AIMS 2021 Conference

28-30 April 2021

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INTERNATIONAL CONFERENCE
Artificial Intelligence and Mechatronics Systems
28-30 April 2021

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IEEE Indonesia CSS/RAS Joint Chapter

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WELCOME SPEECH FROM GENERAL CHAIR OF AIMS 2021

On behalf of the organizing committee of the 2021- International Conference on Artificial Intelligence and Mechatronics Systems (AIMS 2021), we would like to welcome with great pleasure, all delegates to this virtual conference.

As we all know, at the moment, we are facing a situation that has never happened before, the Global Pandemic caused by Coronavirus Disease of 2019 and this issue has affected the lives of people globally, including the lives of academics in education, but this phenomenon must not stop us all, we must face this new challenges

Being held in this April 29, 2021 virtually with the organizer located in Bandung, this event is organized by IEEE Indonesia Section CSS/RAS Joint Chapter; Department of Electrical Engineering, Universitas Padjadjaran, Indonesia and Department of Mechatronics and Biomedical Engineering, Air University, Islamabad, Pakistan and also co-organized by IEEE Indonesia VTS/ITSS Joint Chapter, IEEE Indonesia IMS/ITS Joint Chapter, IEEE Robotics & Automation Society Pakistan and Faculty of Technology & Computer Science, Universitas Prima Indonesia

The AIMS 2021 have attracted many academicians, scientists, engineers, postgraduates, and other professionals from many countries. These conferences aim to promote interaction among engineers, researchers, and scientists active in the related areas. The events are intended to provide a high-level international forum to present, to exchange, and to discuss recent advances, new techniques, and applications in the field of knowledge discussed in this conference.

In total, 138 articles were submitted and 96 articles were received to be presented in this conference, consisting of various countries, Korea, Singapore, Malaysia, China, Pakistan, and also from our beloved country, Indonesia.

Our special thank also goes to all individuals and organizations such as the international program committees (IPC), the conference organizers, the reviewers, and the authors, for their contribution in making AIMS 2021 not only a successful international conference but also as a memorable gathering event.

We are also grateful for the support of the publication services, All Accepted & presented papers (virtual) will be submitted to: IEEE Xplore Digital Library, and other several journal for selected papers.

We hope that it should give you a beautiful memory in addition to new insights and friends gathered during the conference, we are truly grateful for your contribution and interest and hopefully all of us will get pleasure from AIMS 2021.

Thank you.

Arjon Turnip, Ph.D
Chair of Organising Committee AIMS 2021

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Renewable Energy Generation Forecasting on Smart Home Micro Grid using Deep Neural Network

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***Abstract*— The implementation of smart grid on a micro scale in this study was for household electricity fulfillment needs. The use of renewable energy sources such as solar power will be integrated through a smart grid so that households can become independent in providing electricity and not depend on state electricity. Besides, it can also reduce monthly electricity costs when integrated with the state electricity network. Smart Micro Grid also enables the availability of energy management services such as monitoring, prediction, forecasting, scheduling and decision-making that was supported by some technologies such as artificial intelligent, smart sensors so that consumer use of electricity was more efficient. In this research, the forecasting method developed using the Deep Neural Network (DNN) and the Gate Recurrent Unit (GRU) as the architectural model. The GRU model was chosen because it has better performance compared to other models, namely LSTM, Auto-LSTM, Auto-GRU with MAE and MSE values of 0.0342 and 0.00245.**

Keywords—Renewable Energy, Forecasting, Smart Home, Micro Grid, Deep Learning, Gate Recurrent Unit

I. INTRODUCTION

Increasing the capacity to supply electrical energy was very important and carried out massively by various countries in the world. This was done to respond to the increasing demand for electricity in the industrial sector, commercial and office buildings as well as housing. Currently, renewable energy development was being actively implemented in various countries, including Indonesia. Renewable energy technology was a good solution because of the potential for unlimited energy availability and safety. This renewable energy will be converted into electrical energy so that it can reduce dependence on state electricity. This technology provides benefits in the form of reduced electricity costs and reduced carbon emissions.

Photovoltaic (PV) technology was one of the most commonly used renewable energies. This technology will convert solar energy into electrical energy. The application of PV technology on the Smart Home Micro Grid (SHMG) can allow the integration of energy sources from state electricity with solar energy. The use of this technology was highly dependent on the presence of solar radiation, environmental temperature, weather conditions and geographic location. To maintain the availability of electricity supply to consumers, it was necessary to control the use of electricity sources from the sun and utility networks through the forecasting process of the availability of renewable electrical energy that will be produced in the future.

