Plan Overview

A Data Management Plan created using DMPTool

Title: Designing an Intelligent Cloud Motion Vector Sensor (CMVS) System to Detect Clouds and Forecast Real-time PV System Performance

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Template: NSF-ENG: Engineering

Project abstract:

Improving PV power production forecast capabilities is critical to cost-effectively integrating more solar into electric transmission and distribution systems. Varying weather patterns such as a cloud rolling over a PV array is the main cause of voltage fluctuation and flicker. The goal of this project is to develop a system to detect clouds in real time with high accuracy by implementing an intelligent low-cost Cloud Motion Vector System (CMVS) design. The proposed design uses a low-cost array of ambient light sensors and a real-time prediction algorithm based upon gradient matrix and peak detection methods. The algorithm will be capable of forecasting PV power output and voltage flicker severity index (Pst). When the forecast falls below a certain level, a signal at the output is triggered to instantaneously turn on the constant backup power supply until optimal operation is restored. Furthermore, the algorithm will forecast PV maintenance and detect tampering and theft using a sensor fusion algorithm with dust, current, voltage sensors and accelerometer measurements. An API-based IoT platform will be used for data collection, processing, visualization, and energy management. For the same purpose, we will develop a Python script which will offer utility companies an integrated experience with industry standard power management tool. CMVS will feature a smart design for IoT applications with scalable deployment and has the potential to help grid operators better understand and mitigate the effects of PV power variability on grid planning and operations, hence bringing us a step closer to a concept of smart city.

Start date: 08-24-2021

End date: 08-23-2024

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During the course of the project, the real-time performance of the PV system installed on-campus will be monitored and recorded. These include recording values for output voltage (Vdc, in volts) and output power (Pdc, in kWs) as a function of solar irradiance (ir, in W/m2). These values are critical in deriving alpha (the prediction coefficient of PV output power, Pdc) values as they will be embedded into the algorithm to forecast predicted output power. This computational data will also be critical for determining spatial distribution and sizing of PV arrays to ensure optimal grid integration and operation when choosing a PV site location. In addition, data related to clouds will be collected such as cloud speed (v in m/s), direction (theta, in degrees), and size (length, in meters and coverage time, in seconds) for analysis and study of how these parameters individually and collectively impact the performance of a PV system in all kinds of weather. The proposed light sensor-based CMVS design will collect the information related to moving clouds at a fine resolution of 1 second, and this information could be used to improve algorithm (MATLAB scripts) applied on satellite data to predict weather events. All these data will be stored directly onto an IoT Platform (via MATLAB and Python scripts) as well as on a local storage device.

The educational effort will produce curriculum materials and assessment data, which will be archived as Microsoft Word (.docx), Portable Document Format (PDF), and spreadsheet (Microsoft Excel, .xls) files. Included in all files will be a description of the contents and the date that the materials or assessments were generated. These files will be included and described in the journal publications that will result from the proposed educational effort.

During the course of the project, all of the data from light sensor cluster will be recorded in a .csv format spreadsheets. Data sets and post-processing of all sets of data will be included and described in the journal publications that will result from the proposed research effort. Metadata will be comprised of numeric data that reflects solar irradiance data collected through use of CMVS model and will be transmitted to both IoT platform and local drive. The proposed algorithm will run multiple MATLAB scripts to analyze this data. The resulting data, graphs and plots will be readily accessible on IoT platform. These can be downloaded as .jpeg or.png images.

The data will be made available publicly and open source, as well as available to scientific community through their affiliated schools and subscriptions to journals/magazines.

The results of this proposed project will be submitted to journals such as Solar Energy, Energy and Environmental Sciences, Applied Energy, and International Journal of Electric Power and Energy Systems. Faculty and students will also present and share their work at conferences such as Institute of Electrical and Electronics Engineers (IEEE) Conference (PVSC & GTD), and smart electric power grids conferences. In addition, presentations will be given to the middle and high school students, and community college students, in the region, and to the undergraduate students at the regional schools through various programs such as Frontiers or Touch Tommorrow at WPI. Most importantly, Eversource as a collaborator, the research findings will be made available to the utility company via meetings/presentations as their feedback will be important to improve the CMVS design.

Access to research databases and other software tools (MATLAB and Python Scripts) will be available for educational, research, and non-profit purposes. Such access will be provided using web-based applications, such as WPI Digital as appropriate. Research findings from the project will be disseminated in accordance with University and NSF policies. Depending on such policies, research material may be transferred to others under the terms of a material transfer agreement.

PI will be responsible for all data management during and after data collection. All the data generated throughout the course of this project will be preserved on an online sever (such as ThingSpeak) as well as locally on SD cards.

Data will also be available on private-public WPI-maintained storage arrays and password-protected servers with an institutional backup and archiving strategy. Also, all the reports, presentations and research papers will be deposited along with the datasets. Our intent is to make all of the data available for use by research and policy communities in perpetuity. The raw supporting data will be available in perpetuity as well, for use by researchers.

WPI's IT division will provide the necessary procedures for preservation, backup and archiving.

The PI research group will be maintaining a web server.

Personal Research Files:

\\research.wpi.edu\ECE\mamughal

Research Files to be shared with lab:

\\research.wpi.edu\ECE\mamughallab

Data will be retained for at least 5 years after the termination of the project.