

# EILERS GRADUATE STUDENT FELLOWSHIP FINAL REPORT

<b>EILERS FELLOW:</b>	Jize Zhang
<b>FACULTY ADVISOR:</b>	Dr. Alexandros Taflanidis
<b>REPORT PERIOD:</b>	June 1 <sup>st</sup> 2017, to May 31 <sup>th</sup> 2018
<b>PROJECT TITLE:</b>	A comprehensive computational framework for layout optimization of wave energy converters that addresses large dimensional arrays, causal control and uncertain wave environments
<b>CONNECTION TO ND ENERGY'S RESEARCH AREAS (CHECK ALL THAT APPLY):</b>	<input checked="" type="checkbox"/> Energy Conversion and Efficiency <input type="checkbox"/> Sustainable and Secure Nuclear <input type="checkbox"/> Smart Storage and Distribution <input type="checkbox"/> Transformation Solar <input type="checkbox"/> Sustainable Bio/Fossil Fuels <input type="checkbox"/> Transformative Wind

## MAJOR GOALS AND ACCOMPLISHMENTS:

List your major research goals and provide a brief description of your accomplishments (1-2 sentences). Indicate the percentage completed for each goal. Please use a separate sheet to share additional details, technical results, charts, and graphics.

MAJOR RESEARCH GOALS	ACTUAL PERFORMANCE AND ACCOMPLISHMENTS	% OF GOAL COMPLETED
<b>1. Efficient hydrodynamic interaction characterization of wave energy converters (WECs)</b>	A Gaussian process based machine learning algorithm has been designed to predict the hydrodynamic interactions of large dimensional WEC arrays. The algorithm is demonstrated to yield state-of-the-art high prediction accuracy. Consequently, the computational burden of calculating hydrodynamic interaction has been significantly reduced. For addressing large-dimensional arrays the problem is decomposed into consideration of the coupling between subgroups of smaller size, for which higher accuracy of data-driven Gaussian processes is easier to facilitate. As lower order interactions are of greater importance this does not overly reduce computational accuracy	100
<b>2. Formation optimization of WECs using causal control approaches</b>	Formation (layout) optimization of WECs under uncertain wave environments was investigated using the efficient algorithms from the 1 <sup>st</sup> goal to estimate the hydrodynamic interaction between the WECs (within the array). Optimization of arrays of different sizes is examined.	70
<b>3. Formation optimization of WECs using anti-causal control</b>	Extension of the formation optimization problem using anti-causal (rather than causal) controller synthesis is also investigated. There remain several challenges that require further exploration to improve the robustness and efficiency of the causal controller. These are primarily related to noise in the objective function induced by the linearization required to formulate the optimal controller synthesis problem for a given array.	50

## RESEARCH OUTPUT:

Please provide detailed information below regarding any output resulting from your research project.

CATEGORY	INFORMATION
<b>EXTERNAL PROPOSALS</b>	(Sponsor, Project Title, PIs, Submission Date, Proposal Amount) Nothing planned in the near future at this point.
<b>EXTERNAL AWARDS</b>	(Sponsor, Project Title, PIs, Award Date, Award Amount) None directly related to this project
<b>JOURNAL ARTICLES</b>	(Journal Name, Title, Authors, Submission Date, Publication Date, Volume #, Page #s) Couple of journal articles under preparation, anticipated submission in the next 6-9 months. Will update when they become available.

<b>BOOKS AND CHAPTERS</b>	(Book Title, Chapter Title, Authors, Submission Date, Publication Date, Volume #, Page #s) N/A
<b>PUBLIC PRESENTATIONS, SEMINARS, LECTURES</b>	(Event, Presentation Title, Presentation Date, Location) No conference presentations on this year.
<b>AWARDS, PRIZES, RECOGNITIONS</b>	(Purpose, Title, Date Received) N/A
<b>INTERNAL COLLABORATIONS FOSTERED</b>	(Collaborator Name, Organization, Purpose of Affiliation) N/A
<b>EXTERNAL COLLABORATIONS FOSTERED</b>	(Collaborator Name, Organization, Purpose of Affiliation) Collaboration with Jeffrey Scruggs (Associate Professor, University of Michigan) has been further supported by the fellowship. Dr. Scruggs was on sabbatical to JPL (Pasadena, LA) for big portion of the academic year, but collaboration has continued after his return to Ann Arbor.
<b>WEBSITE(S) FEATURING RESEARCH PROJECT</b>	(URL) N/A
<b>OTHER PRODUCTS AND SERVICES</b> (e.g., media reports, databases, software, models, curricula, instruments, education programs, outreach for ND Energy and other groups)	(Please describe each item in detail) N/A

**MAJOR GOALS AND ACCOMPLISHMENTS**  
**(Additional Details, Technical Results, Charts and Graphics)**