Scientia Iranica B (2015) 22(6), 2170–2177

SCIENTIA IRANICA

Sharif University of Technology
Scientia Iranica
Transactions B: Mechanical Engineering
www.scientiairanica.com

Study on cloud-dust based intelligent maximum performance analysis system for power generation with solar energy

C.-C. Huang*

Department of Automation and Control Engineering, Far East University, Tainan City, 744, Taiwan, ROC.

Received 22 May 2014; accepted 15 September 2015

KEYWORDS
Intelligent system;
Cloud-dust based;
Maximum performance analysis system;
Solar energy.

Abstract. In the paper, a cloud-dust based intelligent maximum performance analysis system for power generation with solar energy is proposed. In order to resolve performance problems for power generation using solar energy, factors of the photovoltaic are integrated to the cloud-dust based intelligent maximum power analysis system for computing. This study concerns the development of a maximum performance analysis system for power generation using solar energy, in order to improve the effects of different regions on the solar panels and enable them to get maximum efficiency of power generation. The design methodology of this study includes: (1) Records and surveillance module; (2) Prediction and assessment module; (3) Performance diagnosis module; and (4) Maintenance prescription module, with which we are able to find the design and implementation of records, surveillance, prediction, assessment, diagnosis and prescription for power generation with solar energy. It has worked successfully. The advantages of the cloud-dust based intelligent, maximum performance analysis system for power generation with solar energy include an increase in the overall competitive performance of the products, and a reduction in the cost of the products and use of human resources.

1. Introduction

Considering the management of solar power generation equipment, the choice of surrounding environments, control of weather conditions, surveillance, assessment, diagnosis and the maintenance of power generation, solar generator sets can produce maximum power generation efficiency. The cloud-dust intelligent maximum performance analysis system for power generation consists mainly of four parts:

1. The records and surveillance module;
2. The prediction and assessment module;
3. The performance diagnosis module;
4. The maintenance prescription module.

In 1995, Hussein [1] developed a new MPT algorithm based on the MPOP of a PV generator. It can be tracked accurately by comparing the incremental and instantaneous conductance of the PV array. By both simulation and experiment, the results show that the developed incremental conductance algorithm successfully tracked the MPOP. In 2006, Meng Xian Yao [2] optimized the BP neural network using genetic algorithms to diagnosis the faults of the main rotating device for ships. Considering 8 kinds of common fault as the network output, the signal is divided into 9 different frequency bands, and the peak value is the feature for the training samples. The experimental results demonstrate that optimization of the BP neural network using genetic algorithms can make the training of BP neural networks such as to avoid falling into the local minimum and quick convergence. It

*. *E-mail address: cchuang@cc.feu.edu.tw*

improves computing speed and has good results in fault diagnosis. In 2008, Hong et al. [3] proposed the real-time embedded maintenance system of the excitation system. An expert system is developed to optimize the control parameters, detect and diagnose equipment failure, and remedy both control and maintenance on the basis of on-line monitoring and performance evaluation. In 2005, Bansal [4] proposed a real-time predictive maintenance system to replace expensive motion-sensing technology. It is a new real-time neural network predictive maintenance system using off-line data, which uses Principal Component Analysis (PCA) for feature extraction. The predictive maintenance system uses the load and torque of a micro drill motor to reduce vibration and local thermal effects. In 2010, Kun and Gang [5] used the PCA method to build up principal component, and error monitoring models, design a human-machine-interface for on-line state monitoring, analyze abnormal conditions by the datum of the production process, and implement on-line state monitoring for the production process. By this, it is shown that the PCA method has good application prospects. In 2013, Saxena and Mishra [6] proposed that the maintenance of the solar system determined the life length of the system. Therefore, it is necessary to maintain a solar system for reducing the cost of the system. In 2010, Jiang et al. [7] studied a novel collection system of logistics management in which the data collection terminal RF-Information collection, based on RFID & ZigBee technology, combined with the embedded Linux system and advanced graphics engine technology. The collection system of logistics management enhanced the interconnection of information and increased logistics management efficiency. In 1997, Hiyama and Kitabayashi [8] proposed the application of an artificial neural network for the estimation of maximum power generation from the PV module. The output power from a PV module depends on environmental factors, such as irradiation and cell temperature. They chose irradiation, temperature and wind velocity as the input information for the neural network. The output is predicted maximum power generation under conditions given by those environmental factors. The efficiency of the proposed estimation scheme is evaluated using actual data on daily, monthly and yearly bases. Compared with the conventional multiple regression model, this method gives highly accurate predictions. In summary, it is necessary to develop a cloud-dust based intelligent maximum performance analysis system for power generation using solar energy.

