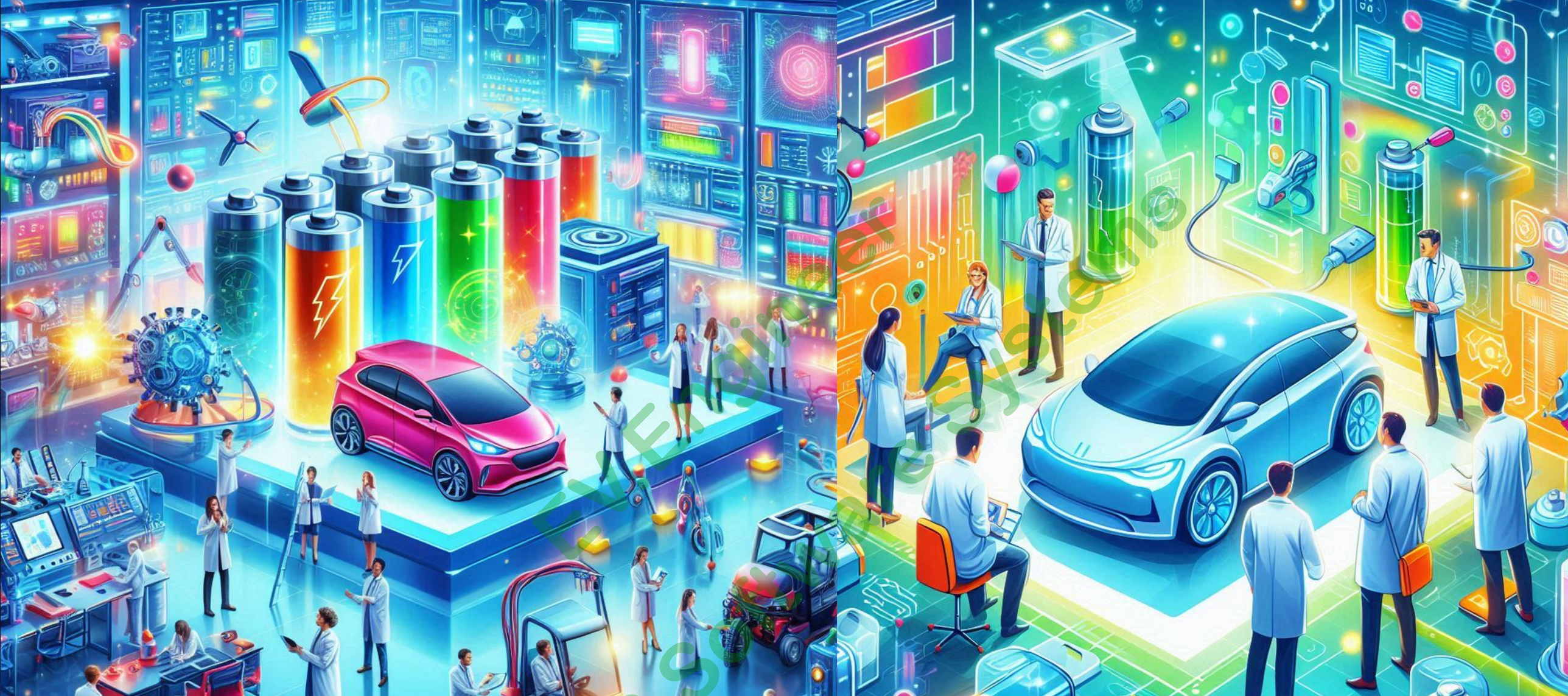
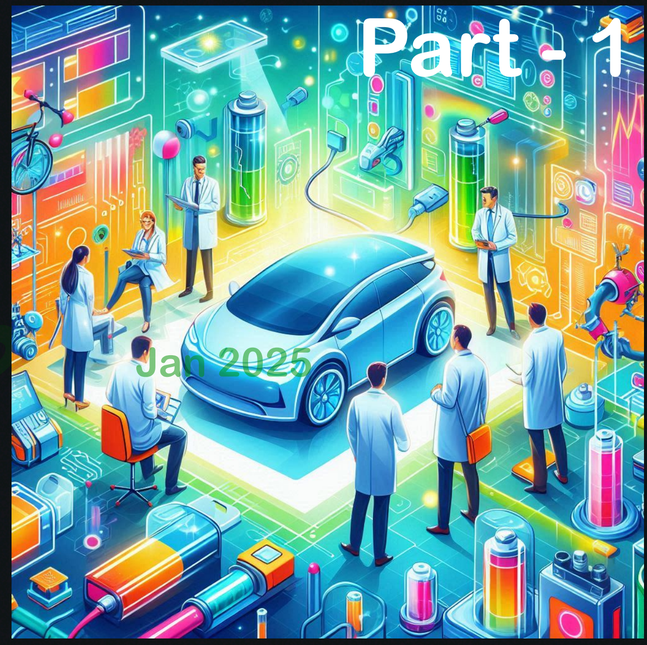


Artificial Intelligence & Machine Learning

AI-Powered EV Battery Fire Prevention System

Sudarshana Karkala | ✆ +91 9845561518 | ✉ carsoftwaresystems @ gmail.com | carsoftwaresystems.com



Artificial Intelligence & Machine Learning

AI / ML - Powered EV Battery Fire Prevention System

Sudarshana Karkala

EV.Engineer, AI-Driven Battery Safety

Electric Vehicle Engineering & Development, CODE, IIT Madras

✆ +91 9845561518 | evdc1200125014 @ code.iitm.ac.in | car software systems @ gmail.com

Introduction to AI & ML

What is AI?

