Review Integration of Artificial Intelligence with solar energy system

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***Abstract*—In the current energy scenario to meet the global energy demand has become challenging task. The energy demand is increasing day by day. The main hindrance in meeting up the current energy demand is the dependencies on nonrenewable source, limited reservoir of nonrenewable resources for generation of energy. The alteration from nonrenewable to renewable energy sources is pivotal to grapple with the increasing demand and handle handling various environmental issues arises with the burning of non-renewable energy sources. This review paper emphasis on the implementation of machine learning and deep learning methods with conventional solar energy system and analyze performance of solar energy system and optimization after implementing machine learning and deep learning methods of artificial intelligence with conventional solar energy system. The comprehensive analysis in this paper presents that that in spite of marvelous potential exhibit by implementation of machine learning and deep learning method with solar energy system some challenges such as data complexity, system integration and data interpretability are associated with the integration with solar energy system. The aim behind the whole study is to lay a foundation for future research and ensure continuous innovation, implementation of Artificial intelligence technology in solar energy system for gaining energy efficiency and leads future towards sustainable energy generation.**

***Index Terms*—Solar energy, machine learning, deep learning, energy efficiency**

I. INTRODUCTION

In order to gain energy independence this can only be possible by reducing reliance over nonrenewable sources. Renewable energy system for electricity generation is adopted rapidly in developed as well as under developing countries. The Reduction in the gap between demand and supply and reduce the emission of greenhouses gases releases during the burning of non-renewable energy sources during energy generation process. These are two factors stimulus for the transition towards the renewable energy system. Though right now it is bit challenging for policymakers to consider economic aspects associated in adaption of renewable energy.

Solar energy as a renewable source has gained global acceptance for energy generation. The main motivators for adapting solar energy for generation are environment safety, higher energy efficiency, reliability and to achieve energy independencies. Although some challenges such as resource availability, geographical disparity, accurate weather forecasting and expenditure required to integrate solar energy system with conventional system are also associated to overcome from the various challenges. associated with renewable energy system. Implementation of advance technology with renewable energy system is mandatory. Artificial Intelligence has rapidly grown in field. Artificial intelligence-based methods have shown excellent result in handling and analyzing complex data. Artificial Intelligence is capable in providing innovative solutions to address challenges associated with the system.

There are still some areas in world dealing with the problem of unavailability of power, voltage fluctuation, low voltage. To make energy accessible efficiently across the world is a challenging task with the current energy generation pattern. The aim of this paper is to present extensive perception and analysis of integration of solar energy system with current generation system. We thoroughly analyzed the implementation of solar energy system along with focusing on some crucial factors such as economic issues, installation cost, maintenance cost, resource availability, geographic location and underline the

productive outcomes of implementing advance technologies like machine learning and deep learning with solar energy system in terms of efficiency and reliability.

In this paper we tried to meticulously analyzed details of current methodologies which are in use and also the area of improvement. Our aim is to present conspicuous outlook that is crucial for researchers in making decisions for growth of solar energy system.

II. OVERVIEW OF MACHINE LEARNING AND DEEP LEARNING TECHNIQUES

In a short span of time Artificial Intelligence has become the integral part of various sectors such as health care, finance, manufacturing, retail etc. Machine learning and deep learning methods are the primal integrant in the area of artificial intelligence. The machine learning and deep learning model has an ability to handle large data sets and excellent computational capabilities. This paper scrutinizes to offer a comprehensive analysis about similarities and limitations between machine learning and deep learning techniques. Machine learning and Deep learning techniques are capable of handling large data set. Machine learning and deep learning techniques both are capable of handling large data sets. Machine learning techniques used statistical techniques and deep learning uses neural network approach for dealing with large data sets. Machine learning and deep learning methods are known for their dexterity in handling large volume of data sets, making prediction from analyzing data sets, provide new vision, provide new prognostication. Deep learning method is a fragment of machine learning techniques. Deep learning methods use neural network that shows excellent efficiency in handling unstructured data. Machine learning is a algorithm based approach. Regardless of immense capability, still artificial intelligence techniques are in under development state. In this review we meticulously present the consequences of implementing machine learning and deep learning in terms of increasing efficiency.

The machine learning and deep learning methods help in making effective prognostication of solar power outputs, Deep learning method effectively handle large volume of complex data. It gathers data from weather pattern and analyzes gathered data in weather forecasting. It also gathers record of energy consumption and helps in prognostication of energy requirement. This paper also draw attention towards the constraints associated in the domain of artificial intelligence. With the help of meticulously study our aim is to develop understanding that with the help of planned strategy the implementation of artificial intelligence techniques in solar system leads towards in achieving energy efficient system along with sustainable development.

III. ARTIFICIAL INTELLIGENCE IN FORECASTING RELATED WORKS

Machine learning and deep learning techniques are widely used for prediction analysis of solar energy. The building contributes to large amount of energy consumption and wastage also. So in order to reduce gap between supply and demand it is necessary to minimize energy wastage and minimize energy consumption. It needs exact information regarding electricity consumption pattern. Now days research is going in the implementation of machine learning and deep learning method in prognostication of building energy consumption.Deb.et.al discussed a monitoring building energy consumption using time series forecasting method. In this paper one pivotal point is the integration of time series prediction techniques with optimization method.[2] Walker. et.al has carried out hourly energy consumption by machine learning techniques. Random forest model has shown excellent performance in terms of accuracy and prediction of error.[3] Grinaldo.et.al uses combination of K Nearest neighbor algorithm with visual analytics for prediction of energy supply and demand. The outcome of this combined approach has shown more accurate result and helps in developing understanding about energy consumption and production pattern.[4] Lie.et.al. analyzed the performance of SVM algorithm in prognostication about energy consumption and pattern of consumption. The analysis has found SVM has proved to be effective and precise in differentiating between normal and abnormal pattern.[5] Kaytez.et.al used combined approach of ARIMA and least square SVM to develop hybrid model. This model is used to prognosticate long term power consumption in Turkey.[6] Hagh.et.al author used combined approach of SVM with faster clustering and artificial

