



Reinforcement Learning Based Intelligent Management of Smart Community Grids

Muhammad Khalid¹(✉), Mir Bilal Khan², Liaquat Ali³, and Faheem Ahmed⁴

¹ Jacobs University Bremen, Campus Ring 1, 28759 Bremen, Germany
Khalid.csd.uob@gmail.com

² University of Hertfordshire, Collage Lane, Hatfield AL10 9AB, UK

³ Department of Computer Science and IT, University of Balochistan, Quetta 87300, Pakistan

⁴ Department of Computer Science - UBIT, University of Karachi, Sindh, Pakistan

Abstract. The fundamental goal and commitment of this article is the exploitation of our perception-based intelligent management method. An examination with 39 elective methodologies was performed, exhibiting the upsides of our methodology as far as interpret able and precise fuzzy principle-based DSGC strength forecast then revealing the chain of importance of DSGC-framework's characteristic criticalness. Shrewd networks are strong, self-recuperating systems that authorized bidirectional circulation of vitality and data inside the utility framework. Therefore, prosumer supervision involves growing attentiveness between scholars in current years. At that point, this evaluation process of nearby market interest is tackled by deep reinforcement learning and deep Qlearning techniques with experience replay system. This idea discovers the safety of upcoming energy frameworks touching near to coordinating extra parts of sustainable power source elements. Particularly, we can manage cold-start clients with less social connections. Later on, we will distinguish further data from informal community to viably tackle client cold-start issues. Moreover, we will investigate the effect of complex data on client utilization conduct to assemble a stable recommender system. The subsequent part presents logical examinations of Internet of Things (IoT) applications in the power business. For the logical examination relevant investigation, brilliant local area meter information-driven and autonomous models are made to figure the likely kilowatt (kW) limit decline from DR. At long last, I bring up open inquiries to empower further exploration.

Keywords: Big data · Wind power · SGD · SVM

1 Introduction

The following and preceding task of the research of which this report is a section centers around dispersal of big-data and data-mining applications in the electric utility industry and commitment of the power business at workshops, conferences, research development and innovation roadmap 2017–2026, webcasts, and so on. Industry gatherings furnish partners with a chance to audit in big-data, new programming advances, and uses of

cutting-edge investigation. The discoveries from this examination impress the estimation of big-data and investigation for the “European Network of Transmission System Operations for Electricity”. electric industry and recognize applications for prescriptive analysis that utilization AI and Machin Learning (Hussain et al. 2015). Certification of greatest performs in big-data. Reinforcement Learning is class of machine learning methods that has emerged only recently. This involves the exploration of intelligent schemes by attempting to achieve objectives and improving gradually improving its performance toward accomplishing human level or even surpassing humans (Mu et al. 2019b). Deep reinforcement learning has rapid changed field of intelligent systems with numerous accomplishments by the utilization of artificial neural networks algorithms in reinforcement learning (Raza et al. 2021a; Raza et al. 2021b). It enables machine learning to tackle issues that were previously too computationally intensive (Boyd and Crawford 2011). The deep reinforcement learning techniques further improve the conventional reinforcement learning which is asked on Markov decision processes. The relationship between deep reinforcement learning and traditional reinforcement learning is presented. Deep reinforcement learning (DRL) being a blend of deep learning and reinforcement learning, utilizes the concept of DL model training in AI applications. Along these lines, DL, RL, and DRL present an opportunity towards the future improvement of smart grids. In the first place, intermittent nature of wind and solar energy bring numerous difficulties for electric power distribution. Deep reinforcement learning can be an answer for overseeing fluctuating sources, load forecasting, planning, management of energy and so forth. To guarantee secure and stable functionalist of huge power systems under complex and uncertain situations is perhaps the greatest challenge that power engineers need to address today.

Environmental change is forcing the energy producers, governments, businesses, and utility providers to utilize sustainable power sources and improve energy efficiency (Bhattarai et al. 2019; Billinton and Wangdee 2006). To meet the requirement for green energy regulations and to comply with new monetary and ecological constraints, the power infrastructure is slowly changing from the conventional centralized model to increasingly decentralized and innovative smart grids. This concept of smart decentralized power generation and distribution infrastructure is called smart community grid where energy customers may assume the role of prosumers, who produce and sell or offer surplus energy (Landberg 1999; Dabrowski and Fern 2009). The effectiveness of smart grid energy sharing depends upon meaningful prosumers’ contribution to the community grid (Ericsson 2010). Energy sharing in community smart grids involves coordination and reliable connections between partners, which included prosumers, energy producers, energy market administrator and so on (Manzoor et al. 2017). All these partners must have accessibility to data for monitoring the community grid’s energy market citeespe2018prosumer. Thus, to enable the prosumers and other partners in acquiring reliable data is a key aspect of intelligent decision-making by the partners (Espe et al. 2018). Henceforth, the test is to help presumes and partners in acquiring suitable data to be progressively creative, profitable, and have the option to settle on choices which sway their social, natural and financial state (Lu and Hong 2019). In today’s conventional retail power distribution infrastructure, customers generally have exceptionally constrained “energy choices” to pick from various kinds of energy providers. Even

