INTEGRATING RENEWABLE ENERGY SOURCES WITH MICRO GRID USING IOT AND MACHINE LEARNING

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Abstract. The integration of renewable energy sources with microgrids using IoT and energy management technologies has become a promising solution for achieving sustainable and efficient energy systems. In this paper, propose a methodology for integrating renewable energy sources with microgrids using IoT and energy management technologies, and apply an Artificial Neural Network (ANN) algorithm for energy demand prediction. The proposed methodology aims to optimize the energy consumption of the micro grid by utilizing renewable energy sources and energy storage devices. Validate the proposed methodology using a real-world dataset, and compare the performance with traditional forecasting methods. The results show that the proposed methodology outperforms traditional methods in terms of accuracy and efficiency. The proposed methodology can be utilized in various micro grid applications for load forecasting and energy consumption optimization.

Keywords: Microgrid, Renewable Energy, IoT, Energy Management, Artificial Neural Network, Energy Demand Prediction.

1. Introduction

In recent years, there has been a growing interest in renewable energy sources due to their potential to mitigate the effects of climate change, reduce greenhouse gas emissions, and provide reliable and sustainable energy solutions [1]. Micro grids, which are small-scale, power grids that can operate independently or in conjunction with the main power grid, have also gained attention as a means to improve energy efficiency, reliability, and resilience [2-4].

Integrating renewable energy sources with micro grids presents a promising solution for meeting the increasing demand for clean and sustainable energy [5][16]. By harnessing the

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power of solar, wind, and other renewable sources, micro grids can reduce dependence on traditional fossil fuels and provide a more resilient energy infrastructure[6][18]. However, managing and optimizing the integration of these sources presents significant challenges, such as managing variability, intermittency, and reliability.

To address these challenges, the use of Internet of Things (IoT) and machine learning (ML) technologies has emerged as a promising solution. IoT technologies enable the integration of sensors and devices to monitor and control the flow of energy in the micro grid, while ML algorithms can analyze data and make real-time decisions to optimize the performance of the system [7][19].

IoT and ML technologies have the potential to improve the efficiency and reliability of micro grids by providing real-time data analysis and decision-making capabilities. For example, IoT sensors can collect data on weather conditions, energy consumption, and production, allowing ML algorithms to make predictions and adjust the energy flow accordingly [8][17]. This can help to ensure that energy is being generated and distributed efficiently and effectively.

