Hierarchical State Estimation of an Underwater Robot in a Feature Sparse Environment

south carolina honors college

Undergraduate Research and Scholars Program

Student information

Name	Hunter Jarrett Damron	**Email**	▓▓▓▓▓	
Major(s)	Computer Science, Mathematics	**Minor(s)**		
Local phone	▓▓▓▓▓	**Cum. credit hours**	▓▓	**Cum. GPA** ▓▓
Local address	▓▓▓▓▓	**USC ID**	▓▓▓▓▓	
Columbia, SC 29201		**Student VIP#**	▓▓▓▓▓	

Title of Grant Project: Hierarchical State Estimation of an Underwater Robot in a Feature Sparse Environment

Research mentor information

Name	Ioannis Rekleitis	**Email**	▓▓▓▓▓
Campus phone	▓▓▓▓▓	**Dept**	Computer Science

Type of application (check one)

[✓] Science Undergraduate Research Fellowship (SURF)

[ ] Exploration Scholars Program

Term(s) for which you are applying   ☑ Spring   ☑ Summer   ☑ Fall   Year: 2019-20

Project proposal

Brief description of faculty member's research program area

Dr. Rekleitis leads the Autonomous Field Robotics Lab (AFRL) which aims "to research mobile robotics and in particular cooperating intelligent agents with application to multi-robot cooperative localization, mapping, exploration and coverage." His personal research interests include "Mobile Robotics, Space Robotics, Multi-Robot Systems, Sensor Networks, Artificial Intelligence, Computer Vision and Image Processing, Computational Geometry, [and] Computer Graphics." Dr. Rekleitis aims to provide experimental verification to various problems using field robots in addition to theory and simulation. His work is often focused on the use of robots for environmental goals such as coastal environment monitoring and cave mapping.

Research question or general area of interest to be pursued

The goal of this project is to develop a robust state estimator which augments a visual inertial odometry (VIO) system with an estimate of the robot's motion commands. VIO is commonly used for robot localization, especially underwater where there is no GPS signal, but it requires an environment with rich visual features to work properly. The proposed method will remove this restriction by using a primitive estimate as a fallback to VIO while still maintaining the pose graph used for loop detection. This combined odometry will greatly extend the navigable range of underwater robots and allow safer path planning. If successful, this project will improve the ability of autonomous robots to be used for oceanographic and environmental objectives.

Daily activities in which the student will be engaged (i.e., data analysis, literature review, lab tests, etc.)

I have worked in this lab for three semester, and I have already begun reviewing literature on VIO to become familiar with the current system and identify situations in which it will fail. I have also worked with the current VIO system on the Aqua2 robot for field trials in Barbados. I will begin by constructing a primitive estimate of the mapping from motion commands to resulting movements by conducting pool trials with the Aqua2. By running VIO on previously collected data, I will develop a test of the feature density of the environment and the quality of the produced odometry. This test will allow me to combine the outputs of the primitive estimator and VIO, weighted based on the VIO quality test. I will also feed this combined odometry back into the VIO system to influence future estimation. We will verify this functionality through pool and field trials of the Aqua2 robot.

Description of educational benefit to student (e.g. presentations at Discover USC, learned research skill, motivations, etc.)

Because I plan to pursue a Ph.D. degree in theoretical computing and become a researcher in the field, my work in AFRL is a strong preparation for a life of research. I chose AFRL as my introduction to research because of my previous robotics experience in high school, and although I will not continue working in robotics during graduate school, I will continue to use much of what I have learned about probability, geometry, and linear algebra. Using the Robot Operating System (ROS) framework to control various robots has made me a better programmer in C++ and Python. I have also become familiar with the Aqua2 robot and will continue to work with it during this project. Aside from technical skills, I have learned much from being a member of a research team and from presenting my previous work at the IROS 2018 conference in Madrid. I hope to develop this project into a paper worth presenting at future robotics conferences and at the Discover USC presentation day.

Have you received SCHC funding in the past? If so, please briefly describe the project, its outcome, & the funding amount and semesters it occurred.

