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EVALUATING A MULTIPLE DECISIONS OF POTENTIAL AND COMPLEX ENVIRONMENT USING DEEP REINFORCEMENT LEARNING AND RECURRENT NEURAL NETWORK FOR ALLOWING ERROR FREE COMMUNICATION IN MODISH (SMART) GRIDS

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Abstract:
A smart grid is a network allowing devices to communicate between suppliers to consumers, allowing them to manage demand, protect the distribution network, save energy and reduce costs. Smart grids are the developmental trend of power systems and they have attracted much attention all over the world. Due to their complexities, and the uncertainty of the smart grid and high volume of information being collected, artificial intelligence techniques represent some of the enabling technologies for its future development and success. A smart grid is an electrical grid which includes a variety of operation and energy measures including smart meters, smart appliances, renewable energy resources, and energy efficient resources. Decreasing cost of computing power, the profusion of data, and better algorithms, AI has entered into its new developmental stage and AI is developing rapidly. Deep learning (DL), reinforcement learning (RL) and their combination deep reinforcement learning (DRL) are representative methods and relatively mature methods in the family of AI.
This paper introduces the concept and status of the above three methods, summarizes their potential for application in smart grids, and provides a sequence of decisions can be achieve potential and complex environment can be developed in smart grids an overview of the research work on their application in smart grids.
Keywords: Deep Learning, deep reinforcement learning (DRL), Recurrent Neural Networks (RNN),Convolutional Neural Networks (CNN).

I. Introduction

Artificial intelligence is a comprehensive science and technology, including a huge domain in breadth and width. After decades of development, much progress has been made across the fields of artificial intelligence (AI). In recent years, driven by the increasing amounts of data, there has been a significant emergence in the advancement of AI algorithms and powerful computer hardware, allowing AI to enter into a new evolutionary stage related technologies are currently in the process of development, and many algorithms are emerging. In their present states, deep learning (DL) and reinforcement learning (RL) are relatively mature; and their combination deep

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reinforcement learning (DRL).

II. Deep Learning

DL is a subset of machine learning, which originally resulted from a multi-layer Artificial Neural Network (ANN). Strictly speaking, DL has a wider meaning, but in its present state, when talking about DL, we just think of a large deep neural network, that is, deep neural networks. Here, deep typically refers to the number of layers. There are different structures of DL that is Boltzmann Machine (BM), Deep Belief Networks (DBN), Feed forward Deep Net- works (FDN), Convolutional Neural Networks (CNN), Recurrent Neural Networks (RNN), Long-short Term Memory (LSTM) Networks, Generative Adversarial Networks (GAN). Among them, CNN and RNN are the most popular structures. CNN is suitable for dealing with spatial distribution data while RNN has advantages in managing time series data. DL frameworks are basic underlying architectures, consisting of popular ANN algorithms, providing a stable DL API (Application Program Interface), supporting distributed learn- ing of training models on GPU, TPU, and playing an important role in popularizing DL applications. Mainstream open source DL frameworks include TensorFlow, Caffe/Caffe2, CNTK, MXNet, Paddle-paddle, Torch/PyTorch, Thenano. Presently, DL has shown its extraordinary ability in many areas, such as image and speech recognition and natural language processing [3], [4].

III. Reinforcement Learning

There are four basic components in RL: agent, environment, reward and action. The objective of RL is for the agent to maximize the reward by taking a series of actions in response to a dynamic environment. RL can support sequential decision making under uncertainty. A typical RL algorithm operates with only limited knowledge of the environment and with limited feedback on the quality of the decisions. The most popular algorithms of RL include Q-learning, SARSA (State–Action–Reward–State–Action), DQN (Deep Q Net) and DDPG (Deep Deterministic Policy Gradients).

