Research Trip Summary Report

Task 2. Foreign mobility of WUST doctoral students

I. Data of the doctoral student

1.Full name: Fachrizal Aksan

2.Year of studies: 3rd year

3. Educational discipline: Automation, electronic, electrical engineering, and space technologies.

II. Foreign research trip (research visit)

1. Research institute in which the foreign research was implemented: Department of Energy Distribution and High Voltage Engineering at Brandenburg University of Technology, Germany.

2. Name and surname of the host person (mentor): Dr. Ing. Klaus Pfeiffer

3. Dates of the research trip: 4 September – 4 December 2023

4. Title and date of a seminar delivered during the research trip:

- Deliver an international conference presentation titled 'Prediction of Regional PV Power Generation Based on LSTM-CNN'. 16 November 2023.
- Present the progress report on the research visit to the supervisor at the Department of Energy Distribution and High Voltage Engineering at Brandenburg University of Technology, Germany. 1 December 2023.

5. Description of work carried out during the research trip:

During the research visit conducted at the Department of Energy Distribution and High Voltage Engineering at Brandenburg University of Technology, Germany, the primary objective of the student was to contribute to the ongoing development of forecasting methodologies tailored for implementation within the power system domain. This endeavor centered on evaluating the efficacy and efficiency of deep learning models in predicting critical elements within power systems, such as power demand and renewable energy generation. The research aimed to comprehensively assess the performance of these models and their potential applicability in enhancing predictive accuracy within the intricate framework of power system dynamics.

The research visit comprised three concurrent main tasks. Firstly, a comprehensive literature review focused on forecasting methods utilizing deep learning models for renewable energy generation was conducted. This review extensively utilized prestigious scientific databases. The literature revealed numerous robust deep learning models capable of predicting renewable energy generation, including Long Short-Term Memory (LSTM), Convolutional Neural Networks (CNN), and hybrid networks. However, the primary focus of this work was to reference and compare these models identified in the literature review for predicting renewable energy generation.

The second task was primarily dedicated to comprehensive data collection and analysis. Collaborating closely with a supervisor from the Department of Energy Distribution and High Voltage Engineering at Brandenburg University of Technology, Germany, the student procured real-world data on renewable power generation and power flow from local Distribution System Operators (DSOs) in the Brandenburg area, alongside weather data obtained from the German Weather Service. For reasons pertaining to data protection, specific details about the DSOs are not disclosed in this report. Python was employed for exploratory data analysis, wherein the student utilized various data preprocessing techniques to refine the raw datasets, ensuring their suitability for the subsequent task of developing deep learning models for renewable power generation.

The final task focused on developing deep learning models specifically for regional PV generation based on the acquired data. Within this phase, the student proposed two hybrid deep learning models. The first model integrated a Convolutional Neural Network with a Long Short-Term Memory (CNN-LSTM), while the second model featured Long Short-Term Memory followed by a Convolutional Neural Network (LSTM-CNN). These proposed models underwent meticulous comparison against baseline models, encompassing single CNN and LSTM architectures, to assess their comparative performance and efficacy.

6. Description of the main results obtained:

During the research visit, the student focused on comparing hybrid deep learning models (LSTM-CNN, CNN-LSTM) and baseline models to predict regional PV power in Eastern Germany. Using data on regional power generation, installed capacity, and weather, the aim was to create a precise model for forecasting PV power, vital for grid stability and efficient planning. In the data analysis phase, correlation analysis highlighted the relationship between input parameters and output values. Solar irradiance showed a strong linear correlation with regional PV power generation, followed by air temperature and wind speed. These insights are pivotal in understanding the primary factors influencing solar power generation at a regional level.

In model training section, the LSTM-CNN took the longest to train, followed by the LSTM, CNN-LSTM, and CNN. Comparing hybrid models LSTM-CNN and CNN-LSTM, their structures were similar, differing only in layer order. The CNN-LSTM trained faster due to parallel processing in the initial CNN layer, reducing data dimensions. In contrast, LSTM-CNN's sequential LSTM layer led to a longer training time, relying on previous computations. In the outcome of model performance, The LSTM-CNN model shows superior performance with lower RMSE (13.12 MW) and MAE (6.29 MW) scores, indicating a strong fit with an R2 coefficient around 0.94. While excelling in predicting new data, achieving this accuracy requires longer training due to LSTM complexities, demanding more computational resources and time. The main result of this work is already accepted and presented in ***1st Asia Meeting on Environment and Electrical Engineering, IEEE EEE-AM 2023.***

7. Future collaborations (if applicable):

Thanks to the invaluable support from supervisors at Brandenburg University of Technology and Wroclaw University of Science and Technology, the student aims to extend his work in "Enhancing Power System Operations through Improved Forecasting." This collaboration, under the supervision of both mentors, aligns seamlessly with the objectives of the NAWA STER program, promoting the internationalization of scientific research. There are plans for potential future collaborations through joint publications in journals or conferences.

8. Title and date of a seminar presenting the results of the trip delivered at Wroclaw University of Science and Technology after returning from the research trip: Prediction of Regional PV Power Generation Based on LSTM-CNN. proposed date 12.12.2023.

III. Doctoral student's signature

1.12.2023
(Date)

Fachrizal Fajrin Aksan
(doctoral student's signature)

IV. Confirmation and information from the host

1. Confirmation of compliance of the information contained in the report:

I CONFIRM / ~~DO NOT CONFIRM~~. (*In justified cases, the confirmation of the host may be sent by e-mail to the Dean's Office of the Doctoral School email: interdocschool@pwr.edu.pl*)

2. Additional information and comments

As the host university, we would like to thank Mr Fachrizal Aksan for his hard work. We can confirm that he has made effective use of his time here in Cottbus to make progress on his doctoral thesis. We are very impressed by his academic performance and the results he has achieved in his short time here at BTU Cottbus-Senftenberg. Overall, we are extremely pleased with his academic achievements.
We wish Mr Aksan continued success on the path to successfully completing his doctoral thesis and would be delighted to welcome him back to Cottbus at any time.

1.12.2023
(Date)

Dr. Ing. Klaus Pfeiffer
(signature(s) of Host)