

FEV Signature Solutions

Battery digital twin on cloud

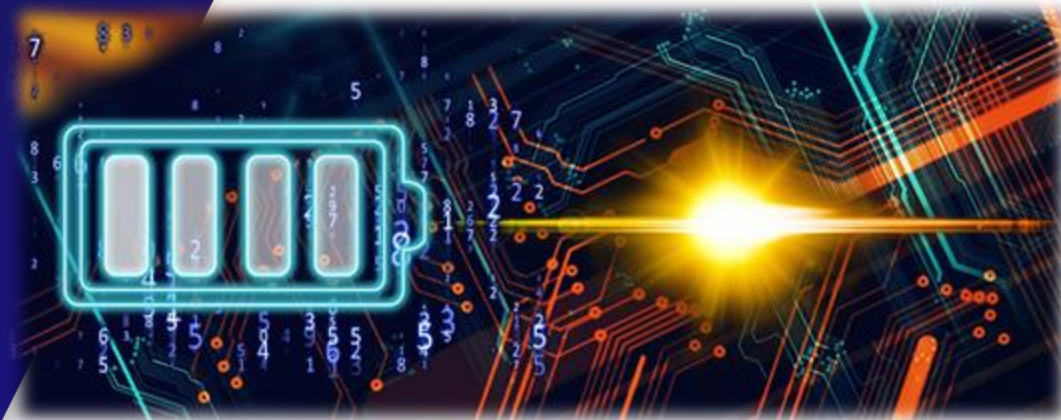
Our cloud-based battery digital twin boosts performance for commercial and passenger vehicles

FEV offers

- Real-time battery performance monitoring and failure prediction for on-road EVs for fleet of 100's of vehicles
- Hybrid approach to battery voltage response prediction and estimation of state of charge and state of health
- Condition based diagnostics and prognostic, such as thermal misbehaviour prediction and RUL prediction
- Battery degradation tracking including capacity fade and internal resistance increase
- Joint estimation of various states provides increase in estimation accuracy
- As data is accumulated with batter ageing, retraining framework for dynamic models such as RUL prediction

Why FEV

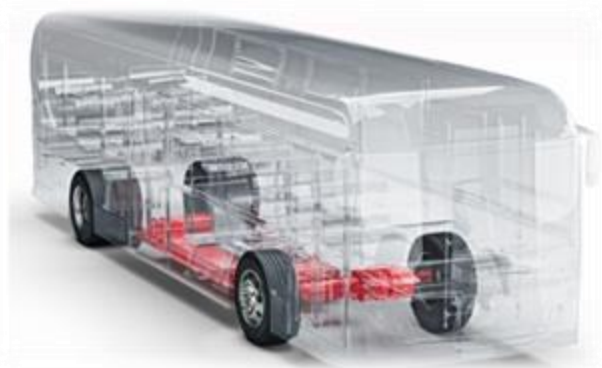
- Data transformation and parsing
- Creation of common data pool serving all functionalities
- Highly modular & flexible architecture which allows algorithms and new functionalities to be updated seamlessly
- Smart control and automatic rule-based model retraining
- Customized algorithm offering for battery prediction
- Engg visualizations from pack to cell level for in-depth analysis



Reference projects

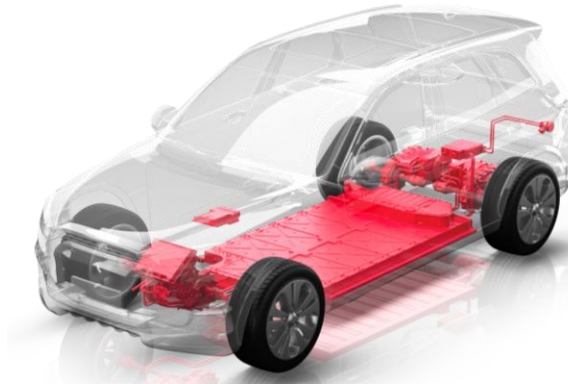
BATTERY DIGITAL TWIN ON CLOUD

Commercial vehicle battery digital twin development for Asian OEM



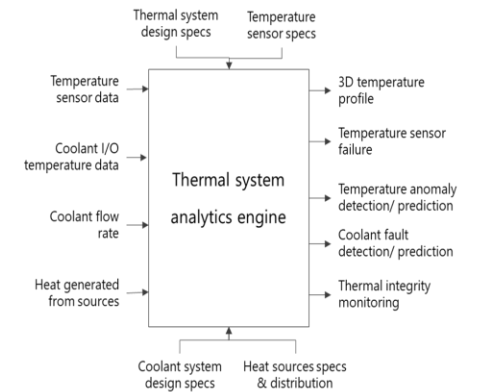
- Customization of digital twin software for target applications
- Integration with vehicle systems and testing
- Validation in real-world scenarios
- Performance monitoring and predictive analytics
- Optimization of battery life and efficiency

