Research Trip Summary Report

Task 2. Foreign mobility of WUST doctoral students

I. Data of the doctoral student

1.Full name: Aleksandra Knapińska

2.Year of studies: 3rd

3. Educational discipline: Information and Communication Technology

II. Foreign research trip (research visit)

1. Research institute in which the foreign research was implemented: Politecnico di Torino

2. Name and surname of the host person (mentor): Cristina Rottondi

3. Dates of the research trip: 25.01.2023 – 25.02.2023

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

Title: "Machine-learning-assisted optimization of multilayer application-aware networks"

Dates: 30.01.2023 at Politecnico di Torino and 7.02.2023 at Politecnico di Milano

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

The research visit was intended to start a more extended collaboration with prof. Cristina Rottondi and Politecnico di Torino (PoliTo) on multilayer application-aware and intent-based networks, building upon the foundations of research we conducted in the last two years as part of my PhD and the NCN OPUS project. The internship started with my presentation about the algorithms and results obtained so far, concluded with an outline of possible future directions. I gave the seminar to the Department of Electronics and Telecommunications members, and after it, the host, prof. Rottondi proposed that I also present my seminar at Politecnico di Milano (PoliMi), to the "Bonsai Lab" members, including the lab head – prof. Massimo Tornatore. Meanwhile, she also proposed a brainstorming session with dr Omran Ayoub from La Scuola universitaria professionale della Svizzera italiana (SUPSI).

The seminars and brainstorming sessions turned into two parallel research directions, which we discussed with prof. Cristina Rottindi during my visit across several meetings. Together with dr Omran Ayoub from SUPSI and prof. Andrea Bianco from PoliTo, we explored the topic of Explainable AI and its application to traffic prediction, which can be applied in multilayer software-defined and intent-based optical networks. Meanwhile, together with Nicola Di Cicco and prof. Massimo Tornatore from PoliMi, we explored the application of Graph Neural Networks to various problems in multilayer optical networks, including quality of transmission estimation (classification and regression) and traffic prediction considering changing graph topology and attention mechanisms.

At the same time, together with Matteo Sacchetto and Leonardo Severi, PhD students of prof. Cristina Rottondi from PoliTo, we discussed the technical details of organizing a distributed concert between Wrocław and Turin, in collaboration with students from the Karol Lipiński Academy of Music in Wrocław – a practical application of application-aware optical networks.

6. Description of the main results obtained:

The research visit mainly consisted of brainstorming sessions. Building on my research and the hosts' experience, we sought possible directions for our joint research, as explained in the previous point. We agreed on some principles and explored the available datasets and methods and their qualities.

In the field of Explainable AI – a direction pursued in collaboration with dr Omran Ayoub from SUPSI and prof. Andrea Bianco, we analyzed the network traffic datasets, including real and synthetic data, with steady-state networks and around link failures. We also explored the possibility of using Shapley additive explanations (SHAP) for feature selection. Finally, we discussed the possible architectures of long short-term memory (LSTM) neural networks with custom loss functions for application-aware networks. As the experiments require a lot of implementation work, during the visit, we outlined the experiments to be conducted and discussed the methods, building on our collective experience. We are planning to analyze the results we obtain and continue our joint research.

Similarly, in the field of Graph Neural Networks (GNNs) – a direction pursued in collaboration with Nicola Di Cicco and prof. Massimo Tornatore from PoliMi, we outlined the experiments to be conducted, which require a lot of implementation work. Building on our collective experience, we outlined the datasets and methods available. We decided to start with the problem of quality of transmission (QoT) estimation, using a dataset the PoliMi group has. This research will give me the necessary experience with the PyTorch Geometric framework for GNNs and enable further joint research on attention-based models for multilayer networks.

In summary, as an immediate preliminary result of the research visit, I learned about new methods (such as SHAP and GNNs) and datasets (e.g., for QoT estimation and traffic prediction) and their application to multilayer application-aware networks. I was also given implementation tools and resources to pursue further joint research. We are planning to continue our collaboration with online meetings and joint publications.

7. Future collaborations (if applicable):

The collaborations described above (all with prof. Cristina Rottondi):

– with dr Omran Ayoub from SUPSI and prof. Andrea Bianco from PoliTo on the topic of explainable AI for traffic prediction,

– with Nicola Di Cicco and prof. Massimo Tornatore from PoliMi on the topic of graph neural networks for quality of transmission estimation and later for multilayer networks,

– with Matteo Sacchetto and Leonardo Severi on a distributed concert between Wrocław and Turin, planned for June 2023 in collaboration with students the Karol Lipiński Academy of Music in Wrocław.

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:

Title: "Explainable AI and Graph Neural Networks as Tools for Networking Problems"

Date: 21.03.2023

III. Doctoral student's signature

…….
(Date)

……
(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

……
……..

……
(Date)

……
(signature(s) of Host)