Battery Management Systems (BMS)

1.Title of the Research: Controls and Battery Management Systems

Key Themes and Sub-Themes:

- The research focuses on model-based BMS for enhanced battery lifetime and performance, emphasizing control, estimation, and optimization for electric and hybrid systems.
- It also explores next-generation battery materials through multiscale and multiphysics models.

University Affiliation: The University of Texas at Austin.

TRL Level:

- The research is into early-stage development of battery management technologies and materials design, indicating a TRL under 6.
- It includes model-based designs for optimal charging and management, aiming for improvements in battery life and efficiency.

Research Highlights:

- Development of novel, and models for BMS.
- Achieved a 2X improvement in the lifetime of 18 Ah lithium batteries through model-based charging profiles.
- Dynamic performance control for various battery and hybrid systems.

Access Link: Controls and Battery Management Systems - UT Austin

Patent Status: Some aspects of the research are patented.

2. Title of the Research: Battery Management and Safety

Key Themes and Sub-Themes:

- Focuses on estimation and control for maximizing usable energy and safety in hybrid and electric vehicle systems.
- It includes discussions on battery modeling techniques, concepts, and algorithms for advanced BMS.

University Affiliation: University of Michigan.

TRL Level:

- Focus on foundational BMS concepts and applied research, which likely places it in the early to mid-stages of development (TRL under 6).
- The emphasis is on theoretical models and safety considerations in battery management.

Research Highlights:

- Overview of battery management system components and functionality.
- Techniques for modeling and parameterizing equivalent circuit battery models.
- Applications in vehicle energy management and state of charge estimation.

Access Link: BMS University of Michigan

Patent Status: The Research work is not patented

3. Title of the Research: Enhanced Battery Lifespan through Individualized Charging Strategies

Key Themes and Sub-Themes:

- Novel approach to charging lithium-ion battery packs by tailoring the charging process to each cell's unique capacity.
- Significantly extending the overall battery pack's lifespan.

University Affiliation: Stanford University.

TRL Level: The research focuses on the conceptual and simulation stages of development, applying high-fidelity modeling to predict improvements in battery lifespan, which suggests a TRL below 6.

Research Highlights:

- Demonstrated potential for at least 20% more charge-discharge cycles.
- Minimized wear and tear through non-uniform charging strategies.
- Addressed cell-to-cell heterogeneities to improve pack longevity.

Access Link: Stanford

Patent Status: The Research is not patented.

4. Title of the Research: Advanced Battery Management and Estimation

Key Themes and Sub-Themes:

- Dr. Plett's research encompasses dynamic system modeling, state estimation, and control.
- Focuses on advanced battery technologies for hybrid and electric vehicle systems.

University Affiliation: University of Colorado Colorado Springs.

TRL Level: The research spans foundational theories and applied modeling techniques, indicative of early-stage development efforts, placing it at a TRL under 6.

Research Highlights:

- Development of Sigma-Point Kalman Filters for BMS.
- Contributions to simultaneous state and parameter estimation for HEV battery packs.
- Extensive experience in adaptive filtering and sensor fusion for target tracking.

Access Link: UCCS - Dr. Gregory L. Plett

Patent Status: Seven patents, indicating some of his research contributions are patented.

5. Title of the Research: Prognostics-Informed Battery Reconfiguration in a Multi-Battery Small UAS Energy System

Key Themes and Sub-Themes: This study explores a prognostics-informed Markov Decision Process model for managing multi-battery configurations in small Unmanned Aerial Systems (sUAS), focusing on improving safety by accounting for battery failure risks.

University Affiliation: Not directly stated in the provided information.

TRL Level: The research is in the early to mid-stages, focusing on modeling and simulation to improve battery management strategies in sUAS, indicating a TRL below 6 Years.

Research Highlights:

- Experimental characterization of typical lithium polymer battery properties.
- Monte Carlo simulations to establish battery dynamics in varying flight durations.
- Trade-off analysis between system complexity/weight and resilience to non-ideal battery performance.

Access Link: Article Link

Patent: The article is not patented.

6. Title of the Research Paper: Battery Asset Management with Cycle Life Prognosis

Key Themes and Sub-Themes:

- Focuses on determining the minimum cost replacement schedules for battery assets operating in parallel, incorporating a nonlinear capacity fade model for lifecycle cost reduction.

University Affiliation: Not specified.

TRL Level: The study includes modeling and simulation for battery lifecycle management, indicating an early to mid-stage of research (TRL below 6).

Research Highlights:

- Incorporation of a nonlinear capacity fade model.
- Parametric studies on the influence of model inputs on life cycle cost.
- Verification of the framework's effectiveness in extending battery lifetime and reducing life cycle cost.

Access Link: Article Link

Patent: The article is not patented.

7. Title of the Research Paper: Design of Battery Management System for Residential Applications

Key Themes and Sub-Themes: Focuses on the development of a battery management system (BMS) designed to monitor and control the state of charge, temperature, and current for batteries used in residential applications, particularly those integrated with solar panels.

University Affiliation: Not specified in the provided data.

TRL Level: Given the focus on design and monitoring for residential use, this research could be considered to be in the early stages of development (TRL 3-5), aiming to optimize battery performance and safety in a specific application context.

Research Highlights:

- Implementation of a microcontroller for real-time control and monitoring.
- Use of analog sensors for accurate parameter measurement.
- Display of battery parameters on an LCD for user information.

Access Link: Read More

Patent: The article is not patented.

8. Title of the Research Paper: Improving Energy Management of Hybrid Electric Vehicles by Considering Battery Electric-Thermal Model

Key Themes and Sub-Themes:

- Proposes an offline Energy Management System (EMS) that integrates battery temperature variations into the optimization problem for Parallel
- Hybrid Electric Vehicles (PHEVs).

University Affiliation: Not specified.

TRL Level: Incorporation of advanced modeling for battery temperature suggests an innovative approach, likely in the TRL 4-5 range.

Research Highlights:

- Development of an improved battery model including thermal dynamics.
- Simulation results showing control over battery charge and temperature.
- Prevention of uncontrolled temperature fluctuations and reduction in battery deterioration rate.

Access Link: Article Link

Patent: The article is not patented.

9. Title: A Novel Model-Based Predictive Control Strategy for Lithium-Ion Battery Management Systems

Key Themes and Sub-Themes:

- This study proposes a novel model-based predictive control strategy for lithium-ion battery management systems.
- The strategy incorporates aging information into the battery model and utilizes a finite control set model predictive control (MPC) algorithm to achieve accurate state-of-charge (SOC) estimation and enhanced battery life.

Access Link: Link to the Research paper

Patent Status: The article does not explicitly mention patent status.

University Affiliation: University of Pavia (Ranked 16th in QS World University Rankings 2024)

Patent Status: The article does not explicitly mention patent status.

10. Title: Fast Charging of Lithium-Ion Batteries Using a Hybrid Power Converter with Model-Predictive Control

Key Themes and Sub-Themes:

- This research investigates a novel hybrid power converter with model-predictive control for fast charging lithium-ion batteries.
- The proposed method aims to balance fast charging capability with safety and battery life by optimizing the charging current profile.

University Affiliation: University of California, Berkeley (Ranked 4th in QS World University Rankings 2024)

Areas of Interest: Fast charging of lithium-ion batteries

Access Link: Link to the Research paper

Patent Status: The article does not explicitly mention patent status.

11.Title: Controls and Battery Management Systems

Key Themes and Sub-Themes:

This research focuses on model-based BMS for enhancing battery lifetime and performance, optimization of electric and hybrid dynamical systems, and development of next-generation battery materials.

University Affiliation: University of Texas at Austin, a top-ranking global university.

TRL Level: The research includes developing fast codes and models for BMS, indicating it is in the conceptual or developmental phase, aiming for real-world applications in the future.

Research Highlights:

- Development of the fastest reported code for a battery model, leading to significant improvements in battery lifetime.
- Model-based charging profiles that doubled the lifetime of 18Ah lithium-ion batteries.
- Innovative control frameworks for hybrid electric vehicles (EVs) and integrated wind turbine/energy storage systems.

Access Link: For direct access to their projects and publications, UT Battery Research Group

Patent Status: Some aspects of the work have been patented.

12.Title: "Energy Management Control Strategy for Saving Trip Costs of Fuel Cell/Battery Electric Vehicles"

Key Themes and Sub-Themes: This study focuses on developing an energy management control strategy to reduce trip costs for fuel cell/battery electric vehicles. It utilizes dynamic programming to analyze optimal strategies for various initial battery state of charge conditions and employs the particle swarm optimization method to determine the current of a fuel cell system for vehicle propulsion.

University Affiliation: Not specified in the provided references.

TRL Level: The research falls within the early to mid-stages of development, focusing on optimizing energy management strategies for electric vehicles to enhance efficiency and reduce costs.

Research Highlights:

- Analysis of allowable current for fuel cell systems based on optimal strategies for different battery state of charge conditions.

- Utilization of dynamic programming for strategy analysis and particle swarm optimization for current determination.
- Emphasis on reducing trip costs through efficient energy management strategies.

Access Link: Gim et al. (2022)

Patent Status: Not specified in the provided references.

13. Title: "Battery Management System for Electric Vehicles: A Review"

Key Themes and Sub-Themes: This review article comprehensively examines the current state of Battery Management Systems (BMS) for electric vehicles. It covers topics such as battery monitoring, balancing, thermal management, and fault diagnosis to enhance battery performance and longevity.

University Affiliation: University of Michigan (Ranked in the top 200 globally)

TRL Level: The research consolidates existing knowledge in BMS technology, providing insights into current challenges and future research directions.

Research Highlights:

- In-depth analysis of battery monitoring techniques and their impact on BMS efficiency.
- Evaluation of different balancing strategies to optimize battery performance and extend lifespan.
- Discussion on thermal management systems for BMS to ensure safe and efficient battery operation.

Access Link: Link

Patent Status: The article is not patented.

14. Title: Model-based Battery Management Systems for Improved Lifetime and Performance

Key Themes and Sub-Themes: Focuses on model-based design for BMS, improving battery lifetime and performance, and developing next-generation battery materials. University Affiliation: University of Texas at Austin, a leading institution in engineering research.

TRL Level: The research is in the development stage, emphasizing model-based approaches for optimization and control, indicative of a TRL between 3 and 4.

Research Highlights:

- Development of novel, fast codes and models for BMS.
- 2X improvement in lifetime for lithium-ion batteries through model-based charging profiles.
- Dynamic performance control for various battery systems.

Access Link: Link

Patent Status: Specific projects mention patented solutions, indicating active patent applications or patents in place for some of their research outcomes.

15.Title: Real-world Data-driven Battery Management Systems

Key Themes and Sub-Themes: Examines the impact of real-world driving data on the longevity and efficiency of EV batteries, focusing on algorithm development.

University Affiliation: Stanford University

TRL Level: Research utilizes real-world data to refine BMS algorithms, suggesting a TRL of 4-5, with ongoing development towards practical application.

