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Daily Power Plant Operation Prediction Using Adaptive Filter Based on Wavelet Symlet

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Abstract

Purpose – This study aims to develop an accurate method for predicting the daily operation of power plants to support optimal scheduling of generation and maintenance activities.

Methodology – An adaptive filter based on wavelet symlet (adaplet) is applied using the Normalized Least Mean Square (NMLS) algorithm. The model adjusts its coefficients dunamically based on historical operational data to minimize prediction error.

Findings – The method was tested on Indonesian power plant operation data and achieved a Mean Square Error (MSE) of 0.079. Segment-based evaluation confirmed the model's ability to provide consistent prediction accuracy across different time frames.

Originality – This research introduces a novel approach by combining wavelet symlet and adaptive filtering in the context of power plant operation prediction, which allows accurate forecasting using limited data.

Research limitations – The study focuses on short-term prediction (up to 3 days ahead) and does not include external influencing factors such as weather or system demand. Only the NLMS algorithm was utilized, without comparison to other adaptive methods.

Practical implications – The proposed method enables operators to generate more accurate and reliable schedules, improving overall system performance and reducing outage risks.

Social implications – Enhancing the reliability of power plant operations contributes to a more stable electiricty supply, indirectly supporting public services and economic activities.

Introduction

Electric power systems involve generating electricity to generate electrical energy. Power plant operations are one of the important things to plan carefully so that the electric power system can operate optimally and reduce the risk of disruptions. One of the important factors in plant operation planning is the prediction of the plant's daily operations Marsudi (2006). Prediction of daily operation of a plant is the process of estimating the value of plant operation variables such as output power, fuel consumption, and efficiency in the coming day.

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Prediction of the daily operation of the plant can be done by various methods. In this study, we propose a method of predicting the daily operation of adaptive filter-based power plants wavelet symlet (Putra, 2008; Mallat, 1998). This method uses adaptive filtering to adjust to the historical data patterns of plant operations.

Research Methods

Adaplet (Adaptif filter based on wavelet)

Adaplet (Adaptive filter based on wavelet) is an adaptive filter where the initial coefficient used is wavelet (Douglass & Mathews, 1999). The adaptive filter is shown Figure 1, the adaptive filter works using *e(n)*, the difference from the output *y(n)* and the expected output *d(n)*, for the algorithm that will affect the adaptive filter so that the coefficient changes over time.

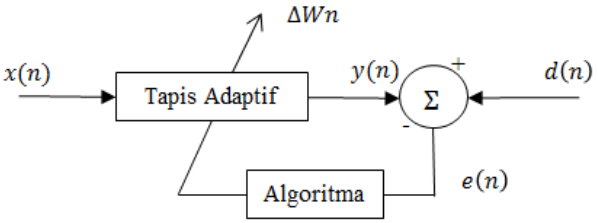

Figure 1. Adaptive Mat

The prediction process uses adaptive filtering with an adaptive algorithm used, namely NLMS with the equation used to update the coefficient as follows (Haykin, 2022).

LMS

$$\widehat{\mathbf{w}}(\boldsymbol{n}+\mathbf{1}) = \widehat{\mathbf{w}}\,(\boldsymbol{n}) + \boldsymbol{\mu}\mathbf{u}(\boldsymbol{n})\boldsymbol{e}*(\boldsymbol{n}) \quad (1)$$

NLMS

$$\widehat{\mathbf{w}}(\boldsymbol{n}+\mathbf{1}) = \widehat{\mathbf{w}}\,(\boldsymbol{n}) + \frac{\mathbf{1}}{\left|\left|\mathbf{u}(\boldsymbol{n})\right|\right|^{2}}\mathbf{u}(\boldsymbol{n})\boldsymbol{e}*(\boldsymbol{n}) \quad (2)$$

$$\widehat{\mathbf{w}}(\boldsymbol{n}+\mathbf{1}) = \widehat{\mathbf{w}}\,(\boldsymbol{n}) + \frac{\widetilde{\boldsymbol{\mu}}}{\left|\left|\mathbf{u}(\boldsymbol{n})\right|\right|^{2}}\mathbf{u}(\boldsymbol{n})\boldsymbol{e}*(\boldsymbol{n})$$

$$\widehat{\mathbf{w}}(\boldsymbol{n}+\mathbf{1}) = \widehat{\mathbf{w}}\,(\boldsymbol{n}) + \frac{\widetilde{\boldsymbol{\mu}}}{\boldsymbol{a}+\left|\left|\mathbf{u}(\boldsymbol{n})\right|\right|^{2}}\mathbf{u}(\boldsymbol{n})\boldsymbol{e}*(\boldsymbol{n})$$

In Figure 1, the daily operating data signal is fed into an adaptive filter where the initial wavelet coefficient will then produce an output *y(n)*. The output *y(n)* is compared to the expected output *d(n)*. The difference between the two results in *an error* value *e(n)*. The algorithm is used to calculate the value of the new coefficient based on *the* error value of *e(n)* so that it affects the adaptive filter and the value of *e(n)* is getting smaller and closer to zero.

