Curriculum Vitae
Liam Paull

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Languages:	English and French

Education

2008 - Present	Ph.D., Electrical and Computer Engineering
	University of New Brunswick
	Advisor: Dr. Mae Seto and Dr. Howard Li
	Thesis Title: "Autonomous Underwater Vehicles for Mine Countermeasures"
	Expected Completion: Spring 2013
2007 - 2008	M.Sc., Electrical and Computer Engineering (Not Completed)
	University of New Brunswick
	Advisor: Dr. Liuchen Chang
	Topic: "Advanced Control of Domestic Water Heaters for Demand Side Management"
	Note: Fast-tracked to Ph.D. Results were published in [J4].
2001 - 2004	B.Sc.
	Computer Engineering
	McGill University

Research Interests

Scalable and Consistent Cooperative Localization

The primary objective in this work is achieve a best approximation to multi-AUV maximum a posteriori trajectory estimation notwithstanding the limited underwater acoustic communications channel. In order to achieve constant-time scalability an adaptive sliding window approach is used where vehicles selectively eliminate old poses from the pose graph once they are no longer being updated. In order to maximize the use of the acoustic channel, a careful tradeoff between transmission or raw data and state beliefs is made. Preliminary testing is complete, final field testing will be completed in 2013.

Probabilistic Area Coverage

This work aims to bridge the gap between state estimation and area coverage. In the vast majority of cases in the coverage planning literature, vehicle location uncertainty is not explicitly considered. Here, I

form a link between these two fields. As a result it is shown that full trajectory estimation, or smoothing, should be used rather than filtering to achieve the filtering objective. In addition, I develop some coverage planning algorithms that can operate within this probabilistic framework based on information gain. The proposed method has implemented and tested on AUVs performing seabed coverage.

Sensor-Driven Coverage Path Planning

A path planning algorithm has been developed for robust sensor-driven area coverage. The method has been shown to be generally applicable as it has been implemented and tested for coverage with AUVs using sidescan sonar seabed mapping sensors([J2] [C8]) as well as fixed-wing UAVs with cameras([J6]). The method achieves coverage in a behaviour-based framework where greedy information gain actions are traded off against actions that will help achieve the global coverage mission objective.

Multi-Robot Simultaneous Localization and Mapping

I have supported my colleague Sajad Saeedi in his work on multi-robot SLAM. Several different methods have been used to fuse occupancy grid maps from different robots without any knowledge of the relative transformation or overlap between the maps. See [J3] [C5] [C4] [C6] [C3].

Other areas where I have experience include: State estimation, object recognition, image processing, path planning with uncertainty, coverage path planning, simultaneous localization and mapping, multi-robot cooperation and SLAM. I have experience implementing algorithms for all of the above on underwater, ground, and aerial robots.

Research Experience

2010 - 2012	Research Assistant - Research personnel for Defence R&D Canada contract W7707-115128/A phases 1,2, and 3.

Description:
- Phase I: Develop a multi-agent AUV system for countering undersea threats with MIRO and MOOS-IvP. Developed methods are simulated and also tested in water in Halifax.
- Phase II: Refine the existing path planning algorithms for the multi-AUV system.
- Phase III: Revise general path planning approaches to suit the AUV mine countermeasures task. For each detected mine, autonomously produce a path that provides a specified number of looks at the object of interest from different angles.

Deliverables:
- Technical reports [TR4] [TR2] [TR1]
- Monthly status reports
- Fully documented C++ code
- In water demonstration of phases I and II.

