

Self-Learning Mechanism for Prediction of Energy Consumption and Generation

Tai-Yeon Ku

IoT Research Division
Hyper-connected Communication
Research Laboratory, ETRI
Dae-jeon, Korea
kutai@etri.re.kr

Wan-Ki Park

IoT Research Division
Hyper-connected Communication
Research Laboratory, ETRI
Dae-jeon, Korea
wkpark@etri.re.kr

Hoon Choi

Chungnam National University
Dae-jeon, Korea
hc@cnu.ac.kr

Abstract—This paper relates to a technique for predicting energy usage and power generation through self-enhancement learning using a big data platform. The energy management system should predict the future energy use and generation amount for the optimal operation of ESS based on the measured energy amount, renewable energy production amount and energy usage, and establish the operation plan. For this, ESS charge / discharge scheduling is established through an optimal control engine, and the service is managed and supervised by the administrator.

Keywords— energy management, energy big data, energy information collection

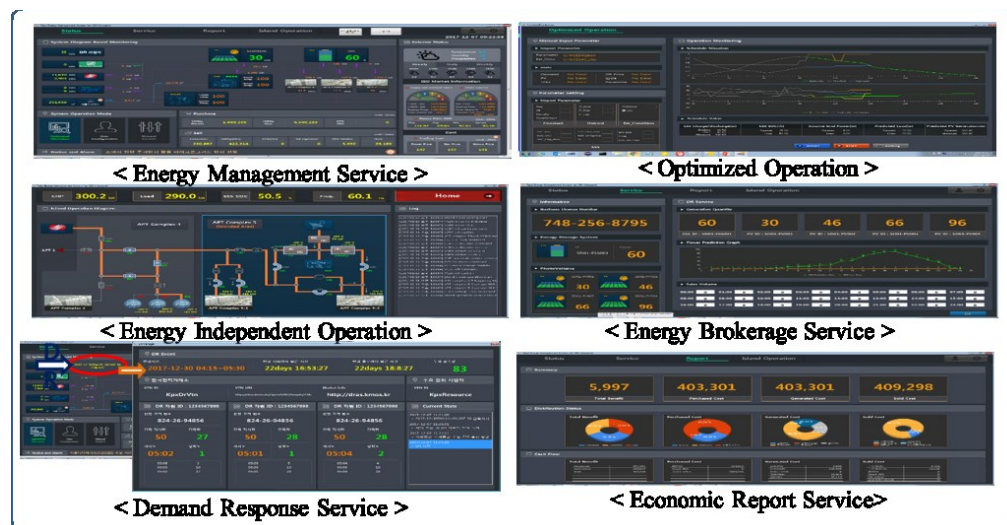
I. INTRODUCTION

There are various forecasting methods for estimating solar power generation through machine learning, but most of the recent studies use Regressive, ANN and SVR for prediction. Regression models such as ARMA are often used for simple modeling. However, prediction accuracy

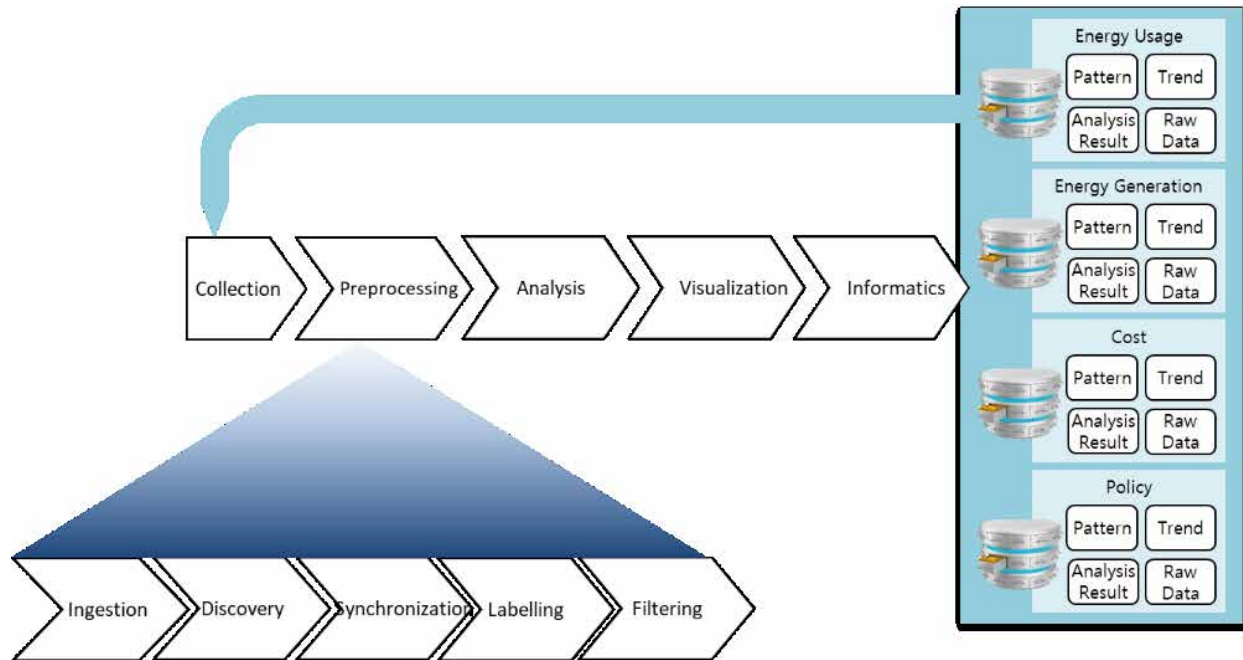
through ANN and SVR is becoming more important as program performance is improved so that accurate prediction becomes more important in recent years, and fast operation can be performed.

