

1. Introduction

This section contains four sub-sections, namely: Background, Topics and Limitation, Research Purposes, Organizational Objectives Article. Below will be explained from each of these sub-sections.

Background

Sea level information is required by operation of ports, especially for scheduling of transport navigation and operational activities in the port [1]. Moreover, the historical sea level information is required for designing coastal and offshore structures, whereas the forecast of the sea level is as well needed during the construction process of the structures. The sea level information is very helpful for all operations that takes place at sea [2].

The sea level is formed by two general components, i.e. the tidal and non-tidal components, whereas the tidal components are the main forces form the sea level. The non-tidal components can be sea level that are generated wind, wave, or other phenomena. In many applications in coastal engineering practices, the sea level is approximated by tidal level. This is based on the fact that tides are the most predictable of oceanographic phenomena [3]. The traditional way to approximate the tide is by using the so-called tidal harmonic analysis, in which the tidal is assumed as a superposition of harmonic components or tidal constituents. In that way, usually using Least Square Estimation (LSE), one can estimate accurately the tidal components at a certain area, by using measured sea level. Nevertheless, in this method, the sea level is approximated only by tidal component, whereas the non-tidal component can not be predicted by the tidal harmonic analysis.

There have been many efforts to improve the accuracy of tidal harmonic analysis method for predicting sea level, especially when using LSE. Amiri-Simkooei et al., 2014 [4] uses the multivariate least square harmonic estimation to calculate unknown tidal frequencies, Li et al. 2019 [5] combines LSE method with a method so-called Inaction Method (IM) that uses normal time -frequency transform (NTFT) for extracting and correcting harmonic components to improve the sea level prediction. Another aim besides the tidal harmonic analysis are by using soft computing approach such as Artificial Neural Network (ANN) as proposed by [6]. In 2004, Lee [7] combines the tidal harmonic analysis with ANN with aim to obtain long term tidal prediction. Rizkina et al. 2019 [8] compares the nonlinear auto regressive neural network and tidal harmonic analysis to obtain a short term prediction of sea level.

The major drawback in the tidal harmonic analysis by using the Least Square Estimation (LSE) is that the method requires long term historical sea level data, in practical application is at least one year data, in order to obtain information of low frequency components. The aim of this research is to investigate an accurate method for sea level prediction that only requires relatively short-term historical data. In this study, we propose a deep learning approach that is a variant of Recurrent Neural Network (RNN) i.e. the so-called Long Short-Term Memory (LSTM) method, to predict the sea level. The LSTM model is claimed to be better and more stable than the traditional ANN model since it has a forget gate section in its network architecture, which results in a smarter and better performance than the traditional ANN [9].

As a study area, we use choose a study are in the southern area of Java island, Indonesia, i.e. Cilacap. Available one-year sea level data is used for this study. For testing the method, only 2 months of sea level data is used for training data, to predict 7, 15, 30, 45, and 60 days ahead. The obtained results will be compared with the tidal harmonic analysis that is obtained by using T-TIDE model by Pawlowicz et al. (2002) [10].

Topics and Limitation

In this paper we investigate an optimal method to obtain best accuracy for sea level prediction. The accuracy in this prediction can be influenced by preprocessing data and choosing a method for prediction. In preprocessing data, the author converts the original data in minutes into hours. And for the selection of methods, the authors use the LSTM method which is used 2 ways namely feedback with no-feedback, with LSTM no-feedback here is the Recurrent Neural Network (RNN). The best results will be compared with Tidal Harmonic Analysis. Then the authors use R-Square and RMSE to find out the best performance of each method.

Reasearch Purposes

This research was conducted with the aim to prove that the LSTM with feedback method is a better method than the LSTM no-feedback (RNN) method and Tidal Harmonic Analysis for a prediction at sea level. With the selected data is quite a lot of data and there are some data that looks strange. And this research also aims to prove that this LSTM can describe some strange data, which cannot be described by Tidal Harmonic Analysis.

Organizational Objectives Article

The organization of this paper is as follows. We briefly discuss literature review regarding the research on sea level prediction, tidal harmonic analysis, and LSTM in Section 2. In Section 3, the methodology proposed in this paper is described, it is then followed by Results and discussions in Section 4. We close the paper in section 5.