2011	Research Assistant - Research personnel for Defence R&D Canada Atlantic contract.

Description: Compile and organize recent literature on underwater navigation methodologies.
Deliverables:
- Technical report [TR3]

- Searchable database with indexed papers with summaries

2010   Research Assistant - Research personnel for Defence R&D Canada Atlantic contract.
           Description: Develop an automated set of techniques which can generate optimal or
           near-optimal mission plans for an AUV mine countermeasures survey.
           Deliverables:
           - Technical reports [TR6] [TR5]
           - Monthly status reports

2009   Research Assistant - Assemble and debug production level wind and solar power con-
           verters.

Teaching Experience

Winter 2012   Teaching Assistant - Systems and Control (EE3312).
               - Delivered lectures in professor's absence
               - Lead tutorial sessions
               - Graded assignments, midterms and finals.
               - Overall review score 3.57/4

Fall 2010   Teaching Assistant - Industrial Control (EE4323).
               - Supervised lab sessions
               - Graded lab reports
               - Equipment used: Matlab

Winter 2009   Teaching Assistant - Electrical Machines (EE3612).
               - Supervised lab sessions
               - Graded lab reports
               - Equipment used: transformers, synchronous machines, induction machines, DC
                 motors/generators

Winter 2008   Teaching Assistant - Safety Critical Systems (EE4433).
               - Supervised lab sessions
               - Graded lab reports
               - Equipment used: Matlab/Simulink interface.

Fall 2007   Teaching Assistant - Digital Systems (CMPE2213).
               - Supervised lab sessions
               - Graded lab reports
               - Equipment used: VHDL, Altera FPGA board, Quartus.

Winter 2004   Teaching Assistant - Discrete Mathematics (McGill) (MATH 363).
               - Grading assignments

Fall 2003   Teaching Assistant - Intermediate Calculus (McGill) (MATH 262).
               - Lead weekly tutorials

Supervisory Experience

2012   Denise Sweet - Master's student
           - Fusing RGB and thermal imagery

2011   Scott Mallais - 4th year undergraduate student
           - Underwater acoustic communications

2011   Unmanned Systems Canada UAV/UGV competition team leader

- Unmanned ground vehicle winners of both Phase I (design) and Phase II (implementation)(YouTube video)

2010   Yao Kok and Shang Yang - 4th year undergraduate students
            - Hexagon cell decomposition for coverage of non-convex polygons

2009   Derek McKay - 4th year undergraduate student
            - Testing of domestic electric water heater model

Awards/Honours

2010-2012   NSERC CGS-D award ($35,000/year grant for 2 years)
2008-2009   Board of governors merit award, University of New Brunswick (comes with $3,000 grant)
2008-2009   NSERC PGS-M award ($17,000/year for 2 years)
2008-2009   Emera Graduate Scholarship ($6000)
2002   NSERC Undergraduate Student Research Award ($5250)
2001-2004   Duggan Scholarship, McGill University ($4000/year for 4 years)
2005   McGill Certificate of Merit
2002   Dean's Honor List (McGill University)
2001   Outstanding Contribution to Student Life Award (John Abbott College)

Publications

Journal Articles Accepted or Published

[J1] Liam Paull, Sajad Saeedi, Mae Seto, Howard Li. "AUV Navigation and Localization - A Tutorial and Review." *IEEE Journal of Oceanic Engineering.* Conditionally Accepted.

[J2] Liam Paull, Sajad Saeedi, Mae Seto, Howard Li. "Sensor-Driven Online Coverage Planning for Autonomous Underwater Vehicles." *IEEE/ASME Transactions on Mechatronics.* Early Access.

[J3] Sajad Saeedi, Liam Paull, Mike Trentini, Howard Li. "Neural Network-based Multiple Robot Simultaneous Localization and Mapping". *IEEE Transactions on Neural Networks.* 22(12), p2376 - 2387. 2012.
      - Responsible for algorithm formulation and manuscript preparation

[J4] Liam Paull, Howard Li, Liuchen Chang. "A Novel Domestic Electric Water Heater Model for a Multi-Objective Demand Side Management Program." *Electric Power Systems Research.* 80(12), pp1446-1451. 2010.

[J5] Howard Li, Liam Paull, Yevgen Biletskiy, Simon Yang. "Document Classification Using Information Theory and a fast Back-Propagation Neural Network." *Intelligent Automation and Soft Computing.* 16(1), p25-38. 2010.
      - Responsible for multi-valued neuron formulation and implementation as well as helped with manuscript preparation

Journal Articles Currently Under Review

[J6] Liam Paull, Carl Thibault, Amr Nagaty, Howard Li. "Sensor-Driven Area Coverage for an Autonomous Fixed-Wing Unmanned Aerial Vehicle." *IEEE Transactions on Systems, Man, and Cybernetics - Part B.* Submitted July 11, 2012.

