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Study the prediction of Solar Radiation through Machine learning Algorithm in different weather condition to Achieve Maximum Power

Sudhir Singh[1] Dr. Nagendra swarnkar[2]
1. Research scholar in electrical deptt,sgvu,Jaipur
2. Professor in Electrical Department, sgvu, Jaipur Rajasthan

Abstract

The integration of a large proportion of renewable energy reduces the reliabilityand stability of a power system. Renewable energy sources such as solar and wind are highly non predictive, making it difficult to maintain system stability with an unacceptably high proportion of renewable energy input. Solar power forecasting can be used to improve system stability by providing estimated future power generation to system control engineers. Machine Learning (ML) algorithms have demonstrated excellent results in time series forecasting and can thus be used to forecast power using weather conditions as model inputs. To forecast solar power, multiple machine learning, deep learning, and artificial neural network techniques are used. In this regression model, machine learning techniques such as support vector machine regression, random forest regression, and linear regression model were used, with the random forest regression outperforming the other two regression models in terms of accuracy.

Keyword

Machine Learning, Solar Radiation, Power, solar power forecasting, renewableenergy, solar power in Sri Lanka, machine learning for forecasting

Introduction

Renewable energy sources, such as solar, provide increased environmental benefits while reducing carbon footprint. Solar panels are a popular technology for capturing solar energy. Solar panel demand is increasing due to improvements in energy conversion efficiency, long-term financial benefits, andcontributions to reducing fossil fuel usage. Solar panels, on the other hand, require a constant supply of sunlight. This can be difficult in a variety of situations, geographies, and environments. [1] This paper employs a number of machine learning (ML) algorithms to forecast future values of solar radiation based on previously observed values and other environmental features measured without the use of complex equipment and with computationally efficient methods, allowing forecasting to take place on consumer premises.

Forecasting the output power of solar systems is necessary for the proper operation of the power grid or the optimal management of energy fluxes entering the solar system. Before forecasting the output of a solar system, it is critical to focus on the solar irradiance. Several methods exist for forecasting global solar radiation; the two major categories are cloud imagery combined with physical models and machine learning models.

Solar energy has many advantages, but the initial investment for installing solar panels is quite high, and not everyone can afford it. Unfortunately, this is a disadvantage of solar panels; however, as prices continue to fall, the future appears bright. Solar panels are currently relatively expensive; however, new government programmes and cutting-edge technology are lowering their cost.
[2] Despite being recognised as a significant source of potential energy production, photovoltaic cells are not widely used due to their low return on investment and high upfront costs. They are not widely used because of their high initial cost. [3] Because photovoltaic cells convert solar energy into electrical energy, the amount of solar energy produced each day influences thesize of the photovoltaic system in the same way that the amount of solar radiation influences the amount of electricity produced each day. Location, time, and weather patterns all have an impact on this. The power obtained per unit area from the Sun via electromagnetic radiation in the wavelength range ofthe solar cell in use is referred to as solar irradiance. [4]

Different weather conditions have different effects on solar panels. In the summer, the amount of energy consumed by the panel from the sun is significantly higher. However, in rainy and windy conditions, the energy consumed is significantly different. Because power generation is largely dependent on weather conditions, weather forecasting is taken into account. As a result, the amount of electricity generated on a given day is determined by solar irradiance, which is determined by a number of factors such as location, time, and weather patterns. [5] We focus on the problem of automatically generating models that predict renewable generation accurately based on National Weather Service forecasts (NWS). We experiment with a variety of machine learning techniques to develop prediction models using historical NWS forecast data and data generated by solar panels.

Estimating solar radiation determines how much energy the sun provides to a specific region. In photovoltaic and solar thermal power plants, this radiation is the primary energy source for conversion. The incident radiation is not constant and is affected by climatic data, resulting in erratic behaviour and changes in electrical energy production. This justifies the development of a tool for predicting and estimating incident radiation in order to forecast changes in photovoltaic generation system performance. [6]

Machine Learning Algorithms

Machine learning (ML) is a type of artificial intelligence that learns patterns from data without the use of explicit programmes or algorithms [7]. In ML models, two techniques are used: supervised and unsupervised learning. In supervised learning, the algorithm learns the rule that maps inputs to outputs by using a set of known inputs and their desired outputs [20]. The model will then be used to forecast new data. [7] Unsupervised learning algorithms are used to discover hidden structures in data inputs when the desired outputs are unknown.

