School of Engineering, Technology and Design

Advancing Safety and Efficiency in Critical Infrastructure with a Novel SOC Estimation for Battery Storage Systems: A Focus on Second Life Batteries

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INTRODUCTION

- Global Shift to EVs: Rapid adoption of electric vehicles is key to decarbonizing transportation.
- Waste Security and Retired EV Batteries: Addressing the surge in retired EV batteries is crucial for environmental safety and sustainable repurposing.
- Opportunity for Second Life Applications: Retired batteries hold significant potential for second life applications, especially in areas requiring high safety and efficiency, like critical infrastructure.
- Novel State of Charge (SOC) Estimation Method: Our research introduces an advanced SOC estimation technique, crucial for safely and efficiently integrating retired EV batteries into energy storage systems.

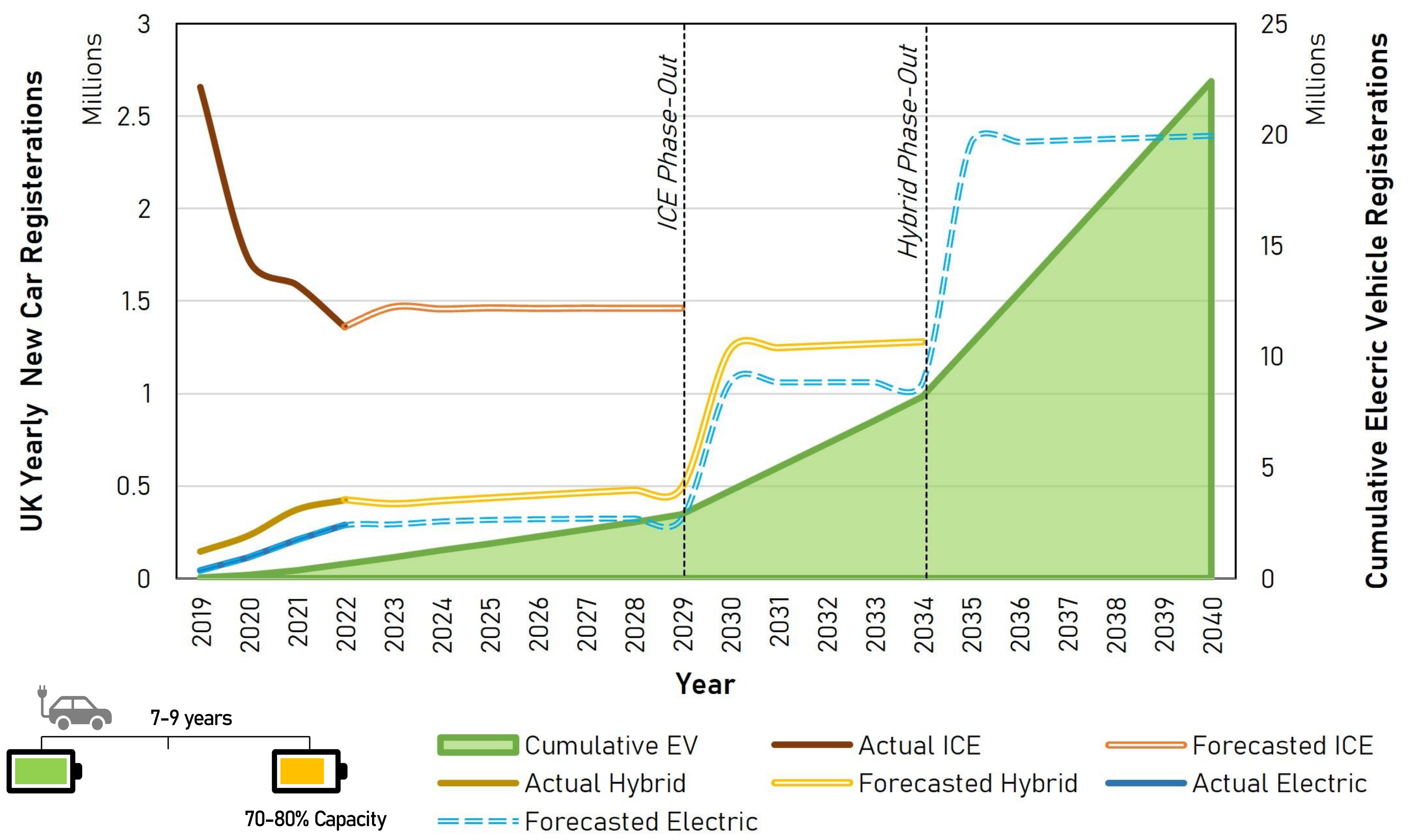

Figure 1: Car registrations in the UK and estimated EV units on UK's roads, Data retrieved from: (Department for Transport (DfT) and Driver and Vehicle Licensing Agency, 2022). Forecast using Seasonal Auto-Regressive Integrated Moving Average (SARIMA).

