completed Thesis: https://calhoun.nps.edu/handle/10945/44027

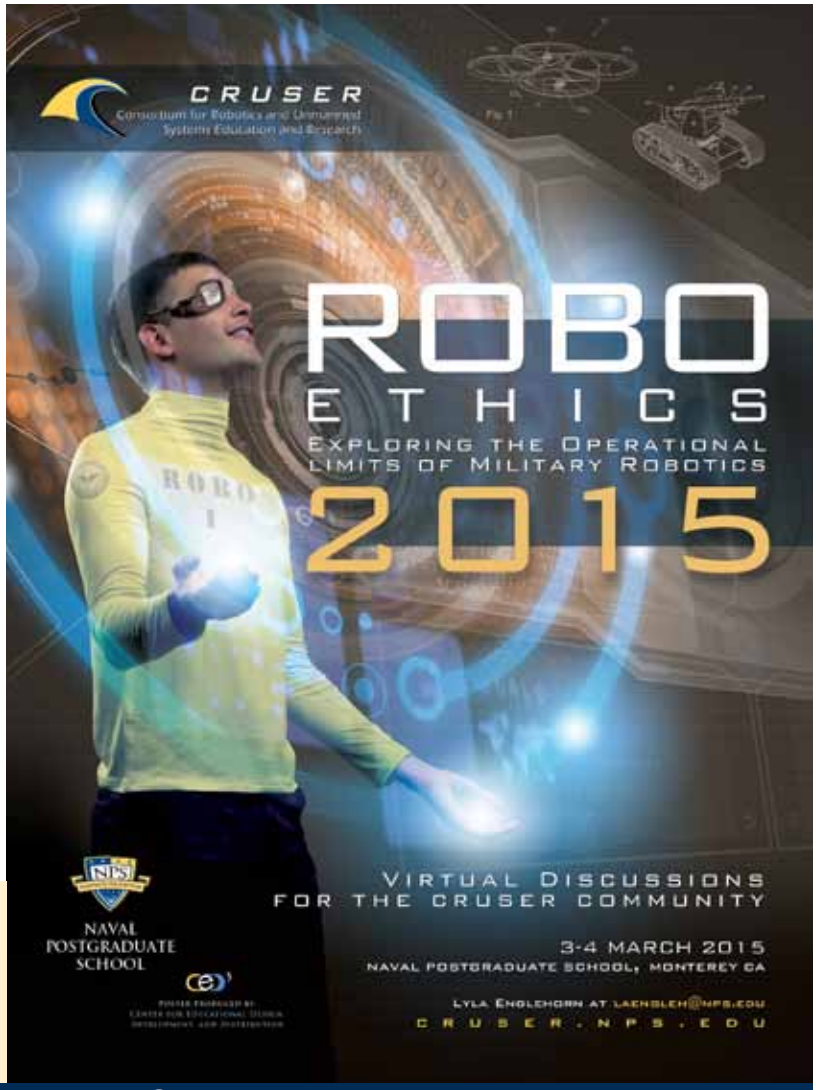
Abstract:

The ability to utilize large numbers of unmanned systems as search agents allows the implementation of different search strategies that are not currently explored utilizing today's search decision support and analysis tools. This thesis develops a framework in MATLAB that allows the investigation of search strategies that utilize large numbers, or a swarm, of search agents. By implementing a modular design, multiple aspects of the search, such as tactics, searcher characteristics, and target characteristics, can easily be varied and analyzed. Utilizing JMP to perform statistical analysis, future design requirements can be refined in order to advise decision makers on possible alternatives and trade spaces for optimizing swarm search performance. Numerical studies demonstrate the ability to leverage the developed simulation and analysis framework to investigate three canonical swarm search models as benchmarks for future exploration of more sophisticated swarm search scenarios.

Robo-Ethics: Exploring the Operational Limits of Military Robots

by Steve Iatrou, CRUSER Director Strategic Communication, sjiatrou@nps.edu

The next iteration of Robo-Ethics is scheduled for 03-04 March 2015. This one is not focused directly on ethical issues associated with the employment UxS systems but rather on the drivers of those ethical issues: employment of autonomous, remote and robotic systems to meet operational requirements. We're taking the lawyers and ethicists out of the mix and asking naval officers to develop their vision of the future battlefield without the constraints of policy, law and ethics. From this foundation we can better inform future discussions on what policies and laws should look like to enable the warfighters and what ethical issues may need to be addressed en route to developing such policies and laws.



There will be three teams working on the issues, one at the Naval Academy, one in San Diego and one at NPS.

There will be two meetings open to the CRUSER CoI via the Internet. The opening discussion addressing the objectives and guidelines for the project (3 MAR 15, AM) and the closing team presentations (4 MAR 15, PM). Exact times and "location" will be promulgated as we draw closer.

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