Various researchers use Genetic Algorithm (GA) and Neural Network (NN) modelling approaches to forecast solar radiation. In their study, average atmospheric pressure and other weather-related data from the previous day is used as an input parameter to another NN. According to the literature, the NN model provides more accurate forecasting of solar radiations. [8] GA is better suited to survival of the fittest scenarios. Through mathematical equations, the physical model definition describes the physical state and dynamic motion of the atmosphere. GA-based algorithms are unsuitable for these types of physical models, and NN methodology necessitates massive amounts of input data, which may also include a few irrelevant parameters.

Machine learning models discover relationships between inputs and outputs even when representation is impossible; this property enables the use of machine learning models in a wide range of applications, including pattern recognition, classification problems, spam filtering, data mining, and forecasting. [9] Classification and data mining are particularly interesting in this domain because one must work with large datasets and machine learning models can handle pre-processing and data preparation. Following this stage, the machine learning models can be applied to forecasting problems. As previously stated, machine learning is a subset of artificial intelligence. It is concerned with the design and study of systems that can learn from data sets, allowing computers to learn without being explicitly programmed. The techniques listed below are used to forecast solar radiation.

A. Deep Learning

Deep learning is a subset of machine learning, which is simply a neural network with three or more layers. These neural networks attempt to mimic how the human brain functions, but fall far short of doing so, allowing it to "learn" from massive amounts of data. Deep learning is a type of machine learning that immitates the brain. [10] It could also be referred to as a large neural network. However, the concept is not limited to neural networks. Because the application of deep learning is well explained through neural networks, it is widely assumed that it is the largeneural network.

B. Decision Tree Method

A decision tree model is built using a branch hierarchy. Each route from the root node through internal nodes to a leaf node represents a classification decision rule. These 'if-then' rules can be used to express these decision tree pathways as well. Decision tree is a machine learning tool that supports decision making by using a tree-like model and identifies simple tree-like models that are easy to understand. A decision tree is made up of three types of nodes: decision nodes, chance nodes, and end nodes. [11] Breiman et al. introduced Decision Tree as a predictive modelling approach for classification and prediction tasks in 1983. To divide the problem search space into subsets, decision trees employ the divide and conquer technique. A decision tree is a tree with a question labelled as the root and each internal node. Each node's arc represents a different possible answer to the associated question. Each leaf node represents a prediction for a solution to the problem at hand. [12]

C. Generalized Learning Method

The ability of our model to respond appropriately to novel, previously unobserved data derived from the same distribution as the model is referred to as generalisation. In statistics, a generalised linear model (GLM) is a flexible generalisation of ordinary linear regression that allowsfor response variables with error distribution models other than a normaldistribution. [13] GLM generalises linear regression by allowing the linear model to be linked to the response variable via a link function and by treating the magnitude of each measurement's variance as a function of its predicted value.

Solar panels working

Photovoltaic cells in solar panels convert sunlight directly into electricity using asemiconductor, typically silicon. The term photovoltaic is derived from the Greek words for "light" (photo) and "electrical" (voltaic). When sunlight strikes photovoltaic cells, a portion of the energy is absorbed by the semiconductor. When this occurs, the energy loosens the electrons, allowing them to flow freely. [14] The flow of electrons is a current, and by placing metal on the top and bottom of photovoltaic cells, we can draw that current and use it externally.

Review of Literature

Narvaez et al. [15] developed a two-step methodology. It selects the best data source in the first step to improve Spatio-temporal resolution, and deep earning is used in the second step to forecast solar radiation [15]. The key parameters considered for forecasting solar radiation are geographical and meteorological variables of a specific location.

Sigauke[16] discussed the application of generalised additive models (GAMs) to the prediction of medium-term electricity demand using SA data. The variable selection in the study was done using Lasso (least absolute shrinkage andselection operator) via hierarchical interactions.

To model and forecast non-linear processes, Marwala and Twala[17] used autoregressive moving average (ARMA), neural networks (NNs), and neuro- fuzzy (NF) systems. They discovered that NF can model the system better than ARMA and NNs, while NNs outperform ARMA.