There are Hybrid-statistical methods that use multiple machine learning techniques together, and ANN and SVR are used together to predict. If the physical configuration of the PV system is known, it is predicted by the physical method without using machine learning. However, to improve the accuracy of the prediction, Hybrid-physical method that uses both machine learning prediction and physical method prediction is also used.

It is also important to evaluate the performance of the forecast after it has been completed. The performance evaluation is mainly based on errors. The types of errors include Normalized Error (NE), Mean Absolute Error (MAE), Mean Absolute Percentage Error (MAPE), and Root Mean Square Error (RMSE). The most commonly used error is RMSE, which has the advantage of being easy to operate.



[Figure 1] Energy Management System



[Figure 2] Self-Learning Mechanism for Energy Consumption and Generation

II. PREDICTION OF DEMAND AND PV GENERATION

Renewable energy, including photovoltaic energy, has a fatal disadvantage that energy is intermittent and the amount available is limited. This is a very deadly disadvantage when compared with fossil fuel-based power generation, which could be used whenever needed. Solar energy, for example, is limited in its use because it can only use the remaining energy from solar cells during the day in the night. In the cloudy weather, the energy is intermittent and the usage is more limited. To overcome these shortcomings, it is necessary to predict the future PV energy as accurately as possible and to use PV energy efficiently.

This paper is about energy consumption and power generation prediction method using self-enhancement learning using big data platform. The energy management system should predict the future energy use and generation amount for the optimal operation of ESS based on the measured energy amount, renewable energy production amount and energy usage, and establish the operation plan. For this, ESS charge / discharge scheduling is established through an optimal control engine, and the service is managed and supervised by the administrator. ESS charge / discharge schedules are established every 24 hours and are updated every 3 hours. Energy production forecasting and energy load prediction are done based on the information from the Korea Meteorological Administration and ESS charge and discharge efficiency

according to the climate collected so far. Based on the data obtained from the prediction, the optimal operation algorithm establishes the charge / discharge schedule of the ESS and transfers this information to the energy management system by storing the big data. The energy management system directs charge / discharge to ESS based on ESS operation scheduling stored in big data.

The operation information of the ESS is transmitted using the remote IO, and the charge / discharge status and the charge amount are transferred to the big data through the collector connected to the RemoteIO. The information transferred using the restAPI is sorted in chronological order in the big data. It should be structured so that it can be used for optimal engine energy prediction and load prediction.

In order to solve such problems, this paper collects information from energy devices and sensors based on the Big Data Platform, preprocesses, processes and analyzes them, predicts energy usage and generation amount. We propose a technique that can be reused in future by storing and managing.

III. ENERGY PEAK REDUCTION MECHANISM

Figure 2 is a flowchart of energy usage and power generation forecasting techniques through self-enhancement learning. Energy data includes current metering data and status data that can be collected directly from a device or sensor, climate data that can be obtained through meteorological agencies related to the weather,

and status data the context data, the power unit price, the facility unit price and the depreciation cost, and the knowledge data including the results accumulated so far. Each of these pieces of information is collected independently of the analysis.

When a region of energy information to be analyzed is determined, a preprocessing process is performed to fetch information of the corresponding region from each knowledge repository. The preprocessing process can be performed through five steps as shown in FIG. In the ingestion process, which is a storage step, the collected data is stored for analysis. An important part of this process is the handling of missing or missing parts. The method can be obtained as an average value of adjacent data in the case of metering data, and the state data can be replaced with the data of the adjacent previous time or the data of the adjacent later time. When the data field is completed without missing data through the storing step, the data field is transferred to the discovery step of the searching step. The searching step includes a process of searching for information corresponding to the area and the object to be analyzed. The result of the search is the synchronization step.