though the establishment of Distributed Energy Resources (DERs) has gained popularity, in current power sector's, clients or prosumers can only decide to exchange their surplus energy or request to fill deficits from utility providers (Bhattarai et al. 2019). With buying vitality since before retailing vitality extra rear toward the services straightforwardly, the customers or prosumers need to endure some value hole. the way to giving more energy exchanging opportunity and open advancement the retail electricity market is to create client driven plans of action and conceivably a restricted energy exchanging stage. Following this faith in the ebb and flow look into network, the cutting-edge retail power advertise framework will in the end become a level playing field, where all clients have an equivalent chance to effectively participate legitimately (Lu et al. 2019). In order to manage the energy effectiveness issue, the demand-side management (DSM) framework (Mnih et al. 2015) provides the solution by load-moving through planned energy usage that flattens the fluctuating energy demand and also decreases the absolute energy consumption of every client in addition to focusing on dynamic pricing strategy. Moreover, the DSM framework can (Zhao et al. 2016) acquire greater adaptability when performing energy scheduling (Ericsson 2010). Addition of household energy-storing structure (ESS) to photovoltaic (PV) energy generation. Centralised QoE and QoS CQoES framework using a hybrid AHP-IOWA, POWA, UCF and KNN methods (Hussain and Merigó 2022). The proposed method handles nonlinear relationships among selection criteria and intelligently weight customized criteria based on complex attitudinal characteristics of the decision-maker (Hussain et al. 2021a). At present, several mechanisms dealing with DSM issues exist in the literature. However, most of these mechanisms cannot employ Big Data. With the improved computation power, the AI approach, for example, reinforcement learning, can give an extraordinary capacity of learning the control arrangement under various circumstances inside a smart home. Along these lines, the proposed work aims to manage the DSM issue dependent on the home zone and domestic performances using a Deep Q Network (DQN) mediator (Mu et al. 2019b; Mu et al. 2019a) coupled with the human decision maker.

2 Background

2.1 Markov Chain Process

The conduct of a significance community grid system can be displayed as far as the processing jobs executing in the framework whenever. Each undertaking advances through an actual existence cycle in which it is first presented by a client, specialist organizations are found to run the errand, an SLA is haggled with chose provider(s), and the errand is either executed to finishing or fizzles to finish. The condition of the community grid system can be depicted by the conditions of the considerable number of errands that are in the framework at some specific time. This area initially portrays the state change model for an individual undertaking and afterwards shows how the total of numerous assignments states are spoken to in a Markov chain model. This possibly huge model can be compacted, or lumped, into an increasingly succinct portrayal where the elements of the community grid system can be concentrated in a significant manner (Dabrowski and Fern 2009).

2.2 Markov Reward Process

A Markov Reward Process is a Markov procedure through esteem decision, saying what way considerable recompense gathered from side to side approximately specific arrangement that we inspected. An MRP is a tuple. (S, P, R, γ) where S is a limited state space, P is the state transition probability function, R is a reward function where, it says how much instant reward we hope to get from state S at right now. Here is the notion of the return G_t , which is the absolute limited rewards from time step (Shi et al. 2008).

2.3 Markov Decision Process

A MDP is a Markov Reward Process with decisions, it's a situation where in all states are Markov. This is the thing that we need to illuminate (Shi et al. 2008). A MDP is a tuple (S, A, P, R, γ) where S is our state space, A will be a limited arrangement of activities, P is the state transition probability function, R is the reward function where, in (Shi et al. 2008) All the more as of late, reinforcement learning (RL), otherwise called the prototype free mechanism method, has gotten consideration whilst a likely Machin Learning approach on behalf of power-driven vitality management. A spearheading effort in RL-based vitality managing stays Google DeepMind, which existed created utilizing the Reinforcement Learning strategy then consumes survived established toward reduce the power beak through conserving the server farm via around 40percent. Deep Reinforcement Learning (DRL) (that survives, the combination of RL and ANN) pragmatic to the switch of HVAC trendy a structure to diminish the vitality price though keeping up an agreeable customer level as far as the indoor temperature (Shi et al. 2008), just by way of equally the roofed warmth then midair superiority (Shi et al. 2008). A few identifications consume provided details regarding household vitality supervision through DERs utilizing Q-learning, happening which the ESS occurred coordinated near accomplish vitality reserves hip a solitary (Shi et al. 2008) household plus a communal alongside numerous structures (Shi et al. 2008).

