Machine Learning for Optical Networking

Today's telecommunication networks have become sources of enormous amounts of widely heterogeneous data. This information can be retrieved from network traffic traces, network alarms, signal quality indicators, users' behavioural data, etc. Advanced mathematical tools are required to extract meaningful information from these data and take decisions pertaining to the proper functioning of the networks from the network-generated data. Among these mathematical tools, Machine Learning (ML) is regarded as one of the most promising methodological approaches to perform network-data analysis and enable automated network self-configuration and fault management. The adoption of ML techniques in the field of optical communication networks is motivated by the unprecedented growth of network complexity faced by optical networks in the last few years. Such complexity increase is due to the introduction of a huge number of adjustable and interdependent system parameters (e.g., routing configurations, modulation format, symbol rate, coding schemes, etc.) that are enabled by the usage of coherent transmission/reception technologies, advanced digital signal processing and compensation of nonlinear effects in optical fiber propagation.

Finally, an interesting, though speculative, area of future research is the application of ML to all-optical devices and networks. Due to their inherent non-linear behaviour, optical components could be interconnected to form structures capable of implementing learning tasks. This approach represents an all-optical alternative to traditional software implementations. For example, semiconductor laser diodes were used to create a photonic neural network via time-multiplexing, taking advantage of their nonlinear reaction to power injection due to the coupling of amplitude and phase of the optical field. Also, a ML method called "reservoir computing" is implemented via a Nano photonic reservoir constituted by a network of coupled crystal cavities. Thanks to their resonating behaviour, power is stored in the cavities and generates nonlinear effects. The network is trained to reproduce periodic patterns (e.g., sums of sine waves). To conclude, the application of ML to optical networking is a fast-growing research topic, which sees an increasingly strong participation from industry and academic researchers.

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