Issue 22 Dec 2012

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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Computer Vision Analysis of Aerial Platforms Dynamics

by Ryan Decker Ph.D. Candidate, Mechanical and Aerospace Engineering (Prof Oleg Yakimenko), NPS, rdecker@nps.edu

As is well known, "Detect, Sense and Avoid" or "See and Avoid" capability is the key deficiency that precludes unmanned aerial platforms from operating in the national airspace. Once a potential threat is detected, its dynamics need to be assessed to proceed with the following step, collision maneuver computation.

This research effort deals with the development of computer algorithms to automatically analyze video streams provided by visual and IR sensors on the ground. The essence of the developed algorithm is to use image-processing methods to segment the shape of the object in each video frame. As shown in the example in Fig.1, pixel operations are conducted to determine the location of gradients that correspond to edges of objects. These edges are then dilated to form connecting lines, and the connecting lines that enclose areas are filled to form bodies. When a large body is found, it is compared to an active shape model to classify the body as the desired object. With subpixel accuracy, the developed code is able to identify key points on the object for further assessment of the object's position and orientation in the camera frame. If using multiple cameras (stereovision) or a single camera (superimposing multiple images taken at different points along a trajectory at successive time instances), so that the location, azimuth and elevation of each shot is known, it is also possible to automatically perform the so-called pose estimation (determine time-space-position information) of the object throughout the video.

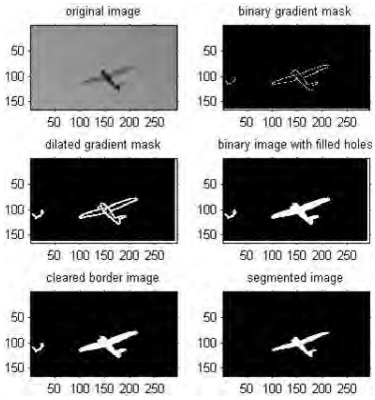

Figure 1. Segmentation an unmanned vehicle from a video frame

As the quality of modern video-capture systems continues to improve, the role that optical systems play in data collection at test ranges is becoming increasingly important. It turns out that the same algorithm developed for the "sense" part of an onboard collision avoidance capability may be successfully applied by the ground kineto-tracking mounts at test ranges for aiding in passive characterization of aerial platform dynamics. Application of the techniques of image processing and computer vision results in a significant increase in the rate at which valuable information from video can be analyzed versus costly conventional techniques that require laborious and often tedious human operation.

As an example, Figure 2 depicts an analysis of a complex two-body aerial platform, parafoil-based aerial delivery system. The data extracted from flight video is then used to recreate trajectories and estimate the attitude history of both the canopy and payload (it should be noted that this is a very difficult problem to address otherwise – no bulky sensors can be mounted onto the delicate surfaces of a flexible parafoil canopy). Automated results are not only delivered to the user within minutes, but are able to measure certain quantities with precision beyond what is capable in some manual data-reduction methods.

Another useful application of the developed technique has been demonstrated in the field of ballistic characterization for artillery weapons. High-speed launch video analysis has previously been used by test engineers to verify important launch events such as rocket ignition, hood extraction,

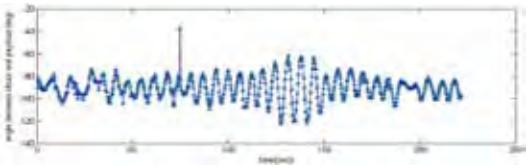

Figure 2. Automated analysis of parafoil canopy and payload relative dynamics

and proper fin deployment. Using the automated analysis method, it is also possible to estimate a projectile's velocity, pitch and yaw angles, and even spin rate (if a projectile carries fiducial markings or stripes painted on its nose). Figure 3 displays a segmented 155mm projectile and the keypoints used to represent its perimeter in an active shape model.

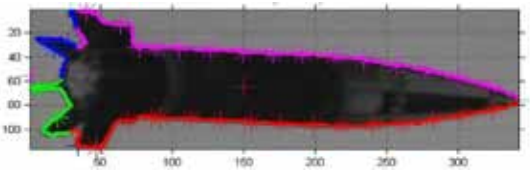

Figure 3. Example of computer vision analysis of an artillery projectile

Understanding aerial platform geometry in a camera frame allows employing fitting techniques that incorporate the epicyclic equations for projectile motion, and are used to estimate the history of projectile pose accurate to 1/20th of a degree. The automated post-processing method is able to re-create the projectile trajectory immediately following cannon launch. In addition, the algorithm can estimate several ballistic coefficients used in trajectory modeling and quantify the observed pitching motion in terms of the precession and nutation frequency, phase, and amplitude. Having two cameras enables complete pose estimation.

