Project Proposal

Optimal Modulation Prediction for Physical Layer Network Planning

Équipe 20

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Abstract

1 Abstract

Over the past decade, optical networks have been growing 'smart' with the introduction of software defined networking, coherent transmission and flexible grid. To name only few arising 23 technical and technological directions. The combined progress towards high-performance hardware and intelligent software, integrated through an SDN platform provides a solid base for promising innovations in optical networking. Machine learning algorithms can make use of the large quantity of data available from network monitoring elements to make them 'learn' from experience and make the networks more agile and adaptive. In this project, which is proposed and strongly advised by Professor Leslie Rusch at the *Centre d'optique, photonique et laser* (COPL), Laval University, we focus on employing machine learning methods in optical networks to predict data transmission quality and identity the best possible capacity for a given configuration to improve the network's resource utilization.

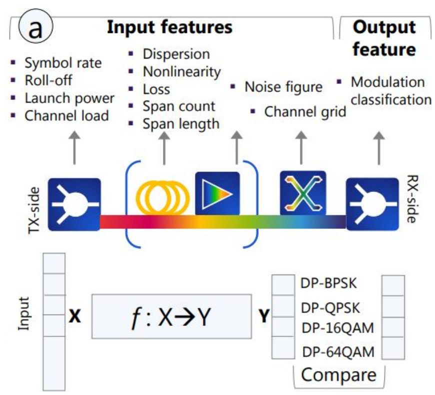
2 Introduction

Optical networks constitute the basic physical infrastructure of all large-provider networks worldwide, thanks to their high capacity, low cost and many other properties and there is no sign that a substitute technology might appear in the foreseeable future. In fact, ML application can be useful especially in cross-layer settings, where data analysis at physical layer, e.g., monitoring Bit Error Rate (BER), can trigger changes at network layer, e.g., in routing, spectrum and modulation format assignments. The application of ML to optical communication and networking is still in its infancy. It is currently perceived as a paradigm shift for the design of future optical networks and systems. These techniques should allow to infer from data useful characteristics that could not be easily or directly measured.

The application of ML to physical layer use cases is mainly motivated by the presence of non-linear effects in optical fibers, which make analytic models inaccurate or even too complex. This has implications on the performance predictions of optical communication systems, in terms of Bit-Error-Rate (BER), quality factor (Q-factor) and also for signal demodulation. Several challenges need to be addressed at the physical layer of an optical network, typically to evaluate the performance of the transmission system and to check if any signal degradation influences existing lightpaths. Such monitoring can be used, e.g., to trigger proactive procedures by varying modulation format before signal degradation occurs.

3 Modulation format recognition (MFR)

Modern optical transmitters and receivers provide high flexibility in the utilized bandwidth, carrier frequency and modulation format, mainly to adapt the transmission to the required bit-rate and optical reach in a flexible networking environment. Given that at the transmission side an arbitrary coherent optical modulation format can be adopted, knowing this decision in advance also at the receiver side is not always possible, and this may affect proper signal demodulation and, consequently, signal processing and detection. The main idea of this work is to **use ML algorithms which could help the modulation format recognition at the receiver side**, thanks to the opportunity to learn the mapping between the adopted modulation format and the features of the incoming optical signal. Researchers have already started exploring the application of machine learning algorithms to enable this. In this case, ML can be employed to build more accurate and optimized network. In this project, we aim to attack this problem: **"How can we predict the optimum modulation format (best capacity) for sending the data based on input features?"**. In this work, we will have access to the start training dataset (of 60000 sample) which is generated by an optical setup simulation. We also have access to this simulation (thanks to professor Leslie Rusch) if we need to increase the dataset or change some features of the problem. The figure below shows our optical links for our dataset: at its transmitter side, there are several features and at the receiver, we will have one output which is the capacity that is need to be predicted. The list of input and output features for our case study is shown in the picture. As can be seen, there are 11 input features affecting our problem. As a first step, we aim to reproduce the results from (Rafique, 2018), which analyse an MLP model to predict the output using parameters (e.g. different number of layers and neurons) and report the results based on the regression accuracy and training time. Then, as future steps, based on rigorous analysis of the data, we will be able to identify and choose the most important features that affects the results, and, finally apply other ML methods and compare it to the published results in terms of accuracy, complexity and efficiency.



References

Danish Rafique. Machine learning based optimal modulation format prediction for physical layer network planning. In *2018 20th International Conference on Transparent Optical Networks (ICTON)*, pages 1–4. IEEE, 2018.