

Special Issue

# Fuzzy-Based Energy Management System With Decision Tree Algorithm for Power Security System

K. Ramya<sup>\*</sup>, Yuvaraja Teekaraman, K. A. Ramesh Kumar*Department of Energy Science, Periyar University, Salem City, India – 636 011*

## ARTICLE INFO

### Article History

Received 31 Jul 2019  
Accepted 06 Oct 2019

### Keywords

Energy security  
Power security service  
Incurion detection system  
Artificial neural network

## ABSTRACT

Energy security (ES) has great impact on power grids. Therefore it is important to have power security service (PSS). The PSS should be designed to handle interference and interruption attack in the grid. The interference and interruption attack in the grid is handled by incurion-detection system (IDS). The IDS is the most obtainable strategy to sense and classify different security issues and abnormal issues that occur in power grids. Therefore the IDS have to be up to date with the latest issues that happened in the entire grid. The proposed concept illustrate the collection of data with reference to intrude-attacks in power-grid and to test and evaluate different machine-learning strategy to illustrate the different attacks and issues that happen in power system grid. The research work is illustrated with a modified J48 decision tree algorithm.

© 2019 *The Authors*. Published by Atlantis Press SARL.This is an open access article distributed under the CC BY-NC 4.0 license (<http://creativecommons.org/licenses/by-nc/4.0/>).

## 1. INTRODUCTION

Incurion-detection system (IDS) combine both software and hardware to distinguish assaults on power-network to guarantee the security of the framework from unapproved access. IDS can be isolated into two fundamental characterizations dependent on the assault's recognition strategy. The initial one is the abuse, and the second is peculiarity location. The peculiarity location can be utilized in various courses all together to recognize any abnormal conduct of the client inside the system traffic.

An Incurion Detection (ID) based on artificial neural network (ANN) and fluffy grouping (FG) has been proposed to discover a few systems issues and assaults in power-grid. However there are some cons of the proposed model; for instance, it has an absence of precision in low frequent assaults. To overcome the specified cons the researchers divides the heterogeneous training sets into homogeneous training sets. The difficulty in each of the identified is taken into consideration and the complexity is reduced in the training set so as to improve the performance of the assaults detection and the back-up of the complete system is taken completely by using restore points [1]. To be more accurate and efficient in facing the troubles and issues faced in power-grid artificial-intelligence with heuristic and ANN algorithm in IDS to improve the reliability and stability in the learning and development environment. Heuristic combined with ANN approach in IDS gives extra performance with more accuracy [2]. In [3] the user action as a parameter in irregularity is detected in this test by using back proliferation algorithm.

The back proliferation algorithm is the most promising technology as the classification rate is 100% while the detection rate is 88% for the known and unknown attacks. This method takes the advantage of utilizing the minimum amount of training data and produces better performance and result in heavy data traffic. An ANN with multilayer perceptron (M-LP) in IDS is considered as more efficient and accurate in terms of detection and normal communication [4]. The use of M-LP limits the detection under low-frequency assaults [5]. In the classifier choice model exhibited by Nguyen and Choi [6], they removed 49,596 cases of KDD dataset and compared the set of classifier under the controlled environment. The exhibited various ways to deal with arrangement with KDD dataset, administered, and unsupervised strategies recreated utilizing MATLAB and the researchers test is done with supervised and unsupervised with the framed fuzzy rules to investigate the performance of the complete system. Search algorithm is proposed in [7] between the tree predictors and research proposed error to focus on random-forest. [8–10] Outlined in choice tree analysis on j48 procedure and how it is critical to compute entropy and data gain for every trait in any dataset prepared to be characterized, they utilized optimal tree with univariate and multivariate techniques, additionally the scientists exhibited multivariate technique as straight machine strategy. The specialists suggested this methodology for huge measure of information. [11–15] expressed that nature of dataset once in a while makes it hard to choose fitting credits to learn, and the researchers explores different avenues regarding Naïve Bayes classifier and measure execution for each call.