King et al. [18] proposed a genetic algorithm (GA) framework based on the 'negative load' and 'inclusive' strategies. They emphasised that because wind power costs are assumed to be zero for the 'negative load' approach, the results do not show the actual cost. As a result, the actual cost of wind power should be included in the 'zero-fee' strategy. They also discovered that using wind power in the economic load dispatch (ELD) computation affects cost, load volatility depicted by other plants, and reserve requirement due to the expectederror.

Objectives

- An overview of solar irradiation forecasting methods based on machinelearning approaches.

- Investigate solar radiation forecasting models;
- Investigate the relationship between temperature and power generation; and
- Investigate machine learning models.
- Investigate the operation of solar energy
- Investigate various types of solar radiation

Research Methodology

A research methodology is a universal approach to addressing a study subject through data collection, data evaluation, and study results. A research technique is a strategy for conducting a research study. Research is the systematic gathering and analysis of facts and information for the advancement of knowledge in any field. The study's goal is to use systematic techniques to solve intellectual and practical problems. The data used to prepare this paper are secondary in nature, gathered from various published resources. The information used to prepare this paper was obtained from various Indian websites.

Result and Discussion

The amount of sunlight that reaches any surface on Earth is determined by a number of factors, including geographical location, time of day, season, local landscape, and local weather. Because the Earth's surface is round, the angle of incidence of light on a given surface depends on the orientation, and the intensity depends on the distance that the light has to travel to reach the respective surface. [19] The radiation received by a surface has two components, one of which is direct and depends on the distance travelled by the rays. The other component is known as diffuse radiation, and it is depicted in fig.

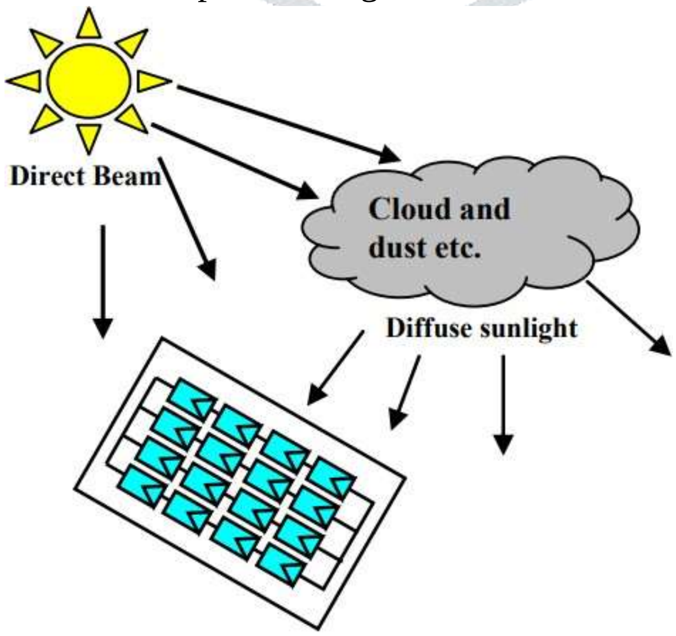

Fig. 1 Types of radiation from the sun

Photovoltaic cells Convert sunlight into direct current (DC) power. The charge controller controls the power from the solar panel, which is reversed when the panel is damaged. When sunlight is not available, the battery system is used to store electric power (i.e. night). [20] This system is linked to an inverter, which converts direct current (DC) to alternating current (AC) (AC).

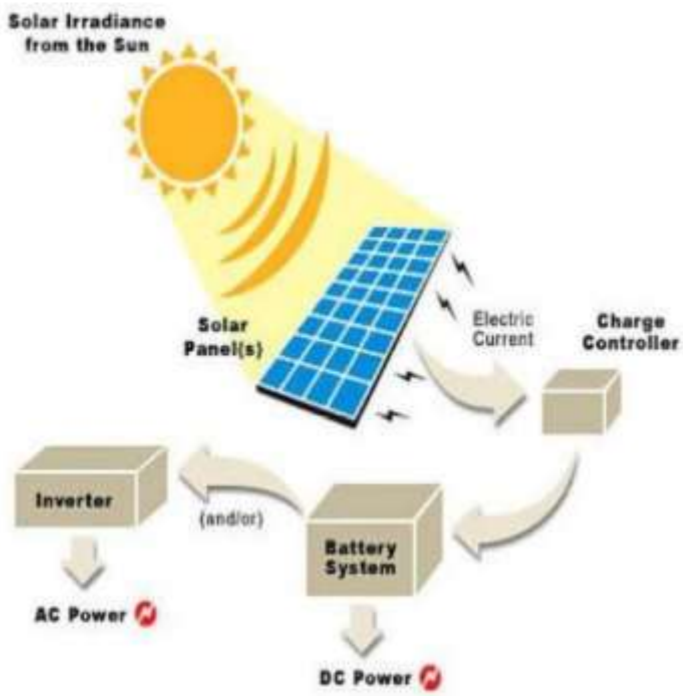

Fig. 2 Working of solar energy

Data pre-processing, model building, and model prediction are all part of Flow of Solar Radiation. Four steps were involved in data pre-processing: data quality control, dataset partitioning, data scaling, and variable selection. [21]

