ABSTRACT

Optical fiber networks, commonly known for data communications can be extended beyond their conventional use. Modern coherent transceivers based on digital signal processing already track the evolution of the transmitted optical signal phase and polarization to recover the transmitted data at the receiver side. As those quantities are strongly affected by external strain, they already contain environmental information.

To fulfill modern traffic requirements, optical networks are evolving towards multi-service autonomous, flexible, and software defined entities based on a centralized intelligence, enabling the orchestration of network functionality to communicate with network elements using standardized interfaces. This trend opens the perspective to exploit these networks for environmental sensing.

In this thesis, we propose an optical data network architecture that exposes sensing functionalities with minimum or no additional hardware. Our focus is on light's polarization-based environmental sensing, with a special focus on early disaster warning. This thesis demonstrates computer-based simulation, followed by a laboratory-based experiment, to conclude with an in-field testing. In-field testing, not only showcase seismic wave detection, but also demonstrates other manual induced external events that might occur in everyday environments. The sensing system can co-exist with WDM networks, without interfering with communication services or even impose any network security threat. We achieve high accuracy in early earthquake detection, distinguishing its impact on polarization from a car passage to mimic real-world noisy environment.

Transforming the existing fiber infrastructure into a large-scale sensing and localization grid, allows a country to re-purpose deployed telecommunications assets for early warning systems, oil & gas pipeline leakage, infrastructure monitoring, human activity monitoring, or security-relevant applications, supporting the vision of smart cities and national resilience frameworks.