Colorado Science and Engineering Fair

2024 Individual Project Abstract Form

Please print 2 copies of the completed form. Sign both copies, keep 1 for your notebook and submit 1 copy to your Regional Fair Director with your other paperwork.

Title of Project: Unfurl: a reservoir computing algorithm for deploying origami structures

Finalist's Name: Malcolm Smith

School and City: Niwot High School, Niwot

Sponsor's Name: Jayme Sneider

Category: Engineering (ENGR)

Division: Senior (9th - 12th grades)

Abstract (250 words or less):

Origami is an incredibly useful approach for any application where a large surface needs to be manipulated and stowed in a much smaller area, such as a solar array. With origami, engineers are able to prototype a design quickly by folding, and manufacture it efficiently in a single sheet. However, there is a hard limit on the development of origami within engineering: complexity. Traditionally, as a design gets more complex and nonlinear, external, non origami mechanisms are required for an over-actuated control of the origami surface. However, this solution is limited to relatively simple structures and retracts the benefits of origami design. I tackle the problem of complexity from a control systems perspective, using a new computing paradigm: closed loop physical reservoir computing. Reservoir computing takes the complexities of a system, and transforms them into a resource, rather than a liability, for generating behavior. Under this system, nonlinearity in a system actually increases its potential for effective control loops. Unfurl is an algorithm for training a reservoir computing control loop to best accomplish a deployment task. Other implementations of reservoir computing train a given input sequence for the reservoir. In Unfurl, I instead train a given output sequence, that way the algorithm will train for optimal output, instead of following arbitrary motor input patterns. Unfurl is tested on prototype deployable origami structures, and is found to generate arbitrary motion patterns, respond well to external disturbances and has the potential to be trained for even finer control loops.

I hereby certify that the above statements are correct and the information provided in the Abstract is the result of one year's research. I also attest that the above properly reflects my own work.

Finalist's Signature: Malcolm Smith Date: 2/28/24

In addition, all students must complete the ISEF Student Checklist (1A), Research Plan, Approval Form (1B), and Checklist for Adult Sponsor (1), and any other ISEF forms required for this type of project. See the International Rules and Guidelines for form requirements. Return COPIES o all of these forms to your Regional Fair Director with you Finalist Verification/Permission Form. A signed copy of this form must be included in your notebook.