3 Methods

This part represents an overview of the deep q-learning algorithm, reinforcement learning and data source and the classes and qualities of data on the smart community grid with an emphasis on large-scale of investigation for DR programs and the job of data normalization in that specific situation and disused the Markov Chain Monte Carlo Simulations. So, we have a numerical model with which system precariousness can be expected. The need for a tool to predict solution unpredictability would have been met, and the double characterization ("stable" versus "unsteady") issue would be unraveled. But the execution of this model depends on noteworthy improvements. A differential condition-based model can be controlled in a few different ways. One customary methodology comprises in running recreations with a mix of fixed qualities for one subset of factors and fixed worth circulations for the rest of the subset. As carefully delineated in Dorin Moldovan (2020).

3.1 Deep Q-Learning Algorithm

In (Hussain 2021), multi-agent RL remained introduced to deal with the household energy utilization. Every mediator compared toward different household apparatuses sorts through nonchargeable, Changeable, plus manageable electric loads, the energy utilization of every machine is improved by the Q-learning method, alongside the current forecasted value of energy by utilizing the ANN. As of late, a novel Q-learning strategy utilizing activity subordinate double heuristic programming was used to resolve the unlimited-time area straight equal-sided follower exclusive of needful data of the technique substances in (Mu et al. 2019b). Cutting-edge (Mu et al. 2019a) Q-learning-based self-organized system existed wherever entirely mediators speak by one another then harmonize alongside pioneer mediator, thusly accomplishing the ideal accord answer aimed at each mediator continuously.

3.2 Shortest Path Using Q-Learning Algorithm

Graphs are numerical structures used to display pairwise relations between objects. A graph is comprised of vertices that are associated with edges. In an undirected graph, I will locate the briefest way between two vertices. Q-learning is a without model reinforcement learning algorithm. The impartial of Q-learning remains toward achievement expertise by a method, whichever indications towards a mediator whatever move near type underneath whatever conditions. The situation does not need a consummate of the background, then its container treaty through questions by stochastic advances plus rewards, exclusive of needful modifications. Q-learning procedure includes a mediator, a usual of positions then a customary of movements for every formal. It utilizes Q-values

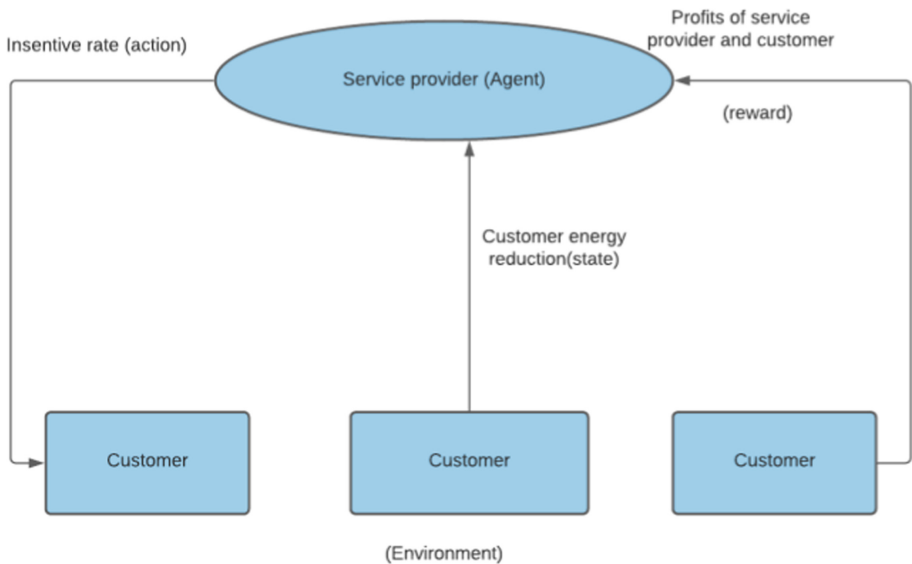


Fig. 1. Reinforcement learning for optimal incentive rate making. (Lu and Hong 2019)

what is more chance at approximately amount toward decide that deed to yield. The reward and conceivable potential rewards of an activity taken (Fig. 1).