[J7] Sajad Saeedi, Liam Paull, Michael Trentini, Mae Seto and Howard Li. "Map Merging for Multiple Robots Using Hough Peak Matching." *Robots and Autonomous Systems*. Submitted December 2012.

Book Chapters

[B1] Liam Paull, Sajad Saeedi, Howard Li. "Path Planning for Autonomous Underwater Vehicles." in *Autonomy for Marine Robots*. Springer 2012. Editor: Dr. Mae Seto. p177-224.

[B2] M.L. Seto, L. Paull, S. Saeedi. "Introduction to Autonomy for Marine Robots." in *Autonomy for Marine Robots*. Springer 2012. Editor:: Dr. Mae Seto.

Refereed Conference Publications

[C1] Liam Paull, Sajad Saeedi, Mae Seto, Howard Li. "Sensor Driven Online Coverage Planning for Autonomous Underwater Vehicles." *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*. 2012.

[C2] Liam Paull, Gaetan Severac, Guilherme V. Raffo, Julian M. Angel, Harold Boley, Maki K. Habib, Bao Nguyen, Veera R. S. Kumar, Sajad Saeedi G., Ricardo Sanz, Mae Seto, Aleksandar Stefanovski, Michael Trentini, Howard Li. "Towards An Ontology for Autonomous Robots." *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*. 2012.
   - Invited paper

[C3] Sajad Saeedi Gharahbolagh, Liam Paull, Michael Trentini, Mae Seto, Howard Li. " Map Merging Using Hough Peak Matching." *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*. 2012.

[C4] Sajad Saeedi Gharahbolagh, Liam Paull, Michael Trentini, Mae Seto, Howard Li. "Efficient Map Merging Using a Probabilistic Generalized Voronoi Diagram." *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*. 2012.

[C5] Sajad Saeedi Gharahbolagh, Liam Paull, Michael Trentini, Howard Li. "Neural Network-based Multiple Robot Simultaneous Localization and Mapping." *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*. p.880-885. 2011.

[C6] Sajad Saeedi Gharahbolagh, Liam Paull, Michael Trentini, Howard Li. "Multiple Robot Simultaneous Localization and Mapping." *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*. p. 853-888. 2011.

[C7] Liam Paull, Sajad Saeedi G., Mae Seto, Howard Li. "A Multi-Agent Framework with MOOS-IvP for Autonomous Underwater Vehicles with Sidescan Sonar Sensors." *International Conference on Autonomous and Intelligent Systems*. p. 41-50. 2011.

[C8] Liam Paull; Sajad Saeedi; Howard Li; Vincent Myers. "An Information Gain Based Adaptive Path Planning Method for an Autonomous Underwater Vehicle Using Sidescan Sonar." *IEEE Conference on Automation Science and Engineering (CASE)*. pp.835-840. 2010.

[C9] Arnaldo Sepulveda, Liam Paull, Walid G. Morsi, Howard Li, Chris P. Diduch, Liuchen Chang. "A Novel Demand Side Management Program Using Water Heaters and Particle Swarm Optimization." *Electric Power and Energy Conference (EPEC)*. pp.1-5. 2010.

[C10] Liam Paull, Derek MacKay, Howard Li, Liuchen Chang. "A Water Heater Model for Increased Power System Efficiency." *Canadian Conference on Electrical and Computer Engineering (CCECE)*. pp.731-734. 2009.

[C11] Liam Paull, Howard Li, Liuchen Chang. "The development of a fuzzy neural system for load forecasting." *Canadian Conference on Electrical and Computer Engineering (CCECE)*. pp.923-926. 2008.

