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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Products of Research

What types of data (experimental, computational, or text-based), metadata, samples, physical collections, models, software, curriculum materials, and other materials will be collected and/or generated in the course of the project? The DMP should describe the expected types of data to be retained, managed, and shared, and the plans for doing so. What descriptions of the metadata are needed to make the actual data products useful and reproducible for the general researcher? For collaborative proposals, the DMP should describe the roles and responsibilities of all parties with respect to the management of data (including contingency plans for the departure of key personnel from the project) both during and after the grant cycle.

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.

Data Formats and Standards

In what format and/or media will the data or products be stored (e.g., hardcopy notebook and/or instrument outputs, ASCII, html, jpeg or other formats)? Where data are stored in unusual or not generally accessible formats, how may the data be converted to more accessible formats or otherwise made available to interested parties? When existing standards are absent or deemed inadequate, this should be documented along with any proposed solutions or remedies. In general, solutions and remedies to providing data in an accessible format should be offered with minimal added cost.

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.

Dissemination, Access and Sharing of Data

What specific dissemination approaches will be used to make data available and accessible to others, including any pertinent metadata needed to interpret the data? In this case, "available and accessible" refers to data that can be found and obtained without a personal request to the PI, for example by download from a public repository. What plans, if any, are in place for providing access to data, including websites maintained by the research group and contributions to public databases/repositories? For software or code developed as part of the project, include a description of how users can access the code (e.g., licensing, open source) and specific details of the hosting, distribution and dissemination plans. If maintenance of a website or database is the direct responsibility of the research group, what is the period of time the website or database is expected to be maintained? What are the practices or policies regarding the release of POST-AWARD MANAGEMENT data – for example, are they available before or after formal publication? What is the approximate duration of time that the data will be kept private? "Data sharing" refers to the release of data in response to a specific request from an interested party. What are the policies for data sharing, including, where applicable, provisions for protection of privacy, confidentiality, intellectual property, national security, or other rights or requirements? Research centers and major partnerships with industry or other user communities should also address how data are to be shared and managed with partners, center members, and other major stakeholders; publication delay policies (if applicable) should be clearly stated.

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.

Re-Use, Re-Distribution and Production of Derivatives

What are your policies regarding the use of data provided via general access or sharing? For data to be deemed "re-usable," it must be accompanied by any metadata needed to reproduce the data, e.g., the means by which it was generated, detailed analytical and procedural information required to reproduce experimental results, and other pertinent metadata. Practices for appropriate protection of privacy, confidentiality, security, intellectual property, and other rights should be communicated. The rights and obligations of those who access, use, and share your data with others should also be clearly articulated. For example, if you plan to provide data and images on your website, will the website contain disclaimers or condition regarding the use of the data in other publications or products?

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.

Archiving of Data

When and how will data be archived and how will access be preserved over time? For example, will hardcopy logs, instrument outputs, and physical samples be stored in a location where there are safeguards against fire or water damage? Is there a plan to transfer digitized information to new storage media or devices as technological standards or practices change? Will there be an easily accessible index that documents where all archived data are stored and how they can be accessed? If the data will be archived by a third party, please refer to their preservation plans (if available). Where no data or sample repository exists for collected data or samples, metadata should be prepared and made publicly available over the Internet and the PI should employ alternative strategies for complying with the general philosophy of sharing research products and data as described above

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.