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Original Article

Renewable Wind Energy using IoT-Based Smart Appliances

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Abstract - *Electricity is one of the key factors in human life to survive on the earth. Major of our work requires electricity so it is important to power saving. It is difficult to get power from the rain in the solar panel. So, we proposed an energy-efficient IoT-based smart appliance, renewable wind energy. The term "distributed energy resource system" refers to the fusion of one or more energy sources in a power method. In this research, smart appliances are used to save energy while considering the aforementioned concerns. A detailed comparative results analysis of some Deep Learning (DL) based Smart Appliances in terms of precision, specificity, accuracy and recall. The Convolution Neural Network (CNN) based Smart Appliances method outperformed. The suggested framework is compared with existing methods such as HGPDO, CNN, and ANN in terms of Accuracy, precision, Recall, and Specificity. According to experimental findings, the proposed technique extends smart appliances by 50%, 9.756%, and 26.829%, compared with HGPDO, CNN, and ANN Methods.*

Keywords - *Convolution Neural Network, Deep Learning.*

1. Introduction

Internet of Things offers top-notch solutions for tracking solar panel electricity consumption. Utility businesses and electricity providers can use IoT technology to get a remarkable amount of control over their resources [1]. In turn, this gives businesses crucial information they may use to make data-driven business decisions [2]. IoT data is transformed into usable information to boost wind turbine performance, lower the cost of wind energy, and lower risk [3].

However, because real-time control is required at the wind turbine system and component levels, IoT deployment is a difficult undertaking [4]. "Wind power" and "wind energy" refer to methods for harnessing the wind to create mechanical or electrical energy, respectively [5,6]. This mechanical energy may be used for particular tasks or may be used to power a generator [7].

According to the IEA's World Energy Outlook and other study endeavours, wind energy has maintained its top position as the least significant renewable energy source [8]. Energy sources are consistently more cost-effective than alternatives that rely on fossil fuels [9,10]. They are also significantly less expensive.

In this article, wind energy was utilized. The suggested method is validated in different scenarios to study the efficacy of the method, expensive energy, fossil fuels, and unsteady performance. To overcome these issues, proposed an energy-efficient IoT-based smart grid renewable wind energy has been proposed. The main contributions of the research work are as follows:

- An energy-efficient IoT-based Smart Grid Renewable Wind Energy has been proposed.
- The suggested technique gives an alert message to the user
- In this research, we used Wind Power Station to save excess energy in Smart appliances for cloud storage.

The remaining portion of the paper is arranged as follows: The literature review is described in Section 2. The proposed model is described in Section 3. The results and discussion are described in Section 4. The conclusion and future enhancement are described in Section 5.

2. Literature Review

In 2022 Al-Abri, T. et al. [1] proposed an intelligent source–load–storage coordination approach to utilize the available renewable energy resources with storage systems. The rise of distributed energy generation technology, dependability issues, and environmental concerns all point to the widespread adoption of distributed generation. The effectiveness of the suggested scheduling strategy is shown by the cost reduction of the suggested ways from $950.4 to $434.3 compared to the basic scenario.

In 2019 Worighi, I., et al. [2] suggested a smart grid system to give an advantageous opportunity for grid-friendly implementation of ESSs in smart grid methods. The suggested grid system, battery energy storage systems, and solar power producing units are all integrated into the virtualized approaches implementation. The simulation results highlight the importance of batteries in preserving system stability and show the effects of integrating renewable energy (RE) into the grid.

In 2020 Aly, H.H., et al. [3] suggested a novel method for short-term load forecasting based on the fusion of different models and the application of clustering techniques to improve the overall performance and quality of the method. These techniques use different Wavelet, Kalman filtering, and Artificial Neural Network (WNN and ANN) approaches. The proposed research is verified using two different datasets from Egypt and Canada.

In 2018 Muralitharan, K., et al. [4] developed a cutting-edge neural network-based optimization plan for forecasting energy demand. First, the CNN technique is employed to forecast consumer energy consumption. Second, neural network weights are automatically updated using neural network-based genetic algorithms (NNGA) and neural network-based particle swarm optimization (NNPSO) schemes. The findings demonstrate that with the smart grid, demand and supply can be controlled, the power system can be planned, and future energy needs can be predicted.