A. Deep Reinforcement Learning

The combination of DL with RL has led to a new field of research, called DRL, which integrates the perception of DL and the decision making of RL. Therefore, DRL can implement a variety of tasks requiring both rich perception of high- dimensional raw inputs and policy control [7]. DRL's success in AlphoGo demonstrates that DRL has become one of the most fascinating research areas in AI.

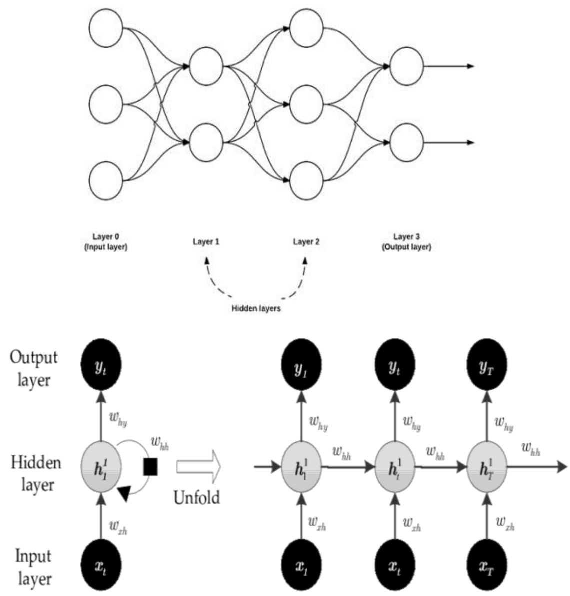

Fig: 1: Deep neural network with different hidden layers b.Hidden layers with input and out put.

Many researches on DRL applications are currently being conducted. Uber is trying to use DRL to teach Grand Theft Auto to handle real cars on real roads. As the key algorithms of machine learning, DL and RL have existed in academic circles for many years, but only recently have they entered the industrial world for application oriented research. This is primarily because of the changes or progress in three respects: increasing amounts of data, and the emergence of advanced AI algorithms and powerful computer hardware. Sensors, monitoring systems, smart phones and social media are producing massive data every minute, which brings us into the era of big data. Data deluge accelerates the development of better algorithms. The development of computational power also plays an important role in promoting, especially DL, RL and of course, DRL. Training a DL model without a GPU would be painfully slow in most cases. Although DRL has proved its value in some practical applications and many experts think DRL has great prospects, some experts have expressed different viewpoints. They think that the present versions of DRL take a long time to converge and learn something meaningful. This restricts the techniques from being used in the real world for real-time learning.

II. Working model with potential in modish (smart) grid

The modish (smart) grid uses computer technology to improve the communication, automation, and connectivity of the various components of the power network. This allows a bulk transmission of power gathered from multiple generation plants. It also improves distribution by relaying information from consumers to transformers and generation plants. One key element to this system is the installation of smart meters in homes and businesses. Replacing the traditional analog meters, these digital devices are capable of two-way communication relaying information about both supply and demand between producers and consumers. Power systems are very complex artificial systems. With the development of the smart grid, high penetration of wind, solar power and customers' active participation have lead smart grids to operate in more uncertain, complex environments. Traditional power system analysis and control decision-making are primarily dependent on physical modeling and numerical calculations. The traditional methods find difficulty in addressing uncertainty and partial observability issues so that they cannot meet the requirements of future development of smart grids. On the other hand, wide spread deployment of Advanced Metering Infrastructures (AMI), Wide Area Monitoring Systems (WAMS), and other monitoring/management systems produce massive data and provide a data basis for algorithm training in AI applications. Therefore, DL, RL, and DRL appear to be some of the enabling technologies for the future development and success of smart grids.