2. Cloud-dust based intelligent maximum performance analysis system

The architecture of the cloud-dust based intelligent maximum performance analysis system for power generation with solar energy is shown in Figure 1. The

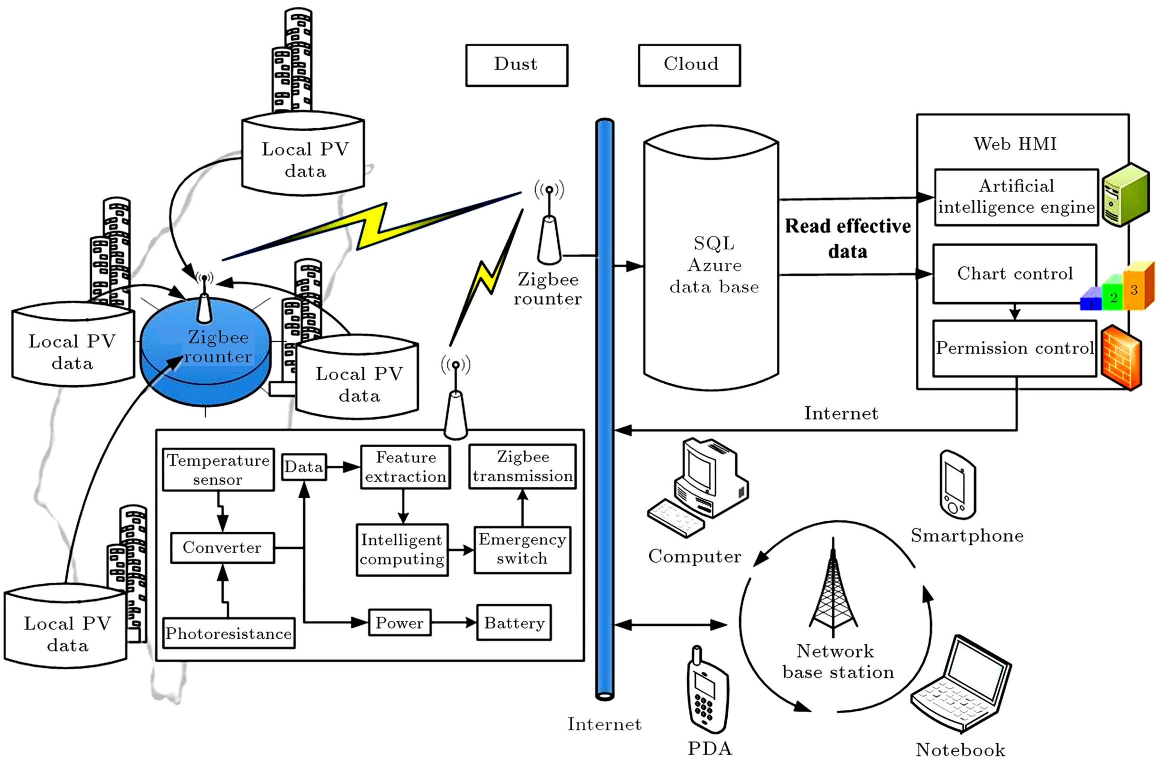

Figure 1. The architecture of the cloud-dust based intelligent maximum performance analysis system for power generation with solar energy.