In 2022 Alhasnawi, B.N., et al. [5] offered an innovative two-stage hybrid technique for planning how much electricity homes with distributed energy generation and storage systems will need. Home energy management systems (HEMSs) that contain DGS like WT and PV were modelled in stage 1 using non-identical HEMSs. Based on customer preferences, power costs, and the amount of energy produced/stored, the HEMS organizes the controlled appliances.

In 2021 Rehman, A.U., et al. [6] proposed an HGPDO method that helps choose the best schedule for each household appliance while considering system limits. Numbers evaluate how well the heuristic algorithms and suggested strategy work. Furthermore, our suggested HGPDO method improves user comfort by 35.55%, 16.66%, 91.64%, and 45%, respectively, regarding latency, temperature, air quality, and visual.

3. Proposed Method

In this research, An energy-efficient IoT-based smart grid renewable wind energy in the smart grid has been proposed to reduce the cost and save power in the smart applicant. A smart grid is a complex network that calls for several two-way interactions between supply chain participants and machines. This system opens up various options for the distribution and administration of generated power. Among other components, the strategies are based on an IoT-based smart grid.

3.1. ESP32 (Microcontroller)

Dual-mode Bluetooth and built-in Wi-Fi are features of the ESP32 system-on-a-chip microcontroller family. The ESP32 series, which also has integrated antenna switches, RF baluns, power amplifiers, low-noise receive amplifiers, filters, and power-management modules, is powered by Tensilica Xtensa LX6 dual-core or single-core or Tensilica Xtensa LX7 dual-core or single-core RISC-V processors. Espressif Systems, a Shanghai-based Chinese firm, designed the ESP32 manufactured by TSMC using its 40 nm technology. [2] A microcontroller replaces the ESP8266.

3.2. Sensors

Here we used three types of Sensors they are,

- Pressure Sensor
- Speed Sensor
- Temperature Sensor

3.2.1. Pressure Sensor

A pressure sensor is a device that measures the pressure of gases or liquids. Pressure is the amount of force required to stop a fluid from expanding, and it is commonly expressed in terms of force per unit area. The typical use of a pressure sensor as a transducer is to produce a signal in response to the applied pressure.

3.2.2. Speed Sensor

Speed sensors are used to measure the rotating speed within devices. Many vehicles require speed sensors, including; automotive vehicles, aerospace vehicles, off-highway & construction vehicles, railway vehicles, and military vehicles.

3.2.3. Temperature Sensor

In order to produce measurements, temperature sensors send electrical signals. Sensors are made of two metals that produce an electrical voltage or resistance in response to a change in temperature and are measured by the voltage between the diode terminals. As the voltage rises, so does the temperature.

3.3. Cloud Storage

A client computer, tablet, or smartphone can upload files and get them from a distant data server using cloud storage. In order for clients to always have access to the same data, regardless of server failure or data loss, the same data is frequently maintained simultaneously on many servers.