Demand Response (DR) is an effective measure to incentivize customers to shift load from peak periods to off-peak periods or to decrease their electricity usage during peak time. With the deployment of smart meters, data reflecting consumers' energy consumption behavior can be collected, and data driven DL and RL algorithms can serve as effective technologies for non-invasive load decomposition, price fore-casting, etc., so that consumers can make the right decisions and demand response can be successfully implemented. In a smart grid, many monitoring systems are installed for equipment supervision. Based on the data from these systems, utilizing DL algorithms, various features can be extracted so that anomalies can be detected, including equipment anomalies, malicious attacks and false data invasions, electricity theft, etc. DL is believed to be of great value in these fields. In smart grids, there are many other technical fields in which DL, RL and DRL have great potential applications. In fact, these algorithms have great prospects in nearly all the technical fields of a smart grid.

A. **Demand Forecasting**

With the high penetration of solar, and wind power, the scheduling and operation of power systems are faced with the challenges of increasing uncertainty. Therefore, accurate forecasting of energy demands at different levels is important. Although there exist many methods for electricity load forecasting, most of them are based on small datasets without considering the large volumes of data provided by smart meters.In paper [9], the authors attempt to improve the load fore- casting accuracy for ISO New England by trying to use various statistical and AI models. A feed forward neural network is adopted, in which different numbers of hidden layers are chosen. As the number of hidden layers increases, the forecast accuracy improves while the training takes a longer time and the risk of over fitting increases. The research result shows that 100 hidden layers is the best choice.

In many cases, more effective solutions can be obtained by combining a DL algorithm with other methods .Some experts are exploring using these types of joint methods for load forecasting. In paper [10] CNN and K-Means algorithms are used jointly to forecast hourly electricity loads. A K-means algorithm is used to cluster large datasets, which contain more than 1.4 million of load records, into subsets and the obtained subsets are used to train the CNN. Experimental results demonstrate that the proposed method is effective. Paper [10] proposes one DBN embedded with parametric Copula models to forecast the hourly load, based on one year data in an urban area in Texas, United States. Experimental results show the proposed method can give more accurate predictions than classical applied for day-ahead load prediction. A 90-day Iberian market dataset is used to train multiple combinations of activation functions of both single and double layer neural networks. The results indicate that the combination of an Exponential linear unit (ELU) with ELU has better performances than other combinations when evaluated against MAPE (Mean Absolute Percentage Error) values for week day datasets; while for weekend data sets, the ReLU.ReLU (Rectifier linear unit) combination outperforms the other combinations.

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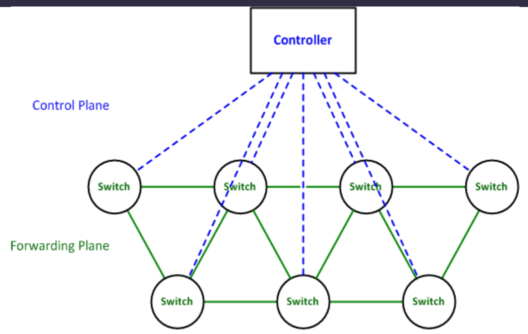

Fig: 2: Grid with switches and controlling all the nodes in forwarding plane

B. Microgrid

Microgrid has renewable energy, EVs and all types of customers included in it, so its planning and operations are faced with challenges from uncertainty because of the difficulty in accurate prediction of future electricity consumption and renewable power generation. DL, RL and DRL are helpful for deriving the solutions of decision-making for microgrids. DRL can deal with the problem of partial observability. Paper [10] applies DRL in the operation of microgrids in the environment of partial observation since a limited amount of data is available. To address the partial observation problem, a specific DL architecture has been designed to extract knowledge from past consumption and production time series as well as any available forecasts. The proposed approach proves to be effective based on the case study of a residential customer located in Belgium.

Energy management is one of the core problems for micro- grids. Paper [9] proposes an online dynamic energy management system (DEMS) for a microgrid by combining evolutionary adaptive dynamic programming with an RL framework, in order to realize optimal or near optimal DEMS in both grid connected and islanded operation modes.