The quality and robustness of developed computer vision algorithms allow relying on cameras being the only source of information. In practice, however, this technology is still complementary to data provided by other on-board instrumentation. Blending heterogeneous streams of data is a subject of following research.

Director's Corner

As efforts across the science and technology community brings us exciting new capabilities in unmanned systems, so it does for potential adversaries. Author of Fleet Tactics CAPT Wayne Hughes, USN (ret) calls this the dawning of the robotic era of warfare. Several CRUSER member organizations are concerned with countering adversary unmanned systems exploring alternatives from conventional weapons to swarm versus swarm and within classification limitations, we invite them to share their concepts with the CRUSER community. This is another important area within CRUSER's charter to explore all aspects of employing unmanned systems

CAPT Jeff Kline
CRUSER Director

Human Rights Group Calls for Worldwide Ban on Autonomous Weapons Systems

by Jeffrey S. Thurnher, Major, USA, Faculty, International Law Department, U.S. Naval War College, jeffrey.thurnher@usnwc.edu

Human Rights Watch, a prominent human rights advocacy group, published a report last month entitled "Losing Humanity: The Case against Killer Robots" which calls for a preemptive ban on all fully autonomous weapons systems. The report, which was jointly published with Harvard Law School's International Human Rights Clinic, asserts that fully autonomous weapons systems are inconsistent with the law of armed conflict and pose too significant of a threat to civilians. Accordingly, Human Rights Watch advocates for an international treaty prohibiting the development, production, and future use of these autonomous systems. The group further recommends that roboticists and other autonomous weapons developers establish a professional code of conduct geared towards protecting civilians on the battlefield.

The report relies on several legal justifications in support of the proposed ban. First, Human Rights Watch contends that autonomous weapons systems will be unable to adequately distinguish between civilians and combatants as is required under international law. It argues, in part, that autonomous systems will lack the ability to understand human emotions, a quality which it deems to be paramount in deciding whether a person is a true threat in a complex battlefield environment. Second, the report cites the fundamental principles of proportionality and military necessity as reasons to ban these systems. Human Rights Watch alleges that the value judgments needed to comply with those principles are highly subjective and dependent on context. They postulate that a robotic system cannot possibly be programmed for how to respond to every conceivable scenario it might face. Without a true grasp of the context of the scenario, these autonomous systems, the group fears, might make dangerously poor targeting decisions. Third, the group maintains that the notion of autonomous systems making lethal choices on the battlefield may shock the public conscience and would thus be both unacceptable and unlawful.

This report is certainly not binding on any nation, and some international law scholars and bloggers have already begun criticizing its positions and legal arguments. It nonetheless represents an opening salvo in what will likely be a continuing discussion of the lawfulness of these systems. The Department of Defense itself issued a new directive shortly after this report was released that established policies and guidelines for the development of autonomous functions in weapons. While such steps may help assuage some of the critics, those involved in the autonomous systems field should remain engaged in this growing debate and be prepared to continually counter these criticisms.

For more information about the lawfulness of autonomous weapons systems or other legal research efforts from the U.S. Naval War College's International Law Department, please go to http://www.usnwc.edu/ild or contact Major Jeff Thurnher at jeffrey.thurnher@usnwc.edu or (401) 841-6589.

Short articles of 300-400 words for CRUSER News are always welcome - cruser@nps.edu

DoD Organizations are invited to give a 15 minute presentation at an upcoming CRUSER Monthly Meeting about their research/projects
Contact Lisa at cruser@nps.edu to sign-up

Upcoming CRUSER Monthly Meetings
Tues 15 Jan 2013, 1200-1250 (PST)
Root 242 or dial-in 831-656-6681
Mon 11 Feb 2013, 1200-1250 (PST)
Root 272 or dial-in 831-656-6685

CRUSER FY12 Annual Report Available

By Lyla Englehorn, CRUSER Project Manager, laengleh@nps.edu

The Consortium for Robotics and Unmanned Systems Education and Research (CRUSER) FY12 Annual Report is now available. FY12 was a transition year for CRUSER with the initiation of our first program Innovation Thread that began with a Warfare Innovation Workshop (WIW) in September 2011; a Robo-Ethics Education Seminar held in the Pentagon addressing the cultural, ethical and legal issues related to employing unmanned systems; a technical continuum held at NPS to advance the concepts generated during the September 2011 Warfare Innovation Workshop; the annual NPS Robots in the Roses research fair attended by Undersecretary of the Navy Bob Work. The September 2012 Warfare Innovation Workshop was also included in FY12, and initiated the second CRUSER program Innovation Thread.