4 Result

In the prospect computerized culture, the power source consistency and power value are firmly needed. The power production is experiencing thoughtful modifications. The smart grid as arises the condition necessitate. The outdated power grid is progressively incorporated with the data communication system, supervising and regulator system (Gelazanskas and Gamage 2014; Gorzałczany et al. 2020). Monte Carlo simulation is frequently expended in the dependability assessment of the power system at current. Though, on account of the limitations of large computing resources and gradual conjunction rapidity, it is challenging to use the simulation method in the operational situation (Hussain et al. 2018; Hussain and Sohaib 2019). In reflection of the wide-ranging of the power system and the huge number of mechanisms, the Monte Carlo technique used on the Markov chain was presented into the analysis of power system process consistency assessment in the works (Gungor et al. 2011; François-Lavet et al. 2016). Nevertheless, the Gibbs lesser required for simulation to create the Markov chain can't essentially reward for the limitations of the simulation method.

4.1 Imported Required Libraries

Alongside conventional libraries imported for tensor control, numerical activities and designs improvement, three scikit-learn modules (StandardAero as a scaler, confusion matrix as the model execution metric of decision and KFold as the cross-validation engine) and two Keras profound learning objects (Sequential and Dense) are utilized in this activity.

4.2 Data Set

The dataset picked for this AI practice has an engineered nature and contains results from recreations of grid stability for a reference 4-hub star arrange, as portrayed in (Moldovan 2020; Kenyon et al. 2020). The first dataset contains 10,000 perceptions. As the reference framework is symmetric, the dataset can be expanded in $3!$ (3 factorial) times, or multiple times, speaking to a change of the three purchasers involving three shopper hubs. The expanded variant has then 60,000 perceptions. It likewise contains 14 essential prescient highlights and two ward factors (Figs. 2 and 3).