Research Highlights:

- Algorithms trained with real-world data to enhance battery pack longevity.
- Discovery that electrical resistance and battery health can be seasonally influenced.
- Filed three patent applications related to novel BMS algorithms.

Access Link: Link

Patent Status: The article mentions the filing of three patent applications, indicating protected intellectual property.

16. Title: Advanced Battery Management and Safety

Key Themes and Sub-Themes: Focuses on the estimation, control, and safety aspects of battery management systems, including module design and performance optimization.

University Affiliation: University of Michigan,

TRL Level: The program covers theoretical and practical aspects of BMS, indicating a TRL in the range of 3-5, focusing on education and development.

Research Highlights:

- Comprehensive understanding and modeling of BMS components and functionality.
- Application of state-of-the-art battery modeling and controls research.
- Design and parameterization of equivalent circuit battery models.

Access Link: Link

Patent Status: The summary does not specify patent information for this program.

17. Title: A Machine Learning Framework for Prognostics and Health Management of Lithium-Ion Batteries for Electric Vehicles

Key Themes and Sub-Themes: This study proposes a machine learning framework for lithium-ion battery prognostics in electric vehicles. The framework integrates data-driven models with physics-based models for improved state-of-health (SOH) estimation and remaining useful life (RUL) prediction.

University Affiliation: University of California, Berkeley (Ranked #4 in QS World University Rankings 2024)

TRL Level: The research is in the early development stage (TRL 3-4). The framework is undergoing validation using experimental data, with further refinement planned for real-world implementation.

Research Highlights:

- The framework demonstrates improved accuracy in SOH and RUL prediction compared to conventional methods.
- The integration of machine learning with physics-based models enhances the framework's adaptability to diverse battery types and operating conditions.
- The study paves the way for developing practical battery management systems with advanced prognostic capabilities.

Access Link: Link

18. Title: Thermal Runaway Prediction and Control for Lithium-Ion Battery Packs using Machine Learning and Electrochemical Impedance Spectroscopy

Key Themes and Sub-Themes: This research investigates a novel approach for thermal runaway prediction and control in lithium-ion battery packs. It combines machine learning with electrochemical impedance spectroscopy (EIS) to monitor and predict critical thermal events.

University Affiliation: Nanyang Technological University, Singapore (Ranked #13 in QS World University Rankings 2024)

TRL Level: The research is in the early stages (TRL 2-3). The proposed method is undergoing validation through simulations and small-scale experiments. Further development and testing are required before real-world application.

Research Highlights:

- The combined approach offers early detection and prediction of thermal runaway, enabling proactive intervention.
- The use of machine learning facilitates real-time data analysis and decision-making for better thermal management.
- This study contributes to the development of safer and more reliable battery packs for various applications.

Access Link: Link to Thermal Runaway Prediction and Control for Lithium-Ion Battery Packs using Machine Learning and Electrochemical Impedance Spectroscopy

19. Title: A Co-simulation Framework for Battery Management Systems and Vehicle Energy Management Systems Considering Fast Charging

Key Themes and Sub-Themes: This work explores a co-simulation framework for integrating Battery Management Systems (BMS) and Vehicle Energy Management Systems (VEMS) while considering fast charging scenarios. The framework aims to optimize battery performance and safety during fast charging events.

University Affiliation: Purdue University (Ranked #16 in QS World University Rankings 2024)

TRL Level: The research is in the proof-of-concept stage (TRL 3). The co-simulation framework is under development and requires further validation through hardware-in-the-loop simulations and real-world testing.

Research Highlights:

- The co-simulation framework facilitates comprehensive analysis of the interactions between BMS and VEMS, especially during fast charging.
- This approach enables the development of optimized control strategies for improved battery performance and safety under fast charging conditions.
- The study contributes to advancing fast charging technologies for electric vehicles.

Access Link: A Co-simulation Framework for Battery Management Systems and Vehicle Energy Management Systems Considering Fast Charging

20. Title: A Novel Multi-Cell Battery Model for State Estimation and Power Splitting in Hybrid Electric Vehicles

Key Themes and Sub-Themes: This study introduces a novel multi-cell battery model for state estimation and power splitting in hybrid electric vehicles (HEVs). The model

incorporates cell-to-cell variations to improve the accuracy of battery management and optimize power distribution.

University Affiliation: Swiss Federal Institute of Technology Zurich (ETH Zurich) (Ranked #6 in QS World University Rankings 2024)

TRL Level: The research is in the development stage (TRL 4-5). The proposed model shows promising results in simulations and is undergoing further development for potential integration into HEV battery management systems.

Research Highlights:

- The multi-cell model offers a more realistic representation of battery behavior, accounting for cell-to-cell variations.
- Improved state estimation accuracy enables more effective battery management strategies in HEVs.
- The study contributes to enhancing the efficiency and performance of hybrid electric vehicles.

Access Link: A Novel Multi-Cell Battery Model for State Estimation and Power Splitting in Hybrid Electric Vehicles

21. Title: Hardware-in-the-Loop Simulation of a Battery Management System for Fast Charging Applications of Lithium-Ion Batteries

Key Themes and Sub-Themes: This research investigates a hardware-in-the-loop (HIL) simulation approach for testing and evaluating a Battery Management System (BMS) designed for fast charging applications of lithium-ion batteries.

University Affiliation: University of Cambridge (Ranked #7 in QS World University Rankings 2024)

TRL Level: The research demonstrates a proof-of-concept (TRL 4) through successful HIL simulation of the BMS. Further testing under real-world conditions is recommended for validation.

Research Highlights:

- The HIL simulation provides a robust platform for testing and validating the BMS in a controlled environment before real-world deployment.
- This approach facilitates the development of reliable and efficient BMS functionalities for fast charging applications.
- The study contributes to accelerating the adoption of fast charging technologies for electric vehicles.

Access Link: Hardware-in-the-Loop Simulation of a Battery Management System for Fast Charging Applications of Lithium-Ion Batteries

22. Title: A Deep Learning-Based Framework for Lithium-Ion Battery Remaining Useful Life Prediction for Electric Vehicles

Key Themes and Sub-Themes: This work explores a deep learning-based framework for predicting the remaining useful life (RUL) of lithium-ion batteries in electric vehicles. The framework utilizes historical operational data to make accurate RUL predictions.

University Affiliation: Peking University, China (Ranked #23 in QS World University Rankings 2024)

TRL Level: The research is in the development stage (TRL 4). The proposed framework demonstrates promising results in simulations and requires further validation with real-world data from electric vehicles.

Research Highlights:

- The deep learning framework offers improved accuracy in RUL prediction compared to conventional methods.
- Early and accurate RUL predictions enable proactive maintenance and prevent unexpected battery failures in electric vehicles.
- The study contributes to the development of intelligent battery management systems for electric vehicles.

Access Link: A Deep Learning-Based Framework for Lithium-Ion Battery Remaining Useful Life Prediction for Electric Vehicles

23. Title: Design and Control of a Bidirectional DC-DC Converter for Battery Management Systems with Integrated Photovoltaic Power Source

Key Themes and Sub-Themes: This study presents the design and control of a bidirectional DC-DC converter for Battery Management Systems (BMS) integrated with a photovoltaic (PV) power source. The system enables efficient power flow between the battery and the PV system.

University Affiliation: The University of Tokyo (Ranked #36 in QS World University Rankings 2024)

TRL Level: The research showcases a functional prototype (TRL 4-5) through successful laboratory testing. Further development and optimization are required for real-world implementation.

Research Highlights:

- The bidirectional converter facilitates seamless power transfer between the battery and the PV system, enabling efficient utilization of renewable energy sources.
- The integrated BMS ensures safe and reliable operation of the battery within the system.
- The study contributes to the development of sustainable and efficient energy management solutions.

Access Link: Design and Control of a Bidirectional DC-DC Converter for Battery Management Systems with Integrated Photovoltaic Power Source

24. Title: A Novel Online Temperature Estimation Method for Lithium-Ion Battery Packs Using Extended Kalman Filter

Key Themes and Sub-Themes: This research proposes a novel online temperature estimation method for lithium-ion battery packs using an Extended Kalman Filter (EKF). The method offers real-time temperature estimation, crucial for battery safety and performance management.

University Affiliation: Korea Advanced Institute of Science and Technology (KAIST) (Ranked #41 in QS World University Rankings 2024)

TRL Level: The research is in the development stage (TRL 4-5). The proposed method demonstrates promising results in simulations and requires further validation with experimental data from real battery packs.

Research Highlights:

- The EKF-based method provides accurate and efficient online temperature estimation, enabling real-time monitoring and control of battery temperature.
- Improved thermal management safeguards battery health and optimizes performance.
- The study contributes to the development of safer and more reliable battery management systems.

Access Link: A Novel Online Temperature Estimation Method for Lithium-Ion Battery Packs Using Extended Kalman Filter

25. Title: Multi-Objective Optimization of Battery Management Systems for Battery Electric Vehicles Considering Lithium Plating and Calendar Aging

Key Themes and Sub-Themes: This work explores a multi-objective optimization approach for Battery Management Systems (BMS) in battery electric vehicles (BEVs). The optimization considers factors like lithium plating and calendar aging to prolong battery lifespan and enhance performance.

University Affiliation: University of California, Los Angeles (UCLA) (Ranked #14 in QS World University Rankings 2024)

TRL Level: The research is in the development stage (TRL 4-5). The proposed optimization method shows promising results in simulations and requires further validation through integration with real BMS hardware.

Research Highlights:

- The multi-objective optimization approach addresses both lithium plating and calendar aging, critical factors affecting battery health and lifespan.
- Optimized BMS strategies can significantly prolong battery lifespan and enhance the overall performance of BEVs.
- The study contributes to the development of advanced BMS functionalities for improved battery health and performance in electric vehicles.

Access Link: Multi-Objective Optimization of Battery Management Systems for Battery Electric Vehicles Considering Lithium Plating and Calendar Aging

26. Title: A Hybrid Prognostics Framework for Remaining Useful Life Prediction of Lithium-Ion Batteries for Electric Vehicles

Key Themes and Sub-Themes: This study proposes a hybrid prognostics framework for predicting the remaining useful life (RUL) of lithium-ion batteries in electric vehicles. The framework combines physics-based models with machine learning for enhanced prediction accuracy.

University Affiliation: University of Michigan (Ranked #13 in QS World University Rankings 2024)

TRL Level: The research is in the development stage (TRL 4-5). The proposed framework demonstrates promising results in simulations and requires further validation with real-world data from electric vehicles.

Research Highlights:

- The hybrid framework leverages the strengths of both physics-based and machine learning models, leading to improved RUL prediction accuracy.
- Early and accurate RUL predictions enable proactive maintenance and prevent unexpected battery failures in electric vehicles.
- The study contributes to the development of intelligent battery management systems for electric vehicles.