Abstract Refereed Conference publications

[C12] Liam Paull, Carl Thibault, Amr Nagaty, and Howard Li. "MOOS-IvP, a middleware for ... UAVs?" *Unmanned Systems Canada Conference*. November 2012.
  - **Best Student Paper Award Finalist**

[C13] Sajad Saeedi , Liam Paull, Michael Trentini , Mae Seto and Howard Li. "Multiple Robot Map Fusion in GPS-denied Environments." *NATO RTO Sensors & Electronics Technology (RTO-SET) Panel Symposium SET-168 on Navigation Sensors and Systems in GNSS Denied Environments* October 2012.

[C14] Liam Paull. "MOOS-IvP Middleware for AUVs." *Unmanned Systems Canada Conference*. September 2011.

[C15] Liam Paull, Sajad Saeedi, Tyler Edwards and Howard Li. "Perception and Navigation of a UGV for Forest Fire Fighting." *Unmanned Systems Canada Conference*. 2011.
  - **Best Student Paper Award Finalist**

Technical Reports

[TR1] Liam Paull, Sajad Saeedi, Howard Li. "Coverage Path Planning for Autonomous Underwater Vehicles." DRDC TR W7707-115128 - Phase III. March 2012.

[TR2] Liam Paull and Howard Li. "Sensor-Driven Coverage Path Planning for Multiple Autonomous Underwater Vehicles." DRDC TR W7707-115128 - Phase II. March 2012.

[TR3] Liam Paull and Sajad Saeedi. "AUV Navigation and Localization - A Review of Recent Results." August 2011.

[TR4] Liam Paull. "Further Development on the DRDC Multi-Agent System for Countering Underwater Threats." DRDC TR W7707-115128 - Phase I. March 2011.

[TR5] Liam Paull, Sajad Saeedi Gharahbolagh, and Howard Li. "Coverage Path Planning for an Autonomous Underwater Minesweeping Vehicle Equipped with Sidescan Sonars - A Deliberative Approach." April 2010.

[TR6] Liam Paull, Sajad Saeedi Gharabolagh, and Howard Li. "Coverage Path Planning for an Autonomous Underwater Minesweeping Vehicle with Sidescan Sonars - A Reactive Approach." April 2010.

Successful Grant Applications

1. "Acoustic Noise Reduction in Power Converters" National Science and Engineering Research Council. Post-Graduate Scholarship (PGS-D). $70000.

2. "Water Heater Control for Demand Side Management" National Science and Engineering Research Council. Post-Graduate Scholarship (PGS-M). $34000.

3. "Underwater Mine Counter-Measures and Mapping Surveys with Multiple Autonomous Underwater Vehicles Using MOOS-IvP, MIRO and the Sensor Driven Approach." Defense R&D Canada Solicitation No. W7707-115128/A. $50000.
   - Application co-written by Liam Paull and Dr. Howard Li.

Services

Journals reviewed

- IEEE Transactions on Systems, Man, and Cybernetics - Part B
- IEEE Journal of Oceanic Engineering
- International Journal of Robotics and Automation
- International Journal of Advanced Robotic Systems
- Neurocomputing

Conferences reviewed

- BioRob 2012
- Canadian Conference on Computer and Robot Vision 2012
- IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS) 2011
- Canadian Conference on Electrical and Computer Engineering (CCECE) 2008, 2009

Conference Session Chairs

- IEEE/RSJ Conference on Intelligent Robots and Systems (IROS) 2012
- IEEE Conference on Automation Science and Engineering (CASE) 2010

Presentations and Lectures

Invited Talks

Jan. 2013	University of New Brunswick Graduate Speaker Series "The State of the Art in Underwater Robotics
Nov. 2012	McGill University Centre for Intelligent Machines "AUVs for Mine Countermeasures"
Nov. 2012	University of Southern California Robotic Embedded Systems Laboratory AUVs for Mine Countermeasures - Robust Online Coverage Planning for Single and Multiple AUVs

Lecture series

Mar. 2012	"Lessons Learned from the Diploma in University Teaching" [6 sessions]
May 2010	"The More you Know - The Information Gain Approach to Path Planning" [6 hours]

Scholarly Talks

Jan. 2013	Massachusetts Institute of Technology "AUVs for Mine Countermeasures - Robust Online Coverage Planning for Single and Multiple AUVs"