Artificial Intelligence (AI) enables machines to mimic human intelligence.

AI includes -

- **Machine Learning (ML)**
- **Deep Learning (DL) and**
- **Neural Networks**

AI is transforming electric vehicles, battery technology, and fire prevention systems.

What is Machine Learning (ML)?

ML is a subset of AI where computers learn patterns from data.

Types of ML :

- **Supervised Learning** (Uses labeled data, e.g., temperature prediction)
- **Unsupervised Learning** (Finds patterns in un-labeled data, e.g., anomaly detection)
- **Reinforcement Learning** (AI learns by trial & error, e.g., optimising battery charging)

ML is widely used in EV Battery Management Systems (BMS).

Role of AI & ML in EV Industry

AI is used for :

- **Battery Safety Monitoring** (Predicting overheating, voltage spikes)
- **Energy Management** (Optimising battery usage, charging)
- **Predictive Maintenance** (Detecting faults before failures)

AI ensures safer, longer-lasting EV batteries.

AI & ML in Battery Fire Prevention

AI analyses real-time battery data to prevent fire hazards.

AI helps in :

- Thermal Runaway Prevention (Detects rising temperatures early)
- Anomaly Detection (Finds unusual voltage/current spikes)
- Predictive Failure Alerts (AI warns users before a critical fault occurs)

AI-powered safety improves EV reliability & consumer trust.

Supervised Learning

Uses labeled datasets to train models.

Algorithms used

- Linear Regression
- Decision Trees
- Neural Networks.

Example :

Predicting battery temperature based on historical data.

Applications in battery management and fire prevention.

Steps involved:

- Collect and preprocess data.
- Split into training and testing sets.
- Train the model and evaluate accuracy.
- Deploy model for real-time monitoring.

Unsupervised Learning

Finds hidden patterns in un-labeled data.

Algorithms used:

- K-Means Clustering
- DBSCAN
- PCA

Example :

Clustering battery behaviour into normal and faulty patterns.

Helps in early detection of potential battery failures.

- Steps involved:
  - Gather battery performance data.
  - Apply clustering algorithms to find anomalies.
  - Identify unusual behaviour without predefined labels.

Reinforcement Learning for Battery Optimisation

AI learns by interacting with the environment.

Used in **Battery Management Systems (BMS)** and **Smart Charging Stations.**

Steps involved:

- Define the reward function for efficient energy use.
- Train reinforcement learning models using simulations.
- Optimise battery performance dynamically.

Example :

Adjusting EV battery charging strategies dynamically.

Reduces risk of overcharging and extends battery lifespan

Anomaly Detection Using AI

AI can detect irregular voltage, temperature, and current fluctuations.

Techniques :

- Auto-encoders
- Isolation Forest
- One-Class SVM

- Steps involved :
  - Collect real-time battery sensor data.
  - Train AI to detect deviations from normal behavior.
  - Implement alerts for abnormal conditions.

Example : Identifying faulty battery cells before failure.

AI Models for Predictive Maintenance

Predict battery failure before it happens.

- Uses historical battery health data to train models.

Techniques :

- Random Forest,
- Long Short-Term Memory (LSTM) Networks.

Steps involved:

- Process past battery usage and failure logs.
- Train AI to predict failure probability.
- Use predictive insights for timely maintenance.

Prevents unexpected battery fires and costly breakdowns.

Battery Thermal Runaway & Fire Causes

Understanding Battery Thermal Runaway

Thermal runaway is an uncontrolled increase in battery temperature.

Causes :

- **Overcharging or Overheating** (Excessive voltage or temperature rise)
- **Short Circuits** (Internal damage, manufacturing defects)
- **Physical Damage** (Accidents, punctures in battery cells)

Once started, thermal runaway leads to fire or explosion.

Real-World Battery Fire Incidents

- **Tesla Model S Fire (2013)** : Battery caught fire after road debris damage.
- **Chevrolet Bolt Recall (2020)** : Faulty battery packs led to multiple fire cases.
- **Samsung Galaxy Note 7 (2016)** : Lithium-ion battery defects caused explosions.

Lessons :

AI can prevent such incidents by early fault detection.