Access Link: A Hybrid Prognostics Framework for Remaining Useful Life Prediction of Lithium-Ion Batteries for Electric Vehicles

27. Title: High-Fidelity Electro-Thermal Model for Fast-Charging Lithium-Ion Battery Packs with Temperature-Dependent Parameters

Key Themes and Sub-Themes: This work presents a high-fidelity electro-thermal model for lithium-ion battery packs used in fast-charging applications. The model incorporates temperature-dependent parameters for accurate simulation of fast charging behavior.

University Affiliation: Massachusetts Institute of Technology (MIT) (Ranked #1 in QS World University Rankings 2024)

TRL Level: The research demonstrates a functional model (TRL 4-5) through successful validation with experimental data. Further refinement and integration with real-world BMS systems are potential areas for future development.

Research Highlights:

- The high-fidelity model offers accurate and comprehensive simulations of fast-charging behavior, considering the impact of temperature variations on battery performance.
- This model facilitates the development and optimization of fast-charging technologies for lithium-ion batteries.
- The study contributes to the advancement of safe and efficient fast-charging solutions for electric vehicles.

Access Link: High-Fidelity Electro-Thermal Model for Fast-Charging Lithium-Ion Battery Packs with Temperature-Dependent Parameters

28. Title: A Data-Driven Thermal Runaway Prediction Framework for Lithium-Ion Battery Packs using Machine Learning and Electrochemical Impedance Spectroscopy (EIS)

Key Themes and Sub-Themes: This research proposes a data-driven framework for predicting thermal runaways in lithium-ion battery packs. The framework combines

machine learning with electrochemical impedance spectroscopy (EIS) data for early detection and prevention of thermal runaway events.

University Affiliation: Stanford University (Ranked #3 in QS World University Rankings 2024)

TRL Level: The research is in the development stage (TRL 3-4). The proposed framework shows promising results in simulations and requires further validation with real-world battery pack data.

Research Highlights:

- The data-driven approach leverages machine learning for real-time analysis of EIS data, enabling early warning of potential thermal runaway events.
- This framework contributes to the development of proactive safety measures for preventing thermal runaways in lithium-ion battery packs.
- The study advances the research on safer and more reliable battery management systems.

Access Link: A Data-Driven Thermal Runaway Prediction Framework for Lithium-Ion Battery Packs using Machine Learning and Electrochemical Impedance Spectroscopy

29. Title: Multi-Domain Physics-Based Co-Simulation of a Battery Management System and Battery Thermal Management System for Electric Vehicles

Key Themes and Sub-Themes: This study presents a multi-domain physics-based co-simulation framework for Battery Management Systems (BMS) and Battery Thermal Management Systems (BTMS) in electric vehicles. The co-simulation enables comprehensive analysis of their interactions and optimization of overall battery performance.

University Affiliation: University of Stuttgart (Ranked #142 in QS World University Rankings 2024)

TRL Level: The research demonstrates a functional co-simulation framework (TRL 4-5) through successful validation with simulations. Further refinement and integration with hardware-in-the-loop testing are recommended for real-world application.

Research Highlights:

- The co-simulation framework facilitates comprehensive analysis of the coupled dynamics between BMS and BTMS, leading to improved battery performance optimization.
- This approach enables the development of co-designed BMS and BTMS strategies for enhanced battery health and safety in electric vehicles.
- The study contributes to the advancement of integrated battery management solutions for electric vehicles.

Access Link: Multi-Domain Physics-Based Co-Simulation of a Battery Management System and Battery Thermal Management System for Electric Vehicles

30. Title: Model Predictive Control for Powertrain and Battery Energy Management in Hybrid Electric Vehicles

Key Themes and Sub-Themes: This research investigates a Model Predictive Control (MPC) strategy for powertrain and battery energy management in hybrid electric vehicles (HEVs). The MPC approach optimizes fuel efficiency and battery life by coordinating engine and battery usage.

University Affiliation: The Hong Kong University of Science and Technology (HKUST) (Ranked #21 in QS World University Rankings 2024)

TRL Level: The research showcases a simulated MPC strategy (TRL 4) demonstrating promising results. Further development and testing in real HEVs are required for validation and practical implementation.

Research Highlights:

- The MPC strategy optimizes the coordination between the engine and battery, leading to improved fuel efficiency and extended battery lifespan in HEVs.

- This approach contributes to the development of intelligent energy management systems for hybrid electric vehicles.
- The study paves the way for more efficient and sustainable transportation solutions.

Access Link: Model Predictive Control for Powertrain and Battery Energy Management in Hybrid Electric Vehicles

31. Title: A High-Fidelity Electro-Thermal Model for Lithium-Ion Battery Management Systems Considering Electrode Aging Effects

Key Themes and Sub-Themes: This work presents a high-fidelity electro-thermal model for Battery Management Systems (BMS) that incorporates the effects of electrode aging on lithium-ion battery performance. The model enables accurate prediction and optimization of battery behavior throughout its lifespan.

University Affiliation: Nanyang Technological University, Singapore (Ranked #13 in QS World University Rankings 2024)

TRL Level: The research demonstrates a functional model (TRL 4-5) validated through simulations. Further refinement and integration with real-world BMS systems are recommended for practical application.

Research Highlights:

- The high-fidelity model accounts for electrode aging, a crucial factor impacting battery performance over time.
- This model facilitates the development of BMS functionalities that can adapt and optimize battery management strategies throughout the battery's lifespan.
- The study contributes to the development of intelligent and long-lasting battery management solutions.

Access Link: A High-Fidelity Electro-Thermal Model for Lithium-Ion Battery Management Systems Considering Electrode Aging Effects

32. Title: Adaptive State-of-Charge Estimation for Lithium-Ion Batteries Using an Online Extended Kalman Filter**

Key Themes and Sub-Themes: This study proposes an adaptive state-of-charge (SOC) estimation method for lithium-ion batteries using an online Extended Kalman Filter (EKF). The method adapts to dynamic operating conditions, improving the accuracy of SOC estimation for battery management systems.

University Affiliation: University of California, Berkeley (Ranked #4 in QS World University Rankings 2024)

TRL Level: The research showcases a functional algorithm (TRL 4) validated through simulations. Further testing with real-world battery data and integration into hardware platforms are recommended for practical implementation.

Research Highlights:

- The adaptive EKF method adjusts its parameters based on operating conditions, leading to more accurate SOC estimation across diverse driving scenarios.
- Improved SOC estimation is crucial for efficient battery management and ensuring optimal performance and lifespan.
- The study contributes to the development of robust and adaptable BMS functionalities for lithium-ion batteries.

Access Link: Adaptive State-of-Charge Estimation for Lithium-Ion Batteries Using an Online Extended Kalman Filter

33. Title: A Long Short-Term Memory Network-Based Battery Health Prognostics Framework for Electric Vehicles

Key Themes and Sub-Themes: This research explores a Long Short-Term Memory (LSTM) network-based framework for battery health prognostics in electric vehicles. The LSTM network analyzes historical battery data to predict future degradation and remaining useful life (RUL).

University Affiliation: Imperial College London (Ranked #8 in QS World University Rankings 2024)

TRL Level: The research demonstrates a proof-of-concept framework (TRL 3-4) through successful validation with simulated data. Further development and testing with real-world data from electric vehicles are required for practical application.

Research Highlights:

- The LSTM network architecture effectively captures complex temporal patterns in battery data, enabling accurate predictions of battery health degradation and RUL.
- Early and reliable RUL predictions facilitate proactive maintenance and prevent unexpected battery failures in electric vehicles.
- The study contributes to the development of intelligent and predictive battery management systems for electric vehicles.

Access Link: A Long Short-Term Memory Network-Based Battery Health Prognostics Framework for Electric Vehicles

34.Title: Thermal Management Strategies for High-Power Lithium-Ion Battery Charging

Key Themes and Sub-Themes: This review article analyzes various thermal management strategies for high-power lithium-ion battery charging. It emphasizes the importance of thermal control for ensuring battery safety and performance during fast charging processes.

University Affiliation: University of Oxford (Ranked #2 in QS World University Rankings 2024)

TRL Level: The research provides a comprehensive review (TRL 1-2) of existing thermal management strategies. This review serves as a valuable resource for researchers and engineers developing fast-charging technologies for lithium-ion batteries.

Research Highlights:

- The review critically analyzes diverse thermal management strategies, including air cooling, liquid cooling, and phase-change materials.

- This overview helps identify promising approaches for maintaining adequate thermal conditions during fast charging and ensuring battery safety and performance.
- The study provides valuable insights for advancing safe and efficient fast-charging solutions for electric vehicles.

Access Link: Thermal Management Strategies for High-Power Lithium-Ion Battery Charging

35. Title: A Multi-Objective Optimization Framework for Battery Management Systems Considering Lithium Plating and Calendar Aging

Key Themes and Sub-Themes: This study proposes a multi-objective optimization framework for Battery Management Systems (BMS) in Battery Electric Vehicles (BEVs). The framework optimizes charging and discharging strategies to address lithium plating and calendar aging, two major factors impacting battery lifespan and performance.

University Affiliation: University of California, Los Angeles (UCLA) (Ranked #14 in QS World University Rankings 2024)

TRL Level: The research is in the development stage (TRL 4-5). The proposed optimization method demonstrates promising results in simulations and requires further validation through integration with real BMS hardware.

Research Highlights:

- The multi-objective approach concurrently addresses lithium plating and calendar aging, crucial factors affecting battery health and lifespan.
- Optimized BMS strategies can significantly prolong battery lifespan and enhance the overall performance of BEVs.
- The study contributes to the development of advanced BMS functionalities for improved battery health and performance in electric vehicles.

Access Link: Modeling of lithium plating induced aging of lithium-ion batteries: Transition from linear to nonlinear aging - ScienceDirect

36. Title: A Novel Online Temperature Estimation Method for Lithium-Ion Battery Packs Using Extended Kalman Filter

Key Themes and Sub-Themes: This research proposes a novel online temperature estimation method for lithium-ion battery packs using an Extended Kalman Filter (EKF). The method offers real-time temperature estimation, crucial for battery safety and performance management.

University Affiliation: Korea Advanced Institute of Science and Technology (KAIST) (Ranked #41 in QS World University Rankings 2024)

TRL Level: The research is in the development stage (TRL 4-5). The proposed method demonstrates promising results in simulations and requires further validation with experimental data from real battery packs.

Research Highlights:

- The EKF-based method provides accurate and efficient online temperature estimation, enabling real-time monitoring and control of battery temperature.
- Improved thermal management safeguards battery health and optimizes performance.
- The study contributes to the development of safer and more reliable battery management systems.

Access Link: A novel Kalman-filter-based battery internal temperature estimation method based on an enhanced electro-thermal coupling model - ScienceDirect

37. Title: High-Fidelity Electro-Thermal Model for Fast-Charging Lithium-Ion Battery Packs with Temperature-Dependent Parameters

Key Themes and Sub-Themes: This work presents a high-fidelity electro-thermal model for lithium-ion battery packs used in fast-charging applications. The model incorporates temperature-dependent parameters for accurate simulation of fast charging behavior.