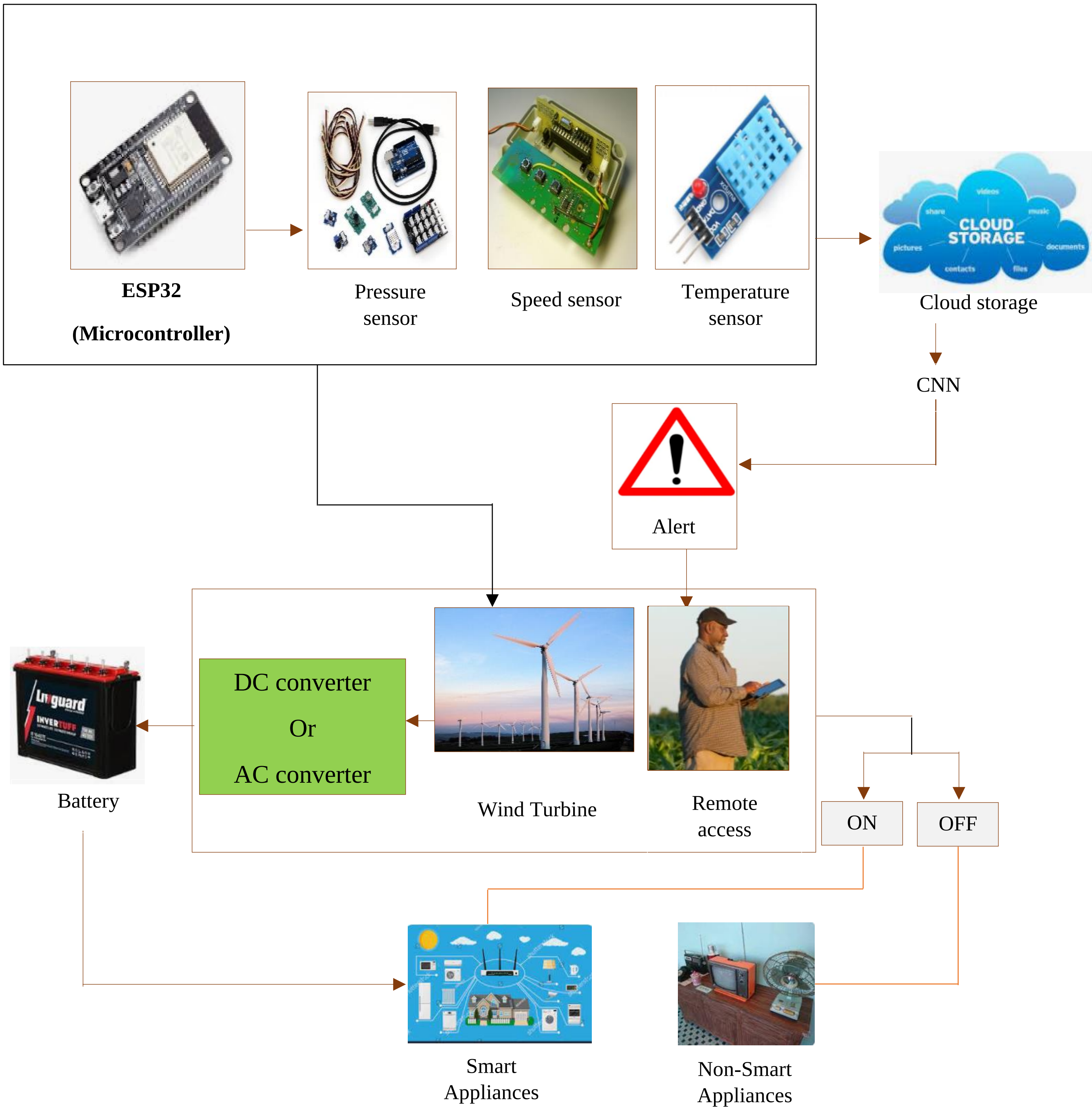

Fig. 2 Overall proposed diagram

3.4. CNN

Convolutional, pooling, and fully-connected layers make up CNN. A nonlinear ReLU activation function is utilized in a convolutional layer, followed by dropout regularisation. Multiple convolutions are used to create convolution layers, which are then utilized to extract input data. The convolution kernels of the convolution layer extract features by performing convolution operations on the input data. The FC layer of the fully connected layer receives flattened input data from the preceding layers. The classifying process is started at this moment. The dense layer with softmax is used to process the probability of the stress score and make the prediction.

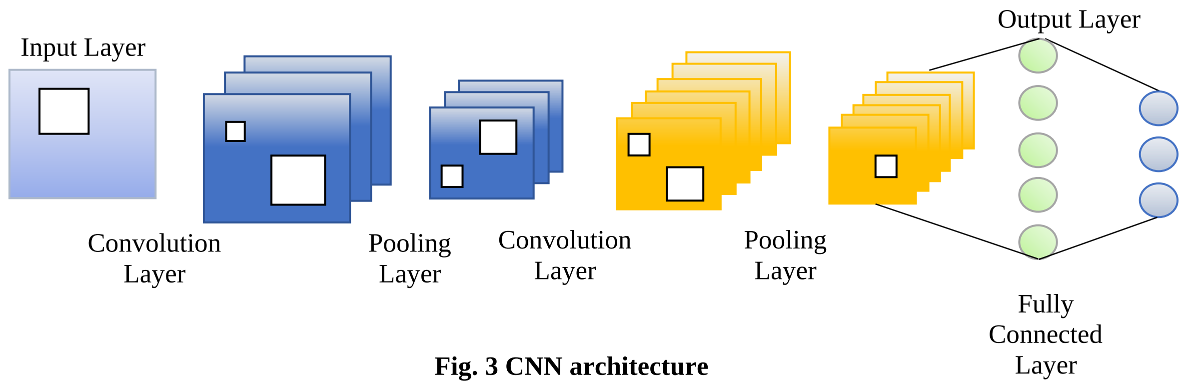

Fig. 3 CNN architecture

3.5. Wind Energy

It is widely known that wind energy is more variable and intermittent in nature compared to solar energy. In order to obtain the maximum benefit from the wind, it is very important to comprehensively analyze the variation and energy flux for the available wind speed data. Wind speed data is collected by the small metrological station in Shanghai Jiao Tong University using an anemometer and assessed using Weibull parameters, i.e., scale parameter (c) and shape factor (k), yearly average wind power density and monthly wind potential are computed to analyze the wind resource. The Weibull probability density function (PDF) in terms of wind speed can be described as