AIM AND OBJECTIVES

- Aim: To develop an advanced machine learning algorithm for accurate state-of-charge (SOC) estimation in lithium batteries.
- Objectives:
  - To develop a novel Cluster-Based Learning Model (CBLM) integrating K-Means clustering with LSTM for SOC estimation.
  - To design a dynamic SOC estimation model that prioritizes safety by accurately predicting SOC, reducing risks of overcharging and thermal runaway, under varying operational conditions of lithium-ion batteries.
  - To minimize the SOC estimation errors significantly, enhancing the safety and extending the lifespan of lithium-ion batteries in various applications.

METHODOLOGY

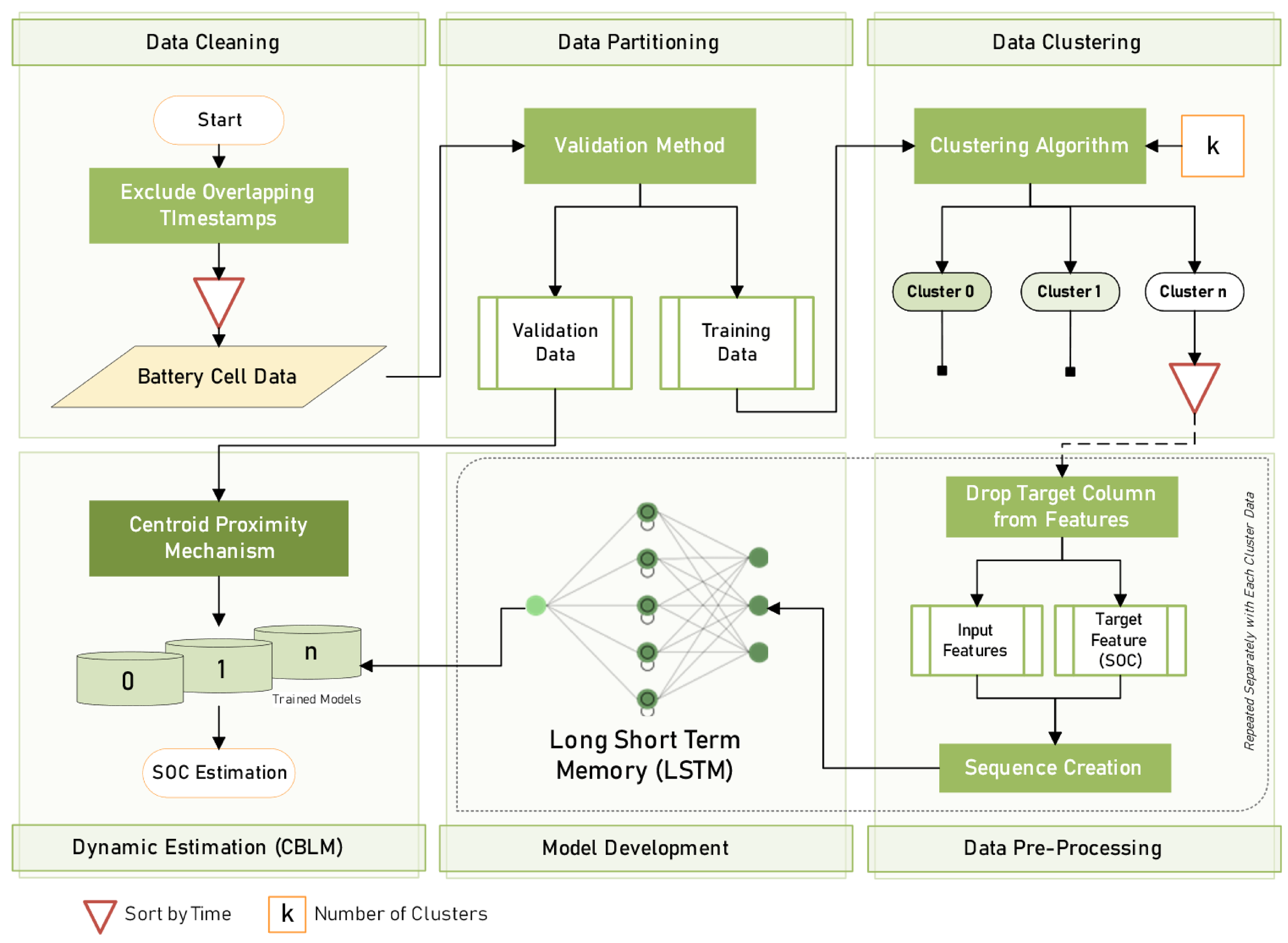

Figure 2: Flowchart of the CBLM Methodology for State of Charge Estimation Using LSTM and Centroid Proximity.

FINDINGS

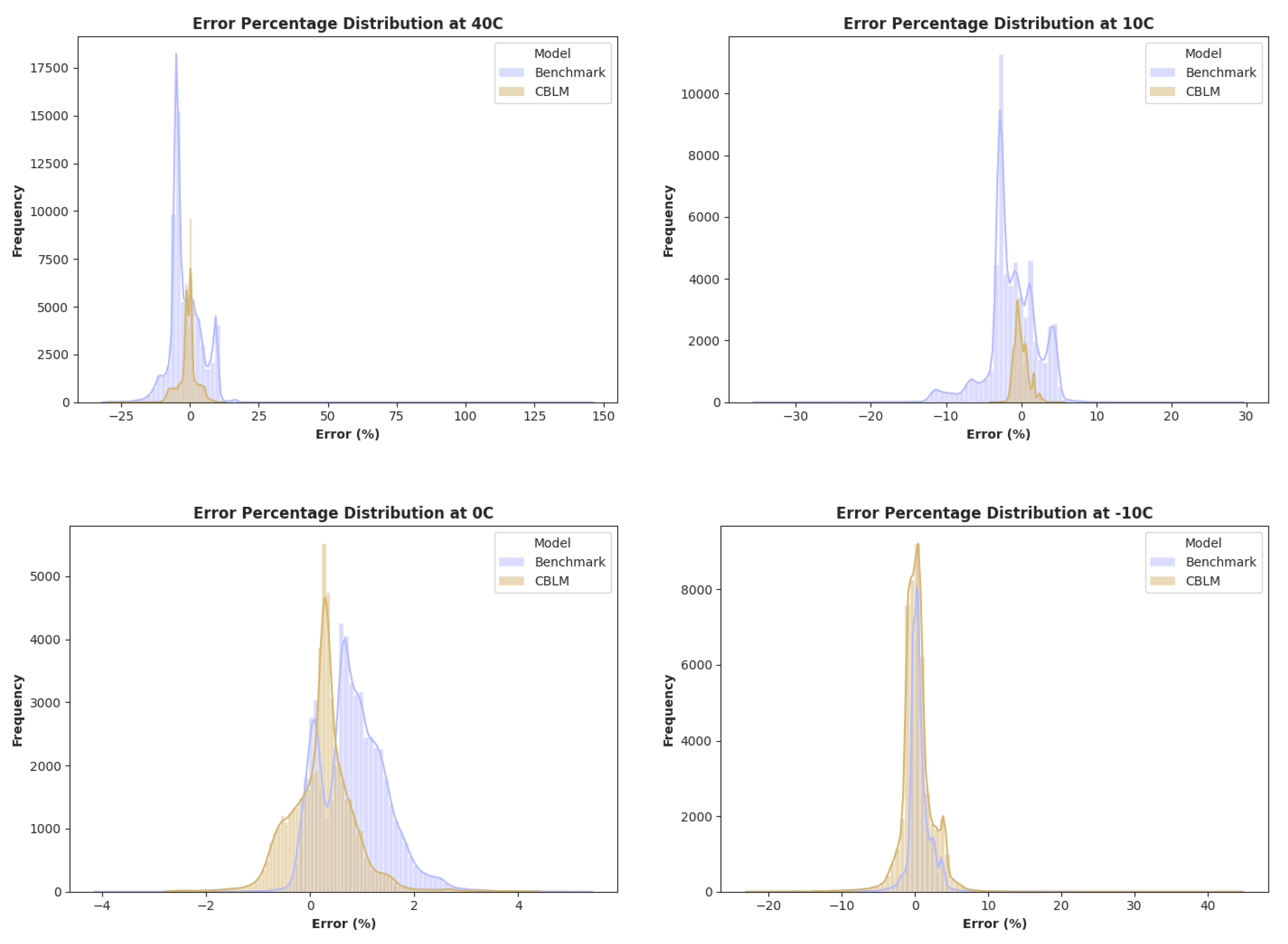

Figure 3: Comparative Error Percentage Distributions of CBLM and Benchmark Models Across Various Ambient Temperatures (-10C, 0C, 10C, and 40C).