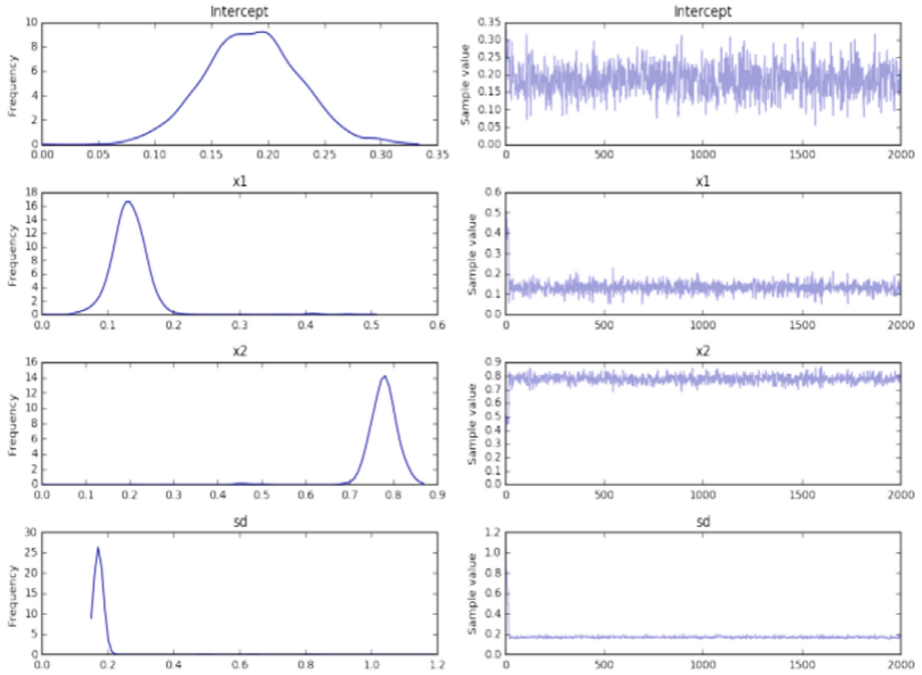


Fig. 2. Markov Chain Monte Carlo to get the improvement over straight averaging

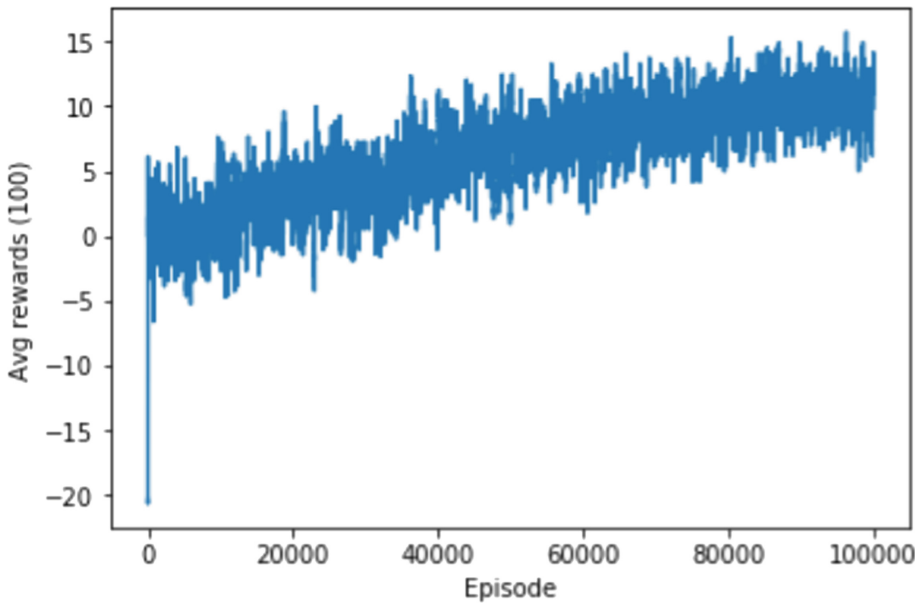


Fig. 3. All average Episode rewards

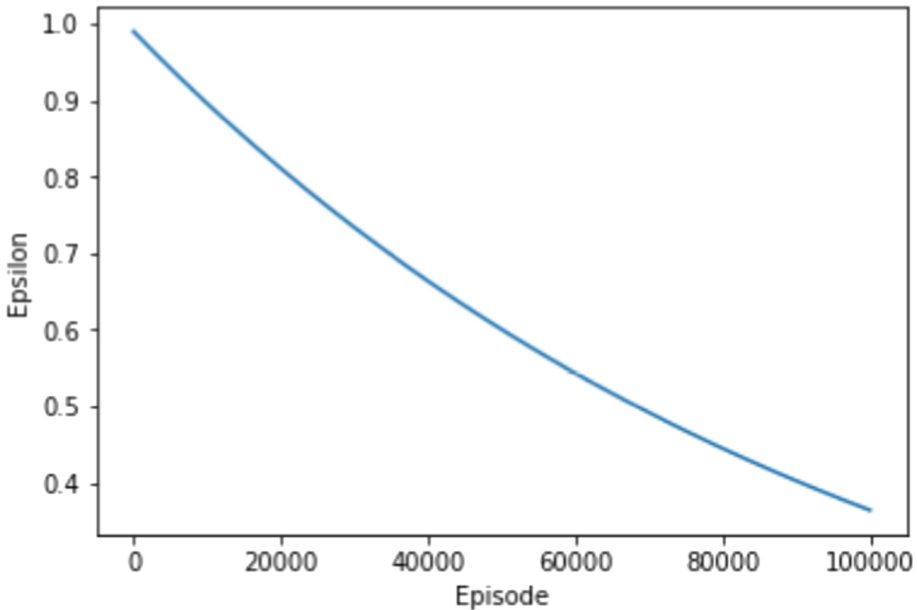


Fig. 4. All average Episode rewards - Monte Carlo simulation

4.3 Monte Carlo Simulation

Monte Carlo simulation is an automatic scientific method that permits individuals to represent a hazard in quantitative analysis and dynamic. Monte Carlo simulations implement risk analysis by building models of potential outcomes by subbing a scope of qualities—a likelihood dispersion—for any factor that has an inalienable vulnerability. It at that point figures results, again and again, each time utilizing an alternate arrangement of random qualities from the probability functions. Contingent on the number of vulnerabilities and the reaches determined for them, a Monte Carlo simulation could include thousands or a huge number of recalculations before it is finished. Monte Carlo simulation produces circulations of conceivable result esteems.

In Actor-Critic, rather than holding up until the finish of the episode as we do in Monte Carlo Reinforce, we make an update at each progression. Since we do an update at each time step, we can't utilize the complete reward $R(t)$. Rather, we must prepare a Critic model that approximates the worth capacity. This worth capacity replaces the reward function in strategy inclination that figures the rewards just toward the finish of the episode (Figs. 4, 5 and Tables 1 and 2).