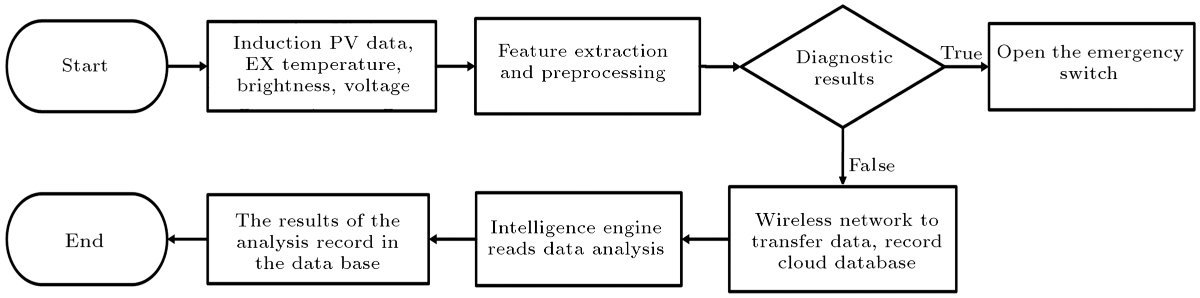

Figure 2. The flowchart of the cloud-dust based intelligent maximum performance analysis system for power generation with solar energy.

flow chart of the cloud-dust based intelligent maximum performance analysis system for power generation with solar energy is shown in Figure 2. The system is separated into the cloud part and the dust part. The dust part includes a wireless sensor network, feature extraction circuits, intelligent computing circuits and an embedded system. The architecture and flowchart of the dust part are shown in Figures 3 and 4. It can preprocess very well. The cloud part includes the cloud database, an intelligent computing engine and a ubiquitous human-machine-interface. The architecture and flowchart of the cloud part are shown in Figures 5 and 6. It can flexibly use computing resources and integrate information from many different dust systems to improve the solar panel effects of different regions and enable them to get maximum efficiency of power generation.

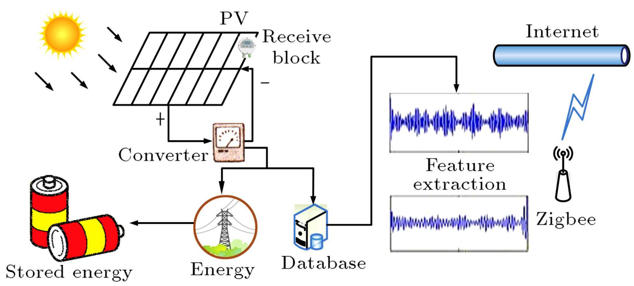

Figure 3. The architecture of the dust part for power generation with solar energy.

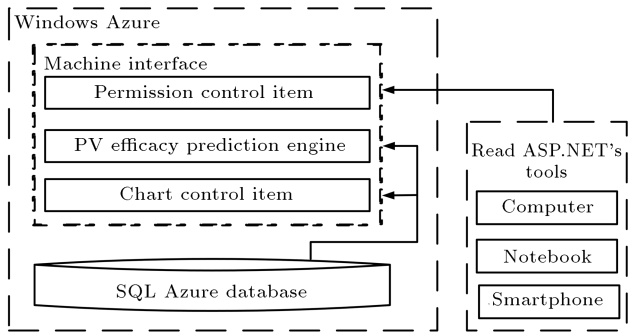

Figure 5. The architecture of the cloud part for power generation with solar energy.

3. Records and surveillance

Because it can real-time preprocess, the dust part can play the role of the monitoring and control of power generation with solar energy. The data of the surveillance can be stored in cloud databases for recording using the NET framework and the SQL Server. The flowchart of surveillance for power generation with solar energy is shown in Figure 7.

4. Prediction and assessment

As shown in Table 1, we proposed 12 influencing factors and 3 power outputs for prediction and assessment of power generation with solar energy, and we can predict and assess power output using the intelligent system.

