ISSUE 5 JULY 2011

CRUSER • NEWS

Consortium for Robotics and Unmanned Systems Education and Research

FROM TECHNICAL TO ETHICAL

FROM CONCEPT GENERATION TO EXPERIMENTATION

NAVAL POSTGRADUATE SCHOOL

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Robot Motion Planning in Dynamic, Cluttered, Uncertain Environments

By: Noel du Toit, Visiting Professor, NPS (Home Institute: Caltech) and Joel Burdick, Caltech

As robots transition from the laboratory to the real world, they must contend with the unknown. Consider a robot moving through a busy market: it must work in close proximity with many other moving agents whose future actions and reactions are difficult to predict accurately. Moreover, only noisy measurements of the robot, obstacles, and environment states are available for planning purposes. This is an example of robot motion planning in Dynamic, Cluttered, and Uncertain Environments (DCUEs).

Planning approaches that naïvely account for system uncertainties tend to be conservative: it is assumed that the robot will execute a plan without receiving any new information (i.e., in Open-Loop, OL). This conservatism leads to failure in cluttered environments. By incorporating anticipated measurements, this conservatism is overcome in the Partially Closed-Loop Receding Horizon Control (PCLRHC) algorithm. The anticipated occurrences of future measurements are captured, thus allowing more accurate representations of the future system state uncertainties. By recursively re-solving the problem, the actual measurements are incorporated as they become available, allowing the robot to adapt to unexpected changes in the environment. However, practical systems do not react instantaneously and it is desirable to account for all possible disturbances over some reaction horizon (probabilistic safety). This can be elegantly accomplished through chance constraint conditioning. The resulting approach reduces conservatism while maintaining system safety, allowing safe, efficient navigation in DCUEs

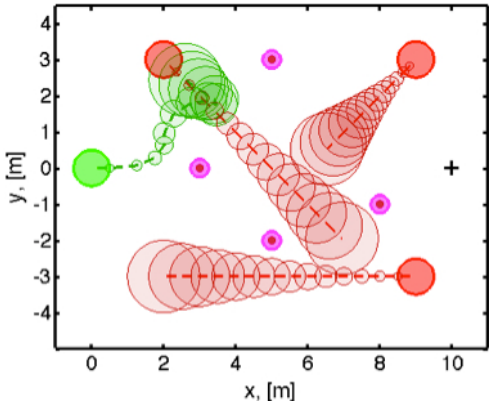
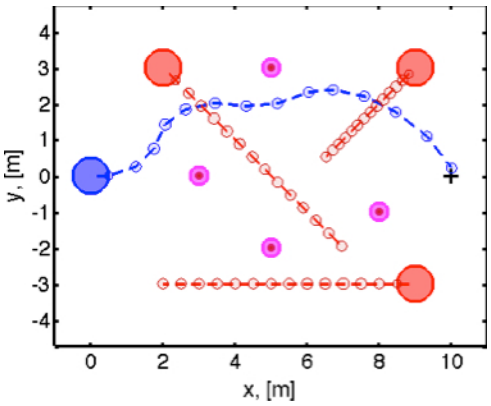


Figure 1: A robot navigating a DCUE with static (magenta) and dynamic (red) obstacles. OL approaches (above) fail to find solutions due to conservatism while the PCL approach (below) succeeds.



Additionally, PCLRHC is applicable to planning for information problems: the robot's actions affect the quality of anticipated information. In particular, the approach can be applied in dynamic environments. Example problems include dynamic surveillance, active sensor placement, and adaptive sampling.

Additional details available at: http://robotics.caltech.edu/~ndutoit/wiki

DIRECTOR'S CORNER

The rapid pace of robotics research provides both an opportunity and a challenge for academia, industry, and defense institutions to partner and shape the field of unmanned and autonomous systems. CRUSER continues to help facilitate interaction, integration, and innovation by leveraging existing relationships and continually forging new ones. By doing so, the CRUSER Community of Interest can collectively lead, rather than lag, the robotics revolution, as illustrated by contributions in this issue's articles from academic, research, and industry partners

Dr Timothy H Chung
CRUSER Director of Research and Education

Sailbot 2011

by Paul H. Miller D.Eng. PE
Assoc. Prof. of Naval Architecture, United States Naval Academy