In this research, the forecasting method will be developed using Deep Neural Network (DNN) to predict solar power generation. This paper consists of five chapters, including chapter one discusses the background, chapter two discusses related research, chapter three discusses solar power generation forecasting methods, chapter four discusses the analysis of experimental results, chapter five contains conclusions

II. RELATED WORKS

Renewable energy was an important solution to increase the capacity of electricity supply with unlimited availability and safety and helps reduce carbon emissions in the air. PV systems were most commonly used and many researchers were developing the use of PV to become a renewable energy source [1]. The process of integrating PV into the power grid was equipped with an energy management system so that it can monitor and control the performance of the energy supply system and can also predict the generation of electrical energy from the PV system so that the electricity supply becomes stable [2]. The process of predicting the generation of solar energy was very dependent on weather conditions which can change at any time so that it becomes a challenge in this research. Therefore, it was necessary to develop appropriate machine learning methods in order to produce valid and accurate predictions.

Several researchers have developed forecasting methods for solar power generation. Person [3] performed solar energy forecasting using a gradient boosted regression trees model. Tang [4] proposed a forecasting model using the Lasso approach. Researchers [5] [6] [7] used a deep learning method consisting of several neuron network structures, such as LSTM, auto encoder, deep belief network and subsequently compared to ANN. This study uses a deep learning approach with a neuron network structure that will be compared with the high prediction accuracy such as GRU [8], LSTM [9], Auto GRU [10] and Auto LSTM [11] so that the exact neuron structure can be found for use in deep learning.

III. Renewable Energy Generation Forecasting

The existence of houses that still rely on conventional power plants that were sourced from fossil fuels can be possible to be integrated with non-fossil power plants that utilize renewable energy, for example solar power plants. Smart home equipped with appliances and home area network can be upgraded to form a grid for energy supply. Smart micro grid was a grid for energy supply in the home area that allows integration of the two energy sources. Through this micro grid, there will be automatic coordination and control in the use of energy supplies. Micro grid response occurs when the sensor detects that the energy supply from the solar panel was in optimal condition so that the electricity supply switches to that source. Figure 1 below shows a SHMG that has been installed.

Fig. 1. Smart Home Micro Grid Installation

The developed IoT module has been implemented on a grid to support the monitoring process on SHMG in obtaining and transferring the data needed to carry out PV generation predictions. This module was made based on the circuit design shown in Figure 2. In this IoT module, the data transfer process was carried out using WIFI access. In addition, this module was also equipped with several sensors, namely temperature, humidity, voltage and current sensors. Furthermore, this grid was also equipped with a data logger module to obtain electrical data for both DC and AC. In the DC data logger, the measurement process was carried out to obtain electrical data generated by solar panels and on batteries. Furthermore, in the AC data logger, the measurement process was carried out to obtain electrical data on the grid after passing through the inverter. Figure 2 below was a number of modules installed on the grid.

(a) (b) (c)

Fig. 2. IoT and Monitoring Module. a) IoT Module, b) Data Looger AC Module, c) Data Logger DC Module

The energy management system on the smart home micro grid has several stages, namely: data monitoring, data analysis, forecasting, optimization and control. Data related to environmental conditions, batarai, weather, and others were carried out through a monitoring process. Some of the sensors that have been installed on SHMG for monitoring purposes include power sensors from solar panels, temperature and humidity sensors, solar radiation sensors and battery sensors. The data resulting from this monitoring process was usually still in the form of raw data so that initial processing must be carried out in the form of noise filtering, discretization, normalization, and others. The data analysis stage was carried out to obtain data in the form of information using the machine learning method. Furthermore, the results of the data analysis process were used for applications in energy management systems including prediction, forecasting and regression applications and others.

SHMG has an energy source that was not only from state electricity but also from renewable energy, namely solar energy which was integrated with each other. Utilization of solar energy uses a photovoltaic system that converts solar energy into electrical energy. The electric power generated from this conversion process depends on weather conditions and the temperature of the surrounding environment. Besides, it was also influenced by the materials used and the geographical location of the solar panels. In this study, modeling forecasting energy originating from solar energy will refer to weather conditions in the form of time series.

The weather time series data can then be modeled for the solar PV power forecasting process in the form (x1, x2, ..., xn). The forecasting process was carried out to predict day futures. Furthermore, this study maps historical weather data and solar PV power prediction [7] [10] for the next day as shown in Formula 1 as follows

$$\hat{y} = f(x_1, x_2, \ldots, x_n) \quad (1)$$

Where,

$\hat{y}$, represents the predicted solar PV power
f, states the weather history data mapping function
x, represents the weather parameter
n, represents the number of weather parameters

The weather parameters used in the solar PV power forecasting process were represented by n = 3, which means there were 3 weather parameters, namely::

- Irradiance (kW/m2)
- Air Temperature (°C)
- Panel Temperature (°C)

This study uses a deep learning approach with several models implemented in solar PV power forecasting applications, including LSTM, GRU, Auto GRU and Auto LSTM. Long short-term memory (LSTM), also known as a recurrent neural network (RNN), was a specialized neural network with repeated connections between neurons that allow it to learn from current and previous information to find solutions. In contrast, RNN will have difficulty getting information when two cells were far apart. LSTMs have special neurons known as memory cells which can be used to store useful information over a period of time. LSTM has three gate controllers, namely forget gate , input gate, and output gate.