I received the SCHC Scholarly Research Travel Support Grant to support my travel to Madrid, Spain for the IROS 2018 robotics conference in the fall semester of 2018. At the conference, I presented my work on bearing-only cooperative localization for underwater cave mapping, a technique in which two sensors determine the distance and relative orientation between them using bright lights. I also had the opportunity to network with other underwater robotics researchers and learn about many different areas of robotics. The grant provided $500 toward the travel cost.

Budget (e.g. student stipend, # hrs per week x $10.00/hr, funding period)

Item

$10/hour

Funding Period Effective: July 1 - June 30, 2020

Estimated Schedule: *If awarded this grant, I request funds be available effective June 1

Fall Semester while classes are in session:

$10/hour * __4__ hr/day * __2__ days/week * __15__ weeks = $ __1200__

Fall Semester during breaks (including Winter Break):

$10/hour * __4__ hr/day * __5__ days/week * __2__ weeks = $ __400__

Spring Semester while classes are in session:

$10/hour * __3__ hr/day * __2__ days/week * __15__ weeks = $ __900__

Spring Semester during breaks:

$10/hour * ____ hr/day * ____ days/week * ____ weeks = $ ____

Summer:

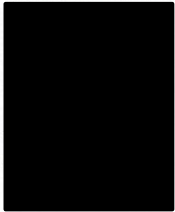$10/hour * __1__ hr/day * __5__ days/week * __10__ weeks = $ __500__

Additional Notation (i.e., planned vacation, etc.):

I applied for CEC McNair Junior Fellows scholarship which would cover 30 hours per week this summer, but I plan to work 35 hours per week as I did last summer so I am counting the remaining 5 hours here. If I do not receive the McNair grant or I work somewhere else, I would not draw from the SURF grant this summer. Like this past winter break, I plan to spend at least 2 weeks during winter break working in Barbados conducting field trials with the robot. This will be 20 hours per week, conservatively. Currently, I aim to work 10-15 hours per week with Dr. Rekleitis, but I work fewer hours because of schoolwork some weeks and many more near conference deadlines. I may be working on a capstone computing project in the spring so I may have less time to work on this project during that semester.

Grand Total: $3000

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Past, current, and pending support

List here **all supplemental support** you have received from the Honors College or other university office (e.g. Office of Undergraduate Research) **or source outside the university**. Please report any funding you have received (or hope to receive) in addition to university and/or state scholarships to support your research and educational efforts. *If you're not sure if you should include it, go ahead and add it.*

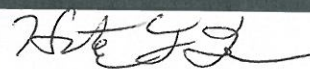| Granting agency/unit	Proposal title/topic	Date of award (or pending)	Amount
Office of Fellowships and Scholar Programs, Carolina Scholar		Fall 2017	███
South Carolina Commission on Higher Education, Palmetto Fellows		Fall 2017	
Office of Undergraduate Admissions, Presidential Scholarship		Fall 2017	
IEEE, IROS Student and Developing Countries Travel Award		Aug. 30, 2018	
Office of Undergraduate Research, Magellan Voyager Award		Aug. 17, 2018	
SCHC, Scholarly Research Travel Support Grant		Aug. 17, 2018	
College of Engineering & Computing, McNair Junior Fellows Award		Pending	

Examples:

University of South Carolina, McNair Scholarship	Aug. 23, 2018	$XX,XXX
Boy Scouts of America, Outstanding Scout	July 4, 2018	$XX,XXX
Office of Undergraduate Research, Magellan Grant	Dec. 5, 2018	$XX,XXX

I certify that I am in support of this project.

Faculty signature _(signature)_

Student signature _(signature)_

Does this project require IRB approval?

No

If so, will you receive the required training?

N/A

By signing below, I understand that, if awarded this grant, I will be required to take the CITI Responsible Conduct of Research (RCR) module or one appropriate to my discipline, as chosen by my mentor. I also understand that, if awarded this grant, I will be required to register my research within the university-wide Research Registry.

(signature)   2019 - 04 - 17