The outcome was in doubt until the very end. Would the defending champion be able to make it across the line in full autonomous mode or would the strong winds cause a failure that would give the competition to the upstart challenger? Such was the finish of the 5th International Robotic Sailing Competition (alias "SailBot 2011") held at the United States Naval Academy from June 13-16, 2011. The event, designed for undergraduate engineering programs, featured events testing the capabilities of the SailBots, two-meter long autonomous sailboats designed, built and operated by the students. Four schools from Canada (University of British Columbia, Royal Military College, Queens University and Memorial University of Newfoundland) went to Annapolis to race against the sole US entry (USNA). The five events that comprised the competition included a design presentation, a precision navigation contest, a station keeping and timing event, a 10 km race and two short fleet races (under RC mode). The events were selected to demonstrate different boat capabilities, from speed to autonomy, and supported a logical development path beginning with a basic boat to a complex autonomous robotic system.

Each team was able to demonstrate reliable sailing and remote control, but the teams had varying success with autonomous control. Making that more difficult were the conditions in the Severn River, which ranged from calm to 20 knots and waves up to 2-3 feet. Breakdowns in either the boat or the controls were common, but the students were quickly able to diagnose and fix their boats, although some put in late hours to be on the starting line the next morning.

Each event was worth 10 points, creating a maximum of 50 potential points.

Four years ago the top school scored 22.7 points. In the following years the winners scored increasingly higher scores. This year's winner scored 40.8 points, a new high, and just 0.7 points ahead of the second place boat.

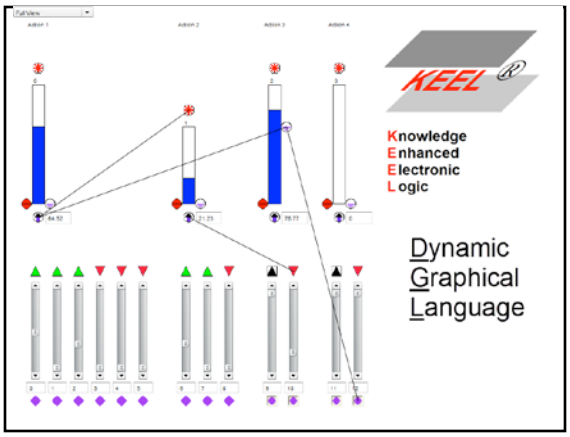
Struggling against the building winds its largest rig was not designed for, "Gill the Boat," from the Naval Academy finished the Long Distance Race in fully autonomous mode, keeping the perpetual trophy at the Academy for another year and holding off a resurgent UBC team. SailBot 2012 will be hosted by UBC and promises to be a great event. For more information see:

http://www.sname.org/SNAME/SailBot2011/Home/Default.aspx

SailBot 2011 entire fleet (L-R Queens, MUN, UBC, RMC, USNA3, USNA4)

KEEL Technology

by Tom Keeley, President Compsim LLC

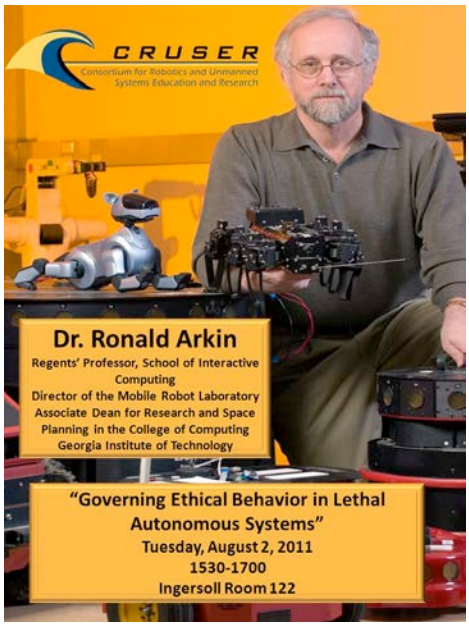


Compsim is a "technology provider" that has created a new way to process information. "Knowledge Enhanced Electronic Logic (KEEL® Technology) allows devices to exercise judgment and reasoning. Tools facilitate the implementation of a technology. The KEEL Toolkit incorporates a "Dynamic Graphical Language" (DGL) that allows subject matter experts (SMEs) to capture, test, package, audit, and explain human-like judgment and reasoning. The ability to exercise judgment and reasoning has historically separated humans from machines. In humans, the left hemisphere of the brain is used to sequentially process rules (like a computer's IF|THEN|ELSE logic). The right hemisphere of the brain processes information using a parallel, analog, balancing act that is more of an image processing function. This allows humans to address conflicting goals and make soft decisions about "how much". Weighted information is balanced to make judgmental decisions and allocate resources. KEEL 'cognitive' models are packaged as platform and architecture independent KEEL Engines for deployment in devices and software applications. KEEL models are explicit, (100% explainable and auditable), which makes KEEL Technology suitable for safety critical systems and for systems where there may be ethical considerations.