The gated recurrent unit (GRU) was a special LSTM to reduce the length of training time of the LSTM. The GRU only has two gates, namely a reset gate and an update gate that controls the flow of information within the unit. Auto-LSTM consists of two machine learning algorithms, namely AutoEncoder (AE) and LSTM. In its implementation, the LSTM model was trained and installed using historically coded weather data generated by the AE coding side. The Auto-GRU model consists of AE and GRU which this model has the same concept as Auto-LSTM.

DNN architecture can be shown in Figure 3. Several weather parameters that were used as historical data will be entered into the DNN architecture. DNN architecture consists of input layer, several hidden layers with memory units will be added to carry out the training process. The results of this training will be output which was forwarded to the Output layer.

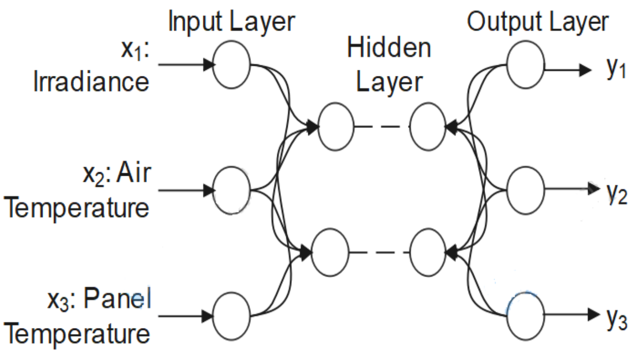
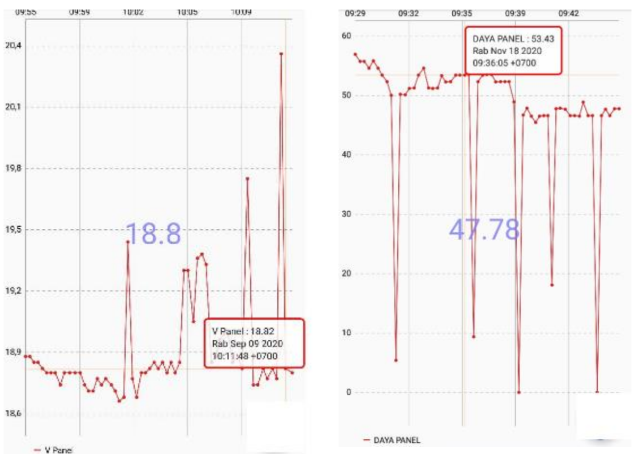


Fig. 3. The Architecture of DNN

IV. Experimental Results and Discussion

Several experiments will be carried out to evaluate the methods used in solar PV power forecasting applications. We will make comparisons on several models implemented in solar PV power forecasting applications, including LSTM, GRU, Auto GRU and Auto LSTM using the dataset obtained from SHMG. Based on the monitoring process carried out by the installed sensor modules, some electrical data from the measurement results on the grid can be obtained, including electrical data on batteries and solar panels, which were shown in Figures 4 and 5 below.



(a) (b)

Fig. 4. Measurement data on solar panels: a). Voltage b) Power

Fig. 5. Measurement data on solar Baterai

The solar PV power forecasting process uses time series data obtained during the monitoring process. This dataset consists of current and voltage data (V-I) and weather data, namely irradiance (kW / m^2), air temperature (^{o}C) and panel temperature (^{o}C). The available dataset consists of five-minute, hourly and daily.

The performance evaluation process was carried out to verify the effectiveness of the deep learning algorithm that was used to predict the generated solar PV power. The DL algorithm was implemented in Python using the Keras API with the Tensorflow framework. Evaluation measurements use Mean Absolute Error (MAE) and Mean Square Error (MSE). Furthermore, prediction accuracy was done by comparing several models implemented in DL including LSTM, GRU, Auto GRU and Auto LSTM. Table 1 below shows the results of the measurement accuracy of the predictions.

TABLE I. Prediction Performance on MAE and MSE

Approach	LSTM	GRU	Auto-LSTM	Auto-GRU
MAE	0.0533	0.0342	0.0803	0.0528
MSE	0.0035	0.00245	0.00893	0.00425

Based on the results of the prediction evaluation in Table 1, it can be seen that GRU was a model that has better performance compared to other models with MAE and MSE values of 0.0342 and 0.00245.

V. Counclusion

The smart home micro grid has an energy source that was not only from state electricity but also from renewable energy, namely solar energy which was integrated with each other. The prediction process for solar PV power was highly dependent on weather conditions, which can change at any time, causing instability in the power grid which causes electricity operators to balance electricity consumption and power generation to avoid wasting energy. Therefore, it was necessary to develop appropriate machine learning methods in order to produce valid and accurate predictions. In this research, the forecasting method was developed using DNN and GRU as architectural models. The GRU model was chosen because it has better performance compared to other models with MAE and MSE values of 0.0342 and 0.00245.

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