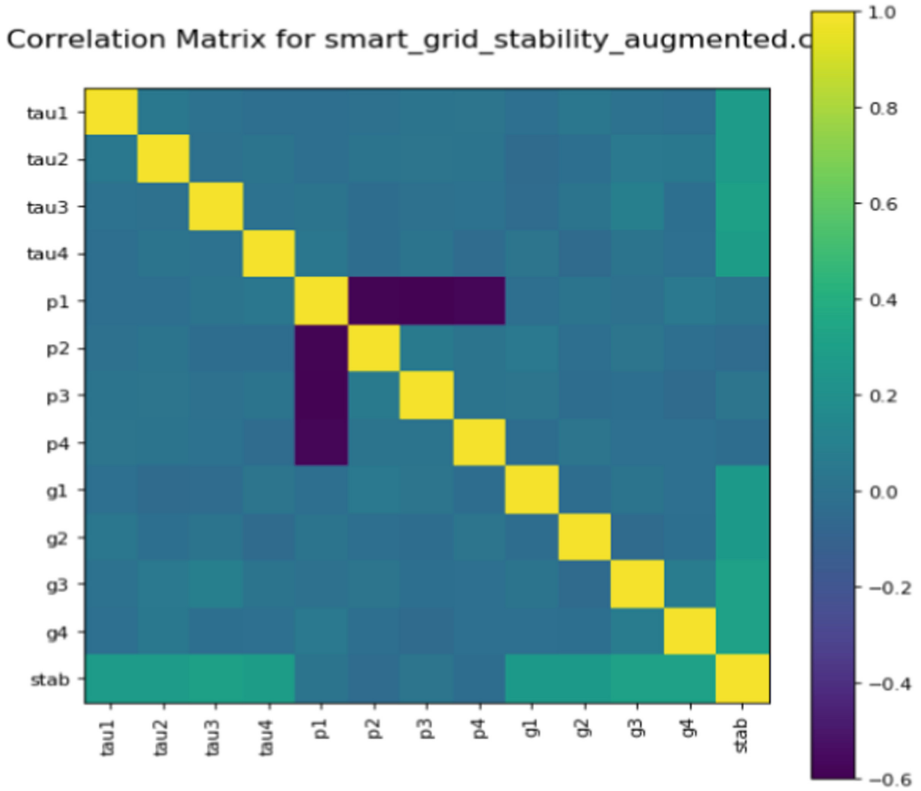


Fig. 5. Distribution graphs (histogram/bar graph) of sampled columns

Table 1. Original dataset (10,000 observation)

ARCHITECTURE	FOLDS	EPOCHS	CONFUSION MATRIX	ACCURACY
24-12-1	10	10	596-28 40-336	93.20%
24-12-1	10	20	605-19 31-345	95.00%
24-12-1	10	50	603-21 35-341	94.40
24-12-1	10	10	604-20 30-346	95.00%
24-12-1	10	20	604-20 31-345	94.90%
24-12-1	10	50	602-22 20-356	95.80%

Table 2. Augment dataset (60,000)

ARCHITECTURE	FOLDS	EPOCHS	CONFUSION MATRIX	ACCURACY
24-12-1	10	10	3795-56 168-1981	96.28%
24-12-1	10	20	3680-73 78-2071	98.00%
24-12-1	10	50	3787-64 67-2058	98.20%
24-12-1	10	10	3864-76 97-2053	97.10%
24-12-1	10	20	3765-83 59-2091	96.95%
24-12-1	10	50	3798-56 68-2083	97.95%

5 Discussion

Although the method we used to study the results of simulations already works quite even though the strategy we used to anticipate the consequences of simulations as of now works very well, we see space for additional speculation. This area contains angles this examination has not tended to which we esteem promising exploration headings. In of our analyses, exactness (the portion of accurately arranged plan focuses) has been around 70%. To get an overall view on the framework, this isn't significant, and our outcomes stay substantial. Be that as it may, when one uses simulations to discover unadulterated stability locales, this might be unacceptable. Considering cost delicate classifiers, which put more accentuation on stable structure focuses, is one potential bearing of exploration. Next, we have utilized the information on framework balance to get the highlights from the underlying information by processing sums. In any case, questions, for example, regardless of whether our structures are ideal in approximately logical, can handle complex nonlinear problems (Hussain et al. 2021a; Hussain et al. 2022), or whether such features can be" naturally stay open. Also, the expansion of investigation for enormous networks, containing more than 10 members, isn't clear.