The interactive nature of the DGL makes it easy to define behavior for complex (dynamic, non-linear, inter-related, multi-dimensional) problem sets. The SMEs gets immediate feedback as they can see how information propagates through the entire system (all without resorting to higher mathematics or coding/compiling/debugging). The SME defines how information is to be interpreted in a dynamic environment, rather than how to address a specific situation. Models are created with drag and drop techniques to define functional relationships (directed graphs on steroids, or a new form of interactive calculus). Using "language animation" a link can be established between a device and the KEEL Toolkit, so one can watch the device think in almost real time.

For additional information and a demonstration, please visit: http://www.compsim.com/demos/d18/ShowKEELDemo1.html

Upcoming CRUSER Sponsored Events



CRUSER Sponsored lecture by Dr Ronald Arkin, in conjunction with the Consortium on Emerging Technologies, Military Operations, and National Security," (CETMONS) a coalition of Notre Dame, GA Tech, Cal Poly, and Arizona State. Please contact Prof George Lucas at grlucas@nps.edu for additional information.

The upcoming Warfare Innovation Workshop held during NPS's Fall Enrichment Week. The concepts generated here will be used for the next two years throughout development and experimentation to determine their feasibility for use. Please contact CAPT (ret) Carol O'Neal at cjoneal@nps.edu for additional information

STUDENT RESEARCH: IN-PROGRESS

CDR CHAS HEWGLEY
Electrical/Computer Engineering Doctoral Candidate

TITLE: "AUTONOMOUS PARAFOILS: TOWARD A MOVING TARGET CAPABILITY"
COMMITTEE CHAIRMAN: PROFESSOR ROBERTO CRISTI (ECE)
ADVISORS: PROFESSOR OLEG YAKIMENKO (SE/MAE) AND PROFESSOR XIAOPING YUN (ECE)

During the last decade, research has intensified in the area of autonomous aerial delivery systems (ADSs). These are autonomous vehicles that are deployed in the air from an aircraft, rocket, or balloon and descend to the earth under a steerable round parachute or rectangular parafoil canopy. Modern ADSs have achieved a high degree of accuracy in guiding toward a fixed target on land. Advanced guidance algorithms being developed at the NPS Aerodynamic Decelerator Systems Center under the direction of Professor Oleg Yakimenko strive to enable landing of an ADS on a moving platform such as a ship at sea.

Autonomous Aerial Delivery System

With a goal of demonstrating the utility of precision aerial delivery in the maritime domain, the current research focuses on implementing novel sensors and algorithms in the small-scale prototype "Snowflake" ADS. The challenges faced by an ADS as it attempts a shipboard landing with either a cooperative or non-cooperative target include first estimating the position and velocity of the moving target landing platform. The next step involves designing a landing trajectory in inertial space in order to enable a successful landing on an appropriate area of the target ship while avoiding collision with the ship's superstructure. This dissertation investigates wind modeling techniques and visual target tracking and guidance methods to enable shipboard landing of an ADS. Field experimentation has been conducted at Camp Roberts, CA, demonstrating in flight test advanced wind modeling and target position beacon tracking algorithms that enabled the Snowflake ADS to land within five meters of a target moving with constant speed and direction.

Thesis Topic Submission by DoD Organizations

Does your DoD Organization have a potential graduate thesis topic related to unmanned systems they would like to find NPS students to research? CRUSER has funds for student travel to support thesis research and attend experiments in CRUSER related topics. Please contact Lisa at cruser@nps.edu

CALENDAR OF EVENTS

The CRUSER Calendar of Events is located on our Wiki:
https://wiki.nps.edu/display/CRUSER/

Submit your events:
http://www.nps.edu/Research/cruser/cruser_EventSub_Form.html

CRUSER COORDINATION GROUP

CAPT Jeff Kline, USN, ret
CRUSER Director
Dr Timothy H. Chung
CRUSER Director, Research & Education
CAPT Carol O'Neal, USN, ret
CRUSER Director, Innovation
Lisa Trawick
CRUSER Operations Manager

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CRUSER News Contributions

Short articles of about 200-300 words are needed for future CRUSER News'. Please contact Lisa Trawick at cruser@nps.edu for additional information