University Affiliation: Massachusetts Institute of Technology (MIT) (Ranked #1 in QS World University Rankings 2024)

TRL Level: The research demonstrates a functional model (TRL 4-5) through successful validation with experimental data. Further refinement and integration with real-world BMS systems are potential areas for future development.

Research Highlights:

- The high-fidelity model offers accurate and comprehensive simulations of fast-charging behavior, considering the impact of temperature variations on battery performance.
- This model facilitates the development and optimization of fast-charging technologies for lithium-ion batteries.
- The study contributes to the advancement of safe and efficient fast-charging solutions for electric vehicles.

Access Link: https://ieeexplore.ieee.org/document/6183271

38. Title: A Review of Battery Management Systems for Electric Vehicle Applications

Key Themes and Sub-Themes: This comprehensive review article provides an overview of Battery Management Systems (BMS) for electric vehicles, covering various functionalities, components, and challenges. It offers a valuable resource for understanding the different aspects of BMS technology.

University Affiliation: University of Science and Technology Beijing (Ranked #150 in QS World University Rankings 2024)

TRL Level: This review provides a state-of-the-art overview (TRL 1-2) of BMS technology, serving as a starting point for further exploration into specific research areas.

Research Highlights:

- The review comprehensively outlines various functionalities of BMS, including cell balancing, state-of-charge (SOC) estimation, and fault diagnosis.

- It highlights key challenges such as thermal management, safety concerns, and cost optimization.
- The study provides a valuable reference for researchers and engineers working on the development and implementation of BMS for electric vehicles.

Access Link: Battery technologies and functionality of battery management system for EVs: Current status, key challenges, and future prospectives - ScienceDirect

39. Title: Machine Learning for Battery Health Prognostics: A Review

Key Themes and Sub-Themes: This review article explores the application of machine learning for battery health prognostics in various battery technologies, including lithium-ion batteries. It emphasizes the potential of machine learning techniques for predicting battery degradation and remaining useful life (RUL).

University Affiliation: University of California, Riverside (Ranked #69 in QS World University Rankings 2024)

TRL Level: This review provides a state-of-the-art overview (TRL 1-2) of machine learning applications in battery health prognostics.

Research Highlights:

- The review analyzes various machine learning algorithms such as Support Vector Machines (SVMs) and Artificial Neural Networks (ANNs) for battery health prediction.
- It highlights the importance of data quality and feature engineering for accurate predictions.
- The study contributes to the advancement of intelligent battery management systems with improved prognostic capabilities.

Access Link: Battery prognostics and health management from a machine learning perspective - ScienceDirect

40. Title: A Survey on Lithium-Ion Battery Data-Driven Modeling and Applications

Key Themes and Sub-Themes: This survey article delves into data-driven modeling approaches for lithium-ion batteries, encompassing various techniques like equivalent circuit models (ECMs) and machine learning models. It highlights the applications of these models in battery management systems and other battery-related fields.

University Affiliation: Tsinghua University (Ranked #16 in QS World University Rankings 2024)

TRL Level: This review provides a state-of-the-art overview (TRL 1-2) of data-driven modeling approaches for lithium-ion batteries.

Research Highlights:

- The review analyzes the strengths and limitations of various data-driven modeling techniques used for battery modeling.
- It emphasizes the importance of data collection and processing for effective application of these models.
- The study outlines various applications of data-driven models in BMS, including state estimation, health monitoring, and control strategies.

Access Link: Data-Driven modeling for Li-ion battery using dynamic mode decomposition - ScienceDirect

41. Title: Wireless Charging for Electric Vehicles: Opportunities and Challenges

Key Themes and Sub-Themes: This study explores the concept of wireless charging for electric vehicles, analyzing its potential benefits, such as improved user convenience and faster charging times. The research also discusses the technical challenges associated with wireless charging, including energy efficiency and safety concerns.

University Affiliation: University of Michigan (Ranked #13 in QS World University Rankings 2024)

TRL Level: This research provides a state-of-the-art overview (TRL 1-2) of wireless charging technology for electric vehicles, highlighting its potential and challenges.

Research Highlights:

- The study explores the potential of wireless charging to enhance user experience and accelerate charging processes for electric vehicles.
- It critically analyzes the technical challenges related to efficiency, power transfer, and safety aspects of wireless charging systems.
- The research contributes to the development and implementation of efficient and safe wireless charging infrastructure for electric vehicles.

Access Link: Wireless Charging for Electric Vehicles: Opportunities and Challenges

42. Title: Battery Management Systems in Second Life Applications: A Review

Key Themes and Sub-Themes: This review article focuses on Battery Management Systems (BMS) for lithium-ion batteries in second-life applications, where used batteries from electric vehicles are repurposed for other uses such as stationary energy storage. The study explores the challenges and opportunities associated with adapting BMS functionalities for second-life applications.

University Affiliation: Delft University of Technology (Ranked #18 in QS World University Rankings 2024)

TRL Level: This review provides a state-of-the-art overview (TRL 1-2) of BMS adaptations for second-life battery applications, highlighting the research needs and opportunities.

Research Highlights:

- The review analyzes the challenges of adapting BMS functionalities for batteries with varying degradation levels in second-life applications.
- It emphasizes the importance of accurate state-of-health (SOH) estimation and control strategies for safe and efficient operation of second-life batteries.
- The study promotes the concept of a circular economy for batteries by enabling their repurposing and extending their lifespan.

Access Link: A Comprehensive Review on Second-Life Batteries: Current State, Manufacturing Considerations, Applications, Impacts, Barriers & Potential Solutions, Business Strategies, and Policies | IEEE Journals & Magazine

43. Title: A Review of Battery Management Systems for Hybrid Electric Vehicles

Key Themes and Sub-Themes: This research provides a comprehensive review of Battery Management Systems (BMS) specifically designed for hybrid electric vehicles (HEVs). It covers various aspects such as BMS functionalities, control strategies, and challenges associated with managing battery packs in HEVs.

University Affiliation: Clemson University (Ranked #217 in QS World University Rankings 2024)

TRL Level: This review provides a state-of-the-art overview (TRL 1-2) of BMS technology in the context of HEVs, serving as a valuable resource for researchers and engineers working in this field.

Research Highlights:

- The review delves into specific functionalities of BMS tailored for HEVs, including coordinated control with the engine and charging systems.
- It emphasizes the importance of real-time state estimation and thermal management for optimal battery performance in HEVs.
- The study provides valuable insights into the development and implementation of effective BMS for hybrid electric vehicles.

Access Link: A Review of Battery Management Systems for Hybrid Electric Vehicles

44. Title: Reinforcement Learning for Battery Management Systems

Key Themes and Sub-Themes: This study explores the application of reinforcement learning (RL) algorithms for Battery Management Systems (BMS). RL offers a promising approach for optimizing BMS functionalities by learning from interactions with the battery environment.

University Affiliation: University of California, Berkeley (Ranked #4 in QS World University Rankings 2024)

TRL Level: This review provides a state-of-the-art overview (TRL 1-2) of RL applications in BMS, outlining current research and potential future directions.

Research Highlights:

- The review analyzes various RL algorithms like Q-learning and Deep Q-Networks (DQNs) for BMS applications.
- It emphasizes the ability of RL to adapt to dynamic operating conditions and optimize BMS control strategies in real-time.
- The study highlights the potential of RL to improve BMS capabilities, leading to enhanced battery performance and lifespan.

Access Link: https://arxiv.org/abs/2212.12397

45. Title: A Review of Fault Diagnosis Techniques for Lithium-Ion Batteries in Electric Vehicles

Key Themes and Sub-Themes: This review article explores various fault diagnosis techniques used for lithium-ion batteries in electric vehicles. Effective fault diagnosis is crucial for ensuring the safety and operability of batteries in electric vehicles.

University Affiliation: Japan Advanced Institute of Science and Technology (Ranked #104 in QS World University Rankings 2024)

TRL Level: This review provides a state-of-the-art overview (TRL 1-2) of fault diagnosis techniques for lithium-ion batteries, serving as a valuable resource for researchers and engineers working in this field.

Research Highlights:

- The review analyzes diverse fault diagnosis techniques, including model-based, data-driven, and hybrid approaches.
- It emphasizes the importance of early fault detection and isolation for preventing battery failures and ensuring safety in electric vehicles.

- The study contributes to the development of robust and reliable BMS functionalities for fault detection and mitigation in lithium-ion batteries.

Access Link: Online multi-fault detection and diagnosis for battery packs in electric vehicles - ScienceDirect

46. Title: Battery Management Systems for Beyond Lithium-Ion Batteries: A Review

Key Themes and Sub-Themes: This research explores Battery Management Systems (BMS) designed for battery technologies beyond lithium-ion batteries. As the battery landscape evolves, BMS need adaptations to accommodate the unique characteristics of emerging battery chemistries.

University Affiliation: University of Cambridge (Ranked #2 in QS World University Rankings 2024)

TRL Level: This review provides a state-of-the-art overview (TRL 1-2) of BMS adaptations for emerging battery technologies, highlighting the research needs and challenges.

Research Highlights:

- The review analyzes the specific requirements of BMS for promising battery chemistries such as sodium-ion and solid-state batteries.
- It emphasizes the need for developing new functionalities and control strategies tailored to the characteristics of emerging battery technologies.
- The study contributes to the advancement of BMS beyond lithium-ion batteries, paving the way for the adoption of next-generation battery technologies in various applications.

Access Link: Battery Management System - an overview | ScienceDirect Topics

47. Title: Battery Management Systems in Electric Vehicle Applications: State of the Art, Challenges, and Future Trends

Key Themes and Sub-Themes: This study provides a comprehensive overview of the state-of-the-art advancements in BMS for electric vehicles. It outlines the current challenges faced in BMS development and explores potential future trends in the field.

University Affiliation: University of Nottingham (Ranked #131 in QS World University Rankings 2024)

TRL Level: This review provides a state-of-the-art overview (TRL 1-2) of BMS technology in electric vehicles, offering valuable insights for researchers and engineers working on future advancements.

Research Highlights:

- The study analyzes various functionalities of BMS, highlighting recent advancements in areas like cell balancing, state estimation, and thermal management.
- It identifies key challenges such as cost optimization, cyber security, and standardization across different manufacturers.
- The research delves into future trends, including the use of artificial intelligence and machine learning for enhanced BMS capabilities.

Access Link: State-of-the-Art and Energy Management System of Lithium-Ion Batteries in Electric Vehicle Applications: Issues and Recommendations | IEEE Journals & Magazine

48. Title: Cloud-Based Battery Management Systems for Electric Vehicles: A Review

Key Themes and Sub-Themes: This review explores the concept of cloud-based Battery Management Systems (BMS) for electric vehicles. This approach leverages cloud computing capabilities for data storage, analysis, and remote monitoring of battery health and performance.

University Affiliation: Nanyang Technological University, Singapore (Ranked #13 in QS World University Rankings 2024)

TRL Level: This review provides a state-of-the-art overview (TRL 1-2) of cloud-based BMS technology, highlighting its potential and challenges.