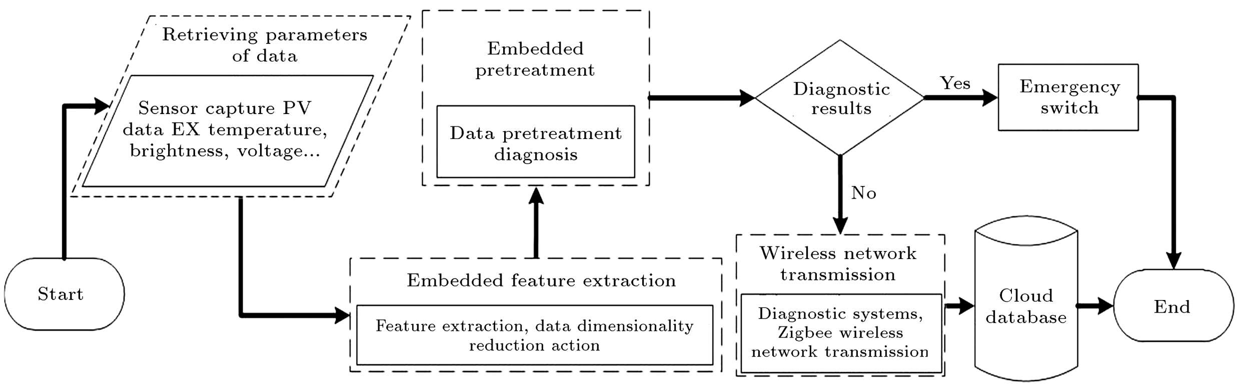

Figure 4. The flowchart of the dust part for power generation with solar energy.

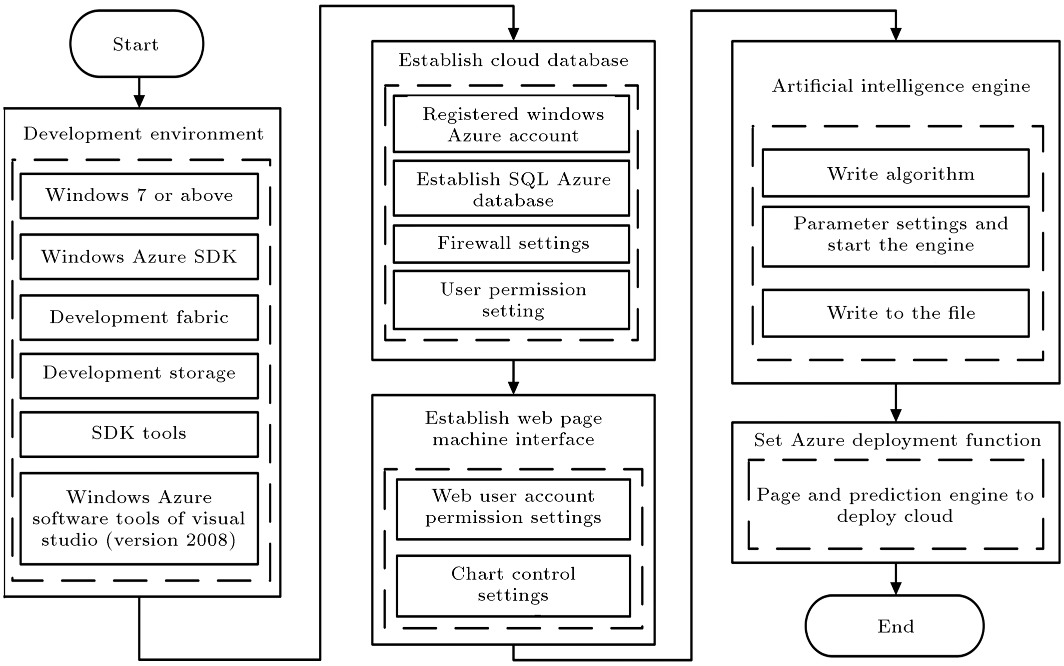

Figure 6. The flowchart of the dust part for power generation with solar energy.

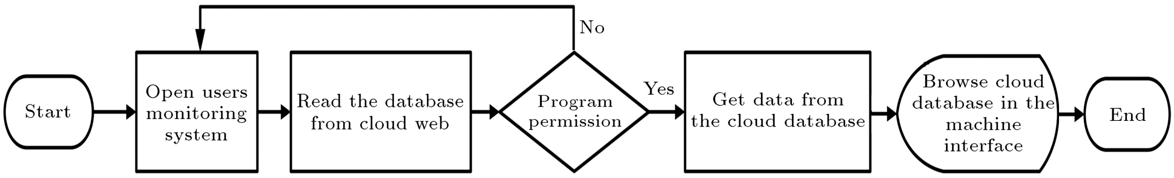

Figure 7. The flowchart of surveillance for power generation with solar energy.

Table 1. Influence factors and power outputs for prediction and assessment of power generation with solar energy.