10°C

CBLM	0.74% Average Error
Benchmark	2.79% Average Error

Average Error Reduction by CBLM

74%

Statistical Test (Kruskal-Wallis Test) confirms that the CBLM model exhibits a statistically significant improvement in SOC estimation accuracy across a range of ambient temperatures when compared to the benchmark (p-value<0.005).

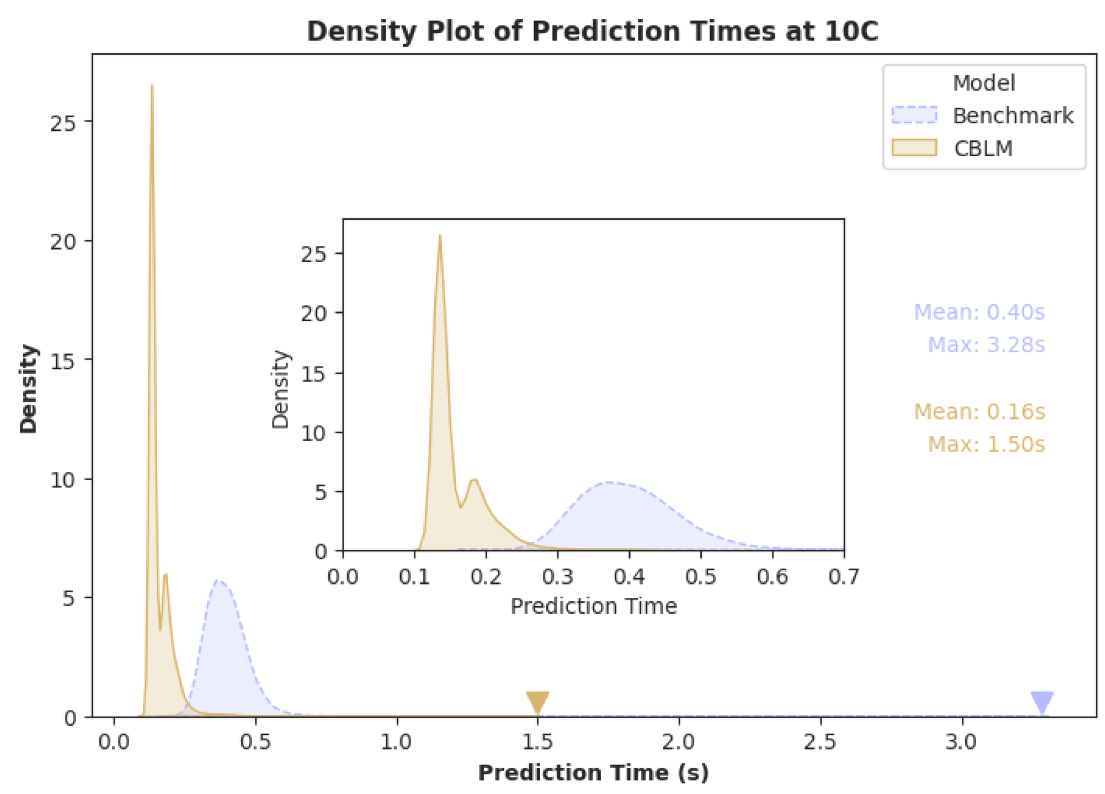

Figure 4: Comparative Prediction Time Plot of CBLM and Benchmark Models at 10C Ambient Temperature.

LEARN MORE ABOUT BATTERY SAFETY

[1] Al-Alawi, M.K., Cugley, J. and Hassanin, H. (2022) 'Techno-economic feasibility of retired electric-vehicle batteries repurpose/reuse in second-life applications: A systematic review', Energy and Climate Change, 3, pp. 100086 Available at: 10.1016/j.egycc.2022.100086

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