C. Demand Response

Identifying and predicting energy flexibility on the demand side is crucial for implementing demand response. At the same time, the latest smart meter applications allow us to conveniently monitor customer side power consumption levels in real time and analyze customers' consumption behavior by means of Nonintrusive Load Monitoring (NILM). By using NILM, it can be determined which appliances are being used and their individual consumption.

Dissertation [5] applies DL to identify the flexibility of loads, and to provide references for demand response. Paper [9] uses Factored Four Way Conditional Restricted Boltzmann Machines to identify and predict flexibility in real time. Actually, direct load control and demand response are high dimension control problems faced with the challenges of partial observability and randomness.

D. Defect/Fault Detection of Electrical Equipment

Adequate fault/defect detection of electrical equipment is vitally important in order to ensure reliable power system operations. In a typical power system, many sensors and monitoring systems are installed and gradual changes are analyzed. Because of the complexity of recorded data, however, defects or faults at an early stage cannot be easily recognized. In the following literature, DL is employed to monitor the states of three important components in power networks: insulators, transformers and transmission lines.Taking advantage of high-level discriminative CNNs to extract the features of the insulators and identify their defects. The experimental results show that the proposed method can achieve an accuracy of 93%.

Considering that oil chromatography online-monitoring data is unlabeled during power transformer failure and therefore traditional diagnosis methods often fail to make full use of those unlabeled fault samples in judging transformer fault types, paper [4] establishes a corresponding classification method based on DL. On this basis, a new fault diagnosis method for power transformers is further proposed, in which a large number of unlabeled data from oil chromatogram on-line monitoring devices and a small number of labeled data from dissolved gas-in-oil analysis (DGA) are fully used in the training process. Testing results from engineering examples indicate that the proposed method is better than that of three other proposed methods: radio, BP neural network and SVM.A large number of unlabeled data from oil chromatogram on-line monitoring devices and a small number of labeled data from dissolved gas-in-oil analysis are fully used in training process. Testing results indicate that the diagnosis performance is better than that of three radio, BP neural network and SVM. In order to improve the recognition of power line fault detection, paper [5]proposes one modeling method based on the sparse self-encoding neural network, in which normalized sub-band energy of wavelet decomposition is used as the characteristic parameters for the DL neural network. Then the characteristics of the fault signal are trained to construct the DL structure.

E Cyber Security

The integration of ICT into power system infrastructure can effectively improve the quality of the monitoring and control smart grids; on the other hand, the dependence on ICT also increases power systems' vulnerability to malicious attacks. False data injection (FDI) is becoming a severe threat to power systems. How to solve the issue has become a hot topic in recent years.

Q-learning to monitor topology changes and analyzes the vulnerability of electrical power grids in sequential topological attacks. The vulnerable sequences leading to critical blackouts in the system can then be found. Paper [7] proposes DL-based algorithms to detect FDI and power theft in real-time. High-dimensional temporal behaviors of the unobservable FDI attacks are featured by using CDBN to detect the potential FDI attacks based on real-time measurements. DL to probe and detect the data corruption by analyzing the real-time measurement data from the geographically distributed Phasor Measurement Units (PMUs).Cyber security of smart grids is one of the most important application areas of DL and RL. Some institutions have become initiated.

V. Renewable Energy Generation Prediction

The prediction of renewable energy generation output is important to improve their integration in the power grid by dealing with their uncertain and intermittent characteristics. Multilayer perception neural networks in combination with a multi-objective genetic algorithm, and ELM combined with the nearest neighbors' approach, for short-term wind speed prediction as observed for the region of Regina in Saskatchewan, Canada. Both approaches have good prediction precision. Recently, there has been a great deal of research on predicting wind ramps. However, the present wind power fore-casting methodologies have disadvantages in different weather conditions.Multi-Layer Perceptions Neural Network (MLP-NN) for wind forecasts, using a Weather Research and Forecasting Model (WRF) model as input. Proposes a Long Short-Term Memory (LSTM) based wind power prediction model, which is advanced and practical in the field of wind power prediction.

