VRIJE UNIVERSITEIT BRUSSEL

The faculty of Engineering of the Vrije Universiteit Brussel invites you to attend the public defense leading to the degree of

DOCTOR OF ENGINEERING SCIENCES

of **Xia Zeng**

The public defense will take place on **Wednesday 28th January 2026 at 10 am** onlinde

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PHYSICS-GUIDED STATES MONITORING AND LIFETIME PREDICTION FOR LITHIUM-ION BATTERY WITH SMART SENSING TECHNIQUES AND MACHINE LEARNING

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Abstract of the PhD research

Lithium-ion batteries are essential for electric vehicles and renewable energy storage, but their internal dynamics and lifetime are difficult to monitor accurately during operation. Conventional battery management systems mainly track voltage, current, and temperature, which provide only an indirect view of what happens inside the cell. This limits the ability to understand real-time dynamics, degradation, and predict failures.

This PhD explores two solutions: advanced sensors and physics-guided machine learning. Spatial mechanical, ultrasonic, thermal sensors, and impedance systems were used to capture signals that reveal internal battery changes in real time. In parallel, scientific machine learning methods were developed to predict battery lifetime, combining physical knowledge with data to ensure both accuracy and generalization ability. Together, these advances contribute to making batteries more observable and predictable, and they lay the groundwork for more proactive, preventive, and ultimately safer battery management in the future.