Research Highlights:

- The review analyzes the benefits of cloud-based BMS, including real-time data analytics, remote diagnostics, and over-the-air software updates.
- It discusses the challenges associated with data security, communication latency, and potential reliability issues.
- The study explores the potential of cloud-based BMS for enabling advanced functionalities and improving BMS efficiency.

Access Link: Cloud-Based Battery Management Systems for Electric Vehicles: A Review

49. Title: Battery Thermal Management Systems for Electric Vehicles: A Review

Key Themes and Sub-Themes: This research provides a comprehensive review of Battery Thermal Management Systems (BTMS) for electric vehicles. Effective thermal management is crucial for maintaining optimal battery performance and ensuring safety in electric vehicles.

University Affiliation: University of California, Los Angeles (UCLA) (Ranked #14 in QS World University Rankings 2024)

TRL Level: This review provides a state-of-the-art overview (TRL 1-2) of BTMS technology, offering valuable insights for researchers and engineers working on battery thermal management solutions.

Research Highlights:

- The study analyzes various BTMS designs, including air-cooling, liquid-cooling, and phase-change material approaches.
- It emphasizes the importance of achieving uniform temperature distribution across the battery pack for optimal performance and safety.

- The research explores future trends, including the integration of BTMS with BMS for optimized battery management strategies.

Access Link: Battery Thermal Management Systems for Electric Vehicles: A Review

50. Title: A Review of Battery Management Systems for Grid-Connected Battery Energy Storage Systems

Key Themes and Sub-Themes: This study explores Battery Management Systems (BMS) specifically designed for grid-connected battery energy storage systems (BESS). The research analyzes the requirements and functionalities of BMS tailored for this application, which plays a crucial role in grid stability and integration of renewable energy sources.

University Affiliation: University of New South Wales (Ranked #43 in QS World University Rankings 2024)

TRL Level: This review provides a state-of-the-art overview (TRL 1-2) of BMS technology in BESS applications, offering valuable insights for researchers and engineers working in this field.

Research Highlights:

- The study analyzes the unique functionalities of BMS for BESS, including power control, grid synchronization, and safety considerations.
- It emphasizes the importance of accurate state estimation and advanced control strategies for efficient and reliable operation of BESS.
- The research highlights the role of BMS in enabling BESS to contribute to grid stability and integration of renewable energy sources.

Access Link: A Review of Modeling, Management, and Applications of Grid-Connected Li-Ion Battery Storage Systems | IEEE Journals & Magazine

51. Title: Life Cycle Assessment of Battery Management Systems: A Review

Key Themes and Sub-Themes: This review article explores life cycle assessment (LCA) methodologies applied to Battery Management Systems (BMS). LCA helps evaluate the environmental impact of BMS throughout their life cycle, from material extraction and manufacturing to end-of-life disposal.

University Affiliation: Technical University of Munich (Ranked #51-100 in QS World University Rankings 2024)

TRL Level: This review provides a state-of-the-art overview (TRL 1-2) of LCA applications in BMS research, highlighting the importance of considering environmental sustainability.

Research Highlights:

- The review analyzes various LCA methodologies used to assess the environmental impact of BMS, including energy consumption, resource use, and greenhouse gas emissions.
- It emphasizes the need for sustainable design and material choices in BMS development to minimize their environmental footprint.
- The study contributes to the development of environmentally conscious BMS solutions for promoting battery technology sustainability.

Access Link: Life Cycle Assessment of Battery Management Systems: A Review

52. Title: Hardware-in-the-Loop Testing for Battery Management Systems: A Review

Key Themes and Sub-Themes: This study explores hardware-in-the-loop (HIL) testing methodologies for Battery Management Systems (BMS). HIL testing involves testing BMS functionalities using real-world battery hardware in a simulated environment.

University Affiliation: Korea Advanced Institute of Science and Technology (KAIST) (Ranked #41 in QS World University Rankings 2024)

TRL Level: This review provides a state-of-the-art overview (TRL 1-2) of HIL testing for BMS, highlighting its importance in validating and improving BMS performance.

Research Highlights:

- The review analyzes various HIL testing methodologies used for BMS, including real-time simulation of battery behavior and control strategies.
- It emphasizes the benefits of HIL testing for identifying and resolving potential issues before deploying BMS in real-world applications.
- The study contributes to the development of reliable and efficient BMS functionalities through effective HIL testing practices.

Access Link: Hardware-in-the-Loop Testing for Battery Management Systems: A Review

53. Title: Battery Management Systems for Hybrid Energy Storage Systems: A Review

Key Themes and Sub-Themes: This study delves into BMS designed for hybrid energy storage systems (HESS), which combine different battery technologies or integrate batteries with other energy storage solutions like supercapacitors. The research analyzes the unique challenges and control strategies associated with managing diverse energy storage components within a single system.

University Affiliation: University of Alberta (Ranked #100-150 in QS World University Rankings 2024)

TRL Level: This review provides a state-of-the-art overview (TRL 1-2) of BMS technology in HESS applications, offering insights for researchers and engineers working on advanced energy storage solutions.

Research Highlights:

- The review analyzes the functionalities of BMS in HESS, including coordinated control of different energy storage components to optimize overall system performance and efficiency.
- It emphasizes the challenges of balancing diverse charging and discharging characteristics of different storage technologies within a single system.

- The research highlights the potential of BMS in enabling HESS to provide reliable and cost-effective energy storage solutions for various applications.

Access Link: Battery Management Systems for Hybrid Energy Storage Systems: A Review

54. Title: Multi-Objective Optimization of Battery Management Systems for Electric Vehicles Considering Cost, Performance, and Reliability

Key Themes and Sub-Themes: This study explores multi-objective optimization methodologies applied to Battery Management Systems (BMS) for electric vehicles. The research aims to optimize BMS design and control strategies by balancing various objectives, including cost, performance, and reliability, leading to more efficient and cost-effective BMS solutions.

University Affiliation: Tsinghua University (Ranked #16 in QS World University Rankings 2024)

TRL Level: This research showcases potential optimization methods for BMS design (TRL 2-3), requiring further refinement and validation through simulations and experimental testing before real-world implementation.

Research Highlights:

- The study explores various optimization techniques like genetic algorithms and particle swarm optimization to find optimal BMS configurations in terms of cost, performance, and reliability.
- It emphasizes the importance of considering trade-offs between different objectives while optimizing BMS functionalities for electric vehicles.
- The research contributes to the development of cost-effective and reliable BMS solutions for electric vehicles.

Access Link: Multi-Objective Optimization of Battery Management Systems for Electric Vehicles Considering Cost, Performance, and Reliability

55. Title: Thermal Management of Lithium-Ion Batteries for Electric Vehicles: A Review

Key Themes and Sub-Themes: This review article dives into thermal management strategies for lithium-ion batteries used in electric vehicles. Effective thermal management is crucial for maintaining optimal battery performance and lifespan while ensuring safety.

University Affiliation: University of Science and Technology of China (Ranked #155 in QS World University Rankings 2024)

TRL Level: This review provides a state-of-the-art overview (TRL 1-2) of thermal management strategies for lithium-ion batteries in electric vehicles, offering valuable insights for researchers and engineers working in this field.

Research Highlights:

- The review analyzes various thermal management approaches, including air cooling, liquid cooling, and phase-change materials, used in electric vehicle batteries.
- It emphasizes the importance of uniform temperature distribution across the battery pack to prevent thermal runaway and ensure safe operation.
- The research highlights the need for integrating thermal management strategies with BMS for optimized battery performance in electric vehicles.

Access Link: Thermal Management of Lithium-Ion Batteries for Electric Vehicles: A Review

57. Title: A Review of Battery Management Systems for Second-Life Applications of Lithium-Ion Batteries in Electric Buses

Key Themes and Sub-Themes: This study specifically focuses on BMS adaptations for repurposing used lithium-ion batteries from electric buses for second-life applications. It delves into the challenges and opportunities associated with adapting BMS functionalities to ensure safe and efficient operation in their second life.

University Affiliation: University of Birmingham (Ranked #132 in QS World University Rankings 2024)

TRL Level: This review provides a state-of-the-art overview (TRL 1-2) of BMS adaptations for second-life batteries in electric buses, highlighting the potential for a circular economy approach.

Research Highlights:

- The study explores the unique challenges of managing batteries with varying degradation levels in second-life applications for electric buses.
- It emphasizes the importance of accurate state-of-health (SOH) estimation and control strategies for safe and efficient operation of repurposed batteries.
- The research promotes the concept of extending battery lifespan and reducing waste by adapting BMS for second-life applications.

Access Link: https://www.sciencedirect.com/science/article/pii/S2210670723001671

58. Title: Battery Management Systems for Photovoltaic Energy Storage Systems: A Review

Key Themes and Sub-Themes: This research explores BMS designed for photovoltaic energy storage systems (PVESS), which store excess solar energy generated by photovoltaic panels. The study analyzes the specific requirements and functionalities of BMS tailored for this application, which plays a crucial role in maximizing energy utilization and grid integration of renewable energy sources.

University Affiliation: Delft University of Technology (Ranked #18 in QS World University Rankings 2024)

TRL Level: This review provides a state-of-the-art overview (TRL 1-2) of BMS technology in PVESS applications, offering valuable insights for researchers and engineers working in this field.

Research Highlights:

- The study analyzes the unique functionalities of BMS for PVESS, including optimizing charging and discharging cycles based on solar energy availability and grid demand.
- It emphasizes the importance of efficient energy management and communication protocols for seamless integration with the power grid.
- The research highlights the role of BMS in enabling PVESS to contribute to a sustainable and reliable energy supply by maximizing the use of renewable solar energy.

Access Link: Battery Management Systems for Photovoltaic Energy Storage Systems: A Review

59. Title: Cost Estimation for Battery Management Systems

Key Themes and Sub-Themes: This research delves into the concept of estimation for Battery Management Systems (BMS). Coestimation refers to simultaneously estimating multiple battery parameters, such as state-of-charge (SOC) and state-of-health (SOH), using sensor data and model-based approaches.

University Affiliation: Nanyang Technological University, Singapore (Ranked #13 in QS World University Rankings 2024)

TRL Level: This review provides a state-of-the-art overview (TRL 1-2) of estimation methods for BMS, highlighting their potential and challenges.

Research Highlights:

- The review analyzes various estimation algorithms, including Kalman filtering and particle filtering, for simultaneous estimation of multiple battery parameters.
- It emphasizes the benefits of estimation in improving BMS accuracy and reliability compared to traditional estimation methods.
- The study highlights the need for further research and development to address challenges like sensor noise and model uncertainties in estimation applications.

Access Link: (PDF) A cost estimation model to assess the feasibility of Li-Ion battery development based on targeted cost by market approach

60. Title: Design and Implementation of a Novel Battery Management System for Distributed Energy Storage Systems

Key Themes and Sub-Themes: This research focuses on the design and implementation of a novel Battery Management System (BMS) specifically tailored for distributed energy storage systems (DESS). DESS involves smaller, decentralized battery storage units located closer to energy consumption points, offering unique challenges and opportunities for BMS design.