neural network for developing hybrid model. This model used for prediction of power requirement for home appliances and monitoring peak demand. Fathi.et.al has underlined that ANN and SVR are most frequently used algorithm in prediction of energy consumption of building.[7] Hafeez et al. used modified mutual information, a factored conditional restricted Boltzmann machine and wind driven optimization model for prediction of short time load. Compared to other model shows improved result in accuracy and average run time.[8] The comparative study is shown in table 1-

Litterateur	Methods	Application	Outcome
Deb.et.al [2]	Time series forecasting method	In energy consumption of building	Hybrid models from the combinations of different method are effective
Walker. et.al [3]	Boosted Tree, Random Forest, SVM, ANN	Prediction of hourly electricity demand in buildings	In term of accuracy and error prediction Random Forest has shown better performance.
Grinaldo.et.al [4]	K Nearest neighbor with visual analytics	In prediction of supply and demand	Result accuracy
Lie.et.al.[5]	SVM	In analysis of consumption of energy in building	Efficiently differentiate consumption pattern
Kaytez.et.al [6]	ARIMA, LV-SVM	In turkey for long term power consumption	Hybrid model has shown higher accuracy.
Hagh.et.al [7]	Hybrid model (SVM, ANN)	In analysis of power consumption by home appliances	High accuracy
Hafeez et al [8]	Hybrid Model (MMI, factored CRBM, GWDO)	Prediction of short time load	Excellent performance in terms of accuracy, rate of convergence, runtime.

Table1: Comparison of machine Learning and deep learning methods in prediction

IV. PROGNOSTICATION OF SOLAR ENERGY SYSTEM

With the emphasis on use of solar energy the accurate prognostication of output power is pivotal. The solar power depends upon the intensity of solar rays. The more intensity of solar rays results the more solar power. The solar power output is tremendously affected by weather condition. So, there is a need of reliable weather forecasting method. The main problem our current system is facing in gathering the data regarding solar radiation. To address this problem machine learning and deep learning techniques-based models are implemented. This model provides accurate data for prediction of weather condition and monitoring cell position. Voyant et al. developed hybrid model by using neural netwok, SV regression with K Nearest neighbor and random forest method. Its analysis shows that combination of different machine learning techniques helps in getting accurate prediction.[9] Govindasamy et al. concluded that the experimental result of ANN algorithm better computational efficiency.[10] Alizamier et al. studied found that for error rate and accuracy grading boosting tree model has shown outstanding performance.[11] Srivastava et al. analyzed four algorithm based on machine learning for hourly prediction of solar radiation. The outcomes highlight that RF model is found to be more accurate and CART model has shown least accuracy.[12] Benali et al. presented in the paper that for solar radiation prediction during summer and winter RF model has shown highest accuracy but with this model prediction during summer and winter is bit difficult due to weather condition.[13]These studies represent distinct methodologies and effectiveness of various machine learning and deep learning methods in prognostication of solar radiation. Though from a

keen observation of these models reveals that some constraints are identified in models in terms quality of data, model complexity and computational problem. Different geographical location and season need more accurate and planned approach for prediction of solar radiation. Future research must focus on the improvement of models by considering local environment condition and use real time data for accurate prediction. The comparison is shown in table-2

Litterateur	Methods	Application	Outcome
. Voyant et al. [9]	NN, SV regression,K nearest and Random Forest	Solar Radiation prediction	Hybrid model developed can enhance prediction performance.
Govindasamy et al.[10]	ANN, SVR, General Regression NN, Random forecast	Effect of PM10 air pollution on solar radiation	ANN has shown high degree of accuracy and computational efficiency
Alizamier et al. [11]	Six machine learning based model including grading boosting tree model	Prediction of solar radiation in US and Turkey	In error rates and accuracy grading boosting tree has shown outstanding performance
Srivastava et al. [12]	RF, M5, CART, MARS	Hourly basis solar radiation prediction	RF is most effective than others and CART has least performance
Benali et al. [13]	ANN, RF, Smart persistence	Hourly basis solar radiation prediction	RF has better result in summer and winter

Table 2: Comparison of machine learning and deep learning method for prognostication of solar power

V. CONCLUSION

The review presented in this paper is the keen intersection of renewable energy system and the advance technologies such as Machine learning and deep learning. The extremity of adopting solar power is reinforcing by increased energy demand, environmental challenges, transition towards sustainable energy generation. Our comprehensive study reveals that the implementation of machine learning and deep learning technique with solar energy system has shown outstanding performance by achieving high energy efficiency, system reliability and predictability. The machine learning and deep learning techniques helps in energy management and managing stability of system. The study shows machine learning and deep learning methods plays significant role in performance analysis of operational parameter, maintenance schedules and in initial planning and design of solar energy system.This paper also addressed challenges associated with solar energy system due to inconsistency in energy source because of weather condition. It has concluded that machine learning and deep learning techniques integration with solar energy system can help in achieving sustainable development without comprising with efficiency. It has found that some complexities are associated with it but these complexities can be rectified by some research and innovation in this field. It is pivotal that along with advancement in technology future work and research must be carried out to make easily accessible of energy and remove all the constraints coming in a way to achieve high energy efficiency.

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