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Ali Muhamed Ali

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"A Machine Learning Approach for Ocean Event Modeling and Prediction"

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ADVISOR:
Hanqi Zhuang, Ph.D.

PH.D. SUPERVISORY COMMITTEE:
Hanqi Zhuang, Ph.D., Chair
Nurgun Erdol, Ph.D.
Valentine Aalo, Ph.D.
Hari Kalva, Ph.D.
Behnaz Ghoraani, Ph.D.
Laurent Ch'erubin, Ph.D.

ABSTRACT OF DISSERTATION

A Machine Learning Approach for Ocean Event Modeling and Prediction

Deep learning models have been successfully applied to a variety of applications and solved many crucial tasks. The ultimate goal of this study is to produce deep learning models to improve the skills of forecasting ocean dynamic events in general and those of the Loop Current (LC) system in particular. A specific forecast target is to predict the geographic location of the (LC) extension and duration, LC eddy shedding events for a longer lead time with higher accuracy. Also, this study aims to improve the predictability of velocity fields (or more precisely, velocity volumes) of subsurface currents. In this dissertation, several deep learning based prediction models have been proposed. The core of these models is the Long-Short Term Memory (LSTM) network. This type of recurrent neural network is trained with Sea Surface Height (SSH) and LC velocity datasets. The hyperparameters of these models are tuned, accounting for each model's characteristics and data complexity. Prior to training, SSH and velocity data are decomposed into temporal and spatial counterparts. A model uses the Robust Principle Component Analysis is first proposed, which produces a six-week lead time in forecasting SSH evolution. Next, the Wavelet+EOD+LSTM (WELL) model is proposed to improve the forecasting capability of a prediction model, termed the Divide and Conquer (DAC) model, developed earlier in out lab. These models are trained to forecast two eddies, Cameron and Darwin. Experimental studies show that the WELL model outperforms the DAC model by two more weeks in lead time. More specifically, it achieves ten to fourteen weeks lead time for two eddy shedding events (e.g., separations of eddy Cameron and eddy Darwin from the LC). Furthermore, the WELL model overcomes the problem due to the partitioning step involved in the DAC model. For subsurface currents forecasting, a layer partitioning method is proposed to predict the subsurface column for the LC system. This model produces a lead time of seven days for forecasting the loop current velocity fields. A weighted average fusion is used to improve the consistency of the predicted layers of the 3D subsurface velocity structure. The main challenge of the forecasting of the LC and its eddies is the small number of events occurred over the time (once or twice a year), which makes the training task difficult. Forecasting the velocity of subsurface currents is equally challenging because of the limited in situ measurements. It is well known that deep learning algorithms perform better when longer time series are available for training. For this reason, improving the accuracy of the historical assimilated ocean data using available in situ measurements is highly desirable. We believe deep learning is the best candidate to meet these challenges in the future.

BIOGRAPHICAL SKETCH
BORN IN BAGHDAD / IRAQ

B.S., Nahrain University, Baghdad, Iraq, 2001
M.S., Nahrain University, Baghdad, Iraq, 2007
M.S., Florida Atlantic University, Boca Raton, Florida, 2016
PH.D., Florida Atlantic University, Boca Raton, Florida, 2021

CONCERNING PERIOD OF PREPARATION & QUALIFYING EXAMINATION
Time in Preparation: 2014 - 2021
Qualifying Examination Passed: Spring 2015

Published Papers:

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