Fuzzy-Logic Based MPT for Photovoltaic Based Power System

Gaurav Kalotra, and Rakeshkumar Mahto
Computer Engineering Program, California State University, Fullerton, CA 92831

Abstract:

Wireless sensor networks (WSNs) have garnered much interest among researchers. One of the critical applications of WSNs is in the detection and mitigation of forest fires [1]. Many mobile ad-hoc networks (MANET) for forest fire surveillance technologies are presented in [2]. The WSN is one of MANET classifications where each node consists of low-power computing devices that can sense environmental conditions such as temperature, humidity, lighting condition, atmospheric pressure, and many others. The primary power source of each of these sensor nodes is rechargeable batteries. However, replacing the batteries of each of the sensors is a tedious task. The other way to power these sensors are by utilizing a hybrid battery/photovoltaics (PV) based power source [3] - [4]. The PV based power source can charge the battery and power the sensors in the daytime, while during the nighttime, the charged battery can provide the necessary power to the sensor network.

However, most of the forests are filled with different types of fauna and flora. Shading resulted from various kinds of plants and trees results in severely deteriorating PV cells' performance, which powers the sensors. Similarly, the fauna found in the forest can cause physical damage to the PV cells. Thus, there is a requirement for having smart PV cells that can able to adapt with the changing lighting conditions and resilient to physical damage. A silicon switch embedded PV modules are ideal for such applications as they can operate efficiently in different lighting conditions and amputate damaged PV cells from the panel without human interventions [5].

This poster presentation mainly focuses on improving the maximum power transfer during shading conditions by using fuzzy logic. Most of the proposed algorithms for the silicon switch embedded PV module use a comparative analysis between the computed power and measure power in fault detection [6]. Detecting the shaded or failed PV cells and determining an optimal configuration for the silicon switch embedded PV module is a tedious process [6]. Furthermore, during the switching effort towards the optimal configuration, the reconfigurable PV module's performance deteriorates further. Thereby ultimately diminishing the increase in the efficiency of PV modules due to reconfigurability. In this presentation, we present a fuzzy logic-based technique for determining the optimal configuration (number of PV cells in series x number of PV cells in series) of the silicon switch embedded PV module. The input to the fuzzy logic includes, the number of PV cells in series and parallel, the number of healthy PV cells in the panel, and the measurement value of generated power. This research work will enable the creation of adaptable PV modules by the use of machine learning (ML).

References:

[1] A. Díaz-Ramírez, L. A. Tafoya, J. A. Atempa, and P. Mejía-Alvarez, "Wireless sensor networks and fusion information methods for forest fire detection," *Procedia Technol.*, vol. 3, pp. 69–79, 2012.

[2] F. T. AL-Dhief, N. Sabri, S. Fouad, N. M. A. Latiff, and M. A. A. Albader, "A review of forest fire surveillance technologies: Mobile ad-hoc network routing protocols perspective," *J. King Saud Univ. - Comput. Inf. Sci.*, vol. 31, no. 2, pp. 135–146, Apr. 2019, doi: 10.1016/j.jksuci.2017.12.005.

[3] J. Taneja, J. Jeong, and D. Culler, "Design, Modeling, and Capacity Planning for Micro-solar Power Sensor Networks," in *2008 International Conference on Information Processing in Sensor Networks (ipsn 2008)*, Apr. 2008, pp. 407–418, doi: 10.1109/IPSN.2008.67.

[4] M. Minami, T. Morito, H. Morikawa, and T. Aoyama, "Solar biscuit: A battery-less wireless sensor network system for environmental monitoring applications," in *The 2nd international workshop on networked sensing systems*, 2005, vol. 2007.

[5] R. Mahto, O. Lavrova, P. Zarkesh-Ha, and L. Lester, "Reconfigurable and Programmable Photovoltaic Power for Micro Autonomous Systems," *ReSpaceMAPLD 2010*, 2010.

[6] R. Mahto, "Fault resilient and reconfigurable power management using photovoltaic integrated with CMOS switches," 2016.