AI Based HEFC System Output Control Approach for Solar Power and Battery SoC Regulation

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Introduction

Solar power is an extensively used renewable energy resource, but its intermittent nature affects the power supply quality as it results in issues such as frequency aberrations and voltage variations. Battery Energy Storage Systems (BESS) are utilized to smooth out and resolve the fluctuation issues. However, a control method is required for BESS charging level regulation to prevent the need for larger storage systems and to extend its operational life through controlled charging/discharging.

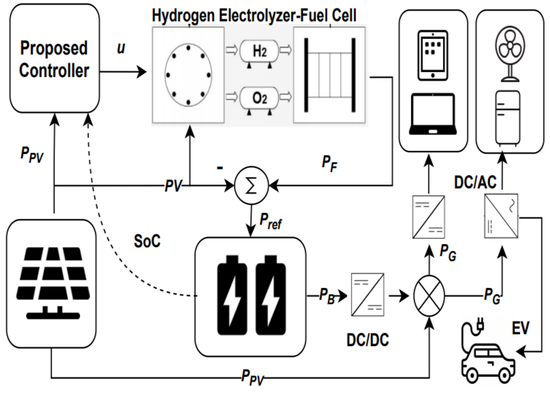
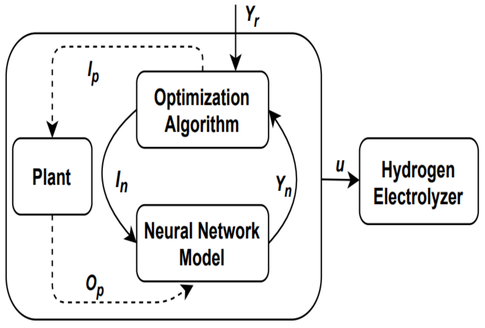


Fig. 1. Microgrid system with hydrogen electrolyzer fuel cell hybrid system.

- This research proposes a novel neural (NN) network based controller (MLC) for solar power control and battery state of charge (SoC) regulation using Hydrogen Electrolyzer (HE) and Fuel Cell (FC) system.
- The MLC is designed for dynamic control of the HE output to allow the dispatching of firmed PV power with controlled battery charging/discharging.
- A comparison between the proposed controller and the popularly used fuzzy logic control (FLC) is conducted.

Methodology

Fig. 2. Proposed ML based controller for HE output control.



$$P_h = \frac{1}{s \cdot T_h + 1} \cdot P_h' \qquad SoC(s) = \frac{-P_B(s)}{s \cdot E_B}$$

$$P_f = \frac{1}{s \cdot T_f + 1} \cdot P_f' \qquad P_G(s) = P_B + P_{PV}(s)$$

$$50\% \leq SoC \leq 100\%$$

$$0 < T_h \leq 120\ sec$$

$$0 \leq h(m) \leq d_1; m = 0, 1, ..., N_v - 1$$

$$J = \sum_{i=N_a}^{N_b} (y_r(t+i) - y_n(t+i))^2 + \lambda \sum_{i=1}^{N_v} (I_n(t+i-1) - I_n(t+i-2))^2$$

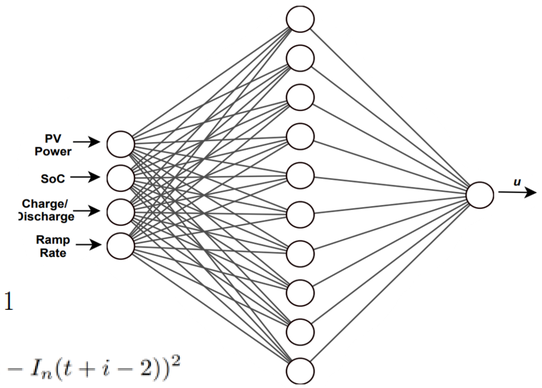


Fig. 3. Neural network for HE input control signal .

Results

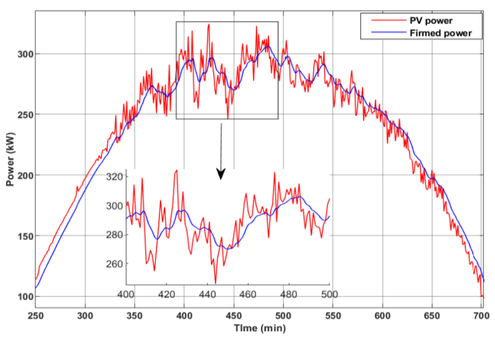


Fig. 4. Solar power with and without the proposed controller.

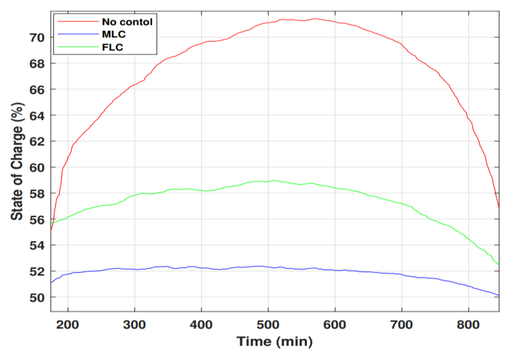


Fig. 5. Battery SoC comparison with no control, MLC, and FLC.

Results

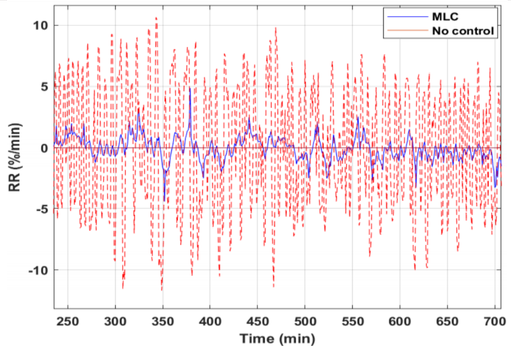


Fig. 6. Ramp rate reduction through MLC employment..

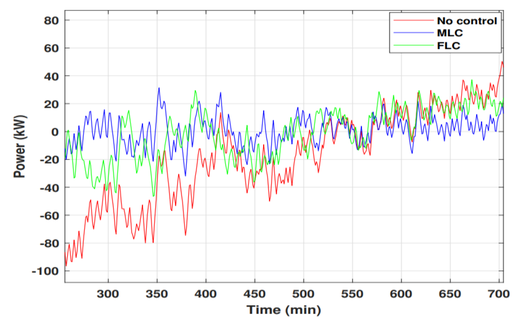


Fig. 7. Charging/discharging power reduction of the FLC & MLC.

Conclusion

- A NN controller has been developed to reduce the Solar power fluctuations and to regulate the battery SoC.
- Simulation results have demonstrated the effectiveness of the MLC combined with HE and BESS for PV power control and SoC management.
- The MLC reduces the peak battery SoC by 26.7% and compared to FLC, the peak SoC is reduced by 11.2%. To demonstrate the power smoothing effectiveness of the MLC, the peak solar power ramp rate is reduced by 30.3%.