Input		Output
Solar panel installation site as a measure of radiation measured value (Irr)		Solar panels output power instant (Pdc)
Solar panel module temperature value (Tm)		
Solar panel installation azimuth (Ort)		
Solar panel installation angle (Mta)		Solar panels instant output voltage (Vpv)
Solar panels standard operating temperature (Tn)		
Equipment specifications	Specifications maximum power output of solar panels ($P\max$)	
	Solar panels specifications maximum power voltage (Vpm)	
	Solar panels specifications maximum power current (Ipm)	
	Solar panels specifications open circuit voltage (Voc)	Solar panels immediate output current (Ipv)
	Solar panels specifications short-circuit current (Isc)	
	Solar panels specifications module conversion efficiency (ηm)	
	Solar panel specification peak power temperature coefficient ($Pmtc$)	

The architecture of the artificial neural network for prediction and assessment of power generation with solar energy is shown in Figure 8.

5. Performance diagnosis

We can assess the results of influencing factors from power outputs through reverse mapping of the neural network model. The influencing factors of the photovoltaic can be adjusted to achieve the desired photovoltaic results. The architecture of the artificial neural network for performance diagnosis of power generation with solar energy is shown in Figure 9 and the flowchart of the neural network model for performance diagnosis of power generation with solar energy is shown in Figure 10.

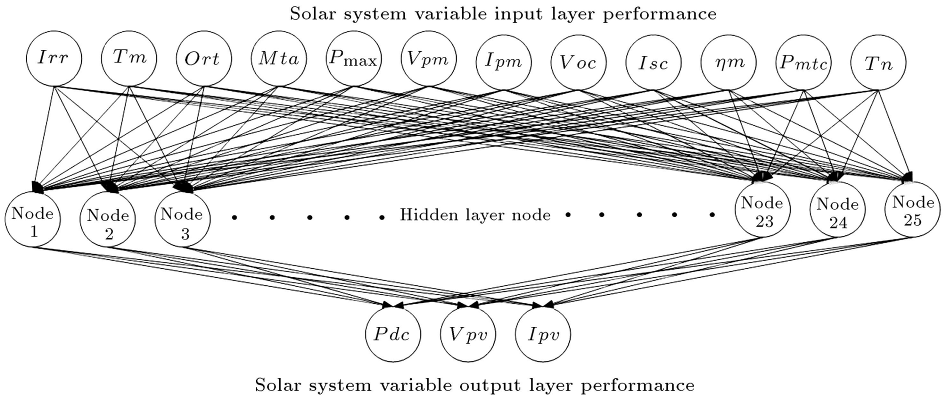

Figure 8. The architecture of artificial neural network for prediction and assessment of power generation with solar energy.

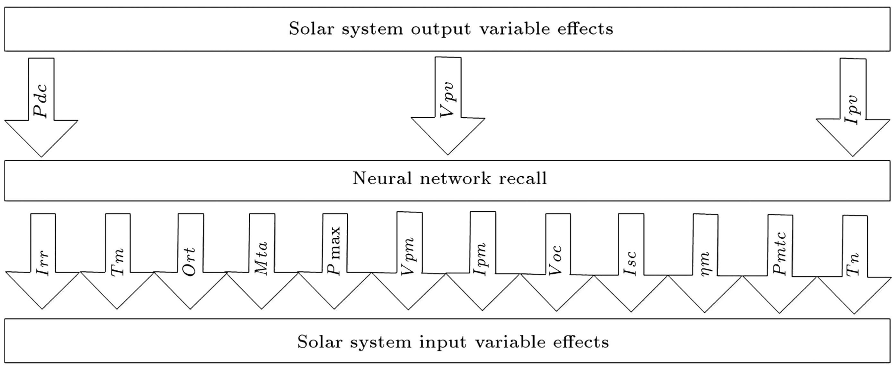

Figure 9. The architecture of artificial neural network for performance diagnosis of power generation with solar energy.