<sup>\*</sup>Corresponding author. Email: [ramyapks26@gmail.com](mailto:ramyapks26@gmail.com)

## 2. RENEWABLE ENERGY SYSTEM DESCRIPTION

The optimal renewable system configuration shown in Figure 1 represent the dynamic regulation model and this is used to feed power to various types of customers using different types of loads. The renewable grid uses solar for generating power under varying atmospheric condition such as variation in irradiance, temperature variation and partial shadow condition. The load used at the customer end has to be satisfied with the energy produced by PV source in renewable grid. The grid connected system shown in Figure 1 need the maximum load used by the customer, types of loads, energy produced by the PV source and state-of-charge (SOC) of battery bank. The generated power and the consumed power should match. If there is any mismatch in the power consumed for not using the loads or power hacked by the unauthorized customer, has to be identified and rectified by means of fuzzy-based energy management system.

## 3. FUZZY-BASED ENERGY MANAGEMENT SYSTEM

The energy transition revolution has to meet the energy demand by various sectors for various loads. The energy generated by solar grid has to be transferred to transmission-distribution substation for the sake of customers to utilize. Also the energy loss and energy consumed by the unauthorized person has to be taken into account for better energy efficiency. In order to do this the power from solar-grid is supplied to various sectors in addition with the battery charging unit. Also control is given in fuzzy energy management system to identify the state of charge of batteries, power consumed, power delivered and also security has been checked for authorized and unauthorized customer in utilizing the generated power.

The operation of fuzzy management system depends on  $P_L$  as a minimum\_power\_element,  $P_H$  as maximum\_power\_element,  $P_C$  as power\_consumed,  $P_D$  as power\_delivered,  $n$  as no\_of\_customer and  $P_L$  as power\_loss. The fuzzy-based energy management system will take decision based on J48 decision tree search algorithm for which the load will be powered and the customer using the source is authorized or an unauthorized. If the customer using the generated source is recognized to be unauthorized then the J48 decision tree algorithm transfer the data to the fuzzy management system to develop the control towards cutting down of the power. To have more precise control the fuzzy concept uses M-LP model and are as shown in Figures 2a and 2b.

## 4. J48 DECISION TREE

Electric power security in decision tree builds the classification and regression of various energy attacks in the form of tree structure. The energy-attack is collected as data set and this data set is break down into small small data set to identify the location where exactly the attack has happened. At the same time each data subset is associated with the decision tree and as a final result it lead to decision/root node and leaf node. The Figure 3 shows the J48 decision tree which can handle both numeric and categorical datas.

This is the usual classifier to manage the supervised learning in fuzzy that gives prediction about the new unlabeled data.

## 5. MODIFIED J48 DECISION TREE ALGORITHM

Assign CADL is a root of the tree for the search process

Tree = {Elements of CADL} // where CADL consists of SMA, SDA, DMA, DDA

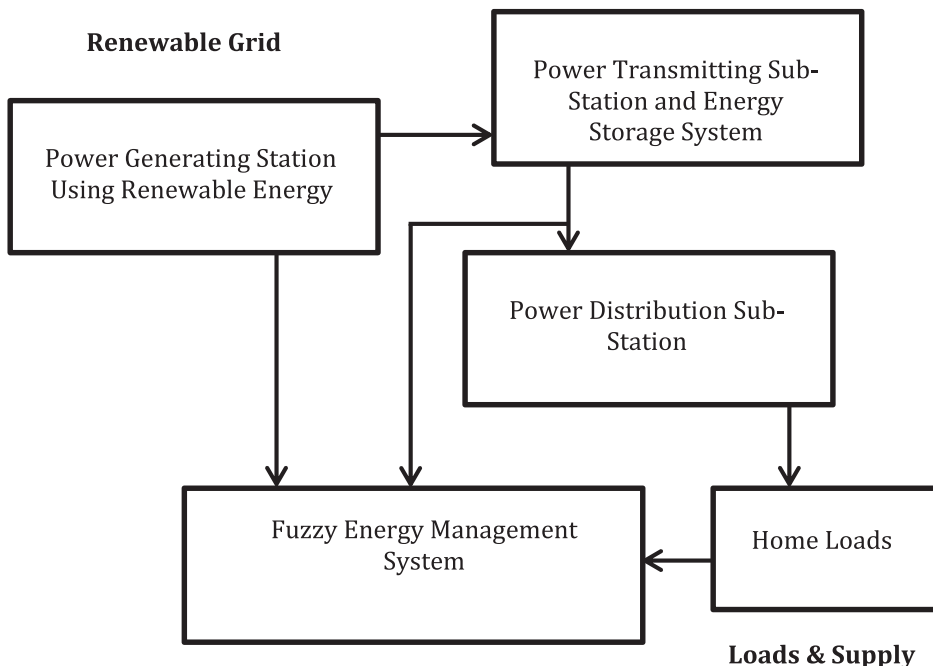


Figure 1 | Block diagram representing dynamic regulation model with renewable source.

