

Implementation of PV Monitoring System Using Python

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Abstract— In this paper, we provide a method for monitoring solar power plants and analyzing monitoring data. Most monitoring systems collect data from the PV inverter through RTU and transmit it to the remote server.

In this paper, We provide a method to collect the information provided by the PV inverter through the Modbus/TCP and analyze it through DNN(Deep Neural Network), one of the techniques of machine learning using python and open source libraries.

Keywords— Photovoltaic, Monitoring system, Python, Modbus, TCP

I. INTRODUCTION

As the photovoltaic system increases, the industrial infrastructure for monitoring the photovoltaic system is increasing. However, the monitoring system for the photovoltaic power generation plant is constructed through different solutions for each company to be constructed, which makes it difficult to integrate management and monitoring. One way to solve this problem is to monitor PV plants and analyze the collected data using simple methods.

In this paper, we propose a data collection method based on Modbus/TCP through python and open library, and propose a method to analyze data through machine learning based on the collected data. First, we will discuss how to collect data based on the memory map information of a solar inverter that supports the Modbus/TCP protocol. Secondly, we will discuss how to estimate the solar power generation based on stored data through machine learning.

II. PV MONITORING SYSTEM

First of all, to build a PV monitoring system, it is necessary to collect data. There are various communication methods for collecting data. In this paper, a method of collecting data based on Modbus/TCP is adopted, because it is widely used as an industry standard[1]. To do this, we use python and pyModbusTCP library.

A. Modbus/TCP

Python[2] is a well-known programming language that needs no explanation, and pyModbusTCP, the open modbus tcp library for python, is packaged in four component : client, server, utils, and constants. [3]

- Client : Modbus TCP client class

- Server : Modbus TCP server class (currently in test)
- Utils : data managing functions
- Constants : all package constants

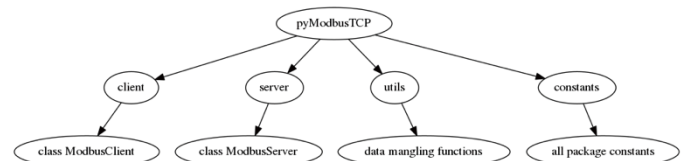


Figure 1. A pyModbusTCP package diagram

B. Monitoring System

Among the four packages, the client package is mainly used to build this system. The inverter of the solar power plant operates as a Modbus/TCP server, and the specific memory information is collected from the remote monitoring system where the Modbus/TCP client is installed and stored in the database in monitoring system. Figure 2 shows this.

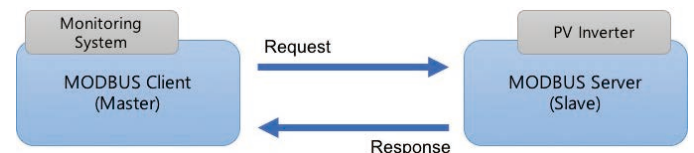


Figure 2. Modbus TCP Protocol between Monitoring system and PV inverter

Although it is possible to control the operation such as stopping the inverter through the modbus / tcp protocol, it is not desirable from the viewpoint of facility management to control the operation of the solar power plant inverter at a remote place without visually grasping the current state of the solar power plant. The monitoring system is mainly used to read the information on the inverter register.

The register map information of the solar power plant inverter varies greatly depending on the inverter manufacturer.

However, there is no significant difference in the information collected, so Table 1 shows the information that can be collected from the PV inverters installed in the ETRI test bed.

TABLE 1. PV INVERTER REGISTERS MAP

Func	Read Input Register (measurement)
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tion Code	Reg.addr	address	parameter
04h	30027	26	Inverter State
	30028	27	SW Fault State
	30029	28	HW Fault State
	30030	29	Today Generation Time
	30033~34	32~33	Total Generation Time
	30035~36	34~35	PV Voltage
	30037~38	36~37	Inverter DC Voltage
	30039~40	38~39	PV Current
	30041~42	40~41	PV Power
	30043~44	42~43	Total Voltage
	30045~46	44~45	Total Current
	30047~48	46~47	Total Active Power
	30049~50	48~49	Total Reactive Power
	30051~52	50~51	Total Power Factor

C. Implementation of Monitoring System

The pictures below are actual pictures of the implemented monitoring system.