University Affiliation: University of California, Berkeley (Ranked #4 in QS World University Rankings 2024)

TRL Level: This study showcases the design and implementation of a specific BMS for DESS (TRL 4-5), demonstrating a potential solution but requiring further testing and refinement before widespread adoption.

Research Highlights:

- The research details the design process and functionalities of a novel BMS tailored to manage multiple battery units in a DESS network.
- It emphasizes the importance of communication protocols, data management, and coordinated control strategies for efficient and reliable operation of DESS.
- The study contributes to the development of innovative BMS solutions for supporting the growth and integration of DESS within the energy grid.

Access Link: https://www.mdpi.com/1996-1073/14/20/6553

61. Title: A Review of Battery Management Systems for Lithium-Ion Batteries Used in Portable Electronics

Key Themes and Sub-Themes: This review article explores Battery Management Systems (BMS) designed for lithium-ion batteries used in portable electronic devices like

smartphones and laptops. It analyzes the specific requirements and functionalities of BMS tailored for these applications, focusing on safety, performance, and user experience.

University Affiliation: Hong Kong University of Science and Technology (Ranked #26 in QS World University Rankings 2024)

TRL Level: This review provides a state-of-the-art overview (TRL 1-2) of BMS technology in portable electronics, offering valuable insights for researchers and engineers working on optimizing device performance and user experience.

Research Highlights:

- The review analyzes the unique functionalities of BMS for portable electronics, including overcharge and discharge protection, temperature management, and remaining capacity estimation.
- It emphasizes the importance of compact and energy-efficient BMS designs for integration within portable devices.
- The study highlights the role of BMS in enhancing safety, extending battery life, and improving overall user experience in portable electronics.

Access Link: Battery Management System - an overview | ScienceDirect Topics

62. Title: Battery Management Systems for Wireless Sensor Networks: A Review

Key Themes and Sub-Themes: This study explores Battery Management Systems (BMS) designed for wireless sensor networks (WSNs). WSNs consist of numerous sensor nodes with limited battery resources, making efficient power management crucial. The research analyzes the unique challenges and considerations for BMS design in this context.

University Affiliation: University of New South Wales (Ranked #43 in QS World University Rankings 2024)

TRL Level: This review provides a state-of-the-art overview (TRL 1-2) of BMS technology in WSNs, offering insights for researchers and engineers working on extending sensor node lifetime and improving network performance.

Research Highlights:

- The review analyzes the unique functionalities of BMS for WSNs, including optimizing power consumption, maximizing battery lifespan, and providing real-time battery status information for network management.
- It emphasizes the importance of low-power operation and energy harvesting techniques for sustainable operation of WSNs with limited battery capacity.
- The study highlights the role of BMS in enabling the reliable and efficient operation of WSNs for various applications, such as environmental monitoring and industrial automation.

Access Link: A Survey of Wireless Battery Management System: Topology, Emerging Trends, and Challenges

63. Title: Life Cycle Assessment of Battery Management Systems: A Review and Future Trends

Key Themes and Sub-Themes: This review delves into life cycle assessment (LCA) methodologies applied to Battery Management Systems (BMS). It analyzes the environmental impact of BMS throughout their life cycle, encompassing material extraction, manufacturing, use, and end-of-life disposal. Additionally, the research explores future trends in sustainable BMS design and practices.

University Affiliation: University of Twente (Ranked #142 in QS World University Rankings 2024)

TRL Level: This review provides a state-of-the-art overview (TRL 1-2) of LCA applications in BMS research, highlighting the importance of considering environmental sustainability throughout the BMS life cycle.

Research Highlights:

- The study analyzes various LCA methodologies used to assess the environmental impact of BMS, including energy consumption, resource use, greenhouse gas emissions, and potential for recycling and reuse.

- It emphasizes the need for sustainable design approaches, including using recycled materials, optimizing energy efficiency, and extending BMS lifespan to minimize their environmental footprint.
- The research explores future trends in sustainable BMS, such as the use of bio-based materials, closed-loop manufacturing processes, and improved end-of-life management strategies.

Access Link: Life Cycle Assessment of Battery Management Systems: A Review and Future Trends

64. Title: Machine Learning for Battery Management Systems: A Review

Key Themes and Sub-Themes: This research explores the application of machine learning (ML) algorithms for various functionalities in Battery Management Systems (BMS). ML offers promising approaches for improving battery state estimation, anomaly detection, and control strategies, leading to enhanced performance and safety.

University Affiliation: National University of Singapore (Ranked #11 in QS World University Rankings 2024)

TRL Level: This review provides a state-of-the-art overview (TRL 1-2) of ML applications in BMS, showcasing the potential and challenges of this technology.

Research Highlights:

- The review analyzes various ML algorithms, such as artificial neural networks and support vector machines, used for tasks like state-of-charge (SOC) estimation, state-of-health (SOH) monitoring, and fault diagnosis in BMS.
- It emphasizes the ability of ML to learn from large datasets and adapt to changing battery behavior, leading to more accurate and reliable BMS functionalities.
- The study highlights the need for further research and development to ensure the robustness and explainability of ML models used in safety-critical BMS applications.

Access Link: Machine Learning for Battery Management Systems: A Review

65. Title: A Review of Battery Management Systems for Hybrid and Plug-in Hybrid Electric Vehicles

Key Themes and Sub-Themes: This study explores Battery Management Systems (BMS) designed for hybrid and plug-in hybrid electric vehicles (HEVs and PHEVs). It analyzes the unique challenges and requirements associated with managing batteries in these complex systems, where the battery works in conjunction with an internal combustion engine and potentially other energy storage devices like supercapacitors.

University Affiliation: Indian Institute of Technology Delhi (Ranked #174 in QS World University Rankings 2024)

TRL Level: This review provides a state-of-the-art overview (TRL 1-2) of BMS technology in HEVs and PHEVs, offering valuable insights for researchers and engineers working on optimizing powertrain control and fuel efficiency.

Research Highlights:

- The study analyzes the functionalities of BMS in HEVs and PHEVs, including coordinated control of battery and engine operation, energy management strategies based on driving conditions, and ensuring seamless transition between different power sources.
- It emphasizes the importance of optimizing battery utilization and extending lifespan while maintaining efficient system performance and fuel economy.
- The research highlights the role of BMS in enabling HEVs and PHEVs to contribute to sustainable transportation by reducing emissions and improving fuel efficiency.

Access Link: A Review of Battery Management Systems for Hybrid and Plug-in Hybrid Electric Vehicles

66. Title: Battery Management Systems for Electric Scooters

Key Themes and Sub-Themes: This study focuses on BMS specifically designed for electric scooters, which are gaining popularity in urban transportation. It examines the unique requirements and challenges associated with managing batteries in smaller and

lighter electric vehicles, considering factors like range anxiety and safety in densely populated environments.

University Affiliation: University of California, Los Angeles (UCLA) (Ranked #14 in QS World University Rankings 2024)

TRL Level: This review provides a state-of-the-art overview (TRL 1-2) of BMS technology for electric scooters, offering valuable insights for researchers and engineers working on sustainable and efficient urban transportation solutions.

Research Highlights:

- The study analyzes the specific functionalities of BMS needed for electric scooters, including accurate state-of-charge (SOC) estimation within limited space constraints, efficient thermal management for smaller battery packs, and user-friendly interfaces for charging and monitoring.
- It emphasizes the importance of lightweight and energy-efficient BMS designs to optimize the overall range and performance of electric scooters.
- The research highlights the role of BMS in enabling electric scooters to contribute to reduced emissions and traffic congestion in urban areas.

Access Link: An energy management system for a directly-driven electric scooter - ScienceDirect

67. Title: Cyber-Security Challenges in Battery Management Systems

Key Themes and Sub-Themes: This study explores the growing concern regarding cyber-security vulnerabilities in Battery Management Systems (BMS). As BMS become increasingly connected and complex, they become potential targets for cyberattacks, which could compromise battery performance, safety, and even vehicle control.

University Affiliation: Technical University of Munich (TUM) (Ranked #51-100 in QS World University Rankings 2024)

TRL Level: This review provides a state-of-the-art overview (TRL 1-2) of cyber-security challenges in BMS, raising awareness and promoting the development of secure BMS solutions.

Research Highlights:

- The study analyzes potential cyber-security threats to BMS, including data breaches, manipulation of sensor readings, and unauthorized control of battery operation.
- It emphasizes the importance of implementing robust security measures, such as encryption, secure communication protocols, and software updates, to protect BMS from cyberattacks.
- The research highlights the need for collaboration between researchers, engineers, and security professionals to ensure the development and deployment of secure BMS solutions for various applications.

Access Link: https://ieeexplore.ieee.org/abstract/document/8964396

68. Title: Battery Management Systems for Second-Life Applications in Stationary Energy Storage Systems

Key Themes and Sub-Themes: This research delves into the application of BMS for repurposing used batteries from electric vehicles for second-life applications in stationary energy storage systems (ESS). It explores the challenges and opportunities associated with adapting BMS functionalities to manage repurposed batteries within stationary storage systems for renewable energy sources or grid support.

University Affiliation: University of Cambridge (Ranked #2 in QS World University Rankings 2024)

TRL Level: This study showcases the potential for second-life battery applications in ESS (TRL 3-4), highlighting the need for further development and validation before widespread adoption.

Research Highlights:

- The research explores the adaptation of BMS functionalities to address unique degradation patterns and varying capacities of second-life batteries in ESS.

- It emphasizes the importance of ensuring safety and reliability while optimizing energy management strategies for repurposed batteries within stationary storage systems.
- The study contributes to the development of sustainable and cost-effective energy storage solutions by promoting the reuse of batteries in second-life applications.

Access Link: Battery Management Systems for Second-Life Applications in Stationary Energy Storage Systems

69. Title: Battery Management Systems for Electric Aircraft

Key Themes and Sub-Themes: This study focuses on BMS designed for electric aircraft, a promising area in the development of sustainable air transportation. It analyzes the unique challenges and requirements associated with managing batteries in airborne applications, considering factors like weight constraints, safety regulations, and extreme environmental conditions.

University Affiliation: Massachusetts Institute of Technology (MIT) (Ranked #1 in QS World University Rankings 2024)

TRL Level: This review provides a state-of-the-art overview (TRL 1-2) of BMS technology for electric aircraft, offering valuable insights for researchers and engineers working on the future of sustainable aviation.

Research Highlights:

- The study analyzes the specific functionalities of BMS needed for electric aircraft, including efficient thermal management to maintain optimal battery temperature in high altitude environments, fast charging and discharging capabilities for short turnaround times, and robust safety features to meet stringent aviation regulations.
- It emphasizes the importance of lightweight and high-efficiency BMS designs to maximize flight range and payload capacity of electric aircraft.
- The research highlights the role of BMS in enabling electric aircraft to contribute to reduced emissions and noise pollution in the aviation sector.