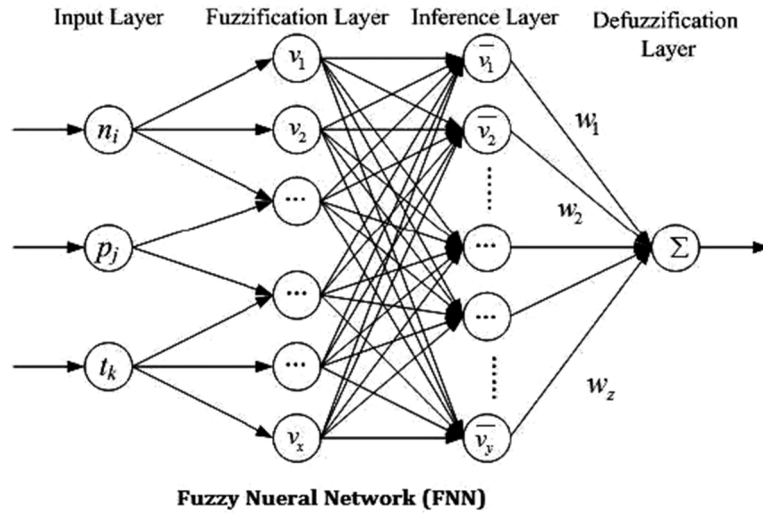


Figure 2a | General fuzzy model.

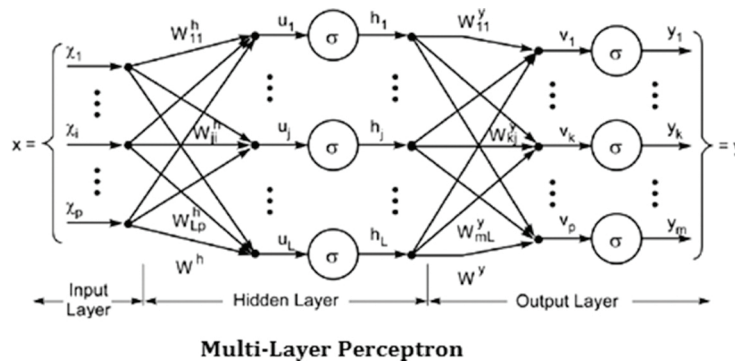


Figure 2b | General fuzzy multilayer perceptron model.

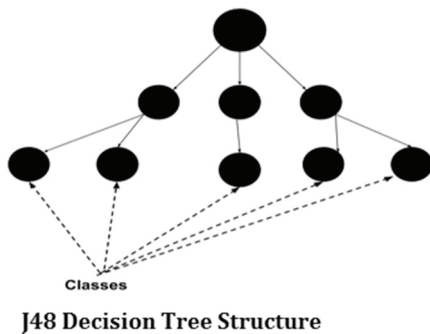


Figure 3 | J48 decision tree.

Calculation

Assign  $P_L$  as a minimum\_power\_element //  $P_L$  is a low range value

Assign  $P_H$  as maximum\_power\_element //  $P_H$  is a highest value

Assign  $P_C$  as power\_consumed //  $P_C$  is a power consumption by various customers

Assign  $P_D$  as power\_delivered //  $P_D$  is a power delivered by distribution station

Assign  $n$  as no\_of\_customer //  $n$  is the total no: of customer using various loads

Assign  $P_L$  as power\_loss //  $P_L$  is a powerloss in the line

$$P_C = P_{C1} + P_{C2} + P_{C3} + \dots + P_{Cn}$$

$$P_D \text{ (Power\_Difference)} = | P_D - P_C | // \text{Difference}$$

$$\text{Mid} = \text{loc} (P_D/2) // \text{Mid - Selection of Middle range of power}$$