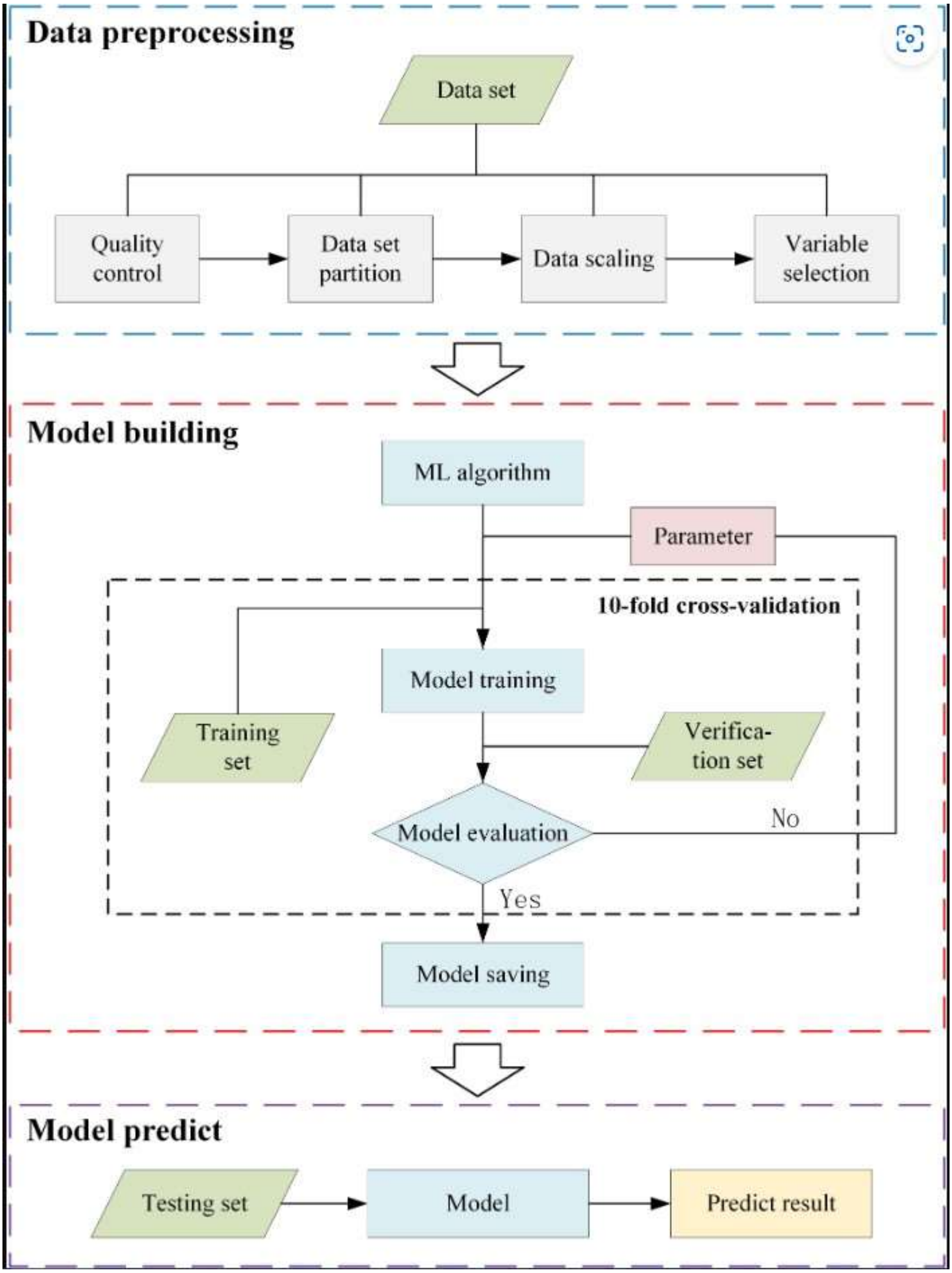

Figure 3 depicts the flow chart of the machine learning models used toestimate solar radiation.