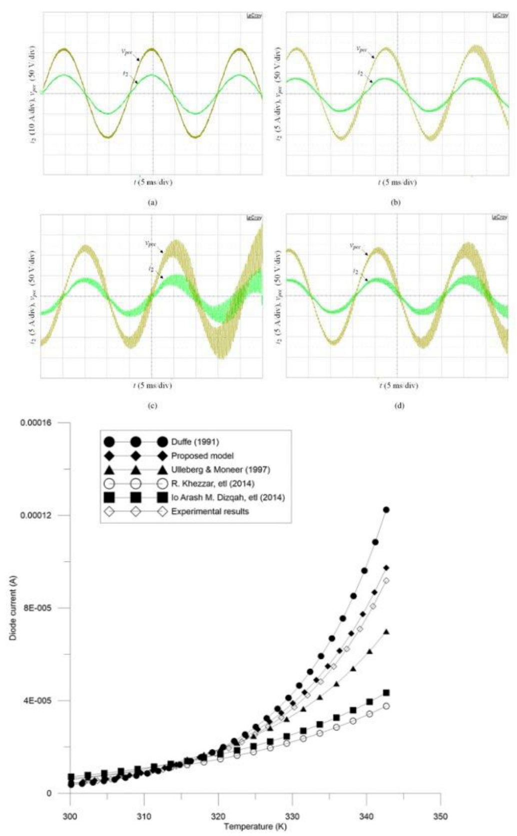

Fig 3 : a) Grid side current single loop control ,b) Photovoltaic Grid connected

In above figure 3.a shows the experimental graph showing the different levels of the signals that the modish or smart grid with loop levels and repeatedly this generate the increasing and decreasing levels of the frequency and with α levels can be noted in the table 1.Figurre b shows th photovoltaic grid connected and will be based on this loop controlled and this can achieved and shown in the table form.

Run no.	***f*(Hz)**	***S***	***Fs/v***	***α***	***L(cm)***
1	2.0	2.0	600	1.99	1
2	3.0	2.0	1200	1.61	2
3	1.0	2.0	1600	168	1
4	3.0	4.0	6400	1.60	2
5	1.0	5.0	2500	1.77	1
6	2.0	4.0	6400	1.52	1
7	1.0	2.0	2200	1.25	2
8	2.0	3.0	2500	1.35	1
9	3.0	1.0	6200	1.32	2

Table 1: Experimental conditions and levels of frequency

VI. Conclusion

DL, RL and DRL have attracted a great deal of attention all over the world in recent years. Unlike traditional AI algorithms, such as expert system, fuzzy logic, and neural networks, which are academic driven, DL, RL and DRL are application oriented, and are being promoted by high tech companies. Their combination with available, massive datasets, and inexpensive parallel computing has made them possible to find actual applications. Smart grids are one of the greatest potential application areas of DL, RL and DRL. Great efforts have been made on researches on their application in smart grids. A lot of papers have been published in this area and most of them were published in the most recent three years. This article only introduces some of them.

DL, RL and DRL can be used in many technical fields of smart grids. From the technological viewpoint, they can be applied in prediction, anomaly detection, decision-making support for control, etc. For business, they can be used in renewable generation prediction, fault detection of equipment, security assessment and control, cyber security defense, demand response, load forecasting, nearly covering all the technical fields of smart grids. Many problems need to be studied in depth, for example, which structure of deep learning is preferable for a specific use case? How many layers are suitable? How to solve the problem of partial observability, and small samples? In addition, DL has the shortcoming of non- interpretable and this can impact the creditability of results, leading to security concerns for the power system operator

VII. Acknowledgement

Dr.Bandi Ashalatha,Mr. Vijaya Kumar Kambala involved in this research work and proved with experimentally how to evaluating a multiple decisions of potential and complex environment using deep Reinforcement learning and Recurrent Neural Network for allowing error free communication in modish (smart) grids.

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