Neural Network Estimation of Photovoltaic Array I-V Curves Under Non-Uniform Conditions

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Abstract:
Since the inception of the solar cell at Bell Labs in 1952, the Photovoltaic (PV) industry has experienced nearly exponential growth. By 2018, it is predicted that PV will replace 5 percent of electricity generation. Despite market growth, reliability testing, and advancement in solar cell efficiency, significant questions remain regarding the actual performance of PV modules in the field under the myriad of environmental conditions that are realized in day to day operation. In this talk, we present a neural network algorithm to estimate the I–V curve of photovoltaic module arrays under non-uniform temperature and shading distributions. We present a novel photovoltaic model which includes the interaction of (1) thermal heat transfer, including conduction, convection, and radiation, (2) an electro-optical two diode model including ohmic heat dissipation, and (3) environmental influences including shading, irradiance, and wind dependencies. In addition, the model incorporates arbitrary placement of bypass diodes in parallel with cell strings and reverse bias characteristics of cells which may occur due to mismatch. Numerous simulation results under non-uniform shading patterns are provided illustrating the performance of the neural network. Recent experimental results obtained from our photovoltaic rooftop lab are also presented.

About the Speaker:
Abraham K. Ishihara received the B.S. degree in Electrical Engineering from Rensselaer Polytechnic Institute, and the M.S. and Ph.D. degrees in Aeronautics and Astronautics from Stanford University, in 1998, 2002, and 2008, respectively. Prior to joining CMU he worked in industry on the adaptive control of drug delivery systems, reconfigurable flight control with saturating actuators and Helicopter Active Control Technology (HACT). At Stanford, he worked on the neural network control of robot manipulators, asymptotic methods for the stability and instability analysis of nonlinear systems and simulated annealing for nonlinear control. Additionally, he has worked on measuring human motor learning rates in unknown environments using surface electromyography and studying motor adaptation in children with movement disorders such as dystonia and ataxia. He was also the recipient of the National Research Service Award (NRSA) NIH training grant. He joined the faculty of Carnegie Mellon West in 2008 and is currently interested in time-delay systems, metrics for adaptive control, and control and diagnostics of PV arrays.