6 Conclusions

In this study, we address the issue of straightforward and exact expectation of smart framework control stability utilizing our insight-based data mining approach executed as the fuzzy rule-based classifier. Smart Grid Control (DSGC), the subject of this object, has been promoted as an approach to acknowledge demand response. We have gathered the suspicions behind it deliberately, some of which are prohibitive. To wipe out certain suppositions, while simultaneously focusing at straightforward and astute models, we have proposed the accompanying: Reproduce the framework for differing sets of information values. A reproduction result has been an induction on whether the framework

is steady for the data prizes. Make structures from unique contributions, to diminish the number of degrees of opportunity. Request a decision tree algorithm to the information coming about because all things considered. This methodology uncovers new bits of knowledge concerning DSGC, not known from past investigations. For instance, we have discovered that the framework can be steady regardless of whether a few members adjust their vitality utilization with a high deferral, or quick variation is best for dependability under specific conditions. Normalized information strategies can empower proficient, practical utilization of expository data to help coordinated grid exercises, for example, power unwavering quality, grid arranging and tasks, DSM projects, and DR execution evaluation. Big-data analytics could utilize to target clients that have the most DR with regards to each DR program. Beginning phase prescriptive examination and progressed prescient investigation strategies are accessible to decide the estimation of DR to both the grid and the client.

Moreover, the fundamental suspicions of the DSGC frameworks, for instance, the fixed info issue, correspondence issue, physical model suppositions, and so forth., can be investigated further for improved area expertise that will prompt an improved Machine Learning Classification Model.

References

- Bhattarai, B.P., et al.: Big data analytics in smart grids: state-of-the-art, challenges, opportunities, and future directions. *IET Smart Grid* **2**, 141–154 (2019). <https://doi.org/10.1049/iet-stg.2018.0261>
- Billinton, R., Wangdee, W.: Predicting bulk electricity system reliability performance indices using sequential monte carlo simulation. *IEEE Trans. Power Deliv.* **21**, 909–917 (2006). <https://doi.org/10.1109/TPWRD.2005.861237>
- Dabrowski, C., Fern, H.: Markov chain analysis for large-scale grid systems. National Institute of Standards and Technology (2009)
- Boyd, D., Crawford, K.: Six provocations for big data. In: *A Decade in Internet Time: Symposium on the Dynamics of the Internet and Society* (2011)
- Ericsson, G.N.: Cyber security and power system communication—essential parts of a smart grid infrastructure. *IEEE Trans. Power Deliv.* **25**, 1501–1507 (2010). <https://doi.org/10.1109/TPWRD.2010.2046654>
- Espe, E., Potdar, V., Chang, E.: Prosumer communities and relationships in smart grids: a literature review, evolution and future directions. *Energies* **11**, 2528 (2018). <https://doi.org/10.3390/en11102528>
- Gelazanskas, L., Gamage, K.A.A.: Demand side management in smart grid: a review and proposals for future direction. *Sustain Cities Soc.* **11**, 22–30 (2014). <https://doi.org/10.1016/j.scs.2013.11.001>
- Gorzalczany, M.B., Piekoszewski, J., Rudziński, F.: A modern data-mining approach based on genetically optimized fuzzy systems for interpretable and accurate smart-grid stability prediction. *Energies* **13**, 2559 (2020). <https://doi.org/10.3390/en13102559>
- Gungor, V.C., et al.: Smart grid technologies: communication technologies and standards. *IEEE Trans. Ind. Inform.* **7**, 529–539 (2011). <https://doi.org/10.1109/TII.2011.2166794>
- Hussain, W., Merigo, J.M., Gao, H., Alkalbani, A.M., Rabhi, F.A.: Integrated AHP-IOWA, POWA framework for ideal cloud provider selection and optimum resource management. *IEEE Trans. Serv. Comput.*, 1 (2021). <https://doi.org/10.1109/TSC.2021.3124885>