Search process

If (Mid = e) // e – search element

Declare power\_theft found

Else

If (Mid < e)

subtree = Tree(L) ... Tree(Mid);

Tree = subtree;

Else

subtree = Tree(Mid) ... Tree(H);

Tree = subtree;

End if

End if

## 6. SIMULATION TEST RESULTS AND ANALYSIS

The fuzzy-based energy management uses Mamdani’s Fuzzy Logic Controller (FLC) approach which has got two fuzzy input i) PV Source temperature ii) Solar irradiance as input and output variable membership function is shown in Figure 4.

After the definition of fuzzy variable and membership function, fuzzy-logic inference is utilized by using if-then statement in Table 1.

### 6.1. Fuzzy Rule Inference Conditions

If temperature = under AND climate = Cold  
 THEN the probability of getting voltages of priority is only VL  
 If temperature = under AND climate = Cool  
 THEN the probability of getting voltages of priority is only L  
 If temperature = under AND climate = Nominal  
 THEN the probability of getting voltages of priority is only M  
 If temperature = under AND climate = Warm  
 THEN the probability of getting voltages of priority is only H  
 If temperature = under AND climate = Hot

If temperature = Normal AND climate = Hot  
 THEN the probability of getting voltages of priority is only VH  
 If temperature = Normal AND climate = Cold  
 THEN the probability of getting voltages of priority is only VL  
 If temperature = Normal AND climate = Cool  
 THEN the probability of getting voltages of priority is only L  
 If temperature = Normal AND climate = Nominal  
 THEN the probability of getting voltages of priority is only M  
 If temperature = Normal AND climate = Warm  
 THEN the probability of getting voltages of priority is only H  
 If temperature = Normal AND climate = Hot  
 THEN the probability of getting voltages of priority is only VH  
 If temperature = Over AND climate = Cold  
 THEN the probability of getting voltages of priority is only VL  
 If temperature = Over AND climate = Cool  
 THEN the probability of getting voltages of priority is only L  
 If temperature = Over AND climate = Nominal  
 THEN the probability of getting voltages of priority is only M  
 If temperature = Over AND climate = Warm  
 THEN the probability of getting voltages of priority is only H  
 If temperature = Over AND climate = Hot  
 THEN the probability of getting voltages of priority is only VH

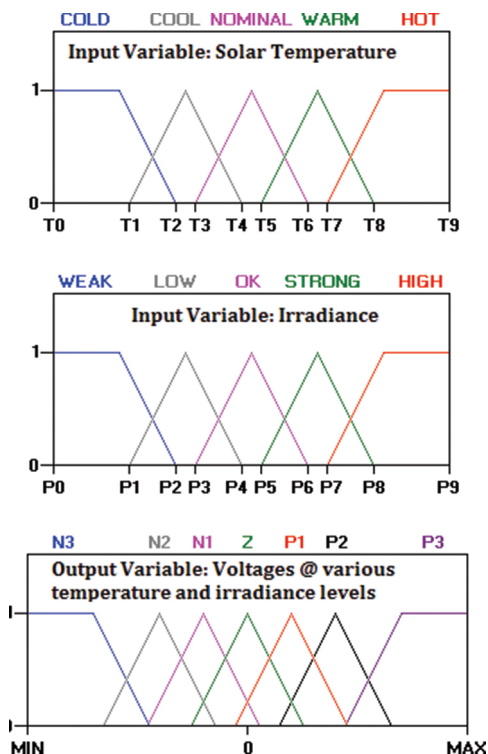


Figure 4 | Membership functions of input and output variable.

Table 1 | Fuzzy rule.

