ABSTRACT

BATTERY ANOMALY DETECTION AND STATE OF HEALTH ESTIMATION USING DBSCAN CLUSTERING

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Battery systems are prone to operational anomalies such as voltage cut-offs, recalibration errors, and inaccuracies in State of Charge (SOC) prediction, which can compromise performance and reliability. This study proposes an unsupervised anomaly detection approach using the DBSCAN (Density-Based Spatial Clustering of Applications with Noise) algorithm to identify abnormal patterns in battery data. By leveraging density-based clustering, DBSCAN effectively detects anomalies caused by voltage irregularities and SOC estimation errors. Furthermore, the ratio of normal to anomalous data points is used to estimate the battery's State of Health (SOH).

The results show that voltage cut-off anomalies occur when battery voltage is outside the range of 3.0–4.2 V, while recalibration anomalies are detected when the SOC error exceeds 10%. DBSCAN successfully estimates the battery's SOH at 16.016 Ah or 96.36%, based on the ratio between the normal and anomalous point 0.014. Model evaluation using Isolation Forest yields an accuracy of 91.89% for anomaly detection and 89.95% for SOH estimation. These outcomes demonstrate that DBSCAN is a reliable method for detecting battery anomalies and estimating health without the need for labeled data.

Keywords: Battery Management System (BMS), Battery Anomaly Detection, DBSCAN, State of Charge (SOC), State of Health (SOH), Machine Learning, Clustering.

INTISARI

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*Sistem baterai rentan terhadap berbagai anomali operasional seperti pemutusan tegangan (*voltage cut-off*), kesalahan re-kalibrasi, dan ketidakakuratan dalam prediksi* State of Charge (*SOC*)*, yang dapat mempengaruhi kinerja dan keandalan baterai. Penelitian ini mengusulkan pendekatan deteksi anomali tanpa pengawasan menggunakan algoritma DBSCAN* (Density-Based Spatial Clustering of Applications with Noise) *untuk mengidentifikasi pola-pola abnormal dalam data baterai. Dengan memanfaatkan teknik klasterisasi berbasis kepadatan, DBSCAN secara efektif mendeteksi anomali yang disebabkan oleh ketidakteraturan tegangan dan kesalahan estimasi SOC. Selain itu, rasio antara data normal dan data anomali digunakan untuk memperkirakan State of Health (SOH) dari baterai.*

Hasil penelitian menunjukkan bahwa anomali pemutusan tegangan terjadi ketika tegangan baterai berada di luar rentang 3,0–4,2 V, sementara anomali re-kalibrasi terdeteksi ketika kesalahan SOC melebihi 10%. DBSCAN berhasil memperkirakan SOH baterai sebesar 16.016 Ah atau 96,36% berdasarkan rasio perbandingan data normal dan anomali 0.014. Evaluasi model menggunakan Isolation Forest *menghasilkan akurasi sebesar 91,89% untuk deteksi anomali dan 89,95% untuk estimasi SOH. Temuan ini menunjukkan bahwa DBSCAN merupakan metode yang andal dalam mendeteksi anomali baterai dan memperkirakan kondisi kesehatannya tanpa memerlukan data berlabel.*

Kata Kunci: *Sistem Manajemen Baterai (BMS), Deteksi Anomali Baterai, DBSCAN,* State of Charge *(SOC),* State of Health *(SOH),* Machine Learning*, Klasterisasi.*