

ABSTRAK

Penelitian ini bertujuan mengembangkan sistem estimasi waktu tiba hujan (*Estimated Time of Arrival/ETA*) berbasis *machine learning* dengan memanfaatkan teknik *data fusion* dari sistem pemantauan cuaca *Internet of Things (IoT) multi-node*. Penelitian dilakukan karena sistem prediksi cuaca konvensional umumnya kurang mampu merepresentasikan kondisi cuaca dan pola perambatan hujan pada skala lokal. Data penelitian diperoleh dari dua node sensor yang ditempatkan di Perumahan Puri Intan Pabuaran dan Universitas Amikom Purwokerto selama dua minggu pengamatan. Variabel yang digunakan meliputi suhu udara, kelembapan udara, tekanan udara, dan kondisi hujan yang dikumpulkan secara *real-time* melalui Firebase. Metode penelitian meliputi pengumpulan data, *preprocessing*, penerapan *data fusion* dan *feature engineering*, analisis spasial-temporal, pemodelan ETA hujan menggunakan algoritma *XGBoost Regressor*, serta analisis *feature importance*. Kinerja model dievaluasi menggunakan *Mean Absolute Error (MAE)*, *Root Mean Squared Error (RMSE)*, dan *Mean Absolute Percentage Error (MAPE)*. Hasil penelitian menunjukkan bahwa penerapan *data fusion* pada data cuaca *multi-node* mampu memberikan representasi kondisi lingkungan yang lebih menyeluruh sehingga mendukung proses estimasi perambatan hujan antar lokasi. Model yang dibangun menghasilkan nilai MAE sebesar 0,52 menit, RMSE sebesar 0,61 menit, dan MAPE sebesar 10,48%. Analisis *feature importance* menunjukkan bahwa perubahan kelembapan antar lokasi (*Delta_Kelembapan*) merupakan parameter yang paling berpengaruh dalam proses estimasi waktu tiba hujan. Berdasarkan hasil tersebut, pendekatan *data fusion* dan *machine learning* menggunakan *XGBoost Regressor* efektif untuk mendukung sistem pemantauan cuaca lokal dan peringatan dini hujan secara lebih responsif.

Kata kunci: IoT, *Data fusion*, *XGBoost Regressor*, Estimasi Waktu Tiba Hujan, Analisis Spasial-Temporal.

ABSTRACT

This study aims to develop a machine learning-based rainfall estimation system (Estimated Time of Arrival/ETA) using data fusion technology from a multi-node IoT weather monitoring system. This study was conducted because conventional weather forecasting systems generally have poor capabilities in representing local weather conditions and rainfall distribution patterns. Research data was obtained from two sensor nodes installed at Puri Intan Pabuaran Housing and Amikom Purwokerto University during a two-week observation period. The variables used include temperature, humidity, atmospheric pressure, and rainfall conditions, which are collected in real-time through the Firebase. The research methodology includes data collection, pre-processing, application of data fusion and feature engineering, spatial-temporal analysis, rainfall ETA modeling using the XGBoost Regressor algorithm, and feature importance analysis. Model performance was evaluated using the mean absolute error (MAE), root mean square error (RMSE), and mean absolute percent error (MAPE). The results of this study indicate that the application of data fusion to multi-node weather data can represent environmental conditions more comprehensively, thus supporting the process of estimating rainfall distribution between locations. The developed model achieved an MAE of 0.52 minutes, an RMSE of 0.61 minutes, and a MAPE of 10.48%. Feature importance analysis showed that the change in humidity between locations (Delta_Humidity) was the most influential parameter in the rainfall arrival time estimation process. Based on these results, the data fusion and machine learning approach using the XGBoost Regressor is effective in supporting local weather monitoring systems and faster rainfall early warnings.

Keywords: IoT, Data fusion, XGBoost Regressor, Rain Estimated Time of Arrival, Spatial-Temporal Analysis.