Figure 4 depicts how much power is generated in different weather conditions, with the x axis representing power generated and the y axis representing distance from solar noon. [22] Solar noon occurs when the Sun passes through a location's meridian (an imaginary line that runs from the North Pole to the South Pole along the Earth's surface.) and ascends to its highest point in the sky.[23]

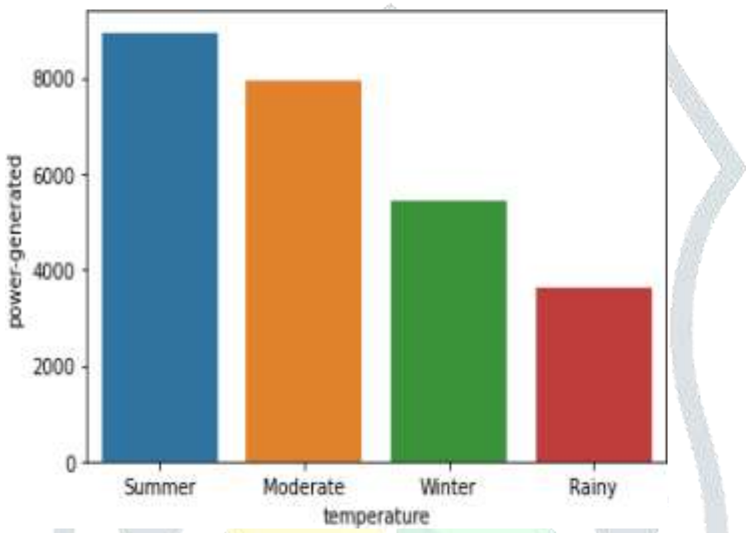

Figure 5 shows the results of different temperature analyses of how much poweris generated.

As shown in Fig.6, accurate site adaptation and solar radiation forecasting models are available.

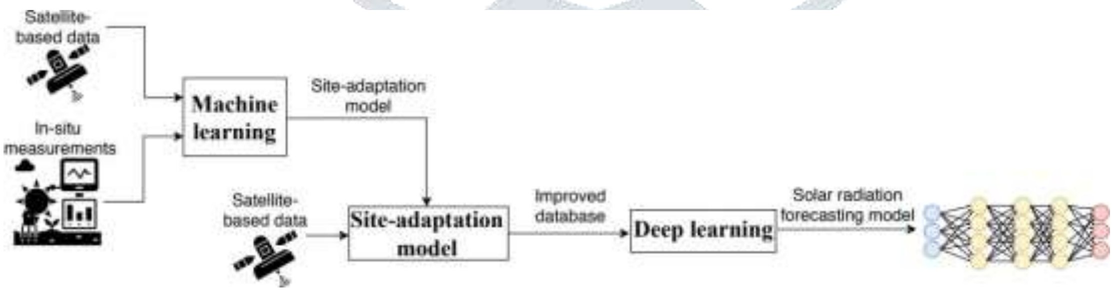

Figure 6 depicts the proposed method for developing an accurate solar radiation forecasting model: Machine learning is used to develop a site-adaptation after collecting and pre-processing solar radiation data from satellite-based data andin-situ measurements. [24] The site-adaptation model is then used to create an improved database of solar radiation, from which a solar radiation forecasting model is developed using deep learning. [25]

Conclusion

The generation of electricity at night is one of the most critical innovative options. Solar energy technologies, based on current technology, are in a cable to provide adequate energy to rising energy needs, and when compared to nonrenewable technologies. As a result, innovation is critical in the solar energysector in order to maximise efficiency. As a result, this paper presents innovativeideas and future perspectives on solar energy technology. The prediction model(Deep Learning Method) can accurately forecast Global Solar Radiation based on hydrological, geographical parameters, and so on, demonstrating the power of machine-based prediction in solving one of the industry's oldest problems. However, the other prediction model provides less accuracy with future prediction data because different machine learning techniques have different prediction mechanisms, but machine learning approach is better than any other traditional methods and the ease of future data findings and the time required for prediction work is much more frequent than other methods.

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