Neural Computing and Applications (2022) 34:19655–19673
https://doi.org/10.1007/s00521-022-07634-2

S.I.: DEEP LEARNING MODELLING IN REAL LIFE: (ANOMALY DETECTION, BIOMEDICAL, CONCEPT ANALYSIS, FINANCE, IMAGE ANALYSIS, RECOMMENDATION)

Known and unknown event detection in OTDR traces by deep learning networks

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Received: 31 January 2022 / Accepted: 11 July 2022 / Published online: 5 August 2022

Abstract

Optical fiber links are customarily monitored by Optical Time Domain Reflectometer (OTDR), an optoelectronic instrument that measures the scattered or reflected light along the fiber and returns a signal, namely the *OTDR trace*. OTDR traces are typically analyzed by experts in laboratories or by hand-crafted algorithms running in embedded systems to localize critical events occurring along the fiber. In this work, we address the problem of automatically detecting optical events in OTDR traces through a deep learning model that can be deployed in embedded systems. In particular, we take inspiration from Faster R-CNN and present the first 1D object-detection neural network for OTDR traces. Thanks to an ad-hoc preprocessing pipeline for OTDR traces, we can also identify *unknown events*, namely events that are not represented in training data but that might indicate rare and unforeseen situations that need to be reported. The resulting network brings several advantages with respect to existing solutions, as these typically classify fixed-size windows of OTDR traces, thus are less accurate in the localization. Moreover, existing solutions do not report events that cannot be safely associated to any label in the training set. Our experiments, performed on real OTDR traces, show very promising performance, and can be directly executed on embedded OTDR devices.

Keywords Detection Network · Open-Set · Recognition · OTDR Events · Time Series

1 Introduction

Optical fiber links represent one of the major communication technologies, ranging from the backbone worldwide telecommunication systems to the last mile connections reaching our homes and apartments. Optical fibers run below our streets and in impervious areas like deserts, oceans or uninhabited lands. Problems along these links are not uncommon because of breakages, bad splicing or conjunctions that impair transmission quality when not entirely stopping the communication. Not surprisingly, monitoring optical spans and identifying faults is a primary activity for companies managing fiber links and optical equipment, and this has become even a more relevant issue since the introduction of coherent transmissions. In fact, optical-fiber monitoring enables a better characterization of the transmission performance, and a better allocation of optical channels.

A powerful and widely used instrument to test optical fiber links is the Optical Time Domain Reflectometer (OTDR) [1]. This device injects a series of optical pulses into the fiber and measures the light that is scattered or reflected back to the source into the *OTDR trace* (see Fig. 1). OTDR traces are characterized by a background signature, due to the attenuation of the signal because of fiber dispersion, and by multiple "event signatures". Optical events result from Rayleigh scattering and Fresnel reflections caused by physical devices connected to the fiber, bendings, knots or any other flaw along the fiber, and as such indicate potential issues on the fiber link.

Optical events are either analyzed by domain experts in laboratories, which can recognize patterns characterizing specific conditions (see Fig. 2) or by ad-hoc software running on embedded devices, which implements rather simplistic detection rules. These algorithms analyze fixed-

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