POLITECNICO DI MILANO

PhD in DATA ANALYTICS AND DECISION SCIENCES - 38th cycle

PNRR_352 Research Field: ANOMALY DETECTION IN ENERGY STORAGE SYSTEMS

Monthly net income of PhDscholarship (max 36 months)
€ 1400.0 In case of a change of the welfare rates during the three-year period, the amount could be modified.

Context of the research activity	
Motivation and objectives of the research in this field	Big Data Analytics has nowadays changed the way companies make decisions, develop their products, and find ways to improve their solutions. This has recently impacted the energy sector which is undergoing a massive transformation by leveraging statistical and machine learning techniques in different use cases thanks to the amount of data collected and stored from the field.Efficient use of such data can be the "game-changer" in the stationary energy storage sector. The project aims at using field data to develop new algorithms that can predict anomalies and potential hazards within battery-based energy storage systems. Techniques to exploit highly correlated time series from battery cells sharing similar conditions and history will be investigated either from a multivariate time series perspective and from a time series embedding perspective using techniques from machine learning and artificial intelligence. A possible custom design to partition these techniques between edge and cloud will be also studied to perform real-time change point detection.
Methods and techniques that will be developed and used to carry out the research	The research will use existing and develop new data-driven algorithms to learn models from historical data in order to estimate battery state or detect battery failures in advance. Indeed, raw battery data (e.g., battery voltage, current, and temperature) contain specific patterns that can be useful features to predict battery failure and performance degradation.

	The research will be conducted in collaboration with NHOA (https://nhoa.energy); the PhD candidate will develop data-driven methods, which are robust to data loss and require minimal training data, to enable anomaly detection in NHOA?s Energy Storage Systems. By analyzing cell-level timeseries measurements coupled with rack and bank battery data, the designed algorithms should be able to detect as early as possible phenomena such as: -Cell thermal runaway -Battery capacity and efficiency loss (w.r.t. nominal degradation curves) -Inefficient thermal management The approaches which will be favored are the unsupervised ones, possibly leveraging correlations between cells in the same battery-pack, rack, storage, etc. If required, semi supervised or supervised learning techniques could be used to detect know (labeled) patterns and events on the basis of simulated data that mimic specific battery failures. Algorithms will be also designed to be distributed along cloud and edge, to enable: -a powerful and scalable environment for algorithm training -an on-site detection with limited computational power resilient with respect to any connection and communication issues Some example readings in the literature could be https://arxiv.org/pdf/2103.08796.pdf or https://ieeexplore.ieee.org/document/9689690.
Educational objectives	We expect the PhD candidate • become proficient in machine learning and deep learning models for time series forecasting • become proficient in machine learning and deep learning models for anomaly detection

	• gain a direct experience in the energy storage monitoring scenario
Job opportunities	We expect the PhD candidate to develop a blend of theoretical and practical expertise opening access to several position as data scientist in many companies, not only in the energy sector. Nevertheless, the energy sector has been steadily growing over the past few years and we will foresee a high demand for researchers specialized in battery data analysis and battery specialists for companies dealing with storage system and battery packs.
Composition of the research group	1 Full Professors 2 Associated Professors 1 Assistant Professors 2 PhD Students
Name of the research directors	Matteo Matteucci

Contacts
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Additional support - Financial aid per PhD student per year (gross amount)	
Housing - Foreign Students	--
Housing - Out-of-town residents (more than 80Km out of Milano)	--

Scholarship Increase for a period abroad	
Amount monthly	700.0 €
By number of months	6

National Operational Program for Research and Innovation	
Company where the candidate will attend the stage (name and brief description)	NHOA Group (settore attività: Energy Storage)
By number of months at the company	6
Institution or company where the candidate will spend the period abroad (name and brief description)	
By number of months abroad	0

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information

Impresa presso cui si svolgera' l'attivita' esterna:

- nome impresa: NHOA Group
- settore attività: Energy Storage
- link alla pagina dell'azienda: https://nhoa.energy/
- numero di mesi previsti: sei mesi
- descrizione sintetica attività: sviluppo di un sistema di acquisizione e analisi di dati relativi a consumi, temperature ed efficienza di celle per l'accumulo di energia in un contesto reale. Applicazione dei modelli teorici sviluppati dal dottorando ad un caso reale e validazione sul serie temporali multiple acquisite sul campo. Progetto di un partizionamento dei modelli tra sistemi prossimi al campo (IoT) e in cloud secondo il moderno approccio che vede un continuum tra Edge e Cloud soprattutto nel campo dell'intelligenza artificiale e del machine learning.
- eventuali collaborazioni pregresse: nessuna

Attinenza alla tematiche, alle missioni/componenti prescelte del bando PNRR v. D.M. 352, art.6

Il Progetto di ricerca è attinente alle seguenti missioni del PNRR:

- Rivoluzione verde e transizione ecologica: l¿applicazione dei risultati dello studio sviluppato nel presente progetto di ricerca a un caso applicativo di Energy Storage contribuisce alla componente M2C2 ¿ Transizione energetica e mobilità sostenibile in quanto abilita la costruzione di un ecosistema di comunità energetiche che possono fornire servizi di ricarica a coloro che utilizzano veicoli elettrici, garantendo la sicurezza delle transazioni, dei pagamenti e dell¿autenticazione verso il sistema.
- Inoltre contribuisce alla componente M2C3 poiche' per raggiungere la progressiva decarbonizzazione, sono previsti interventi per incrementare significativamente l¿utilizzo di fonti di energia rinnovabili, attraverso investimenti diretti e la semplificazione delle procedure di autorizzazione per le rinnovabili.
- La Missione 2 nel suo complesso dedica risorse al potenziamento della capacità delle reti elettriche, della loro affidabilità, sicurezza e flessibilità (Smart Grid). I sistemi di accumulo ed energy storage sono un elemento chiave di queste infrastrutture e quindi assumono un ruolo centrale per quests missione.