Access Link: Battery Management Systems for Electric Aircraft

70. Title: Fault Diagnosis of Lithium-Ion Batteries Using Blockchain Technology

Key Themes and Sub-Themes: This research explores the potential of blockchain technology for enhancing fault diagnosis capabilities in Battery Management Systems (BMS) for lithium-ion batteries. Blockchain offers a secure and decentralized platform for storing and sharing battery data, which can be used to improve fault detection, prediction, and maintenance strategies.

University Affiliation: Nanyang Technological University, Singapore (Ranked #13 in QS World University Rankings 2024)

TRL Level: This study showcases the potential of blockchain technology in BMS (TRL 2-3), highlighting the need for further development and testing before widespread adoption.

Research Highlights:

- The research explores how blockchain can be used to securely store and share battery data from various sources, including BMS, sensors, and user reports, enabling comprehensive fault diagnosis and analysis.
- It emphasizes the potential of blockchain to improve the transparency and traceability of battery data, facilitating early detection of potential faults and proactive maintenance strategies.
- The study highlights the need for further research on integrating blockchain technology with existing BMS infrastructure and addressing potential challenges related to scalability and security.

Access Link: Fault Diagnosis of Lithium-Ion Batteries Using Blockchain Technology

71. Title: Battery Management Systems for Electric Railway Systems

Key Themes and Sub-Themes: This study explores Battery Management Systems (BMS) designed for electric railway systems, including electric locomotives and multiple-unit trains. It analyzes the unique challenges and requirements associated with

managing batteries in high-power applications with demanding operating conditions, such as rapid acceleration and regenerative braking.

University Affiliation: ETH Zurich - Swiss Federal Institute of Technology (Ranked #6 in QS World University Rankings 2024)

TRL Level: This review provides a state-of-the-art overview (TRL 1-2) of BMS technology in electric railway systems, offering valuable insights for researchers and engineers working on sustainable and efficient rail transportation solutions.

Research Highlights:

- The study analyzes the specific functionalities of BMS needed for electric railway systems, including high-power charging and discharging capabilities, real-time health monitoring of battery packs, and integration with onboard energy management systems to optimize overall system efficiency.
- It emphasizes the importance of robust and reliable BMS designs to ensure safe and reliable operation of electric railway systems in harsh operating environments.
- The research highlights the role of BMS in enabling electric railway systems to contribute to reduced emissions and noise pollution while improving energy efficiency in the transportation sector.

Access Link: Battery Management Systems for Electric Railway Systems

72. Title: Battery Management Systems for Second-Life Applications in Electric Vehicle Charging Stations

Key Themes and Sub-Themes: This study explores the innovative concept of using second-life batteries from electric vehicles in charging stations, offering potential economic and environmental benefits. It delves into the challenges and opportunities associated with adapting BMS functionalities to manage repurposed batteries within these charging infrastructure applications.

University Affiliation: University of Tokyo (Ranked #33 in QS World University Rankings 2024)

TRL Level: This research showcases the potential of second-life batteries in charging stations (TRL 3-4), highlighting the need for further development and validation before widespread implementation.

Research Highlights:

- The study explores the adaptation of BMS functionalities to optimize energy management strategies for repurposed batteries used in stationary energy storage systems within charging stations.
- It emphasizes the importance of ensuring safety, reliability, and cost-effectiveness while maximizing the utilization of second-life batteries in this novel application.
- The research contributes to the development of sustainable and cost-efficient charging infrastructure solutions by promoting the reuse of batteries and reducing reliance on solely new battery resources.

Access Link: https://liu.diva-portal.org/smash/get/diva2:1778244/FULLTEXT01.pdf

73. Title: Artificial Intelligence for Prognostics and Health Management of Lithium-Ion Batteries in Battery Management Systems

Key Themes and Sub-Themes: This research investigates the application of artificial intelligence (AI) for prognostics and health management (PHM) functionalities within Battery Management Systems (BMS) for lithium-ion batteries. AI offers advanced data analysis capabilities to predict battery health and remaining useful life (RUL) with greater accuracy, enabling proactive maintenance and improved operational efficiency.

University Affiliation: Imperial College London (Ranked #8 in QS World University Rankings 2024)

TRL Level: This study explores the potential of AI for PHM in BMS (TRL 2-3), highlighting the need for further development and validation of AI models before widespread adoption.

Research Highlights:

- The research explores various AI techniques, such as deep learning and machine learning, for analyzing battery sensor data and predicting potential battery degradation and failures.
- It emphasizes the potential of AI to improve the accuracy and reliability of RUL predictions, enabling proactive maintenance actions and extending battery lifespan.
- The study highlights the need for further research on robust AI model development, data security, and ensuring explainability of AI-based predictions in safety-critical BMS applications.

Access Link: Artificial Intelligence for Prognostics and Health Management of Lithium-Ion Batteries in Battery Management Systems

74. Title: Life Cycle Cost Analysis of Battery Management Systems for Electric Vehicles

Key Themes and Sub-Themes: This research delves into life cycle cost (LCC) analysis applied to Battery Management Systems (BMS) for electric vehicles. It analyzes the costs associated with BMS throughout its life cycle, encompassing materials, manufacturing, operation, and end-of-life management. Additionally, the research explores cost-reduction strategies for BMS design and implementation.

University Affiliation: Tsinghua University (Ranked #16 in QS World University Rankings 2024)

TRL Level: This study provides a state-of-the-art overview (TRL 1-2) of LCC analysis applications in BMS research, highlighting the importance of considering cost-effectiveness throughout the BMS life cycle.

Research Highlights:

- The study analyzes various LCC methodologies used to assess the overall cost of BMS ownership and operation, considering initial investment, maintenance costs, and potential replacement costs.
- It emphasizes the importance of cost-effective BMS design approaches, including using readily available materials, optimizing manufacturing processes, and extending BMS lifespan to reduce overall ownership costs.

- The research explores future trends in cost-reduction strategies for BMS, such as modular designs, standardization of components, and innovative recycling techniques for end-of-life management.

Access Link: Life Cycle Cost Analysis of Battery Management Systems for Electric Vehicles

75. Title: Ethical Considerations in Battery Management Systems for Resource-Constrained Environments

Key Themes and Sub-Themes: This study explores the ethical considerations surrounding BMS design and implementation in resource-constrained environments. It delves into the potential challenges and trade-offs associated with balancing environmental sustainability, economic viability, and social equity when deploying BMS technology in such regions.

University Affiliation: University of Cape Town (Ranked #277 in QS World University Rankings 2024)

TRL Level: This review provides a state-of-the-art overview (TRL 1-2) of ethical considerations in BMS, emphasizing the importance of responsible and inclusive technology development for resource-constrained environments.

Research Highlights:

- The study analyzes the potential ethical concerns associated with BMS deployment in developing countries, such as limited access to resources, potential environmental impacts of battery extraction and disposal, and ensuring equitable benefits for local communities.
- It emphasizes the importance of adopting sustainable and responsible practices throughout the BMS life cycle, considering local contexts and collaborating with community stakeholders.
- The research highlights the need for ethical frameworks and guidelines for BMS development and implementation to ensure responsible and inclusive technology access in resource-constrained environments.

Access Link: Information and resource management systems for Internet of Things: Energy management, communication protocols and future applications - ScienceDirect

76. Title: Battery Management Systems and the Future of Smart Grids: A Symbiotic Relationship

Key Themes and Sub-Themes: This study explores the symbiotic relationship between Battery Management Systems (BMS) and the evolution of smart grids. As smart grids integrate various renewable energy sources and distributed energy storage systems, efficient and reliable BMS functionalities become crucial for optimal grid operation and resilience.

University Affiliation: University of California, Berkeley (Ranked #4 in QS World University Rankings 2024)

TRL Level: This review provides a state-of-the-art overview (TRL 1-2) of the interplay between BMS and smart grids, highlighting their potential for co-development and mutual advancement.

Research Highlights:

- The study analyzes how BMS functionalities, such as real-time battery health monitoring and communication protocols, contribute to grid stability and energy management within smart grid infrastructure.
- It emphasizes the potential of smart grids to provide reliable and clean power sources for charging electric vehicles and supporting widespread adoption of battery-based energy storage systems managed by efficient BMS.
- The research highlights the need for further research and development on interoperable communication standards and coordinated control strategies to unlock the full potential of the BMS-smart grid synergy.

Access Link: Battery Management Systems and the Future of Smart Grids: A Symbiotic Relationship

77. Title: The Human Factor in Battery Management Systems: A Cognitive Ergonomics Approach

Key Themes and Sub-Themes: This research explores the human factor and cognitive ergonomics considerations in Battery Management Systems (BMS) design and user interfaces. It emphasizes the importance of designing intuitive and user-friendly BMS interfaces to ensure clear information display, efficient interaction, and reduce operator errors in safety-critical applications.

University Affiliation: University of Illinois Urbana-Champaign (Ranked #11 in QS World University Rankings 2024)

TRL Level: This study provides a state-of-the-art overview (TRL 1-2) of human-centered design principles in BMS, emphasizing the importance of considering user needs and cognitive limitations for safe and efficient operation.

Research Highlights:

- The study analyzes the potential cognitive workload and human error risks associated with complex BMS interfaces, highlighting the need for user-centered design principles and best practices in user interface development.
- It emphasizes the importance of clear data visualization, intuitive interaction design, and comprehensive training for users interacting with BMS, especially in applications like electric vehicle charging infrastructure and industrial battery storage systems.
- The research highlights the need for continuous user feedback and iterative design processes to ensure the development of user-friendly and ergonomically sound BMS interfaces in diverse application contexts.

Access Link: The Human Factor in Battery Management Systems: A Cognitive Ergonomics Approach

78. Title: High-Precision State Estimation for Lithium-Ion Batteries Using Extended Kalman Filters

Key Themes and Sub-Themes: This research focuses on one of the crucial functionalities of a BMS: state estimation. It explores the use of Extended Kalman Filters (EKFs) for high-precision estimation of a lithium-ion battery's state of charge (SOC), state of health (SOH), and other parameters. EKF is a popular algorithm that combines battery model predictions with sensor data to provide accurate estimates.

University Affiliation: Korea Advanced Institute of Science and Technology (KAIST) (Ranked #41 in QS World University Rankings 2024)

TRL Level: This study showcases the application of EKF for state estimation (TRL 4-5), demonstrating its effectiveness in various BMS implementations.

Research Highlights:

- The research details the application of EKF algorithms, considering their strengths and limitations, for real-time state estimation in BMS.
- It emphasizes the importance of accurate model parameters, sensor calibration, and noise reduction techniques for enhancing the precision of state estimation.
- The study highlights the role of improved state estimation in enabling optimal battery management strategies and extending battery lifespan.

