Battery Oracle

Battery Machine Learning System (BMLS)

ELECOMP Capstone Design Project 2022-2023

Sponsoring Company:

EaglePicher Technologies
2000 S. County Trail
East Greenwich, RI 02818
Phone: 401-471-6580
https://www.eaglepicher.com/

Company Overview:

EaglePicher Technologies is a leading producer of batteries and energetic devices. For more than 75 years, we have been serving the mission-critical aerospace, defense and aviation battery markets. EaglePicher's batteries are a key component of the U.S. space program; our batteries provided the emergency power that successfully brought the Apollo 13 crew home. Today, EaglePicher batteries power the International Space Station, Mars Rovers, commercial jets and helicopters and more than 85 percent of U.S. missile platforms.

Technical Directors:

Frank Puglia
Director of Research and Development, Yardney Division
Frank.Puglia@eaglepicher.com

Tee B. Dee
Hardware Integration
Tee.Dee@eaglepicher.com

Project Motivation:

Under water, over land, in the air and out in space; EaglePicher batteries are providing power to the most extreme applications ever conceived. Our batteries are commonly required to deliver high power and energy while exposed to dynamic conditions and over a long service life. While advancements in battery performance develop at a rapid rate, Improvements in battery management systems have consistently lagged behind. Leveraging the success of AMBATS-part deux, this project seeks to illuminate the fundamental indicators of optimal battery management through the application of Machine Learning algorithms. The Battery Oracle will lead to advancements in BMS designs, improving the safety and longevity of future batteries

Anticipated Best Outcome:

A) Develop the Battery Oracle machine learning system, applying the lessons learned from the AMBATS program, to identify performance indicators of Li-Ion batteries for specific use cases.
B) Demonstrate the application of the Battery Oracle methods to empirical data produced on the AMBATS and Eagle-Li systems for *fault detection* and *life optimization*.
C) In working with Eagle-Li, propose optimizations to BMS designs for applications such as electric vehicles, directed energy weapons, etc., to improve battery safety, performance and longevity.

Project Details:

The objective of this project is to develop improved machine learning methods and algorithms to improve the performance of Li-Ion battery management systems for a variety of battery applications. The team will evaluate and select tools for developing machine learning solutions. Using the selected ML tools and data produced from the AMBATS and Eagle-Li platforms, the team will seek to identify parametrics that would predict future performance. There are two separate goals. The first is to use Machine Learning/Optimization to determine the best operating parameters for mission. The second is to use Machine Learning for anomaly/Fault detection. The fault detection will use data generated by the Eagle-Li team whereas the optimization team will use a digital twin created by EaglePicher.

[Hardware/Electrical Tasks:]

1. Evaluate the AMBATS platform and propose enhancements to improve the utility for the Battery Oracle project
    a. Propose new sensor types from which data can be extracted (e.g. thermal camera images)
2. Develop a proposal specification outlining the team plan for the platform
3. Document the design details with hardware descriptions
4. Present the detailed design for critical review with EaglePicher
5. Using the updated Eagle-Li platform, collect synchronized BMS and DAQ battery cell performance data for specific use cases.
    a. Start by collecting data with Eagle-Li on the existing platform to baseline performance. Both teams will benefit from showing the sensitivity improvements.
6. Present findings

[Firmware/Software/Computer Tasks:]

1. Evaluate the AMBATS Machine Learning implementation and propose enhancements to improve the utility for the Battery Oracle project (e.g. changes to data type/format)
2. Develop a project plan and schedule
3. Identify options for both types of ML (Simulation an Anomaly)
    a. Machine Learning/Optimization
    b. Fault/Deviation Detection
4. Use fault detection ML to develop functional fault detection software that can be deployed into BMS code.
5. Test and validate the implementation of the Battery Oracle platform's software for fault detection using faulty cells with unknown faults.
6. Present findings

Composition of the Team:

1Electrical Engineers & 2 Computer Engineers/Math Majors (ML and SPC/Statistics will help).

US Citizenship Required; Background Checks will also be conducted before the first kick-off meeting with the Technical Director.

Electrical Engineering Skills Required:

- Organization and Documentation of Machine Operation
- Be responsible for operating the existing platform and the new platform including implementing operation changes requested by the data analysis team members
- Circuit simulation
- Electrical Safety knowledge and awareness
- Analog circuit design
- Digital circuit design
- Power circuit design
- Knowledge and use of common lab equipment
- PCB layout
- Soldering, Troubleshooting, Repair

Computer Engineering Skills Required:

- Organization and Documentation
- Embedded software development
- User interface design
- IDEs / Debuggers
- Machine Learning Experience
- Algorithm development
- Digital Signal processing and Filters
- Test, Debug and Validate code

Anticipated Best Outcome's Impact on Company's Business, and Economic Impact

If successful, this project will yield enhancements to battery performance for use in demanding maritime, aviation, space and military applications. Improved battery performance will further solidify EaglePicher Technologies as the leader in high performance Li-Ion batteries.

Broader Implications of the Best Outcome on the Company's Industry:

This project has the potential to advance the state of the art for battery reliability, safety and longevity across many applications and industries.