Faculty Member: Dr. Hector Ochoa **Faculty ID:** 202284630
Department: Physics, Engineering and Astronomy **Faculty Email:** ochoah@sfasu.edu

Have you previously received a SURE award? Yes **If yes, when?** Summer 2018

If yes, how did you disseminate results from previous awards (successfully published a paper or obtained a grant, submitted paper or grant based on results, presented results at external conference, etc.):

The project is still an ongoing project. We are in the process of collecting data. Once the data has been collected, it will be used to write a journal paper. The student will be presenting the results obtained during the summer and the fall of 2018 at the AAPT/APS/SSP Spring Meeting.

Student's Name: Robyn Jillian Logan **Student ID:** 10589244
Major: CSC and Engineering Physics - Electrical **Student Email:** loganrj@jacks.sfasu.edu

Have you previously received a SURE award? No **If yes, when?**

Proposed SURE Project

Title of proposed SURE project: A Simple Biologic Connectome in a Flight Capable Device

Description of proposed project (describe the scope of the project, including specific objectives):
A simple biologic connectome will be converted to Python code and uploaded to a quadcopter. The connectome to be used is of the worm C. Elegans. The goal of the research project is to achieve stable flight and hovering, avoid obstacles, and have stable flight for a period of at least 5 minutes. This whole process will require the training of the connectome to learn how to use the sensors' outputs, and use them to maintain flight.

Is this a new project or a continuation of a current project? If a continuation, what new work will be done as part of SURE?
This is a new project.

Potential impact or significance of research:
Show that the connectome of an organism that is much simpler than any flying organism is capable of adapting to flight. Furthermore, the team will identify the necessary adaptations to the connectome in order to achieve the desired research goals.

Research Design (approach/methodology):
First, the connectome will be loaded into a smaller drone using a Raspberry Pi to study its behavior, and analyze any possible difficulties that may appear. This will be a proof of concept for the project, allowing the research team to move forward with a better understanding of the problem. On the next step, the team will use a larger drone. The drone will be carrying a powerful processing unit capable of running the connectome, and learning how to flight in real-time. The experiments will be taking place at Dr. Ochoa's Research Laboratory (STEM 315), and the drone will be tethered to the table for safety purposes. Once the connectome has been properly trained, the next step will test it for stable flight and obstacle avoidance. At this moment, the research team is unsure on where these experiments are going to be conducted, but the team will make sure that all safety measures will be considered.

Literature review for project (must provide at least five peer-reviewed sources):

[1] Varshney L. R., Chen B. L., Paniagua E., Hall D. H., Chklovskii D. B. "Structural Properties of the Caenorhabditis elegans Neuronal Network," PLOS Computational Biology, Vol. 7, No. 2, February 2011 https://doi.org/10.1371/journal.pcbi.1001066

[2] Yan G., Vértes P.E., Towlson E. K., Chew Y. L., Walker D. S., Schafer W. R., Barabási A. "Network control principles predict neuron function in the Caenorhabditis elegans connectome," Nature International Journal o Science, Vol. 550, pp 519-523, October 2017 https://www.nature.com/articles/nature24056

[3] Towlson E. K., Vértes P. E., Ahnert S. E., Schafer W. R., Bullmore E. T., "The Rich Club of the C. elegans Neuronal Connectome," The Journal of Neuroscience, Vol. 33, Issue 15, pp 6380-6387, April 2013 http://www.jneurosci.org/content/33/15/6380.short

[4] Boyle J. H., Johnson S., Dehghani-Sanij A. A. "Adaptive Undulatory Locomotion of a C. elegans Inspired Robot," IEEE/ASME Transactions on Mechatronics, Vol. 18, Issue 2, pp 439-448, April 2013 https://ieeexplore.ieee.org/abstract/document/6272363

[5] Morse, T. M., Lockery, S. R., Ferrée, T. C., "Robust Spatial Navigation in a Robot Inspired by Chemotaxis in Caenorhabditis elegans," Adaptive Behavior, Vol. 6, No. 3-4, pp 393-410, January 1998 https://journals.sagepub.com/doi/abs/10.1177/105971239800600303

Project timeline (activity/task and time to complete):

Week 1: Alter connectome code to work with quadcopter I/O.
Test code using Raspberry Pi and low cost quadcopter.
Week 2: Troubleshoot code to achieve stable flight
Week 3: Upload code to Udoo on larger quadcopter
Optimize code to produce more stable flight and reliable obstacle avoidance
Week 4: Compile the changes that the connectome made to achieve stable flight and find trends
Week 5: Finalize SURE poster and present findings

Description of research and professional skills that the student will develop from the project:
A basic understanding of connectomes, motor controllers, pulse width modulation, Python programming language, and research and presentation techniques.

Description of the involvement and activities that the student and mentoring faculty will have in this project:
Programming the quadcopter with the C. Elegans connectome, interfacing the connectome with the sensors and motors onboard the quadcopter. During the summer program the student and mentoring faculty will be performing the following tasks:

1. Disassembling the quadcopters and replacing the internal circuitry with ultrasonic sensors, motor controllers, and the Raspberry Pi or Udoo.
2. Uploading the connectome, and making any changes necessary to connect motor neurons to motors, and sensory neurons to outputs from ultrasonic sensors.
3. Record in detail the process and data collected, to prepare the poster presentation and any other publications.
4. The mentoring faculty will also ensure that the project remains on schedule and the student properly executes all steps of the research.

Description of how you will disseminate results from the project:
A presentation at the Spring 2020 SPS zone meeting, and IEEE Region 5 Conference.

Budget ($0-$500 with justification):

Description	QTY	Cost
Quadcopters	2	Available
Raspberry Pi	1	$35
Udoo x86 Ultra	1	$250
Ultrasonic Sensors	5	~$20
Motor Controllers	4	~$60
Battery	1	Available

A set of quadcopters are already available at the research laboratory. The Raspberry Pi and Udoo will be used to control the drones. The Udoo will be used for the training of the neural network, while the Raspberry Pi will be used for the proof of concept. The ultrasonic sensors will be mounted on the drone, and connected to the microcontrollers to achieve stable flight. The motor controllers are needed to drive the drone's motors. Finally, batteries are already available at the department, and they will be used for this project.

Amount requested for supplies from SURE: $ ~~365.00~~ 0.00

Amount requested for supplies from department: $ ~~0.0~~ 500.00 JM

Amount department will fund faculty stipend: $ ~~0.0~~ 500.00 JM

Amount department will fund student stipend: $ 0.0

Chair approval: Joe Mennon

Chair Signature For HP

I have reviewed and agree to fulfill the expectations of the SURE award.

Student Signature

Faculty Signature

For internal purposes only:

Proposal Awarded _____ Proposal not award_____ Amount awarded: _____

Accounts to be used for award:_____