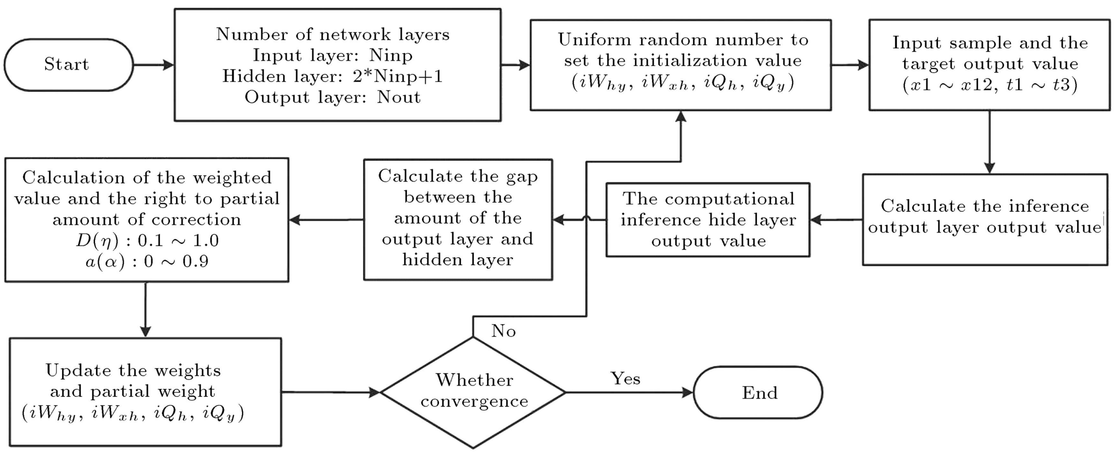

Figure 10. The flowchart of the neural network model power generation with solar energy.

6. Maintenance prescription

The solar radiation data provided by the Central Weather Bureau in Taiwan was used as training samples for prediction, and the maintenance prescription will be generated by the performance diagnosis. The flow chart of the maintenance prescription for power generation with solar energy is shown in Figure 11, and the list of maintenance prescriptions for power generation with solar energy is shown in Table 2.

7. Results and discussion

Predictions and assessments are shown in Figure 12. We input the influence factors to the back-propagation neural network for system identification, and obtain the output results. The model is a 3-layer back propagation neural network. It contains 12 neurons in the input layer, 28 neurons in the hidden layer and 3 neurons in the output layer. The experimental results show that the correction of the diagnosis is over 99.93%. Surveillance is shown in Figure 13.

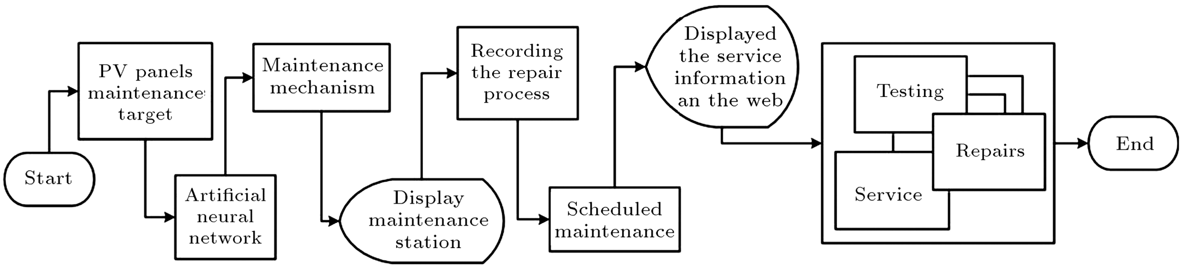

Figure 11. The flowchart of maintenance prescription for power generation with solar energy.

