A Study On Database Structure Of Prosumer System For Online Analysis

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Abstract: Energy prosumer can not only save on electrical bills but also make profits by selling energy produced. To develop online prosumer platform, this paper present database structure of each prosumer system (Photovoltaic system, Energy Storage System, Wind power system, EV Charger system). The cause of abnormalities in prosumer facilities and designed the database and developed the reference model by big data measured from the hardware. The data was preprocessed all values from the acquired data between 0 and 1 and training set and test set generated for the data transposition process. For applied AI algorithms, this paper adapted DNN (Deep Neural Network) method. This paper used Precision, Recall, Accuracy, F1-score. The result of experiment is high value of each expression. Recall value is high values and this expression is important to safety area focus. This database structure will provide online prosumer platform system and batter prediction safety system.

Keywords: Prosumer, Database, AI algorithm, Deep Neural Network, Online platform.

1. Introduction

A prosumer is a customer who want to buy high-quality products or equipment. The word is formed from “producer” and “consumer”. Energy prosumer can produce and sell electrical energy. This word used by futurist Alvin Toffler in the third wave, it is characterized by switching to a producer if energy production is greater than consumption and a consumer if energy consumption is greater than production. Energy prosumer can not only save on electrical bills but also make profits by selling energy produced [1-5]. This system require power transactions between individual producers. The government is working on system to revitalize prosumer while implementing the 3020 renewable energy policy. In Britain, the operation of Piclo, a web-based power trading platform, links and matches power producers and consumers every 30 minutes. Power generation companies and consumers present transaction prices and conditions, and the system in which transactions are made. Germany operated a trading platform between neighbors. It connected owners of solar power facilities by using platforms and shared supply power online. In order to operate the platform, it is important to transfer online data from the prosumer facilities [6-8]. This paper, we present data structure of prosumer system for online platform. This work is useful for studying online prosumer platform. Firstly, we analyze the causes of abnormalities in prosumer facilities and designed the database and developed the reference model by big data measured from the hardware. Finally, The data was preprocessed all values from the acquired data between 0 and 1 and the training set and test set generated for the data transposition process [11-13].

2. Database design and development for data analysis

In order to analyze the cause of abnormalities in the prosumer systems, it needs reference model from data with hardware. Measured data should be big data and designed database. Generally, prosumer system is ESS (energy storage system), Wind power system, Photovoltaic system, EV charger system. Data acquired from each facilities contain Min-value, Max-value, Avg-value, RMS-value. This paper used MS-sql database and the table was as follows [Figure 1].

![Database table structure](image)

Figure 1 Database table structure
Database used consisted of a table containing the measurement values (TMEASUREMENTITEM) and measurement time table (TMEASUREMENTROW). TMEASUREMENTITEM table consisted as bellows.

| Table 1 | TMEASUREMENTITEM table data |
|---------|-----------------------------|
| Table Name | Attribute | Reference data | Key |
| MEASROWID | bignit | Primary |
| LOGCHACODE | Char(12) | Primary |
| MINVAL | Real | - |
| MAXVAL | Real | - |
| AVGVAL | Real | - |
| RMSVAL | real | - |

TMEASUREMENTROW table consisted as bellows.

| Table 2 | TMEASUREMENTROW table data |
|---------|-----------------------------|
| Table Name | Attribute | Reference data | Key |
| MEASROWID | bignit | Primary |
| MEASUREMENTID | bignit | - |
| MODINFID | Bignit | - |
| MTIME | datetime | - |
| GMT | Samllint | - |

The entire data was stored in classified data frame and import pandas module from jupyter. Combine the entire data frame into one data frame using the concat function.

3. Prosumer data classification criteria

In this paper, the safety standard of prosumer facilities were defined through the technical standard and regulations for electrical equipment. The classification criteria for each prosumer facility are as follows.