Temperature/Climate	Cold	Cool	Nominal	Warm	Hot
Under	VL	L	M	H	VH
Normal	L	M	H	VH	VH
Over	M	H	VH	VH	VH

Figure 5 is the output from fuzzy Mamdani’s FLC for fuzzy-based energy management system. In order to test the efficiency of the fuzzy-based energy management system and test the efficient of energy security, the energy demand by the customer according to the load and the power generated are taken as reference in fuzzy system. Again the power generation depends on the climatic conditions in the respective months. The analysis is done based on fuzzy rule and the output of the system at different moments are shown in Figure 6. The Figure 6 shows the output variation with reference to irradiance with and without energy management. Figure 7 shows

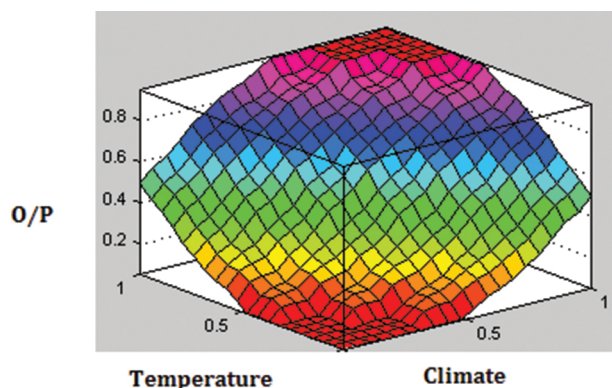


Figure 5 | Generated surface of fuzzy-based energy management system.

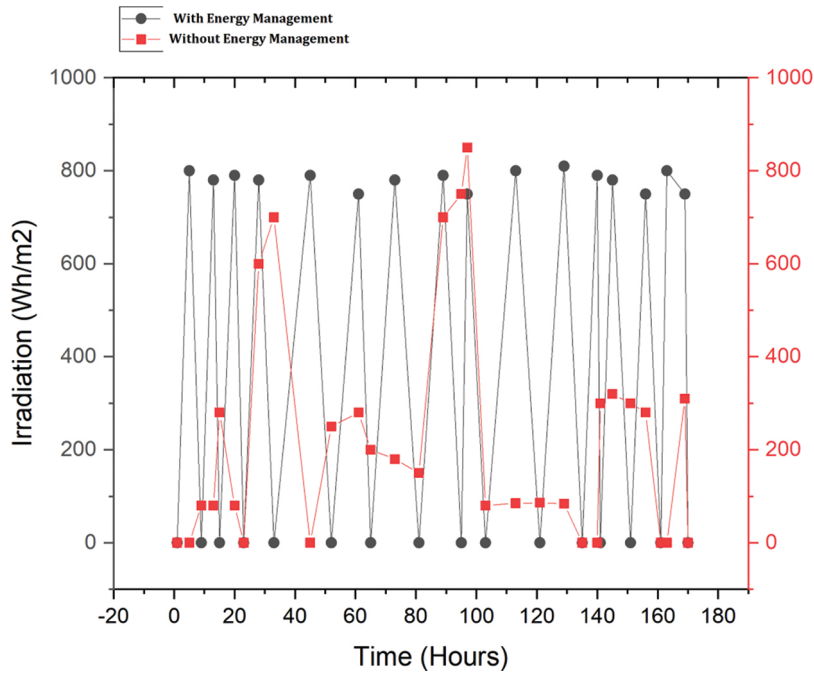


Figure 6 Solar irradiation at various time fact.

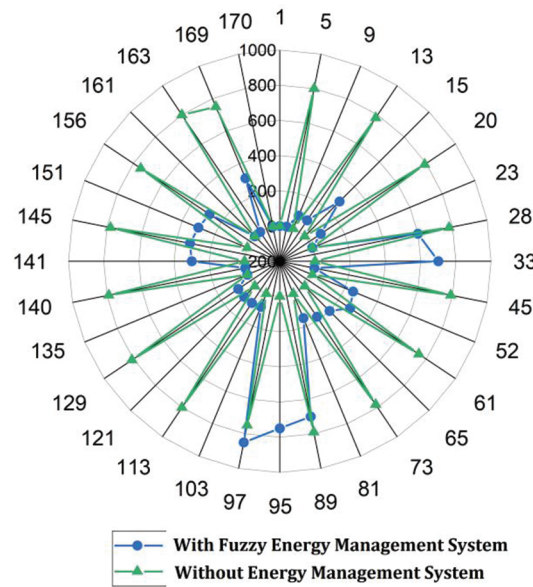


Figure 7 Energy consumption with and without energy management.

the energy management strategy with and without fuzzy in polar chart and from the result it is observed that the energy management is efficient with a fuzzy-based controller.