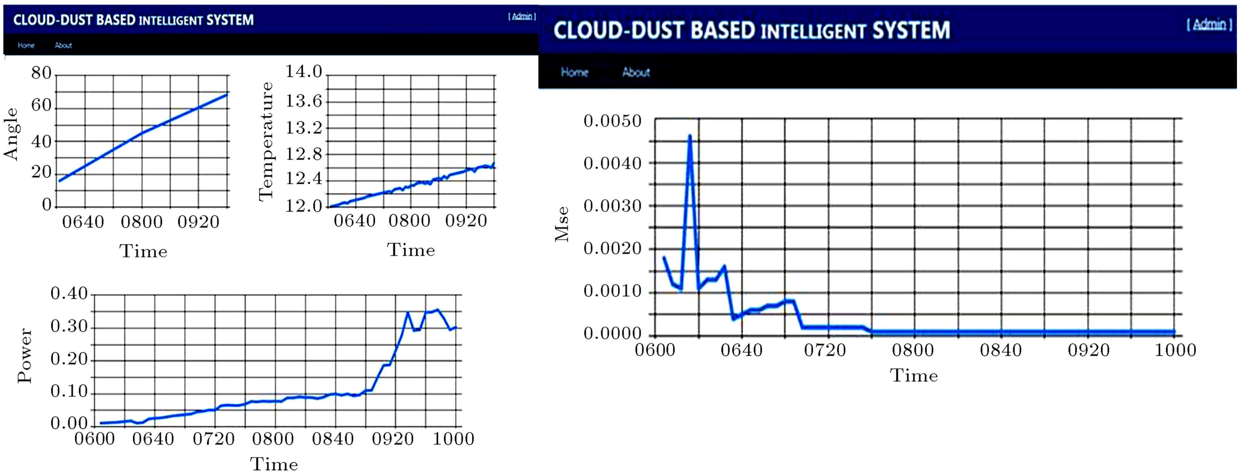

Figure 12. Results of cloud-dust based intelligent prediction and assessment for power generation with solar energy.

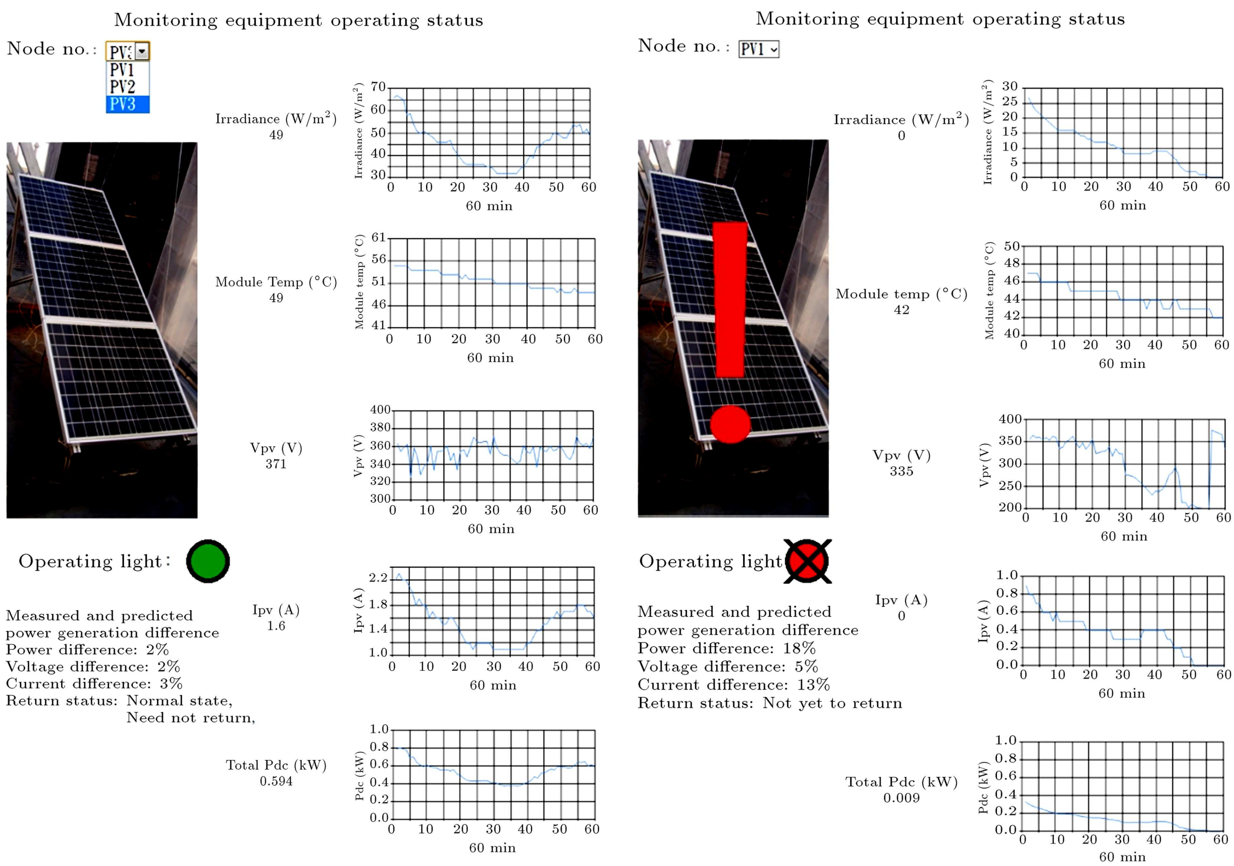

Figure 13. Results of cloud-dust based intelligent surveillance for power generation with solar energy.