| Table 3 | Classification criteria (Photovoltaic system) |
|---------|---------------------------------------------|
| Item    | Description | criteria |
| Frequency | ±0.2hz | 59.8< Minval, Maxval < 60.2 |
| Voltage(R phase) | ±10% | 198< Minval, Maxval < 242 |
| Voltage(S phase) | ±10% | 198< Minval, Maxval < 242 |
| Voltage(T phase) | ±10% | 198< Minval, Maxval < 242 |
| V_THD(R phase) | <5% | Minval or Maxval <5 |
| V_THD(S phase) | <5% | Minval or Maxval <5 |
| V_THD(T phase) | <5% | Minval or Maxval <5 |
| I_THD(R phase) | <10% | Minval or Maxval <10 |
| I_THD(S phase) | <10% | Minval or Maxval <10 |
| I_THD(T phase) | <10% | Minval or Maxval <10 |
| Flicker_s(R phase) | <1 | Minval or Maxval <1 |
| Flicker_s(S phase) | <1 | Minval or Maxval <1 |
| Flicker_s(T phase) | <1 | Minval or Maxval <1 |
| Flicker_l(R phase) | <1 | Minval or Maxval <1 |
| Flicker_l(S phase) | <1 | Minval or Maxval <1 |
| Flicker_l(T phase) | <1 | Minval or Maxval <1 |
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| Item                | Description | criteria          |
|---------------------|-------------|-------------------|
| Frequency           | <±0.2hz     | 59.8< Minval, Maxval < 60.2 |
| Voltage(R phase)    | <±10%       | 198< Minval, Maxval < 242 |
| Voltage(S phase)    | <±10%       | 198< Minval, Maxval < 242 |
| Voltage(T phase)    | <±10%       | 198< Minval, Maxval < 242 |
| V_THD(R phase)      | <5%         | Minval or Maxval < 5 |
| V_THD(S phase)      | <5%         | Minval or Maxval < 5 |
| V_THD(T phase)      | <5%         | Minval or Maxval < 5 |
| I_THD(R phase)      | <10%        | Minval or Maxval < 10 |
| I_THD(S phase)      | <10%        | Minval or Maxval < 10 |
| I_THD(T phase)      | <10%        | Minval or Maxval < 10 |
| Flicker_s(R phase)  | <1          | Minval or Maxval < 1 |
| Flicker_s(S phase)  | <1          | Minval or Maxval < 1 |
| Flicker_s(T phase)  | <1          | Minval or Maxval < 1 |
| Flicker_l(R phase)  | <1          | Minval or Maxval < 1 |
| Flicker_l(S phase)  | <1          | Minval or Maxval < 1 |
| Flicker_l(T phase)  | <1          | Minval or Maxval < 1 |
| Temperature         | -20℃<temp<40℃ | -20<Minval or Maxval < 40 |
| Humidity            | <80%        | Maxval <80 |

### Table 5 Classification criteria (EV charger system)

| Item                | Description | criteria          |
|---------------------|-------------|-------------------|
| Frequency           | <±0.2hz     | 59.8< Minval, Maxval < 60.2 |
| Voltage(R phase)    | <±10%       | 198< Minval, Maxval < 242 |
| Voltage(S phase)    | <±10%       | 198< Minval, Maxval < 242 |
| Voltage(T phase)    | <±10%       | 198< Minval, Maxval < 242 |
| V_THD(R phase)      | <5%         | Minval or Maxval < 5 |
| V_THD(S phase)      | <5%         | Minval or Maxval < 5 |
| V_THD(T phase)      | <5%         | Minval or Maxval < 5 |
| I_THD(R phase)      | <10%        | Minval or Maxval < 10 |
| I_THD(S phase)      | <10%        | Minval or Maxval < 10 |
| I_THD(T phase)      | <10%        | Minval or Maxval < 10 |
| Flicker_s(R phase)  | <1          | Minval or Maxval < 1 |
| Flicker_s(S phase)  | <1          | Minval or Maxval < 1 |
| Flicker_s(T phase)  | <1          | Minval or Maxval < 1 |
| Flicker_l(R phase)  | <1          | Minval or Maxval < 1 |
| Flicker_l(S phase)  | <1          | Minval or Maxval < 1 |
| Flicker_l(T phase)  | <1          | Minval or Maxval < 1 |
Table 6  Classification criteria (Wind power system)

| Item                | Description | criteria |
|---------------------|-------------|----------|
| Frequency           | <±0.2hz     | 59.8< Minval, Maxval < 60.2 |
| Voltage(R Phase)    | <±10%       | 198< Minval, Maxval < 242 |
| Voltage(S phase)    | <±10%       | 198< Minval, Maxval < 242 |
| Voltage(T phase)    | <±10%       | 198< Minval, Maxval < 242 |
| V_THD(R phase)      | <5%         | Minval or Maxval <5 |
| V_THD(S phase)      | <5%         | Minval or Maxval <5 |
| V_THD(T phase)      | <5%         | Minval or Maxval <5 |
| I_THD(R phase)      | <10%        | Minval or Maxval <10 |
| I_THD(S phase)      | <10%        | Minval or Maxval <10 |
| I_THD(T phase)      | <10%        | Minval or Maxval <10 |
| Flicker_s(R phase)  | <1          | Minval or Maxval <1 |
| Flicker_s(S phase)  | <1          | Minval or Maxval <1 |
| Flicker_s(T phase)  | <1          | Minval or Maxval <1 |
| Flicker_l(R phase)  | <1          | Minval or Maxval <1 |
| Flicker_l(S phase)  | <1          | Minval or Maxval <1 |
| Flicker_l(T phase)  | <1          | Minval or Maxval <1 |
| Wind Speed          | <25m/s      | Maxval <25 |

For data classification, a column called label was created in the integrated data frame. After column generation, each data labeling was carried out. By comparing the measurements of MEASROWID and each LOGCGACODE, the data entered the normal results within the normal classification criteria (label = 1). Abnormal results were entered as label 0. After comparing the labels of each LOGCHACODE, if the whole label is normal, enter label is 1 or abnormal data enter label is 0. [Figure 2] shows an example of the results determined by labelling the data.

![Figure 2 Labelling data result example](image-url)
4. Results and Discussion

This paper applied labeled data to AI algorithms, verification through DNN (Deep Neural Network) method. DNN is an artificial neural network consisting of several layers of concealment between the input and output layers. In general, complex nonlinear relationships can be modeled. DNN is useful in areas such as classification, numerical prediction, image training, and literacy.