Factors Causing Battery Fires

- **High Temperature** : Leads to chemical breakdown inside cells.
- **Overcharging** : Causes excessive heat & electrolyte breakdown.
- **Manufacturing Defects** : Poor design can lead to internal short circuits.
- **External Damage** : Punctured or crushed batteries become unstable.

AI can monitor & predict these risks, preventing failures.

How AI Prevents Battery Fires?

AI models analyse temperature, voltage, and current trends in real-time.

AI can :

- **Detect** voltage spikes before a short circuit occurs.
- **Predict** high-temperature zones and send early warnings.
- **Optimise** charging cycles to prevent overcharging.

AI enhances battery safety with predictive intelligence.

Industry Case Studies on AI in Battery Safety

- **Tesla** : Uses AI to optimise battery performance & safety.
- **NIO** : AI-based battery swapping & monitoring system.
- **BMW** : Predictive maintenance for EV battery packs.

AI is shaping the future of safe and efficient EV batteries.

Practical AI Applications in Battery Fire Prevention

AI-Powered Thermal Management

- AI models predict heat buildup in battery cells before critical failure.
- Uses real-time data from **thermal sensors** embedded in battery packs.
- Detects abnormal temperature increases and **activates cooling systems proactively.**
- Implements **adaptive cooling strategies** based on AI-predicted heat patterns.
- Reduces fire risk by **adjusting cooling intensity dynamically.**
- Example: **Tesla's AI-driven thermal regulation system optimises cooling efficiency.**

AI in Battery Charging Optimisation

- AI helps prevent **overcharging** and optimises battery lifespan.
- Uses **Reinforcement Learning** to adjust charging cycles based on past data.
- AI-based algorithms monitor **voltage**, **current**, and **temperature** during charging.
- **Prevents excessive fast charging**, reducing heat buildup.
- Smart AI-driven **charging stations adapt based on real-time battery conditions.**
- Example: **NIO's AI-driven charging infrastructure optimises energy flow.**

AI for Battery Fault Prediction

- AI-powered models detect **early signs of battery degradation** before failure.
- Uses **Classification Algorithms** to identify weak or faulty battery cells.
- Analyses patterns in **voltage fluctuations**, **charge retention**, and **discharge cycles**.
- Implements **Predictive Analytics** to forecast potential breakdowns.
- Helps EV manufacturers conduct **preventive maintenance**, reducing costs.
- Example : **BMW uses AI-based battery diagnostics for early fault detection.**

AI for Real-Time Anomaly Detection

- AI monitors battery health through **continuous data collection**.
- Detects anomalies in **voltage**, **temperature**, and **current** variations.
- Uses **Deep Learning** (**Autoencoders**, **LSTMs**) to recognise normal vs. abnormal patterns.
- Generates alerts when **critical thresholds are breached**.
- AI-powered dashboards provide **real-time insights to operators**.
- Example: **Google AI's DeepMind research in anomaly detection for energy systems.**

AI-Powered Predictive Maintenance for EV Batteries

- Uses AI models trained on historical battery performance data.
- Predicts remaining battery life and optimal replacement schedules.
- Implements Random Forest and LSTM-based AI models for accurate forecasting.
- AI enhances Battery Management System (BMS) reliability.
- Ensures longer battery life and reduced unexpected breakdowns.
- Example : Tesla’s AI-driven predictive maintenance system.

TO BE DONE

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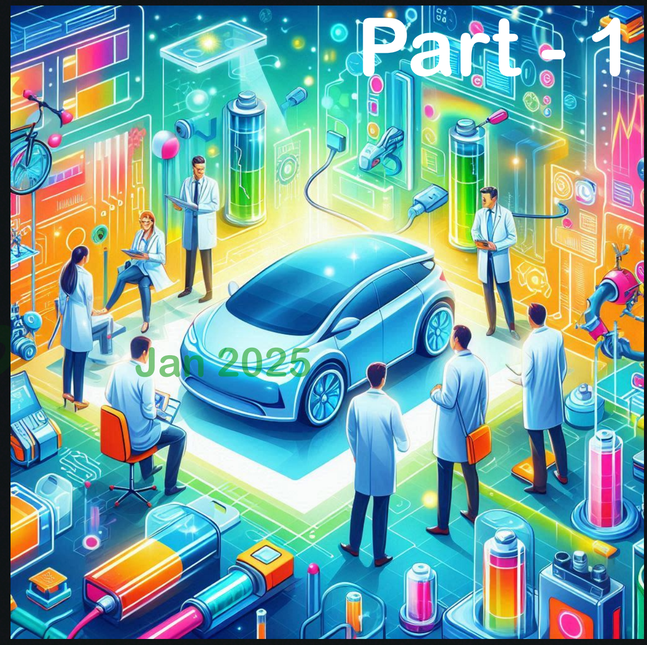

Join Us in Creating a Fire-Free EV Future!

Looking for Strategic Partners, Pilot Customers & Investors.

Thank you

Sudarshana Karkala

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Electric Vehicle Engineering & Development, CODE, IIT Madras

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