Major aligned events starting in FY11 through FY14 are plotted along major program Innovation Threads (see Figure 1) starting with concept generation workshops, developed in technical symposia, and demonstrated in field experimentation to test selected technologies. These activities each have separate reports, and are available upon request. However, research and education will continue to include a broader landscape than just mission areas.

The first program Innovation Thread will be continued in FY13 by experimenting with two concepts originally proposed in the September 2011 Warfare Innovation Workshop: 1) Digital Semaphore, the use of QR codes to silently pass tactical information via display and E/O sensors; and 2) Aerial Combat Swarms, the use of UAVs to combat a swarm of UAVs. CRUSER also supported or executed a variety of STEM and research events associated with unmanned systems. Highlights from this year include a continuing education seminar

Our second Innovation Thread has already begun with the execution of another Warfare Innovation Workshop (WIW) in September 2012 to advance unmanned systems in undersea operations. Several promising concepts generated at that workshop and at the follow-on WIW in March 2013 will be advanced to the May 2013 Technical Continuum including undersea UUV stations and autonomous docking.

In FY12, CRUSER's transition year, the nationwide community of interest grew from 375 to just over 800 participants representing government, academia, industry and allied interests in unmanned systems. As of December 2012 our current membership already exceeds 900 and continues to grow.

The CRUSER coordination team plans to travel to Washington D.C. in June 2013 to hold an hour-long seminar at ONR to report on CRUSER activities and status, as well as the results of our first CRUSER Innovation Thread and progress along the second Innovation Thread.

CRUSER annual reports from FY11 and FY12 are available for download at http://libguides.nps.edu/cruser, or you may request a copy of the FY12 annual report via email to cruser@nps.edu.

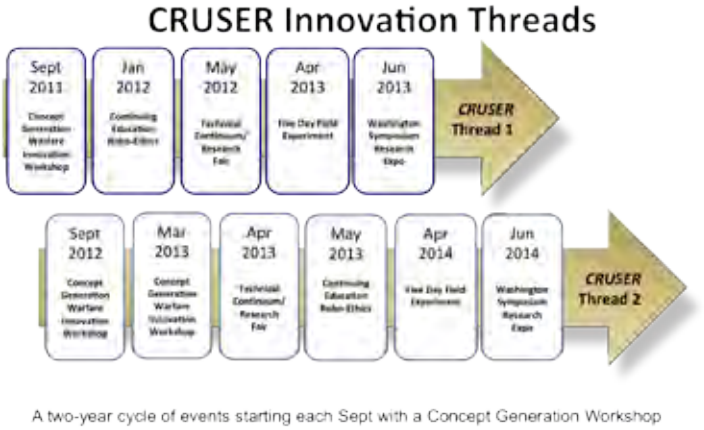

Figure 1. CRUSER program Innovation Threads

Department of Defense Directive Number 3000.09 (Autonomy in Weapon Systems) is Released

On 21 Nov 2012 the release of DoD Directive Number 3000.09 established DoD policy for autonomous/semi-automous weapon systems.

Abstract:

1. PURPOSE. This Directive:
   a. Establishes DoD policy and assigns responsibilities for the development and use of autonomous and semi-autonomous functions in weapon systems, including manned and unmanned platforms.
   b. Establishes guidelines designed to minimize the probability and consequences of failures in autonomous and semi-autonomous weapon systems that could lead to unintended engagements.
4. POLICY. It is DoD policy that:
   a. Autonomous and semi-autonomous weapon systems shall be designed to allow commanders and operators to exercise appropriate levels of human judgment over the use of force.

To download a copy of the full directive: https://www.hsdl.org/?abstract&did=726163

The Robot Report - Interactive Map of Global Robot Providers

by Frank Tobe, The Robot Report, ftobe@therobotreport.com, www.everything-robotic.com
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The Robot Report started because as I attempted to invest in stocks in the robotics industry, I found that there was a serious lack of information available. Most companies are not publicly-traded; they are privately held with no requirement to provide information. Thus I began an intensive research project that took me to Japan, Korea, China, Germany, France, Switzerland and all over the Internet. In an effort to share my research I set up The Robot Report to track the business of robotics. Later I started the Everything-Robotic blog to supplement The Robot Report with periodic in-depth reviews and insights. Recently I produced a map showing the location of start-up companies involved with robotics.

