SOLAR POWER FORECASTING

Software Requirement Specification

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1. Introduction

1.1 Purpose

The main objective is to benchmark different forecasting techniques of solar PV panel energy output. Towards this end, machine learning and time series techniques can be used to dynamically learn the relationship between different weather conditions and the energy output of PV systems. Four ML techniques are benchmarked to traditional time series methods on PV system data from existing installations. This also required an investigation of feature engineering methodologies, which can be used to increase the overall prediction accuracy

1.2 Document Conventions

The document is prepared using Microsoft Word 2016 and has used the font type "Times New Roman". The fixed font size that has been used to type the document is 14pt with 1.5 line spacing. It has used the property of bold to sets the headings of the document. Standard IEEE template used to organize the appearances of the document and its flow.

1.3 Intended Audience and Reading Suggestions

This project is a prototype for the Solar Power Forecasting and it is restricted within the college premises. This has been implemented under the guidance of college professors. This project is useful for predict the power consumption in future.

1.4 Product Scope

*--- **Advantage-** Solar power forecasts are used for efficient management of the electric grid and for power trading. As major barriers to solar energy implementation, such as materials cost and low conversion efficiency, continue to fall, issues of intermittency and reliability have come to the fore.*
*--- **Goal-** The main objective is to forecast the future power using Machine Learning and Time Series Modeling techniques.*

1.5 References

[1] Kesh Bahadur Pun, "SHORT TERM FORECASTING OF SOLAR POWER WITH MACHINE LEARNING AND TIME SERIES TECHNIQUES", December, 2020, pp.
[2] Authors' name(s),"Paper Title," Proceedings of Conference Name, Place, Date, pp.
[3] Authors' name(s), Book Title, Edition No. Publisher, Year, pp.
*[4] **https://machinelearningmastery.com/time-series-forecasting-methods-in-python-cheat-sheet/**, "**11 Classical Time Series Forecasting Methods in Python (Cheat Sheet)**".*
*[5] **https://schooltutoring.com/help/solar-energy-and-its-applications/**, Solar energy and its Application.*
*[6] **https://freedomsolarpower.com/blog/7-uses-of-solar-energy**, Uses of solar energy.*
*[7]**https://www.researchgate.net/publication/335880904_Applying_Data_Science_to_Improve_Solar_Power_Production_and_Reliability**. Problem Domain.*
*[8] **https://medium.com/@chenjing.claire/https-medium-com-chingchen-17-data-analysis-report-solar-powered-house-7c915ac10132**. System Domain.*

2. Overall Description

2.1 Product Perspective

Time series forecasting is a technique for the prediction of events through a sequence of time. The technique is used across many fields of study. The techniques predict future events by analyzing the trends of the past, on the assumption that future trends will hold similar to historical trends.
Time series forecasting is performed in a variety of applications including:

- *Weather forecasting*
- *Earthquake prediction*
- *Pattern recognition*
- *Signal processing*
- *Control engineering, etc.*

Time series forecasting is sometimes just the analysis of experts studying a field and offering their predictions. In many modern applications, however, time series forecasting uses computer technologies, including:

- *Machine Learning*
- *Neural Network, etc.*

2.2 Product Functions

It'll predict the power consumption in future. In response to many factors, including economics, global warming and climate change, electric power generation has been shifting towards renewable sources. There is no doubt that solar energy is one of the chief sources of renewable energy. Solar energy can be directly converted into electrical energy using photovoltaic (PV) cells. Extensive research and increasing use of the PV cells to generate utility level electricity is driving the drop in price that can be easily seen by the price difference of PV panels between 2010 and 2018, which decreased by 74% during that period.

2.3 User Classes and Characteristics

Time series forecasting is a technique for the prediction of events through a sequence of time. The technique is used across many fields of study. The techniques predict future events by analyzing the trends of the past, on the assumption that future trends will hold similar to historical trends. So, after train the Solar Power Forecasting model, we'll deploy the model using the Power BI or Tableau tool. Power BI and Tableau are two important Business Intelligence (BI) technologies for the collection, integration, analysis, and presentation of business information. They help you perform data analysis, data manipulation, and data visualization to make sense of business data and draw insights.

2.4 Operating Environment

Operating environment for the airline management system is as listed below:-

- *Power Bi or Tableau*
- *Google Colab*
- *Jupyter Notebook*
- *Operating system: Windows.*
- *Skills : Python, Machine Learning Techniques, Time Series Techniques and Neural Network*

2.5 Design and Implementation Constraints

We have selected several established machine learning models, LSTM based Neural Metwrok and a time series prediction model. These models are ARMA, ARIMA, SARIMA, FACEBOOK PROPHET, etc. The focus will be to study and compare the results of standard machine learning techniques and a time-series technique for short term (1 hour - 1 day) forecasting. The main aim is to investigate the performance of kernelized machine learning techniques rather than to develop any specific machine learning technique.