The synchronization step includes a step of sorting the data to a time or spatial reference point. Time points of the time series and spatial data can be set as energy events. For example, energy use explosion, energy device failure, and climate change are the targets of the event. Data collected and stored through independent energy devices need time synchronization. However, global time synchronization is difficult, so there is a need to synchronize based on the events to be analyzed. Event - based synchronization is a very important and difficult part of preprocessing. Once the synchronization is done based on the event, the data will be related to each other. Based on this association, it is possible to assign the meaning of the event, that is, labeling, to the data through the next step, the labeling step. This enables fast processing for future synchronization and retrieval. After the semantic step, it performs a filtering step to extract only data that is suitable for the analysis purpose. This preliminary process detects a wide range of data as meaningful data.

The data detected through the preprocessing process leads to the analysis results through the analysis process. The analysis result is visualization service through visualization process which is the most understandable visualization process before the knowledge acquisition. Visualization is finalized, and analysis results and visualization results are knowledgeable through the knowledge repository in the knowledge repository. There are four categories of energy knowledge repositories. Energy consumption for prediction of energy consumption Energy storage for information on power generation reserves for knowledge repository and renewable energy, cost repository for costs and benefits of such produced and consumed energy, government policies and trends in current energy

technologies There is a policy repository. Each repository consists of trend information containing forecasting information, patterns containing similar trends in the past, representative algorithm results, analysis information containing already analyzed results, and raw information with raw data. When data is divided and information is not available, it is used again in the preprocessing process, such as the data collected in real time, so that it can be used to lead to higher analytical results in later analysis. There is not much accumulated information in the renewable energy sector, but this self-enhancement learning technique can improve the accuracy of the analysis.

IV. SIMULATION

To build a predictive model through machine learning, a programming language for learning and equipment capable of performing complex operations are needed.

Learning is performed using R, Python (Tensorflow) and MATLAB, which are mainly used for machine learning. R is a statistical programming language that is most commonly used in machine learning. Tensorflow is an open-source machine learning library at Google that uses Python to perform computations. MATLAB is a specialized language for matrix operations, but it is a language with a growing trend for users as a result of various machine learning functions.

When using programming languages such as R, Python, and MATLAB to perform complex operations required for learning, it is necessary to build an environment that can use GPU server. For example, Tensorflow has two public and GPU-accelerated versions available, so you can do this using Tensorflow's GPU-accelerated version.

V. CONCLUSION

As described above, this paper provides a structure for enhancing energy consumption and power generation rate through self-enhancement learning. Due to the surge in demand for renewable energy, energy trading and energy forecasting are evolving. Predictions are based on Google's machine learning techniques and their accuracy is also evolving. However, the technology of the learning and analysis techniques that reflect the characteristics of the energy field is still insufficient. This paper can improve the accuracy of energy production and power generation prediction and produce more advanced analysis results based on the results of the preliminary analysis. Therefore, not only the stability in the energy electric power market can be improved, but also a new Business will be created.

ACKNOWLEDGMENT

This work was supported by the Korea Institute of Energy Technology Evaluation and Planning(KETEP) and the Ministry of Trade, Industry & Energy(MOTIE) of the Republic of Korea (No. 20161210200360).

REFERENCES

- [1] Naver knowledge, "Microgrid", Hankyung Economic Dictionary, <http://dic.hankyung.com>, Oct.2016.
- [2] Tai-Yeon Ku, Wan-Ki Park, Il-Woo Lee, "BigData Demand Analytics Service Platform for Energy Brokering Market", IPEG 2016, Oct. 2016
- [3] Tai-Yeon Ku, Wan-Ki Park, Il-Woo Lee, "Big Data Service Combination for Efficient Energy Data Analytics" CCSC 2016, Nov. 2016



Tai-Yeon Ku is PhD student in Computer Science and Engineering from Chungnam National University, Korea, and received the B.S. and M.S. degrees in computer engineering from Pusan National University, Korea, in 1999 and 2001.

She works ETRI (Electronics and Telecommunications Research Institute) as a senior researcher. Her research interests include to manage energy big data platform and IoT data. And she has interests in micro-grid technology based on community energy system (CES).



Wan-Ki Park received the B.S. and M.S. degrees in electronics engineering from Chungnam National University, Korea, in 1991 and 1993 respectively and Ph. D. degrees in information Communication Engineering from the same university in 2006. He had been a researcher in ADD from 1993 to 2000. In 2000, he joined ETRI (Electronics and Telecommunications Research Institute) as a senior and principal researcher. His research interests include to optimize energy usage in customer domains including home,

building and community and to provide innovative energy services using cooperative and interactive ICT technologies of in Smart Grid. He is in charge of a project leader of R&D program of micro-grid technology based on community energy system (CES).



Hoon Choi is a professor of the Department of Computer Science and Engineering, the Chungnam National University (CNU), Korea. He received a MS and a PhD in computer science from Duke University in 1990 and 1993, respectively. His research area includes the system software for mobile, distributed computing and the communication middleware.