Legend: Red markers are industrial robot makers; Blue with an "S" are service robots used by corporations and governments; Blue with a "P" are service robots for personal and private use; Green markers represent robotic start-up companies and Yellow shows where the top 20 robotics-focused universities and research labs are located. Please send companies we've missed to info@therobotreport.com.

STUDENT CORNER

Student: LCDR Robert E. Atkinson, III, USN

Title: Tropical Cyclone Reconnaissance Over the Western North Pacific with the Global Hawk Operational Requirements, Benefits, and Feasibility

Curriculum: Meteorology

Abstract: Over the North Atlantic Ocean, an operational manned aircraft-based tropical cyclone (TC) reconnaissance program is conducted by the United States Air Force. However, no such program is conducted over the western North Pacific (WPAC), where the maximum annual number of TCs occurs. Rather, remotely-sensed observations from satellites provide data on TC characteristics. While operational forecasts of TC track over the WPAC have improved, the rate of improvement has declined, and no such decline has been observed over the North Atlantic. In this study, the declining rate of improvement in WPAC forecast accuracy is examined relative to the lack of direct observations.

The capabilities of manned-aircraft are compared with use of a Global Hawk unmanned aerial system for use as an observing platform. This is proposed in view of a declining capability in satellite data coverage. Current Global Hawk programs are reviewed with respect to requirements for operational tropical cyclone reconnaissance over the western North Pacific. A multi-year demonstration project is proposed to obtain in situ observations of TC location and intensity. The observation impacts on improved tropical cyclone forecasts will be assessed such that a positive impact will lead to recommendation of a Global Hawk for operational tropical cyclone reconnaissance.

Does your DoD Organization have a potential thesis topic for NPS Students? Contact us at CRUSER@nps.edu

Come Plug and Play at the USSCOOM – Field Experimentation Cooperative!

Bring your systems, software or ideas to the USSOCOM - NPS Tactical Network Testbed (TNT), an event that explores the application of the latest technologies including network communications, unmanned systems, situational awareness, collaborative environments, sensors, and human systems integration. Operators, engineers and scientist come together in a field environment to test technologies and accelerate the delivery of new capabilities to the Special Operations warfighters.

Next Event: TNT 13-2 Avon Park, FL. 26 February – 7 March 2013 with a focus on the Digital Soldier. Experiment Submission forms can be submitted electronically via the SOCOM site below (deadline 17 Dec 2012)
Following Event: 4 - 13 June 2013 at Camp Roberts Paso Robles, CA with a focus on Signature reduction.

Contact: Dr. Ray Buettner rrbuettn@nps.edu, 831-656-3387
More information: http://www.socom.mil/sordac/directorates/sciencetechnology/pages/ExpEvents.aspx
Submission Form: http://www.socom.mil/_layouts/FormServer.aspx?XsnLocation=/FormServerTemplates/whitepaper-submission.xsn

Librarian's Corner:

National Press Academy - "Application of Lightweighting Technology to Military Vehicles, Vessels, and Aircraft"

Abstract: Of interest to the military, manufacturers and designers of military equipment, and decision makers, Lightweighting is a concept well known to structural designers and engineers in all applications areas, from laptops to bicycles to automobiles to buildings and airplanes. Reducing the weight of structures can provide many advantages, including increased energy efficiency, better design, improved usability, and better coupling with new, multifunctional features. While lightweighting is a challenge in commercial structures, the special demands of military vehicles for survivability, maneuverability and transportability significantly stress the already complex process.

Application of Lightweighting Technology to Military Vehicles, Vessels, and Aircraft assesses the current state of lightweighting implementation in land, sea, and air vehicles and recommends ways to improve the use of lightweight materials and solutions. This book considers both lightweight materials and lightweight design; the availability of lightweight materials from domestic manufacturers; and the performance of lightweight materials and their manufacturing technologies. It also considers the "trade space"--that is, the effect that use of lightweight materials or technologies can have on the performance and function of all vehicle systems and components. This book also discusses manufacturing capabilities and affordable manufacturing technology to facilitate lightweighting.

This and other articles are available on the Unmanned Systems Guide http://libguides.nps.edu/cruser
Questions? We're here to help! libcruser@nps.edu