- Hussain, W., Hussain, F.K., Hussain, O.K.: Towards soft computing approaches for formulating viable service level agreements in cloud. Paper presented at the Neural Information Processing (2015)
- Hussain, W., Hussain, F.K., Saberi, M., Hussain, O.K., Chang, E.: Comparing time series with machine learning-based prediction approaches for violation management in cloud SLAs. *Futur. Gener. Comput. Syst.* **89**, 464–477 (2018)
- Hussain, W., Merigó, J.M.: Centralised quality of experience and service framework using PROMETHEE-II for cloud provider selection. In: Gao, H., Kim, J.Y., Hussain, W., Iqbal, M., Duan, Y. (eds.) *Intelligent Processing Practices and Tools for E-Commerce Data, Information, and Knowledge*, pp. 79–94. Springer International Publishing, Cham (2022)
- Hussain, W., Merigó, J.M., Raza, M.R.: Predictive intelligence using ANFIS-induced OWAWA for complex stock market prediction. *Int. J. Intell. Syst.* (2021). <https://doi.org/10.1002/int.22732>
- Hussain, W., Merigó, J.M., Raza, M.R., Gao, H.: A new QoS prediction model using hybrid IOWA-ANFIS with Fuzzy C-means, subtractive clustering and grid partitioning. *Inf. Sci.* **584**, 280–300 (2022)
- Hussain, W., Sohaib, O.: Analysing cloud QoS prediction approaches and its control parameters: considering overall accuracy and freshness of a dataset. *IEEE Access* **7**, 82649–82671 (2019). <https://doi.org/10.1109/ACCESS.2019.2923706>
- Kenyon, R.W., et al.: Stability and control of power systems with high penetrations of inverter-based resources: an accessible review of current knowledge and open questions. *Sol. Energy* **210**, 149–168 (2020). <https://doi.org/10.1016/j.solener.2020.05.053>
- Landberg, L.: Short-term prediction of the power production from wind farms. *J. Wind Eng. Ind. Aerodyn.* **80**, 207–220 (1999). [https://doi.org/10.1016/S0167-6105\(98\)00192-5](https://doi.org/10.1016/S0167-6105(98)00192-5)
- Lu, R., Hong, S.H.: Incentive-based demand response for smart grid with reinforcement learning and deep neural network. *Appl. Energy* **236**, 937–949 (2019). <https://doi.org/10.1016/j.apenergy.2018.12.061>
- Lu, R., Hong, S.H., Yu, M.: Demand response for home energy management using reinforcement learning and artificial neural network. *IEEE Trans. Smart Grid* **10**, 6629–6639 (2019). <https://doi.org/10.1109/TSG.2019.2909266>
- Manzoor, S., Manzoor, M., Hussain, W.: An analysis of energy-efficient approaches used for virtual machines and data centres. Paper presented at the 2017 IEEE 14th International Conference on e-Business Engineering (ICEBE) (2017)
- Mnih, V., et al.: Human-level control through deep reinforcement learning. *Nature* **518**, 529–533 (2015). <https://doi.org/10.1038/nature14236>
- Moldovan, D.: Horse optimization algorithm: a novel bio-inspired algorithm for solving global optimization problems. In: Silhavy, R. (ed.) *Artificial Intelligence and Bioinspired Computational Methods*, pp. 195–209. Springer International Publishing, Cham (2020)
- Mu, C., Zhao, Q., Gao, Z., Sun, C.: Q-learning solution for optimal consensus control of discrete-time multiagent systems using reinforcement learning. *J. Frankl. Inst.* **356**, 6946–6967 (2019a). <https://doi.org/10.1016/j.jfranklin.2019.06.007>
- Mu, C., Zhao, Q., Sun, C., Gao, Z.: An ADDHP-based Q-learning algorithm for optimal tracking control of linear discrete-time systems with unknown dynamics. *Appl. Soft Comput.* **82**, 105593 (2019b). <https://doi.org/10.1016/j.asoc.2019.105593>
- Raza, M.R., Hussain, W., Merigó, J.M.: Cloud sentiment accuracy comparison using RNN, LSTM and GRU. Paper presented at the 2021 Innovations in Intelligent Systems and Applications Conference (ASYU) (2021a)
- Raza, M.R., Hussain, W., Merigó, J.M.: Long short-term memory-based sentiment classification of cloud dataset. Paper presented at the 2021 Innovations in Intelligent Systems and Applications Conference (ASYU), Elazig, Turkey (2021b)
- François-Lavet, V., Taralla, D., Ernst, D., Fonteneau, R.: Deep reinforcement learning solutions for energy microgrids management (2016)

Shi, W.-H., Shi, W.-H., Shi, W.-H.: Applications of Markov chain Monte Carlo in large-scale system reliability evaluation (2008)

Zhao, Y., Ye, L., Li, Z., Song, X., Lang, Y., Su, J.: A novel bidirectional mechanism based on time series model for wind power forecasting. *Appl. Energy* **177**, 793–803 (2016). <https://doi.org/10.1016/j.apenergy.2016.03.096>