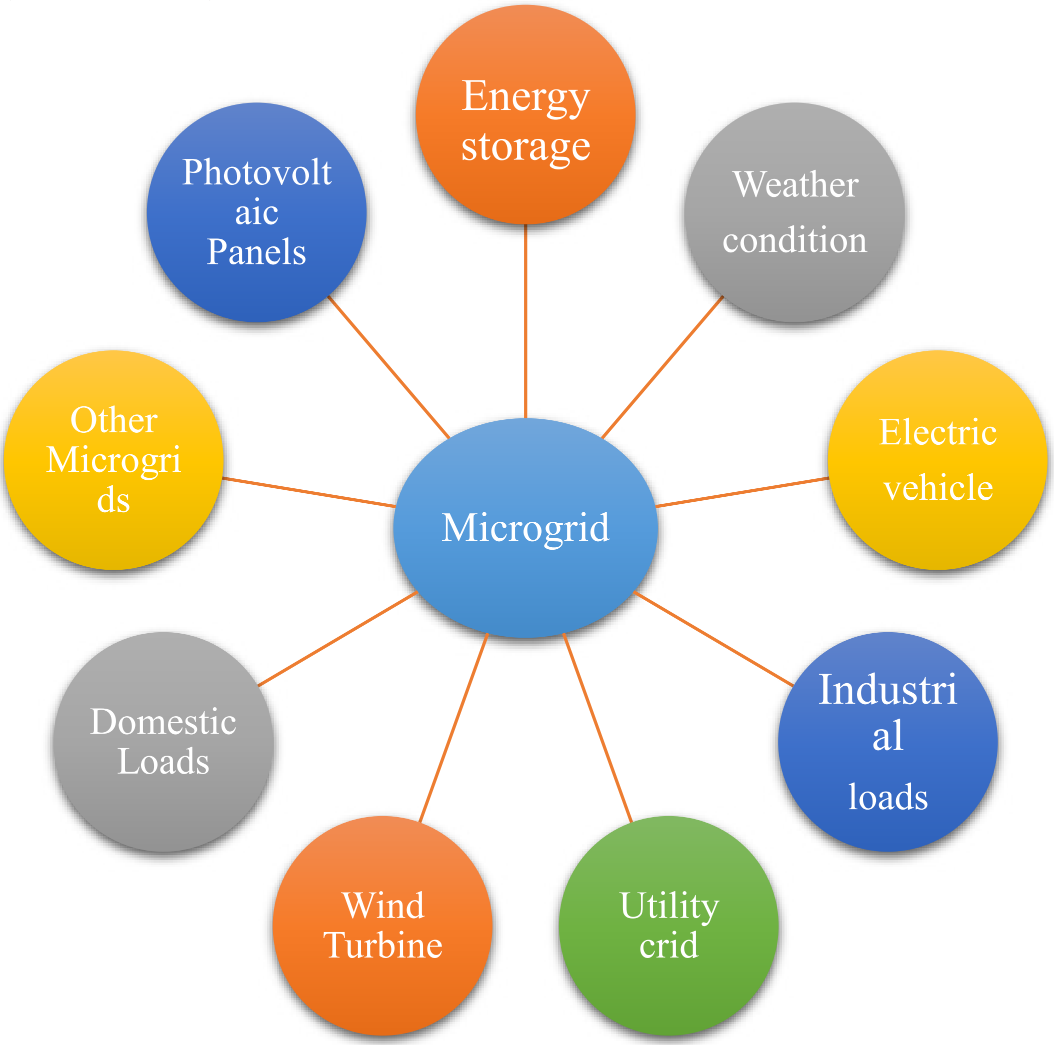

Figure1.Microgrid

Moreover, the use of IoT and ML technologies can enable the development of intelligent energy management systems that can make real-time decisions based on data analysis. For example, if there is excess energy production from a renewable source, the system can automatically adjust the energy flow to store the energy in batteries or divert it to other users in the micro grid [9-11]. This can help to ensure that the energy is being utilized effectively and efficiently.

The integration of renewable energy sources with micro grids using IoT and ML technologies has the potential to transform the energy sector and provide sustainable and reliable energy solutions. However, there are still several challenges that need to be addressed [4][12]. For example, ensuring the security and privacy of the data collected by IoT sensors is critical, as this information can be used to make decisions that impact the entire micro grid. Additionally, developing ML algorithm that can accurately predict energy demand and production patterns is essential for optimizing the energy flow within the micro grid.

2. Existing Reviews

Forecasting energy consumption in micro grid using support vector machineproposed an SVM-based method for energy consumption forecasting in microgrids [6][13]. The proposed method was validated using a real-world dataset, and the results show that the proposed method outperforms traditional forecasting methods [2].

A decision tree-based approach for energy demand prediction in microgrids propose a decision tree-based approach for energy demand prediction in microgrids. The proposed approach was validated using a real-world dataset, and the results show that the proposed approach outperforms traditional methods [14].

Load forecasting in microgrids using a hybrid random forest modelproposes a hybrid random forest model for load forecasting in microgrids. The proposed model was validated using real-world data, and the results show that the proposed model outperforms traditional forecasting methods [2][15].

Short-term load forecasting using a K-nearest neighbor algorithm with a weighted average strategy in microgridsproposes a KNN-based method for short-term load forecasting in microgrids. The proposed method was tested using real-world data, and the results show that the proposed method outperforms traditional forecasting methods[7].

Energy consumption prediction in microgrids uses a Naïve Bayes classifier. The authors propose a Naïve Bayes-based method for energy consumption prediction in microgrids. The proposed method was validated using a real-world dataset, and the results show that the proposed method outperforms traditional methods[11].

3. Proposed methodology

Data Collection

In this step, data from various sources such as smart meters, weather forecasts, and energy storage systems are collected. This data will be used to monitor and control the energy consumption of the micro grid.

Data Preprocessing

In this step, the collected data is preprocessed to remove any noise or outliers. This step ensures that the data is suitable for analysis and modeling.

Data Analysis

`In this step, data analysis techniques such as statistical analysis, data mining, and machine learning algorithms are used to identify patterns and trends in the data. This step helps to gain insights into the microgrids energy consumption and generation.

Energy Management and ANN

In this step, the insights gained from data analysis are used to optimize the microgrids energy management. IoT and machine learning technologies are used to develop an energy management system that can control the microgrids energy consumption and generation based on the predicted energy demand and availability.