$$g(u)=\frac{l}{b}.\left(\frac{u}{b}\right)^{l-1} exp[-(\frac{u}{b})]^{l} \quad (l>0, b>0, u>0) \qquad (1)$$

$$g(u)=\int_0^u g(u)dv \qquad (2)$$

$$l=\left(\frac{\sigma}{\bar{u}}\right)^{-1.086}(1\leq l \leq 10) \qquad (3)$$

$$c=\frac{\bar{u}}{(1+1/l)} \qquad (4)$$

3.5.1. Energy Storage Modeling for Wind

A collection of storage attributes and a storage control strategy must be chosen to model the impact of energy storage on power quality. There were as few parameters as feasible employed in these simulations. Among the characteristics are maximum storage power, energy capacity, charge and discharge efficiency, and optimum state of charge.

3.5.2. Comparison of Traditional Appliances vs Smart Appliances

Traditional systems are outdated and ineffective as a result of the increasing electricity demand. The illustration below demonstrates a smart grid's fundamental distinctions and advantages over a conventional one.

Table 1. Comparison via Traditional Appliances vs Smart Appliances

	TRADITIONAL APPLIANCES	SMART APPLIANCES
Metering	Electromechanical, Solid state	Digital / Microprocessor
Communication	One-way and Local two-way communication	Global/integrated two-way communication
Customer Interaction	Minimum	Extensive
Generation	Centralized	Centralized and Distributed generation
Power Flow Control	Minimum protection, monitoring and control systems	WAMPAC, Adaptive protection
Monitoring	"Blind"	Self-monitoring
Restoration	Manual	Automated, 'Self-healing'
Operation & Maintenance	Check equipment manually	Monitor equipment remotely
Control	Minimum control system contingencies	Pervasive control system
Reliability	Estimated: prone to failures and cascading outages	Predictive: pro-active real-time protection and islanding
Topology	Radial	Network

4. Result and Discussion

The experimental arrangement of the proposed technique-based smart appliances was implemented using MATLAB. Accuracy, specificity, precision, and recall are the different metrics used to evaluate it. The proposed technique performance is compared with HGPDO, CNN, and ANN regarding accuracy, specificity, precision and recall. MAT LAB is used to run the simulation.

4.1. Performance Metrics

The effectiveness of the categorization strategy is assessed using the following statistical parameters as precision, recall, accuracy, specificity and sensitivity.

4.2. Accuracy

Accuracy is defined as the number of corrected predictions for all of the input samples. It is evaluated by,

$$Accuracy = \frac{TP + TN}{TP + TN + FP + FN}$$

4.3. Specificity

Specificity measures when the real condition is absent and an attack is classified negatively. It is evaluated by,

$$Specificity = \frac{TN}{TN + FP}$$

4.4. Precision

Precision, when the rate of false positives is large, offers an accurate assessment, and it is evaluated by,

$$Precision = \frac{TP}{TP + FP}$$

4.5. Recall

A model that produces no false negatives has a recall, and it is calculated by,

$$Recall = \frac{TP}{TP + TN}$$

Where TN, FN represents the true and false negatives and TP, FP denotes the true and false of the sample.