Passenger vehicle battery digital twin development for Asian OEM



- Adaptation of digital twin software for passenger vehicle applications
- Seamless integration with onboard systems
- Rigorous testing & validation for passenger use cases
- Real-time performance monitoring and diagnostics
- Enhancement of battery safety and longevity through predictive modeling

Thermal anomaly prediction and detection



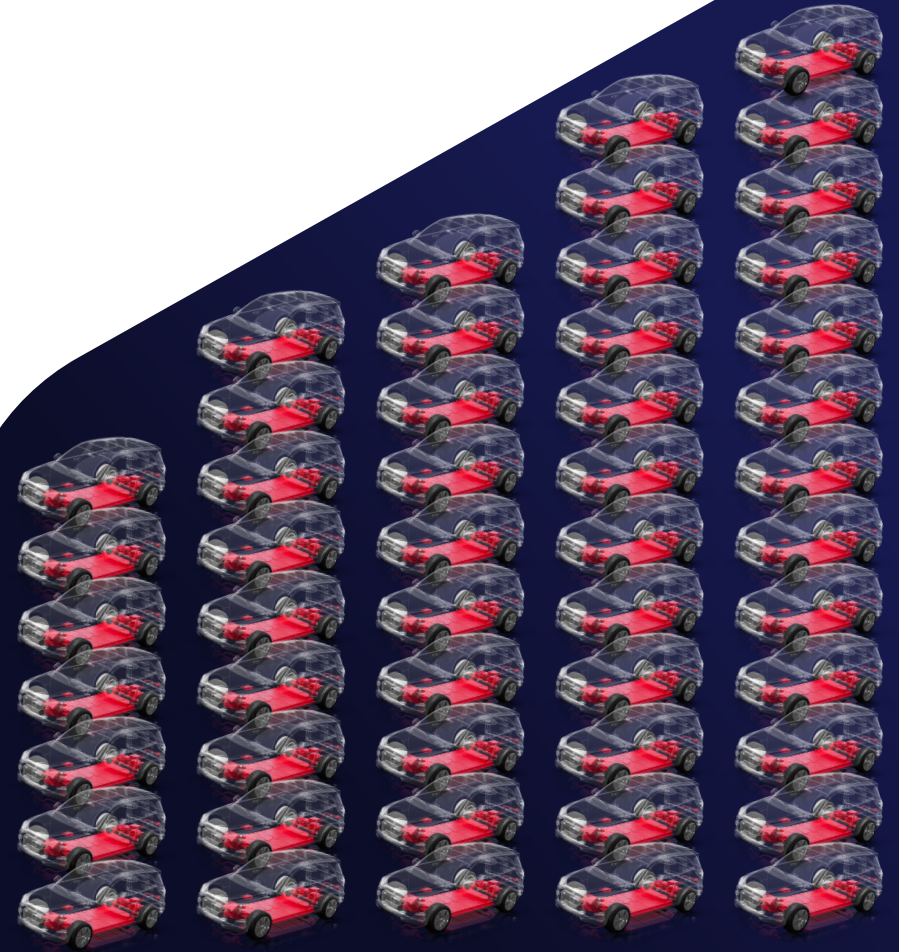
Pending patent application
IN 2024 110 565 88

Reference project

BATTERY DIGITAL TWIN ON CLOUD

Battery digital twin system for fleet of battery electric vehicles

- Real-time simulation and monitoring of battery performance across the fleet Battery performance estimations and tracking of key parameters like capacity, resistance, and temperature
- Predictive analytics for proactive maintenance and optimized operations
- Enhanced fleet management through centralized data insights and reduced operational costs by optimizing energy consumption
- Condition-based monitoring with fault/failure diagnostics and failure prognostics at both cell and battery pack levels
- Customizable models tailored for various vehicle types and operational conditions, integration with vehicle telematics for seamless data exchange
- Improved battery lifespan and efficiency through virtual estimations & optimization, leading to a projected saving of ~15% unused life of the EV battery pack for a fleet of commercial vehicles
- Anticipated battery life prolongation of ~7% through continuous improvement driven by digital twin technology
- Physics-based Li-ion cell model with over 97% accuracy, validated on cell characterization data mimicking Li-cell operation and performance degradation



