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Published in:
International Journal of Electrochemical Science

Published: 01/04/2020

Document Version:
Final Published version, also known as Publisher's PDF, Publisher's Final version or Version of Record

Published version (DOI):
10.20964/2020.04.50

Publication details:
Zhang, Q., Han, J., Li, G., & Liu, Y. (2020). An Adaptive Energy Management Strategy for Fuel Cell/Battery/Supercapacitor Hybrid Energy Storage Systems of Electric Vehicles. *International Journal of Electrochemical Science*, *15*(4), 3410-3433. https://doi.org/10.20964/2020.04.50

Int. J. Electrochem. Sci., 15 **(2020)** 3410 – 3433

International Journal of ELECTROCHEMICAL SCIENCE
www.electrochemsci.org

An Adaptive Energy Management Strategy for Fuel Cell/Battery/Supercapacitor Hybrid Energy Storage Systems of Electric Vehicles

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doi: 10.20964/2020.04.50

Received: 23 December 2019 / *Accepted:* 10 February 2020 / *Published:* 10 March 2020

This paper presents an adaptive energy management strategy for fuel cell/battery/ supercapacitor hybrid energy storage systems of electric vehicles. The strategy consists of a game theory controller for power distribution and an neural network model for driving pattern recognition. First, the power distribution problem is formulated as a non-cooperative game in which the strategy decides how much power to deliver over each power source to maximize individual benefit. The utility function considered here is to minimize the difference between the actual power demand supplied by each power source and its optimal power demand, which is obtained using a particle swarm optimization algorithm. However, the optimized results for a given driving cycle cannot cover various driving cycles. To cope with this problem, adaptive utility function concept, which is realized based on driving pattern recognition, is further proposed to guarantee the optimum performance from the presented game theory controller. Finally, computer simulation has been conducted to validate the proposed strategy. Compared with the conventional game theory strategy without prediction, simulation results demonstrate that the consistency of the Nash equilibrium under different driving scenarios can be guaranteed using the proposed adaptive strategy.

Keywords: Electric vehicle, hybrid energy storage system, game theory, adaptive utility function, driving pattern recognition.

FULL TEXT