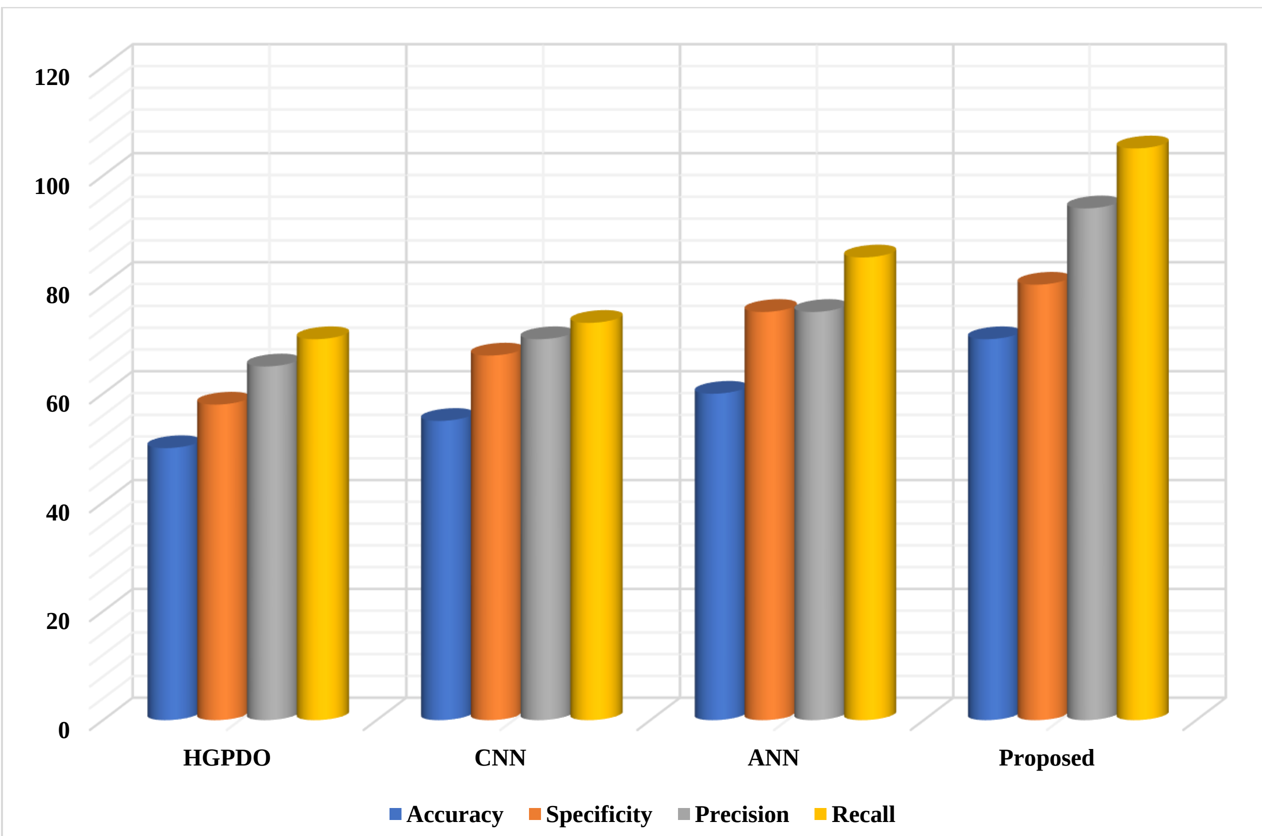

Fig. 7 Comparison via performance analysis

Fig. 7 shows a comparative result analysis of the proposed model. With respect to accuracy, Specificity, Precision and Recall while the HGPDO, CNN, and ANN systems have accomplished.

