Fusion wind and solar generation prototype design with Neural Network

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Abstract. Wind and solar power are the most common renewable resources of energy and their usage for power generation is quickly growing all over the world. However, both wind and solar power are difficult to predict manually due to every time changes in weather condition; therefore, power output of wind and solar is associated with some uncertainty. A reliable wind-solar day ahead load prediction with neural network was proposed to support a small microgrids system. All the system performance measurement such as sensitivity, specificity and accuracy give higher than 90%.

1. Introduction
Nowadays, electrical distribution or grid are mostly centralize in order to transfer generating power between big power plant towards end users, therefore, decentralized of production unit is highly expected to increase significantly, also, in accordance to increase of electricity transfer amongst grids at different level, penetration of renewable energy will may improve power flow and provide a more efficient grid management but the challenges of grid operator is to synchronize the energy demand with energy supply by renewable energy power generation system [1]-[4], therefore interest in using artificial neural networks (ANNs) for power generation forecasting has gain lot of attention to tackle such challenges.

2. Previous Work
Renewable energy generation brings new views to the power and energy system while the variability requires some degree of flexibility and reliability from the whole system however, one famous method employed by researchers is by using adequate forecasting techniques applied to both generation and consumption for artificial intelligence (AI) approach and statistical approach, high time series data consisting of weather prediction and the output of power from past [5]-[6].

The famous historical and physical method learning model is the artificial neural network; however, this method has found to have large number of uncontrollable factors such as the luminosity, number of consumer presence in the building and unexpected external temperature or wind condition, makes the forecasting of energy consumption a difficult task.

In order to get the highest benefit from the deployment, generation of power using fossil fuel unit has to kept as low as possible [7]-[8], several study has been carried out on electrical energy forecasting problem such as studying of correlation between electrical consumption of lights and solar radiation, three different forecasting method was approach in this method which include support vector regression, multi-layer the ANN and linear regression method, the final study analyzed using real time collected
data in campus of the polytechnic of Porto, this data kept increase the whole day and start again in accumulation in the next day [3], since most data collection might resulted from large amount of uncontrollable factor, utilization of real time set of data provide unique set of data that is useful for analysis procedure.

Therefore next phase of this project will provide the design concept, the implementation and testing of the proposed neural network techniques using skills and information gathered from previous researcher.

3. Overall System

3.1 Prototype Design
The prototype of the design is shown in Figure 1, this is mainly for energy data collection and display purpose, the circuit comprises of solar panel, wind turbine, hybrid charge controller, current sensor, voltage sensor circuit, battery, Arduino Mega and personal computer that is install with MATLAB.

![Hardware Prototype](Figure 1. Hardware Prototype)

Based on the constructed circuit, as shown in Figure 2, Arduino MEGA is connected to PC using serial communication in order to send current and voltage data to MATLAB for power calculation, the solar panel and the wind turbine is connected to charge controller, this charge controller have the capability to combine both energy to a single output energy and use it to power load and store into battery, however, the battery is a 12V also connected to charge controller, the charge controller have a load output, this is then connected to a load using light bulb, this load is circuited with a current sensor in series.

In order to measure the amount of current flowing through the load as energy consumption, there is a voltage sensor using voltage divider circuit based on 11K ohms resistor and 1K ohms resistor, this is connected in parallel to battery to measure the voltage of battery to load while both the output of the current sensor and the voltage sensor connected to microcontroller A0 and A1 respectively, this are analogue which will then convert to digital signal by microcontroller using MATLAB software while multiplication of collected voltage and current data will result to power consumed by the system.
3.2 Data Collections
A short terms wind and solar power forecasting using feed forward back propagation neural network is presented, first approach is to design and construct a wind-solar power generating system, the basic data source for wind-solar power will be historical data measurement record and recorded data. Current, voltage and power were taken. All three data was taken 24 hours per day for 6 months from 1 January 2020 until 30 June 2020.

3.3 GUI and Artificial Neural Network Construction
ANN process can be done using different method or software tools, for the ANN construction, this project utilizes Neural Network Toolbox, and this perform in three major different stages, these are training, verification and operation and all this staged simulate using Neural Network Toolbox located in MATLAB. In order to implement the training stage, set of data gathered as explain earlier, this is to allow ANN familiar with wind-solar system characteristics based on diverse condition. There are several ways of doing this but the suggested setting from MATLAB is 70% ANN training of the total data, 15% for verification and 15% for testing while the simulation intends to use this whenever MATLAB Neural Network Toolbox is approach as shown in Figure 3.
The neural network training goal set to 0 in order to ensure zero tolerance to the computational error of the network, in this construction, the transfer function utilize include log-sigmoid or tan-sigmoid in the hidden layer neuron and the function used in the output layer is purelin function so that the output value can be constrain. In using the toolbox, the learning function utilize is the default steepest gradient descend method, therefore, Levenberg-Marquardt learning function utilize because it is better rate when compare to other available function.

4. Results and Discussion
Table 1 shows the average performance results for every 24. The proposed method has proven with minimum sensitivity, specificity, and accuracy of 90.000%, 90.033 and 90.073% respectively. Meanwhile, the highest sensitivity is 99.166%, follow by the best specificity 99.117 and 99.000% for the accuracy results. To ascertain the performances provided in Table 1, the performances of the proposed method are further evaluated by computing the time process. The performance of the time process that have been obtained based on our model have provided good results with 0.007s.

| Hours | Sensitivity | Specificity | Accuracy | Time Taken (s) |
|-------|-------------|-------------|----------|----------------|
| 1     | 96.666      | 98.611      | 96.666   | 0.317          |
| 2     | 95.666      | 94.611      | 96.774   | 0.162          |
| 3     | 95.000      | 97.916      | 99.000   | 0.833          |
| 4     | 99.000      | 97.916      | 95.238   | 0.017          |
| 5     | 97.000      | 96.250      | 91.706   | 0.409          |
| 6     | 91.666      | 96.527      | 91.666   | 0.529          |
| 7     | 90.000      | 95.138      | 93.627   | 0.016          |
| 8     | 98.333      | 97.916      | 98.039   | 0.099          |
| 9     | 99.166      | 91.764      | 90.277   | 0.086          |
| 10    | 90.277      | 97.156      | 95.833   | 0.007          |
| 11    | 96.660      | 98.611      | 96.666   | 0.793          |
| 12    | 96.000      | 97.638      | 94.487   | 2.120          |
| 13    | 93.333      | 93.055      | 84.848   | 0.833          |
| 14    | 96.666      | 91.666      | 83.333   | 3.750          |
| 15    | 98.666      | 97.916      | 95.341   | 3.444          |
| 16    | 91.333      | 96.388      | 91.408   | 3.343          |
| 17    | 96.666      | 95.833      | 90.625   | 0.018          |
| 18    | 96.666      | 98.611      | 98.666   | 0.066          |
| 19    | 94.583      | 96.176      | 93.333   | 0.052          |
| 20    | 93.750      | 99.117      | 93.039   | 0.015          |
| 21    | 93.333      | 95.138      | 88.888   | 0.257          |
| 22    | 95.000      | 95.139      | 89.065   | 0.147          |
| 23    | 98.333      | 90.033      | 90.073   | 0.827          |
| 24    | 90.972      | 81.944      | 90.242   | 0.955          |

5. Conclusion
The system achieved around 90% to 99% performance and proves it is reliable. Therefore, it can be concluded that the proposed work is successfully implemented and tested while the project developed is very useful for energy monitoring, power management and hourly energy forecast.
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