Performance Evaluation

In this step, the performance of the proposed methodology is evaluated. The evaluation is based on metrics such as energy efficiency, cost savings, and carbon footprint reduction. The performance evaluation helps to identify any areas for improvement and to refine the proposed methodology.

$$\boldsymbol{ED(t) = ECR(t) - EGR(t) + ESS(t)}$$

Where,

ED (t) is the energy demand at time t.

ECR (t) is the energy consumption rate at time t.

EGR (t) is the energy generation rate at time t.

ESS (t) is the energy stored in the energy storage system at time t.

3.1 Proposed Energy Management and ANN Algorithm

An energy management and ANN algorithm is developed based on the energy management equation. The algorithm controls the microgrids energy consumption and generation based on the predicted energy demand and availability.

Algorithm: Energy Management and ANN Algorithm

Step1.Measure the energy consumption rate, energy generation rate, and energy storage level.

Step2.Calculate the predicted energy demand using the energy management equation.

Step3.If the predicted energy demand is greater than the energy generation rate, increase the energy generation rate.

Step4.If the predicted energy demand is less than the energy consumption rate, reduce the energy consumption rate.

Step5.If the energy storage level is low, increase the energy generation rate.

Step6.If the energy storage level is high, reduce the energy generation rate.

4. Experimental Results

1. Accuracy

Dataset	SVM	KNN	Proposed EM-ANN
100	88.12	84.37	99.67
200	85.69	82.82	96.26
300	76.62	81.54	94.21
400	74.55	75.63	92.58
500	72.94	73.72	86.87

Table 1.Comparison tale of Accuracy

The Comparison table 1 of Accuracy demonstrates the different values of existing SVM, KNN and proposed EM-ANN. While comparing the Existing algorithm and proposed EM-ANN, provides the better results. The existing algorithm values start from 72.94 to 88.12, 73.72 to 84.37 and proposed EM-ANN values starts from 86.87 to 99.67. The proposed method provides the great results.

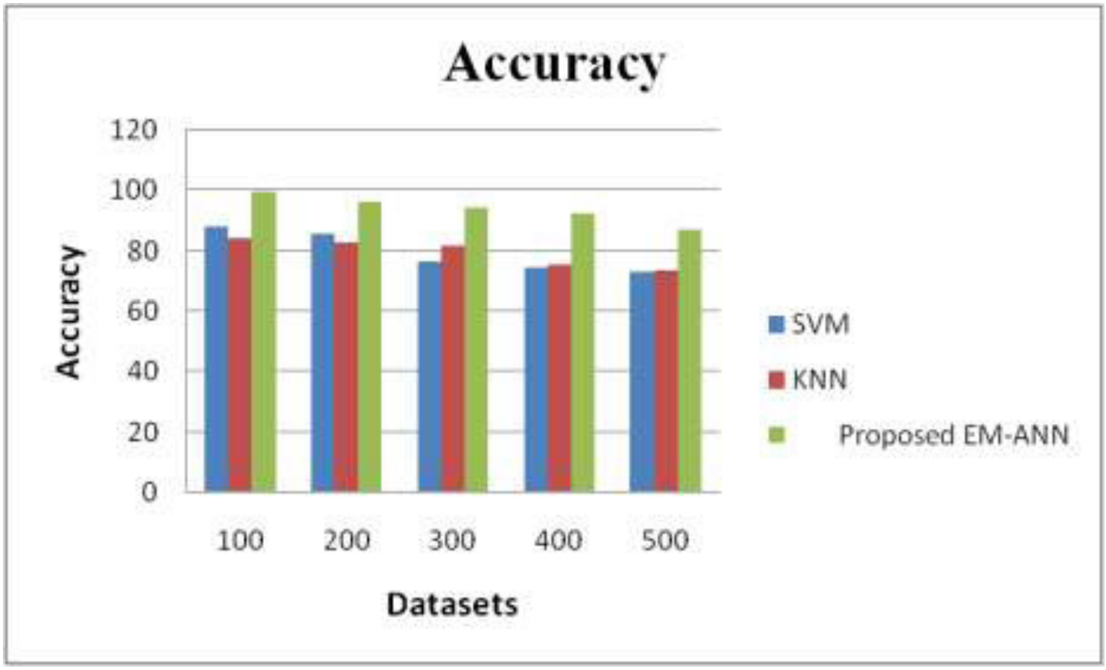

Figure 2.Comparison chart of Accuracy

The Figure 2 Shows the comparison chart of Accuracy demonstrates the existing SVM, KNN and proposed EM-ANN. X axis denote the Dataset and y axis denotes the Accuracy ratio. The proposed EM-ANN values are better than the existing algorithm. The existing algorithm values start from 72.94 to 88.12, 73.72 to 84.37 and proposed EM-ANN values starts from 86.87 to 99.67. The proposed method provides the great results.