2.6 User Documentation

- *AI Engineering (YouTube Channel): https://youtu.be/-r7wB9DJtiU*
- *Krish Naik (YouTube Channel): https://www.youtube.com/user/krishnaik06*
- *towardsdatascience.com: https://towardsdatascience.com/an-end-to-end-project-on-time-series-analysis-and-forecasting-with-python-4835e6bf050b#:~:text=Time%20series%20forecasting%20is%20the,retail%20sales%20in%20this%20post.*
- *R Core Team. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria, 2013. ISBN 3-900051-07-0.*
- *W. N. Venables and B. D. Ripley. Modern Applied Statistics with S. Springer, New York, fourth edition, 2002. ISBN 0-387-95457-0.*
- *Peter J. Brockwell and Richard A. Davis "Introduction to Time Series and Forecasting." Springer, 3rd edition, 2016.*

3. External Interface Requirements

3.1 User Interfaces

- *Back-end technology: Python, Machine Learning Techniques, Time Series Modeling, Neural Network*
- *Front-end technology: Power BI / Tableau*
- *Environment: Google Colab, Jupyter Notebook*

3.2 Hardware Interfaces

- *Windows*
- *GPU*
- *I3 or above*
- *4 GB Ram (If System contains SSD, then training will be faster)*

3.3 Software Interfaces

Following are the software used for the flight management online application.

- *Jupyter Notebook*
- *Python*
- *Libraries: Scikit Learn, Tensorflow, Keras, Matplotlib, Seaborn, Pandas, Numpy, statsmodel, pmdarima, facebook-prophet, etc.*
- *Google Colab*

3.4 Communications Interfaces

We'll deploy the project on the cloud. The project supports all type of web browsers. If the project is not on cloud then it will run only in local system (Google Colab or Power BI).

4. System Features

- *System Feature: Name of the feature.*
- *Priority: Indicate the priority of the feature to the user whether it is of High, Medium, or Low.*
- *Description: Provide a short description of the feature*
- *Action/ Response Sequences: List the sequences of actions required to be done in order to use this feature.*
- *Result: List the system responses of this feature.*
- *Functional Requirements: List the software modules required to carry out the function provided by the feature.*

4.1 System Feature 1

This section illustrates the functional features using the following template:

4.1.1 System Feature

Solar Power Forecasting

4.1.2 Priority

High

4.1.3 Description

Forecast the future power consumption.

4.1.4 Action

This module is activated after the user provides a query (topic, service or a product) or following the activation of the hot topic module.

4.1.5 Result

The system shows the results of the search of a query or the output of the hot topic module associated with the time series forecasting of power consumption.

4.1.6 Functional Requirements

A focused crawler, preprocessing module, time series, hot topic module and power forecasting visualization module.

5. Other Nonfunctional Requirements

5.1 Performance Requirements

As for this prototype version we will keep on detecting if the system crashed, hanged or an operating system error occurred. Also detecting the performance of the system in terms of the efficiency of integration of the different components

5.2 Safety Requirements

For the safety requirements nothing but an operation of weekly backups for the data base should take place.

5.3 Security Requirements

- ***Fooling the System:*** *One of the most common attacks on machine learning systems is to trick them into making false predictions by giving malicious inputs. Simply put, they are optical illusions for machines, which show them a picture which does not exist in real world and force them to make decisions based on that.*

- ***Data Poisoning:*** *Machine learning systems depend on data for learning purposes. That is why it is important for businesses to ensure reliability, integrity, and security of that data otherwise, you might get false predictions.*

- ***Data Privacy and Confidentiality:*** *As mentioned before, machine learning algorithms use data for training and learning. Ensuring privacy and confidentiality of that data especially when it is built right into the machine learning model is critical. Hackers can launch data extraction attacks that can fly under the radar, which can put your entire machine learning system at a risk.*

5.4 Software Quality Attributes

- ***CORRECTNESS:*** *The degree to which a system is free from faults in its specification, design, and implementation.*
- ***MAINTAINABILITY:*** *The administrators should check*
- ***REUSABILITY:*** *The ease with which users can learn and use a system.*
- ***Efficiency:*** *Minimal use of system resources, including memory and execution time.*
- ***Reliability:*** *The ability of a system to perform its required functions understated conditions whenever required — having a long mean time between failures.*
- ***Accuracy:*** *The degree to which a system, as built, is free from error, especially with respect to quantitative outputs. Accuracy differs from correctness; it is a determination of how well a system does the job it's built for rather than whether it was built correctly.*

5.5 Business Rules

Indian states are slowly adopting new forecasting rules that will force solar power plant operators and regional load dispatch centres (RLDCs) to provide more frequent and accurate projections of power production or face penalties.

6 Other Requirement

Appendix A: Glossary

- *it covers all the requirements that are actually expected from the system.*
- *there are no conflicts between any set of requirements. Examples of conflict include differences in terminologies used at separate places, logical conflicts like time period of report generation, etc.*
- *It exists a specific technique to quantifiably measure the extent to which every requirement is met by the system.*