The general equation of filtering Finite Impluse Response (FIR) with many taps is as follows:

$$\begin{aligned} y(n) \quad &= \textstyle\sum_{i=0}^{N-1} w_n(i)\, x(n-i) \qquad (3)\\ &= w_n(0)x(n) + w_n(1)x(n-1) + \\ &\cdots + \quad w_n(N-1)x(n-N-1)= \end{aligned}$$

From equation (3) it is implemented into the program to predict *N* the next day with the program flow.

Results and Discussion

Segmentation Analysis

The prediction uses daily operation data of the plant in the form of data on the realization of the plant load for 221 days. From 221 days, it is divided into 3 segments to obtain daily prediction data for the next 3 days of plant operations in each segment. From the prediction of each segment, the average error value or MSE is obtained by comparing the original data and prediction data.

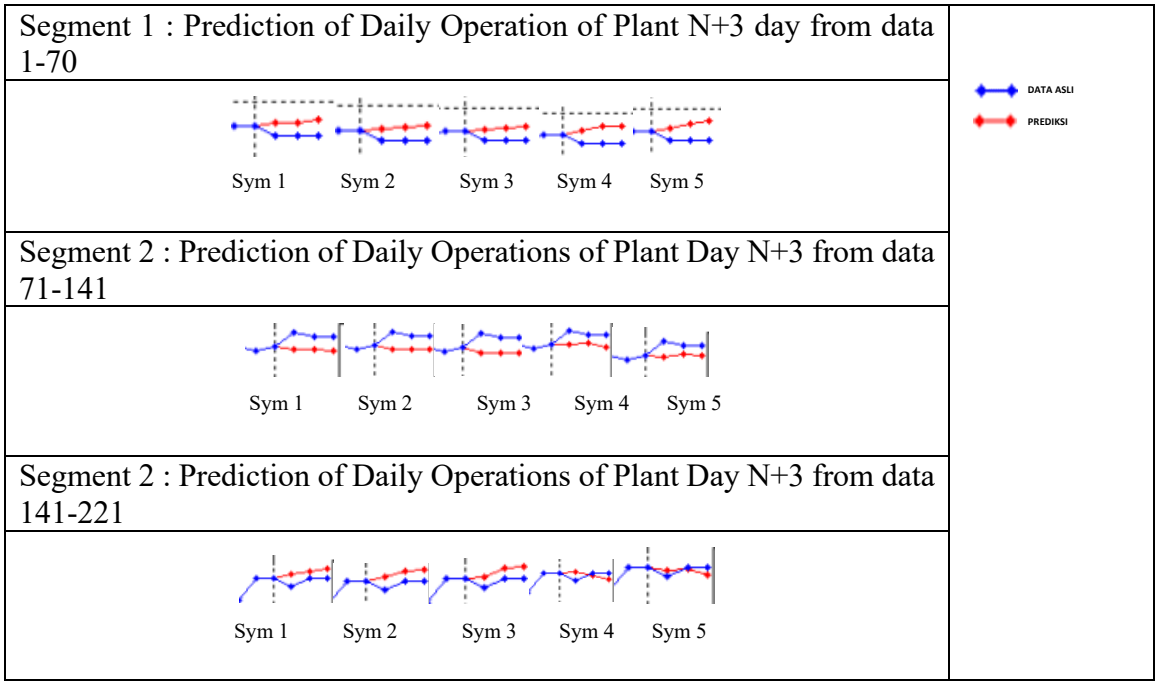

Figure 2. Prediction results in each segment of the plant's daily operation data

From the results of segmentation analysis, prediction data and the average value of errors were obtained as follows.

Tabel 1. Mean Square Error Wavelet Symlet

Orde	MSE Segment 1			MSE Segment 2			MSE Segment 3			Average
	70+1	70+2	70+3	141+1	141+2	141+3	221+1	221+2	221+3	
1	0,063	0,071	0,081	0,063	0,071	0,081	0,063	0,071	0,081	0,072
2	0,061	0,071	0,079	0,061	0,071	0,079	0,061	0,071	0,079	0,070
3	0,06	0,07	0,079	0,06	0,07	0,079	0,07	0,079	0,070	0,071
4	0,075	0,098	0,105	0,075	0,098	0,105	0,075	0,098	0,105	0,093
5	0,064	0,093	0,109	0,064	0,093	0,109	0,064	0,093	0,109	0,089
MSE Average										0,079

Conclusion and Suggestion

Symlet-based wavelet-based adaptive filter is a method that can be used to predict the daily operation of the plant with a mean square error value of 0.079. This method can provide accurate predictions using limited data.

Henceforth, the prediction of the daily operation of the plant can be done by increasing the length of the coefficient of the parent wavelet order used or using the RLS (Recursive Least Square) filter implementation.

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