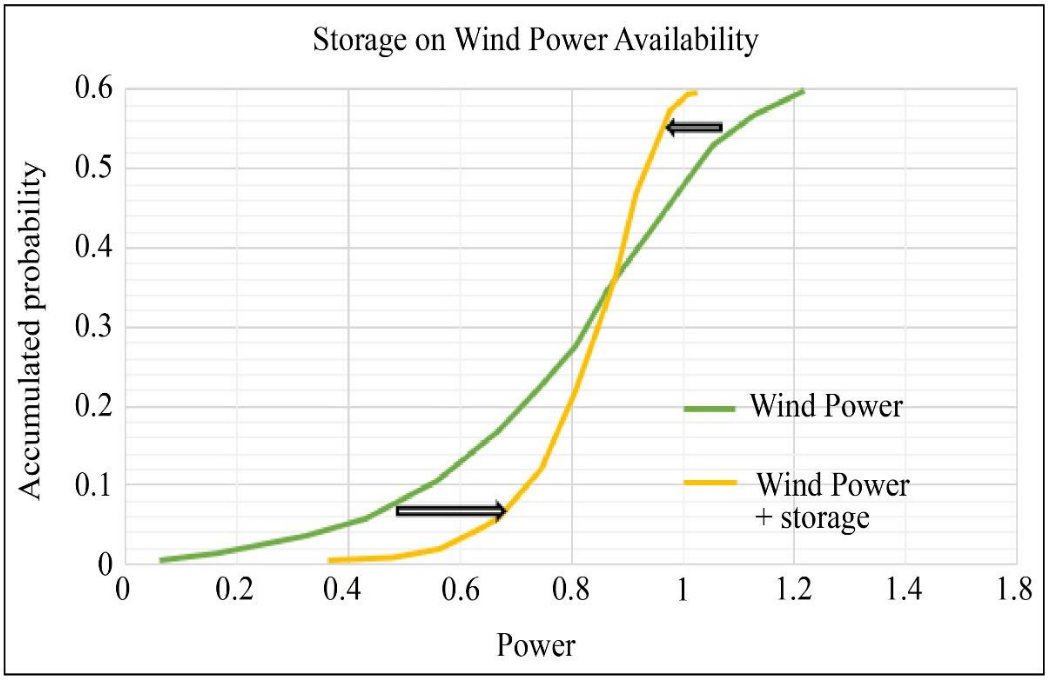

Fig. 8 Power via accumulated probability

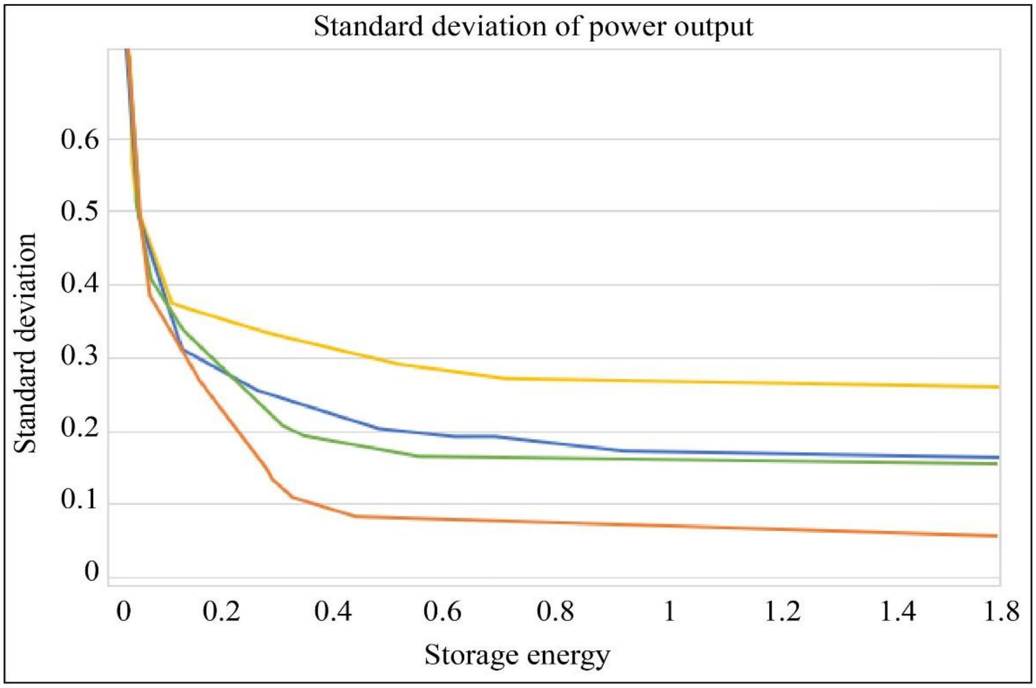

Fig. 9 Standard deviation of total output power

Figure 8: Change in the cumulative distribution of power output due to introducing energy storage in relation to wind power.

Fig. 9. Standard deviation of total output power from the combination of wind power and storage as a function of storage power and energy capacity. Data from a 2 MW wind generator during a 2000h period.

5. Conclusion and Future Enhancement

Customers may connect, control, and monitor their smart appliances, allowing them to track their usage and save time, energy, and money. To save time, money, and the environment, they can, for instance, adjust operating periods to accommodate individual schedules, use cheaper off-peak energy, or harness solar power to its fullest potential. In this study, smart appliances are used to save energy while considering the aforementioned concerns. A detailed comparative results analysis of some Deep Learning (DL) based Smart Appliances in terms of precision, Specificity, Accuracy and recall. The Convolution Neural Network (CNN) based Smart Appliances method outperformed. The suggested framework is compared with existing methods such as HGPDO, CNN, and ANN in terms of Accuracy, precision, Recall, and Specificity. According to experimental findings, the proposed technique extends smart appliances by 50%, 9.756%, and 26.829%, compared with HGPDO, CNN, and ANN Methods.

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