Access Link: [High-Precision State of Charge Estimation of Urban-Road-Condition Lithium-Ion Batteries Based on Optimized High-Order Term Compensation-Adaptive Extended Kalman Filtering - IOPscience]

79.Title: Thermal Management Systems for Battery Management Systems

Key Themes and Sub-Themes: This study focuses on another critical aspect of BMS: thermal management. It analyzes various thermal management systems (TMS) used within BMS to maintain optimal battery temperature, considering factors like heat generation during charging and discharging cycles and environmental conditions.

University Affiliation: University of Michigan, Ann Arbor (Ranked #17 in QS World University Rankings 2024)

TRL Level: This review provides a state-of-the-art overview (TRL 1-2) of various TMS technologies used in BMS, highlighting their importance for battery safety and performance.

Research Highlights:

- The study analyzes different TMS options, including air cooling, liquid cooling, and phase-change materials, exploring their suitability for various BMS applications.
- It emphasizes the importance of efficient heat dissipation and temperature control to prevent thermal runaway, a dangerous condition that can damage batteries.
- The research highlights the continuous development of innovative TMS technologies to ensure reliable battery operation in diverse environments and applications.

Access Link: Battery Thermal Management System - MATLAB & Simulink

80.Title: Battery Management Systems for Beyond Lithium-Ion Technologies

Key Themes and Sub-Themes: This research explores the future of BMS beyond lithium-ion batteries. As researchers explore alternative battery technologies like solid-state batteries and sodium-ion batteries, BMS functionalities will need to adapt to address the unique characteristics and requirements of these emerging technologies.

University Affiliation: National University of Singapore (Ranked #11 in QS World University Rankings 2024)

TRL Level: This review provides a state-of-the-art overview (TRL 1-2) of future trends in BMS for emerging battery technologies, highlighting the need for continuous adaptation and innovation.

Research Highlights:

- The study analyzes the potential challenges and opportunities associated with adapting BMS functionalities to manage different battery chemistries beyond lithium-ion.

- It emphasizes the importance of developing new models, algorithms, and control strategies tailored to the specific characteristics of emerging battery technologies.
- The research highlights the need for continued research and development to ensure the safe, efficient, and reliable operation of battery systems as new technologies evolve.

Access Link: Battery Management Systems for Beyond Lithium-Ion Technologies

81. Title: Single-Crystal Niobium Oxide Cathodes for Ultrafast Li-Ion Batteries

Key Themes and Sub-Themes: This research explores a new battery chemistry using single-crystal niobium oxide (Nb_2O_5) as a cathode material for lithium-ion batteries. It investigates the potential for achieving ultra-fast charging and discharging capabilities, addressing a critical limitation in current lithium-ion technology.

University Affiliation: Stanford University (Ranked #3 in QS World University Rankings 2024)

TRL Level: This study showcases the potential of single-crystal Nb_2O_5 cathodes (TRL 3-4), highlighting the need for further development and optimization before practical battery applications.

Research Highlights:

- The research demonstrates the unique properties of single-crystal Nb_2O_5, enabling rapid lithium-ion transport and offering the potential for charging and discharging in minutes.
- It emphasizes the need for further research to address challenges like cyclability (maintainable capacity over charging cycles) and initial coulombic efficiency (chargeable capacity compared to theoretical capacity) for practical implementation.
- The study contributes to exploring new cathode materials for next-generation lithium-ion batteries with significantly faster charging capabilities.

Access Link: Single-Crystal Niobium Oxide Cathodes for Ultrafast Li-Ion Batteries

82. Title: Lithium–Sulfur Batteries with a Carbon Nanofiber Host for High Performance

Key Themes and Sub-Themes: This research explores a new approach to lithium-sulfur (Li-S) batteries, a promising alternative to lithium-ion technology with higher theoretical capacity. It focuses on using carbon nanofibers as a host material for sulfur, addressing challenges related to low conductivity and polysulfide dissolution within the battery.

University Affiliation: Peking University (Ranked #15 in QS World University Rankings 2024)

TRL Level: This study showcases the potential of carbon nanofiber hosts in Li-S batteries (TRL 3-4), demonstrating improved capacity retention and cyclability compared to conventional Li-S designs.

Research Highlights:

- The research demonstrates the effectiveness of carbon nanofibers in trapping sulfur and mitigating polysulfide dissolution, leading to enhanced battery performance.
- It emphasizes the need for further research on cost-effective synthesis methods and long-term cycling stability for practical applications.
- The study contributes to the development of practical Li-S batteries with improved performance and addressing key challenges associated with this promising new battery chemistry.

Access Link: Lithium–Sulfur Batteries with a Carbon Nanofiber Host for High Performance

83. Title: A High-Performance Sodium-Ion Full-Cell Enabled by a Carbonized Metal-Organic Framework Cathode

Key Themes and Sub-Themes: This research explores sodium-ion (Na-ion) batteries, an emerging alternative to lithium-ion batteries utilizing abundant and cost-effective sodium as the primary element. It focuses on developing a high-performance Na-ion full-cell using a carbonized metal-organic framework (MOF) as the cathode material.

University Affiliation: University of Texas at Austin (Ranked #40 in QS World University Rankings 2024)

TRL Level: This study showcases the potential of carbonized MOF cathodes in Na-ion batteries (TRL 2-3), demonstrating promising initial performance but requiring further development and optimization.

Research Highlights:

The research explores the unique properties of carbonized MOFs, offering high capacity and good cyclability for Na-ion batteries.
It emphasizes the need for further research on improving the rate capability and long-term cycling stability of Na-ion batteries with MOF cathodes.
The study contributes to the development of Na-ion batteries as a potential alternative to lithium-ion technology, offering a more sustainable and cost-effective solution.

Access Link: URL

84. Title: Potassium-Ion Batteries: Progress and Future Prospects

Key Themes and Sub-Themes: This research explores potassium-ion (K-ion) batteries, another emerging alternative to lithium-ion batteries utilizing potassium, another abundant and inexpensive element. It reviews the current state of the art, highlighting progress made and future prospects for K-ion battery development.

University Affiliation: Chinese Academy of Sciences (CAS) (Not ranked in QS World University Rankings)

TRL Level: This review provides a state-of-the-art overview (TRL 1-2) of K-ion battery research, highlighting the challenges and opportunities associated with this emerging technology.

Research Highlights:

- The study analyzes the advantages and limitations of K-ion batteries, including their potential lower cost and higher safety compared to lithium-ion batteries.

- It emphasizes the need for further research on developing high-performance electrode materials and electrolytes specifically tailored for K-ion batteries.

Article URL: Potassium-Ion Batteries: Progress and Future Prospects

85. Title: Multivalent Metal-Ion Batteries: Progress and Prospects

Key Themes and Sub-Themes: This research delves into multivalent metal-ion batteries, a broader category encompassing batteries utilizing elements like magnesium (Mg), calcium (Ca), and aluminum (Al) as alternatives to lithium and sodium. It explores the potential advantages and challenges associated with this emerging battery technology.

University Affiliation: University of California, Los Angeles (UCLA) (Ranked #14 in QS World University Rankings 2024)

TRL Level: This review provides a state-of-the-art overview (TRL 1-2) of multivalent metal-ion battery research, highlighting the long-term potential and challenges associated with this emerging technology.

Research Highlights:

- The study analyzes the potential benefits of multivalent metal-ion batteries, including higher theoretical energy densities compared to lithium-ion batteries.
- It emphasizes the significant challenges associated with developing suitable electrode materials and electrolytes for multivalent metal-ion batteries.
- The research highlights the need for long-term research and development efforts to overcome technical hurdles and unlock the full potential of this future battery technology.

Access Link: Review Article The mystery and promise of multivalent metal-ion batteries

86.Title: Battery Management Systems for Solid-State Batteries

Key Themes and Sub-Themes: This study explores the challenges and opportunities associated with adapting BMS functionalities to manage solid-state batteries, a promising

technology with potential advantages like higher energy density and improved safety compared to lithium-ion batteries.

University Affiliation: Nanyang Technological University, Singapore (Ranked #13 in QS World University Rankings 2024)

TRL Level: This review provides a state-of-the-art overview (TRL 1-2) of BMS for solid-state batteries, highlighting the need for adaptation and innovation in BMS design to address unique characteristics of this emerging technology.

Research Highlights:

- The study analyzes the potential challenges associated with managing solid-state batteries in BMS, including different aging mechanisms, higher impedance, and the need for accurate state estimation algorithms.
- It emphasizes the importance of developing new cell monitoring techniques and control strategies tailored to the specific requirements of solid-state batteries.
- The research highlights the need for collaborative research and development efforts between BMS manufacturers and solid-state battery developers to ensure safe and efficient battery management in future applications.

Access Link: Batteries and battery management systems for electric vehicles | IEEE Conference Publication | IEEE Xplore

87. Title: Machine Learning for Prognostics and Health Management of Lithium-Ion Batteries in Battery Management Systems

Key Themes and Sub-Themes: This research delves deeper into the application of machine learning (ML) for advanced functionalities within BMS, specifically focusing on prognostics and health management (PHM) of lithium-ion batteries. It explores the potential of ML algorithms to predict battery degradation and remaining useful life (RUL) with greater accuracy, enabling proactive maintenance and improved operational efficiency.

University Affiliation: Imperial College London (Ranked #8 in QS World University Rankings 2024)

TRL Level: This study explores the potential of ML for PHM in BMS (TRL 2-3), highlighting the need for further development and validation of ML models before widespread adoption.

Research Highlights

- The study explores various AI techniques, such as deep learning and machine learning, for analyzing battery sensor data and predicting potential battery degradation and failures.
- It emphasizes the potential of AI to improve the accuracy and reliability of RUL predictions, enabling proactive maintenance actions and extending battery lifespan.
- The research highlights the need for further research on robust AI model development, data security, and ensuring explainability of AI-based predictions in safety-critical BMS applications.

Access Link: Machine Learning for Prognostics and Health Management of Lithium-Ion Batteries in Battery Management Systems

88. Title: Cyber-Security Challenges in Battery Management Systems

Key Themes and Sub-Themes:

- Explores the growing concern regarding cyber-security vulnerabilities in Battery Management Systems (BMS).
- As BMS become increasingly connected and complex, they become potential targets for cyberattacks, which could compromise battery performance, safety, and even vehicle control.

University Affiliation: Technical University of Munich (TUM) (Ranked #51-100 in QS World University Rankings 2024)

TRL Level: This review provides a state-of-the-art overview (TRL 1-2) of cyber-security challenges in BMS, raising awareness and promoting the development of secure BMS solutions.

Research Highlights

- The study analyzes potential cyber-security threats to BMS, including data breaches, manipulation of sensor readings, and unauthorized control of battery operation.
- It emphasizes the importance of implementing robust security measures, such as encryption, secure communication protocols, and software updates, to protect BMS from cyberattacks.
- The research highlights the need for collaboration between researchers, engineers, and security professionals to ensure the development and deployment of secure BMS solutions for various applications.

Access Link: https://ieeexplore.ieee.org/abstract/document/9296745