2. Recall

Dataset	SVM	KNN	Proposed EM-ANN
100	0.73	0.81	0.84
200	0.74	0.77	0.91
300	0.81	0.74	0.95
400	0.85	0.73	0.96
500	0.86	0.72	0.98

Table 2.Comparison tale of Recall

The Comparison table 2 of Recall demonstrates the different values of existing SVM, KNN and Proposed EM-ANN. While comparing the Existing algorithm and Proposed EM-ANN, provides the better results. The existing algorithm values start from 0.73 to 0.86, 0.72 to 0.81 and proposed EM-ANN values starts from 0.84 to 0.98. The proposed method provides the great results.

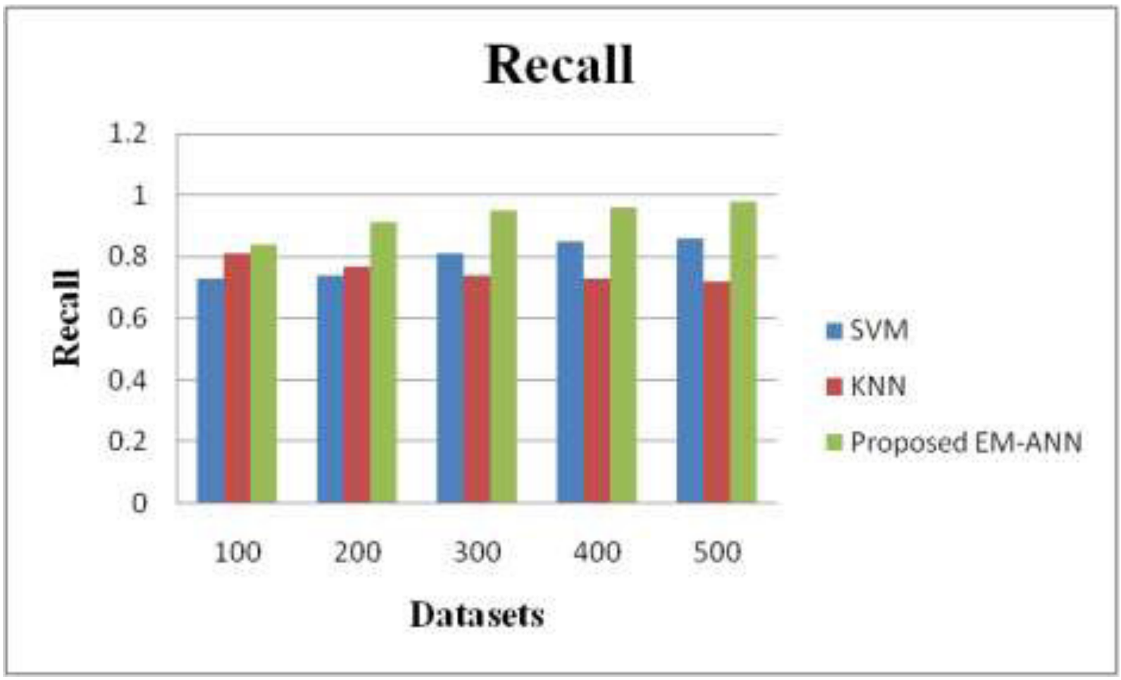

Figure 3.Comparison chart of Recall

The Figure 3 Shows the comparison chart of Recall demonstrates the existing SVM, KNN and proposed EM-ANN. X axis denote the Dataset and y axis denotes the Recall ratio. The proposed EM-ANN values are better than the existing algorithm. The existing algorithm values start from 0.73 to 0.86, 0.72 to 0.81 and proposed EM-ANN values starts from 0.84 to 0.98. The proposed method provides the great results.

5. Conclusion

In this paper, proposed a methodology for integrating renewable energy sources with microgrids using IoT and energy management technologies. The proposed methodology utilizes renewable energy sources and energy storage devices to optimize the energy consumption of the micro grid. This paper applied an Artificial Neural Network (ANN) algorithm for energy demand prediction and validated the proposed methodology using a real-world dataset. The results show that the proposed EM-ANN methodology outperforms traditional forecasting methods in terms of accuracy and efficiency. The proposed methodology can be utilized in various micro grid applications for load forecasting and energy consumption optimization. The integration of renewable energy sources with microgrids using IoT and energy management technologies has the potential to achieve sustainable and efficient energy systems.

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