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Supplementary Information:

A Hybrid TCN-LSTM Model for Predictive Maintenance of AWS Power Supplies

Marzuki Sinambela[1*], Rifqi Daffa Ul-haq[2], Dibyo Susanto[1], Agustina Rachmawardani[1]
[1] *Program in Applied Instrumentation Meteorology, Climatology, and Geophysics, STMKG, Indonesia.*
[2] *Undergraduate Program in Applied Instrumentation Meteorology, Climatology, and Geophysics, STMKG, Indonesia.*

Corresponding Author's E-mail: sinambela.m@gmail.com

Evaluation Metrics

The mathematical expressions for each metric used to quantify the discrepancy between the empirically measured battery voltages and the forecasted values are defined as follows.

1. Coefficient of Determination (R^2 Score)

The R^2 score represents the proportion of variance in the dependent variable that is predictable from the independent variables. It serves as a reliable measure of goodness-of-fit (1).

$$R^2 = 1 - \frac{\sum_{i=1}^{N}(y_i - \hat{y}_i)^2}{\sum_{i=1}^{N}(y_i - \bar{y})^2} \quad (1)$$

Where N denotes the total number of observations, y_i is the actual voltage measurement, $\hat{y}_i$ is the predicted output, $\bar{y}$ represents the arithmetic average of the actual values, and $\sum(sigma)$ represents the summation over all data points. This metric highlights the model's overall capability to track continuous voltage fluctuations.

2. Mean Squared Error (MSE)

MSE computes the average of the squared errors, penalizing larger discrepancies more heavily than smaller ones (2).

$$MSE = \frac{1}{N}\sum_{i=1}^{N}(y_i - \hat{y}_i)^2 \quad (2)$$

By squaring the differences between predictions ($\hat{y}_i$) and ground truths (y_i), this statistic provides a rigorous assessment of extreme forecast errors.

3. Root Mean Squared Error (RMSE)

Derived by taking the square root of the MSE, RMSE provides the error margin in the same unit as the original dataset (3).

$$RMSE = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(y_i - \hat{y}_i)^2} \quad (3)$$

A lower RMSE indicates a smaller residual standard deviation, reflecting higher precision in estimating battery health.

4. Mean Absolute Error (MAE)

MAE measures the average absolute difference between the predicted and actual values, treating all deviations equally (4).

$$MAE = \frac{1}{N}\sum_{i=1}^{N}|y_i - \hat{y}_i| \quad (4)$$

The absolute operator ($| |$) prevents positive and negative errors from canceling each other out. This metric offers a clear representation of the average deviation without being overly sensitive to outliers.

5. Mean Absolute Percentage Error (MAPE)

MAPE normalizes the forecast error as a percentage, which is highly intuitive for relative accuracy assessments (5).

$$MAPE = \frac{1}{N}\sum_{i=1}^{N}\frac{|y_i - \hat{y}_i|}{y_i} \times 100\% \quad (5)$$

By dividing the absolute error by the true value, this metric indicates the percentage by which the model's estimations diverge from the real operational conditions.