Methods for applying DNN are as follows.
- Divide entire data in training sets and test sets
- Normalized deviation between data is between 0 and 1 using MinMaxScaler
- Creating deep learning model
- Extract predictive results to the created model

For analyzing the accuracy of the generated model, this paper used Precision, Recall, Accuracy, F1-score. Precision is the fraction of relevant instances among the retrieved instances. Recall is the fraction of the total amount of relevant instances that were actually retrieved [9~10]. Accuracy is closeness of the measurements to a specific value. The F1-score is the harmonic mean of Precision and Recall has a value from 0 to 1. Each expression is expressed as follows.

\[
\text{Precision} = \frac{TP}{TP+FP} \quad (1)
\]
\[
\text{Recall} = \frac{TP}{TP+FN} \quad (2)
\]
\[
\text{Accuracy} = \frac{TP+TN}{TP+FN+FP+TN} \quad (3)
\]
\[
\text{F1-score} = 2 \times \frac{\text{Precision} \times \text{Recall}}{\text{Precision} + \text{Recall}} \quad (4)
\]

Experiment data used from Energy storage system. DNN analysis results shows as Table 7.

| Class | Precision | Recall | F1-score | Support |
|-------|-----------|--------|----------|---------|
| 0     | 0.92      | 0.98   | 0.95     | 310     |
| 1     | 1.00      | 0.99   | 0.99     | 1,755   |
| Accuracy | 0.98 |        | 0.98     | 2.065   |
| Macro avg | 0.96 | 0.98 | 0.97     | 2.065   |
| Weighted avg | 0.99 | 0.98 | 0.99     | 2.065   |
5. Conclusion
This paper presented database structure of prosumer systems (Photovoltaic system, ESS system, Wind Power system, EV charger system). The safety standard of prosumer facilities were defined through the technical standard and regulation for electrical equipment. The classification criteria for each prosumer facility. By comparing the measurement data and each logical code, the data entered the normal results is label 0 or abnormal data results is label 0. And then all criteria data compared each other, whole label data is normal entered label 1 or abnormal entered label 0. For applied AI algorithms, this paper adapted DNN(Deep Neural Network) method. This paper used Precision, Recall, Accuracy, F1-score. The result of experiment is high value of each expression. Especially, Recall value is high values and this expression is important to safety area focus. This database structure will provide online prosumer platform system and better prediction safety system.

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7. References
1. A.J.D Rathnayaka. Analysis of energy behavior profiles of prosumers. IEEE 10th International Conference on Industrial informatics. 2012 July
2. Keyhani, Design of Smart Power Grid Renewable Energy stems, Wiley, 2011.
3. J. D. Rathnayaka, V. M. Potdar, O. Hussain and T. Dillon, "identifying prosumer's energy sharing behaviours for forming optimal prosumer-communities", Int. Conf. Cloud Serv. Comput., 2011.
4. P. G. D. Silva, S. Karnouskos and D. Ilic. A Survey Towards understanding Residential Prosumers in Smart Grid Neighborhoods in innovative Smart Grid Technologies Europe. ISGT Europe. 2012.
5. Asif Raza Butt. Energy sharing and management for prosumers in smart grid with integration of storage system. ICSG. 2017
6. CamposInês, Pontes Luz Guilherme, Marín-González Esther, Gährs Swantje, Hall Stephen, Holstenkamp Lars. Regulatory challenges and opportunities for collective renewable energy prosumers in the EU. Energy policy. 2020;138
7. T. Bauwens, P. Devine-Wright. Positive energies: An empirical study of community energy participation and attitudes to renewable energy. Energy Policy. 2018;118:612-625
8. D. Brown, S. Hall, M.E. Davis. Prosumers in the post subsidy era: an exploration of new prosumer business models in the UK. Energy Policy. 2019;135;110984
9. Y. LeCun, Y. Bengio, and G. Hinton, Deep learning. Nature.2015;521;7553;436–444
10. D. Silver, A. Huang, C. J. Maddison et al. Mastering the game of Go with deep neural networks and tree search. Nature.2016;529;7587;484–489
11. Satapathy, S. K., Mishra, S., Mallick, P. K., Badiginchala, L., Gudur, R. R., & Guttha, S. C. (2019). Classification of Features for detecting Phishing Web Sites based on Machine Learning Techniques. International Journal of Innovative Technology and Exploring Engineering, volume8(8S2), 425-430.
12. Monika, P., Rao, P. V., Premkumar, B. C., & Mallick, P. K. (2020). Implementing and Evaluating the Performance Metrics Using Energy Consumption Protocols in MANETs Using Multipath Routing-Fitness Function. In Cognitive Informatics and Soft Computing (pp. 281-294). Springer, Singapore.
13. Satapathy, S. K., Mishra, S., Sundeep, R. S., Teja, U. S. R., Mallick, P. K., Shrutı, M., & Shravya, K. (2019). Deep learning based image recognition for vehicle number information. International Journal of Innovative Technology and Exploring Engineering, 8, 52-55.