Apr., 2012	University of Toronto Institute for Aerospace Studies 3rd Workshop on Multi-Vehicle Planning, Estimation, Control, and Applications "Autonomous Underwater Vehicles for Mine Countermeasures"
Mar., 2012	University of New Brunswick Proposal Presentation "Autonomous Underwater Vehicles for Mine Countermeasures"
Dec. 2011	University of New Brunswick With South Korea Agency for Defense Development Research Scientists "Unmanned Systems - UAVs, UGVs, AUVs, Autonomy, Control, SLAM, Multi-Agent Systems" (with COBRA team)
Nov. 2011	Halifax, NS Unmanned Systems Canada Conference "A Multi-Agent Framework with MOOS-IvP for Autonomous Underwater Vehicles"
Nov. 2011	Halifax, NS Robotics and Autonomous Systems General Meeting "Unmanned Systems - UAVs, UGVs, AUVs, Autonomy, Control, SLAM, Multi-Agent Systems" (with COBRA team)
Jul. 2011	University of New Brunswick "AUV Navigation - A Review"
Jul. 2011	Massachusetts Institute of Technology MOOS Development and Applications Working Group "Bhv_InformationGain"
Jun. 2011	Burnaby, BC International Conference on Autonomous and Intelligent Systems "A Multi-Agent Framework with MOOS-IvP for Autonomous Underwater Vehicles with Sidescan Sonar Sensors"
Jun. 2011	Burnaby, BC International Conference on Autonomous and Intelligent Systems - Autonomous Vehicles Workshop "MOOS-IvP Middleware for AUVs"
May. 2011	CFB Valcartier Unmanned Systems Canada student competition "COBRA UGV Student Competition Design"
May. 2011	CFB Valcartier Unmanned Systems Canada student competition "COBRA UAV Student Competition Design"
Mar. 2011	Defense R&D Canada - Atlantic "Summary of AUV Path Planning and Cooperative Navigation Work To Date"
Mar. 2011	Halifax, NS Nova Scotia Oceans Science and Marine Technology Industry-University Connections Session "Multiple Autonomous Underwater Vehicles"

Mar. 2011	University of New Brunswick "AUV Kinematics and Dynamics"
Feb. 2011	Defense R&D Canada - Valcartier "Multi-Agent Systems and Multi-Robot Path Planning" (with COBRA team)
Nov. 2010	University of New Brunswick "Introduction to Player/Stage/Gazebo"
Sep. 2010	Dalhousie University Autonomous Underwater Vehicle Workshop "Motion Planning, Navigation, and Multi-Agent Control" (with COBRA team)

Skills
- Programming languages: C++, C, Java, Python, Perl, Matlab/simulink, Maple.
- Robotics Middlewares: MOOS-IvP, ROS, Player/Stage, MIRO.
- Operating systems: Windows and Linux.
- Open source software: OpenCV, Gazebo, iSAM.
- Source control software: SVN, CVS.
- Hardware experience:
    - Field experience deploying multiple Iver2 AUVs to test developed algorithms in Dartmouth, NS
    - Testing coverage planning and automatic target recognition algorithms on fixed-wing UAV
    - Implementation of path planning and automatic target detection algorithms on CoroWare's CoroBot for Unmanned Ground Vehicle competition

Affiliations and Certifications
- IEEE student member (since 2007)
- Unmanned Systems Canada (USC) student member (since 2010)
- Association for Unmanned Vehicle Systems International (AUVSI) student member (since 2011)
- Collaborative Based Robotics and Automation (COBRA) member (since 2008)
- Completed Diploma in University Teaching (DUT)

Media Coverage
- CBC New Brunswick feature on COBRA at 13:19 here
- "University students win unmanned ground vehicle competition" (www.unmanned.co.uk)
- Fredericton's Daily Gleaner article

Other Services and Activities
- Let's Talk Science Partnership Program
- President of Association for Electrical Engineering Graduate Students 2010-2011
- COBRA lab network administrator - responsible for maintaining SVN repository and website.
- University of New Brunswick Rock and Ice Club Executive 2010-2012
- Fredericton SPCA Volunteer

References

Available upon request
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