### 7. CONCLUSION

In this manuscript, J48 decision tree algorithm along with a fuzzy-based energy management technique is proposed for better power

security and efficient energy management strategy. The energy management strategy is tested for various loads and the result takes load profile, voltage profile. The simulation proved that the optimal energy management is attained with the use of fuzzy as shown in Figure 7 at various loads. From Figure 7 it is very clear and understood that the energy consumption is reduced by controlling the loads with the use of fuzzy-based energy management system. The J48 decision tree algorithm is the best search algorithm used to identify the energy attack in the entire system.



## CONFLICT OF INTEREST

The authors declare no conflict of interest.

## AUTHORS' CONTRIBUTIONS

All authors contributed equally to the publication of this article with regard to the design of the target model, validation of the numerical model, parametric study, analysis and writing.

## Funding Statement

There is no Funding for this manuscript.

## REFERENCES

- [1] S. Paliwal, R. Gupta, Denial-of-service, probing & remote to user (R2L) attack detection using genetic algorithm, *Int. J. Comput. Appl.* 60 (2012), 57–62.
- [2] D. Gaikwad, S. Jagtap, K. Thakare, V. Budhawant, Anomaly based intrusion detection system using artificial neural network and fuzzy clustering, *Int. J. Eng.* 1 (2012), 1–6.
- [3] V. Bapuji, R.N. Kumar, A. Goverdan, S. Sharma, Soft computing and artificial intelligence techniques for intrusion detection system, *Netw. Complex Syst.* 2 (2012), 24–31.
- [4] M. Pradhan, S.K. Pradhan, S.K. Sahu, Anomaly detection using artificial neural network, *Int. J. Eng. Sci. Emerg. Technol.* 2 (2012), 29–36.
- [5] M. Sammany, M. Sharawi, M. El-Beltagy, I. Saroit, Artificial neural networks architecture for intrusion detection systems and classification of attacks, in *The 5th International Conference INFO2007, 2007*, pp. 24–26.
- [6] M. Al-Kasassbeh, G. Al-Naymat, A. Hassanat, M. Almseidin, Detecting distributed denial of service attacks using data mining techniques, *Int. J. Adv. Comput. Sci. Appl.* 7 (2016), 436–445.
- [7] M. Al-kasassbeh, An empirical evaluation for the intrusion detection features based on machine learning and feature selection methods, *J. Theor. Appl. Inf. Technol.* 95 (2017), 5692–5976.
- [8] H. Nguyen, D. Choi, Application of data mining to network intrusion detection: classifier selection model, in: *Challenges for Next Generation Network Operations and Service Management, Springer, APNOMS, 2008*, pp. 399–408.
- [9] M.K. Lahre, M.T. Dhar, D. Suresh, K. Kashyap, P. Agrawal, Analyze different approaches for IDS using KDD 99 data set, *Int. J. Recent Innov. Trends Comput. Commun.* 1 (2013), 645–651.
- [10] L. Breiman, Random forests, *Mach. Learn.* 45 (2001), 5–32.
- [11] N. Bhargava, G. Sharma, R. Bhargava, M. Mathuria, Decision tree analysis on j48 algorithm for data mining, *Int. J. Adv. Res. Comput. Sci. Softw. Eng.* 3 (2013), 1114–1119.
- [12] C. Fleizach, S. Fukushima, A Naive Bayes Classifier on 1998 KDD Cup, Technical Report, Department of Computer Science and Engineering, University of California, San Diego, 1998.
- [13] G.P. Raman, V. Perumal, Neuro-fuzzy based two-stage spectrum allocation scheme to ensure spectrum efficiency in CRN–CSS assisted by spectrum agent, *IET Circuits Devices Syst.* 13 (2019), 637–646.
- [14] R. Sharma, V. Vashisht, U. Singh, EEFCM-DE: energy-efficient clustering based on fuzzy C means and differential evolution algorithm in WSNs, *IET Commun.* 13 (2019), 996–1007.
- [15] S. Faddel, O.A. Mohammed, Automated distributed electric vehicle controller for residential demand side management, *IEEE Trans. Ind. Appl.* 55 (2019), 16–25.