Table 2. The list of maintenance prescription for power generation with solar energy.

Diagnose problems	Maintenance time	Affect the performance of solar power problem diagnosis
1	3 HR	Excessive dust
2	3 HR	Coverings
3	3 HR	Excretions
4	3 HR	Panel overheat
5	5 day	Panel damage
6	3 day	Cable connection problem
7	3 day	Cable is damaged

8. Conclusions

This study is the development of a maximum performance analysis system for power generation with solar energy. It improves the solar panels effects of different regions and enables them to get maximum efficiency of power generation.

The design and implementation of records, surveillance, prediction, assessment, diagnosis and prescription for power generation with solar energy was found and it worked very well. The advantages of a cloud-dust based intelligent maximum performance analysis system for power generation with solar energy include the increased overall competitive performance of products, and a reduction in the cost of products and user rates of human resources.

Acknowledgment

We would like to thank the Ministry of Science and Technology of Taiwan for financial support of this research under grant No. MOST 103-2221-E-269-012-.

Conflict of interest statement

We declare that we have no conflict of interest.

Nomenclature

ηm	Solar panel specification module conversion efficiency
Irr	Solar panel installation site as a measure of radiation measured value
Ipm	Solar panel specifications maximum power current
Isc	Solar panel specifications short-circuit current
Ipv	Solar panel immediate output current
$P\max$	specifications maximum power output of solar panels
Pdc	Solar panel output power instant
$Pmtc$	Solar panel specification peak power temperature coefficient
Tm	Solar panel module temperature value
Mta	Solar panel installation angle
Ort	Solar panel installation azimuth
Tn	Solar panel standard operating temperature
Vpv	Solar panel instant output voltage
Vpm	Solar panel specifications maximum power voltage
Voc	Solar panel specifications open circuit voltage

References

1. Hussein, K.H., Muta, I., Hoshino, T. and Osakada, M. "Maximum photovoltaic power tracking an algorithm for rapidly changing atmospheric conditions", *Generation, Transmission and Distribution*, **142**, pp. 59-64 (1995).

2. Meng, X.Y., Han, X.J. and Meng, S. "BP network model optimized using the genetic algorithms and the application on fault diagnose of equipments", *Proceedings of the 25th Chinese Control Conference*, 7-11 August, Harbin, Heilongjiang (2006).

3. Hong, T., Zeng, J.G. and Zhi, H.X. "Real time embedded maintenance system of hydro generator excitation system", *Condition Monitoring and Diagnosis, CMD, International Conference*, pp. 402-406 (2008).

4. Bansal, D., Evans, D.J. and Jones, B. "A real-time predictive maintenance system for machine systems - an alternative to expensive motion sensing technology", *Sensors for Industry Conference*, pp. 39-44 (2005).

5. Kun, I.Z. and Gang, R. "Improving monitoring performance of on-line process based on PCA method", *Control and Decision Conference*, pp. 4144-4148 (2010).

6. Saxena, A. and Mishra, S.K. "Review of system maintenance and troubleshooting of solar photovoltaic grid connected system", *International Journal of Emerging Science and Engineering (IJESE)*, pp. 67-68 (2013).

7. Jiang, B., Ma, L.b. and Xu, J.W. "Research of the collection system of logistics management based on RFID & ZigBee technology", *Computer Application and System Modeling (ICCASM) International Conference*, **6**, pp. 526-529 (2010).

8. Hiyama, T. and Kitabayashi, K. "Neural network based estimation of maximum power generation from PV module using environmental information", *IEEE Transactions on Energy Conversion*, **12**, pp. 241-247 (1997).

Biography

Chung-Chi Huang received BS and MS degrees in Mechanical Engineering from National Chung Hsing University, Taiwan, ROC, in 1992 and 1995, respectively, and a PhD degree in Manufacturing Information and Systems from National Cheng Kung University, Taiwan, in 2010. He is currently Associate Professor of Automation and Control Engineering at Far East University, Taiwan. His research interests include intelligent systems, cloud computing, embedded systems, wireless sensor networks, automation and control.