Hybrid Deep Learning Model for Renewable Energy Forecasting

Masterarbeit

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1 Introduction

1.1 Motivation and Relevance

Fossil fuels are the major source of energy worldwide and are namely hydrocarbons and their variants, involving natural resources, which are oil and natural gas. Fossil fuels release greenhouse gases, which have a negative effect on the climate and can lead to divers natural catastrophes, such as global warming [16]. On the other side, the increasing demand on energy is pushing forward the electricity production and distribution [1]. Facing this energy crisis and the pollution caused by fossil fuels, renewable energy sources have gained a huge interest worldwide. Renewable energy has more benefits in comparison to fossil fuels. They are free, green and limitless. Using renewable energy helps reducing the pollution by decreasing the emission of sulfide (SO2), carbide (CO) and dust and limits the use of fossil fuels [16].
Microgrids are joining the digital generation [3].Microgrids are seen as smart grids connecting the renewable energy sources (RESs) load, distribution and storage equipments [4]. Ensuring the efficiency, reliability and sustainability in using energies requires smart grids with many technologies, such as Internet-of-Things (IoT), real-time control and cyber-security. This structure of smart grids makes the management tasks very difficult for humans. The huge quantity of collected data introduced the artificial intelligence (AI) approaches as a the new implementation in the power systems. AI can be applied to forecast the energy load, demand or even to detect the defaults in energy devices [3]. Furthermore, external weather conditions, namely solar radiation, cloud coverage, temperature, humidity, pressure and wind speed, have a strong impact on renewable energy output which explains its variable nature and makes the forecasting role challenging [17].
Forecasting methods can be divided on physical models, statistical models and AI models. Physical models generally compute wind turbine/solar power curves based on the situation of weather and plants output. This type of models are recommended if all the inputs are carefully calculated. On the other side, AI methods, in particular machine learning (ML) has demonstrated a success in energy forecasting [6]. Recently, deep learning (DL) methods have proven a better performance in energy generation and power load forecasting problems, while DL models contrary to ML models do not need intervention for feature extraction or complexity simplification[4]. However, using a single model can not in some cases perform accurately . This issue can be related to a autonomous procedure. A hybrid model as a combination of more then two models can solve this issue. This kind of models can ensure a

better performance. Nevertheless, the hybrid model performs depending on the capacity of its single models. limitations of the single models have an impact on the results of the final model [5].

1.2 Objective and Structure

The main objective of this work is to study a hybrid deep learning model and its performance in terms of forecasting renewable energies, especially solar energy. This first chapter gives a global introduction to the state of the art in renewable energy sources, the motivation and objective behind the forecasting approach, and finally the structure of this research. In Chapter 2, the importance of the renewable energy sources is introduced, while this area gains over years more interest regarding the planet sustainability importance by reducing carbons emissions. This section outlines the theoretical background of the energy forecasting starting from the different aspects of energies until the divers forecasting methods that can be used. Multiple factors, which has to be considered while building the model for energy forecasting, are then displayed. Chapter 3 gives an overview of Artificial Intelligence (AI) and its importance in dealing with various issues. Artificial intelligence is a huge field that combines many techniques and approaches, such as learning methods, statistical methods, search methods and optimization theory. Machine learning (ML) is one of the AI learning methods [10] In this section different models of deep neural networks, as an advanced type of ML, are explained with their applications in the field of energy prediction. Chapter 4 examines the selected hybrid deep learning model CNN-LSTM. This model will be tested using a case study. The results obtained and the findings are then interpreted. The evaluation of the model and its given results is discussed in Chapter 5. Limitations to this research and recommendations for future work is also presented. Finally, the conclusion and an outlook on future researchs are summarized in Chapter 6.

7 Conclusion

Electricity is an essential factor for the technology development and the economic growth of the countries [1]. Fossil fuels are the principal source of energy worldwide[16]. However, they are one of the factors causing pollution and climate changes. On the other side, the increasing need of energy has accelerated the generation and distribution of electricity [1]. Renewable energy sources are free and clean sources of energy, which has attracted the attention of researchers to focus on this area. There are divers methods destinated to forecast the energy output, whatever solar power or wind power. Recently, studies have shown that hybrid models improve the prediction results in comparison with single traditional models. This work was proposed to investigate the performance of a hybrid deep learning model. A hybrid deep learning network was built based on convolutional neural network (CNN) and long short term memory (LSTM) for Forecasting the solar radiation. The convolutional neural network was used to extract features and long short term memory to train the time series data. The combination is made to improve the accuracy of the forecasting results. The chosen dataset for this experiment is taken from the NASA Space Apps Challenge for the year 2017.
The forecasting process was made in several steps:First, the input data was normalized and then the training data representing 80% of the initial input data and the test data separated. Then the hybrid CNN-LSTM model was executed to train the training data. The obtaines predicted values were visualized in comparison with the true data. Finally, the model results were evaluated with the performance metrics, which are RMSE and MAE. The whole process was also made for the traditional LSTM model as a benchmarking model. Both models were trained and tested unter different data resolution, and with univariate and multivariate dataset. The results show that the univariate models perform better results. In addition, RMSE and MAE are lower with the hybrid CNN-LSTM model than LSTM. CNN-LSTM occurs fewer prediction errors compared to the true values. However, some modifications are recommended to achieve better accuracy and to be promoted to other future works. In the future, considering a relevant features or a dataset with different weather conditions and season will improve the forecasting ofthe solar radiation.