Supported features and applications

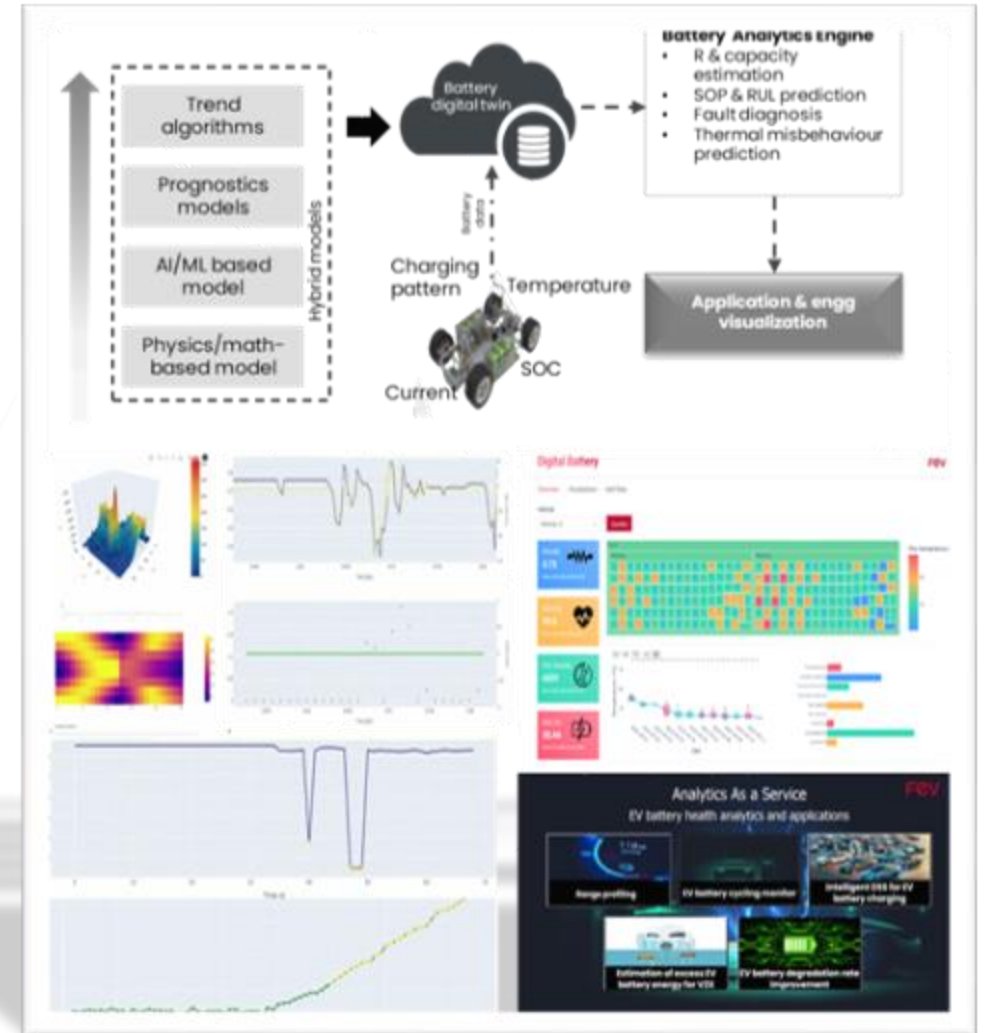
BATTERY DIGITAL TWIN ON CLOUD

Features

- Real-time monitoring and diagnostics of battery health
- Predictive maintenance capabilities for enhanced reliability
- Integration with vehicle management systems for seamless operation
- Data-driven insights into battery performance and efficiency
- Scalable architecture to support diverse fleets and usage scenarios

Applications

- Range profiling for optimized vehicle performance
- Monitoring EV battery cycling for longevity
- Intelligent Decision Support System for efficient EV battery charging
- Estimation of excess EV battery energy for V2X applications
- Improvement of EV battery degradation rate through advanced analytics



Cell model options

BATTERY DIGITAL TWIN ON CLOUD



Physics based	Semi analytical	Data driven / hybrid
Electrochemical single particle model incorporating electrolyte dynamics	Incremental capacity-based approach	Hybrid data driven approach including statistical algorithms
Coupled thermal model for cell heat generation	Computationally thin framework, suitable for edge deployment	Physics-informed architecture for enhanced explainability
Ageing mechanisms integrated – SEI growth and Lithium plating	Robust feature engineering and dynamic noise analysis	Hysteresis & higher order effects included in multilayer voltage prediction
Outputs: terminal voltage, SOC, capacity, internal resistance, heat	Ensemble predictions from multiple individual models	Joint estimation of battery states improves accuracy
Developed using cell testing and characterization data	Modular architecture & data environment customizable algorithms	Valid for wide variety of configurations, geometries, capacities and chemistries
Validated on fleet data in real-time operation	Outputs are capacity, SOH based on capacity and RUL	Outputs: voltage, SOC, capacity, internal resistance, temperature change & RUL

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