Intelligent control and Hydrogen-powered Electric Propulsion system

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Research Overview

The problem addressed in this research is the lack of efficient, real-time energy management in Hydrogen powered propulsion system based on FC/Battery/UC, leading to reduced system efficiency, higher fuel consumption, and accelerated degradation of fuel cells and batteries. This matters because extending the lifetime, performance, and reliability of hydrogen-powered vehicles is essential for achieving the UK's net-zero transport goals and reducing dependence on fossil fuels. We have developed and validated **a Real-Time Advanced Model Predictive Control (RtAMPC)** system that intelligently manages power flow, minimizes component aging, and demonstrates high real-time performance through Hardware-in-the-Loop (HIL) testing—paving the way for industrial deployment in automotive, aerospace, and energy sectors.

Industry Relevance

Potential Applications
Automotive Industry:
Development of Hydrogen Fuel Cell/Battery/Ultra-Capacitor Electric Vehicles (HFCBEVs) for passenger cars, commercial vans, heavy-duty trucks, and public transport buses.
Relevant partners: Automotive OEMs (Toyota, Hyundai, RightBus, Mahle Powertrain)
Aerospace industry: Hybrid power management for hydrogen-based aircraft; Aerospace firms such as Airbus, Rolls-Royce, GKN,
Renewable energy and microgrid sector; e.g., National Grid, Siemens
Marine and rail transport: Integration into hydrogen-powered ships, ferries,

Methods & Technologies

Key Techniques, Tools, and Technologies Used:

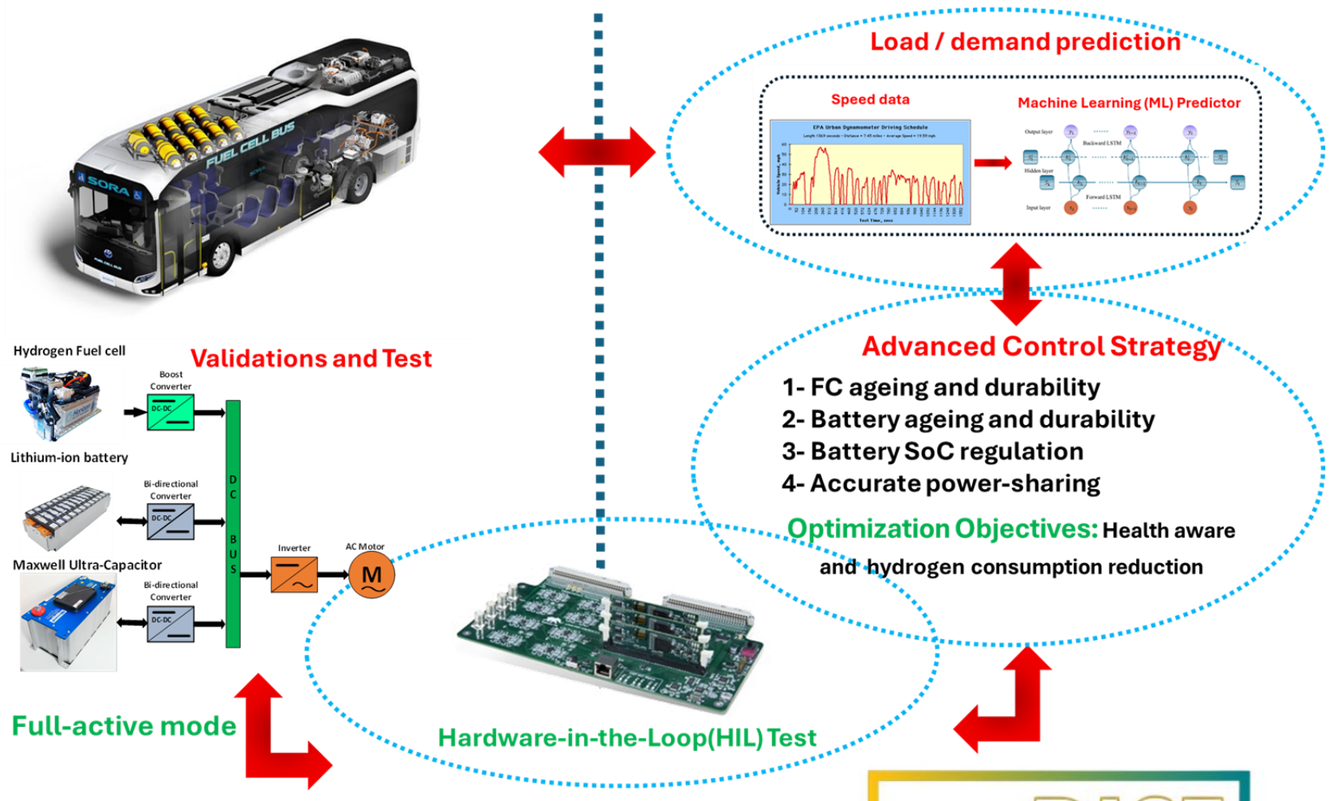
- **Commercialization Steps:** Deployment on embedded ECUs by conversion of MATLAB-based algorithms to C/Python for commercialization
- Real-Time Advanced Model Predictive Control (RtAMPC) for intelligent, degradation-aware energy management.
- Hybrid Energy Storage System integrating a Fuel Cell, Lithium-ion Battery, and Ultra-Capacitor through three DC-DC converters.
- Hardware-in-the-Loop (HIL) testing for real-time validation.

Unique Facilities and Capabilities at UWE

- Access to **HIL simulation platforms** and **Future Transport Zone** research facilities.

Innovations

- Intelligent power management Based on MPC control for hydrogen consumption reduction
- Hardware-in-the-Loop (HIL) testing for real-time validation.
- Deployment of Advanced EMS control on ECU by conversion of MATLAB-based algorithms to C/Python for embedded.
- Degradation-aware control to extend fuel cell and battery life.
- Scalable, transferable design of hydrogen powered propulsion system on automotive, aerospace, and energy applications.



Opportunities

We are seeking **co-development**, **testing**, and partnerships with automotive, aerospace, and renewable energy industries to further develop and validate the Real-Time Advanced Model Predictive Control (RtAMPC) system in real-world applications.
Benefits to Industry Partners

Industry partners will gain access to **cutting-edge control technology** that improves energy efficiency, reduces fuel cell and battery degradation, and supports **Net Zero targets**. Collaboration with UWE also offers **shared R&D resources**, faster innovation, and **opportunities for talent development** through student placements and research exchange.

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