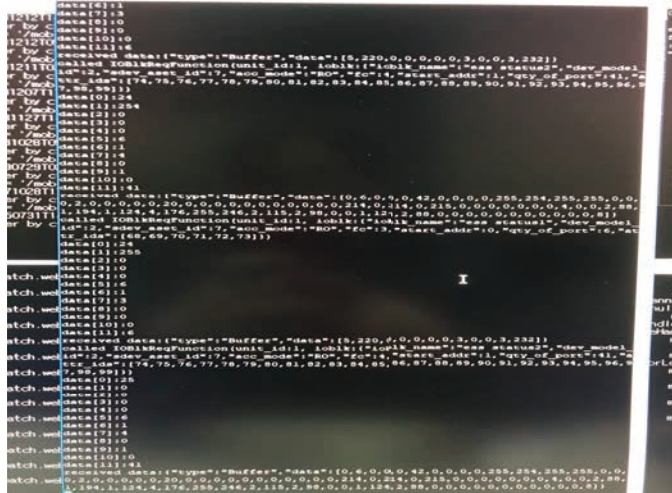


Figure 3. Collecting Data from PV Inverter

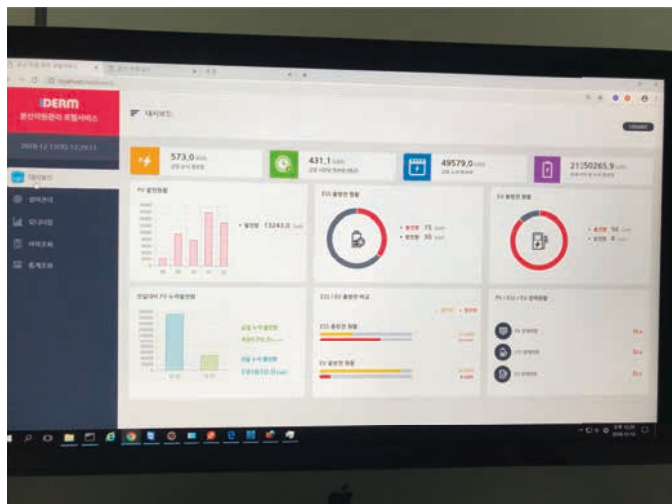


Figure 4. Monitoring System UI - Dashboard

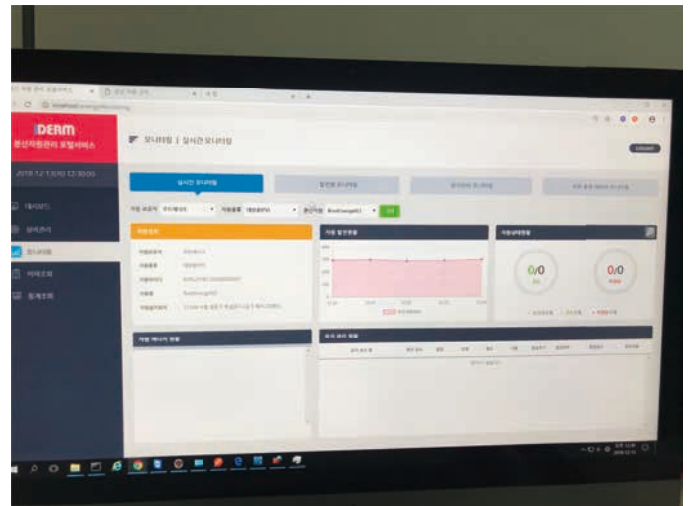


Figure 5. Monitoring System UI – Realtime Monitoring

III. DATA ANALYSIS

After the monitoring system is built, data collection and analysis are needed. The most important analytical work in PV plants is to predict the generation of electricity under the changing weather conditions.[4]

The analysis steps are based on the collected inverter information for the prediction of solar power generation.

First, the collected data was randomly divided into 70% of the training data and 30% of the test data.

Then, training is performed on the given training data, and then test data based prediction is performed based on the built model.

The prediction accuracy is determined by comparing the original value with the model-based prediction value predicted through the test data.

The number of nolds was set to 10, and the the number of epochs was set to 500, to generate DNN models using 189,170 training samples. The following is the analysis result of DNN through the above process.

A. Metrics reported on full training frame

- MSE : 0.3418188
- RMSE : 0.5846527
- MAE : 0.4200251
- RMSLE : 0.02989865

B. 10-fold cross-validation on training data

- MSE : 10.39999
- RMSE : 3.224902
- MAE : 2.166242
- RMSLE : 0.1490695

C. RMSE Value

- Valid_rmse : 3.224902
- Test_rmse : 4.307058

IV. CONCLUSIONS

Generation amount by using the monitored data is also presented, the estimation method of the generation amount is various, so that this is merely an example of constituting a system for constructing and analyzing the monitoring system.

Additional work will be done to compare and analyze various statistical techniques applied to various collected sites.

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