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EDITORIAL

# Machine learning for networking

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## 1 Introduction

The recent development of big data, which aims to collect and store large amounts of data, and cloud computing, which allows large amounts of data to be processed quickly and efficiently, has enabled the emergence of machine learning solutions that learn from huge datasets in order to be able to respond quickly to similar problems at a later time.

The latest generation networks (4G, 5G, and future 6G) also benefit enormously from the cloud and tend to rely more and more on this computing capacity. Advances in research in this area also make it possible to retrieve a great deal of information on the state of the network, the state of communications, the end users, and/or any connected applications.

Using machine learning for network management and developing new machine learning techniques on top of networks are a positive feedback loop that will benefit both machine learning and networking.

This special issue brings together recent research and advanced knowledge regarding the use of machine learning in networks.

## 2 Reviewing process and selected papers

We received many submissions. At the end of the selection process, we selected thirteen papers for their originality, their relevance to the theme, and the quality of the work presented.

The selected articles mainly address two of the major themes in the field of networks.

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The first theme concerns improving the quality of service to users or applications. It brings together different aspects of network management, such as channel allocation, radio coverage, or localization in wireless networks. This theme is of fundamental importance in the field of network management since it allows the loss of connection to the network to be significantly reduced. It also allows the development of new types of use for operators. The selected articles that are related to this first theme are summarized below.

In the paper entitled *Estimating and Predicting Link Quality in Wireless IoT Networks*, by M. Landry et al. evaluated the performance of four machine learning techniques on the traces collected from a real IoT network. In addition, they present issues dealing with the deployment of such techniques in IoT networks with limited resources and energy.

V. Rayavarapu et al. the authors of *NLOS Identification and Mitigation in UWB Positioning with Bagging based Ensembled Classifiers*, performed the nonline-of-sight (NLOS) path identification and mitigation using the bagging-based ensembled classifier where they analyzed the classification performances over varying feature subsets and validated the associated hyperparameters using three datasets.

G. Famitafreshi et al. the authors of *Achieving Proportional Fairness in WiFi Networks* via *Bandit Convex Optimization*, proposed an algorithm able to learn the optimal slot transmission probability only by monitoring the throughput of the network to revisit the proportional fair channel allocation in IEEE 802.11 networks.

O. Aouedi et al. the authors of *Unsupervised Learning for Software Defined Networking: An approach to understand and slice your network*, focused on analyzing network data with the objective of defining network slices according to traffic flow behaviors. The proposed solution used feature selection for dimensionality reduction and *K*-means clustering to better understand and distinguish behaviors of traffic.

A. Djama et al. the authors of *A Learning-based Adaptive Forwarding Strategy for NDN-based IoT Networks*, presented LAFS, a learning strategy for NDN-based IoT networks to enhance network performance while alleviating

the use of its resources. The proposed strategy is based on a learning process that provides the necessary knowledge allowing network nodes to collaborate smartly and offer a lightweight and adaptive forwarding scheme, best suited for IoT environments.

A. Boualem et al. the authors of *Fibonacci Tiles Strategy for Optimal Coverage in IoT Networks*, use the paving rectangle technique, which provides a minimal number of squares based on Fibonacci's tiles in order to find a minimal set of nodes to optimize coverage, connectivity, and energy-efficiency for 2D and 3D wireless sensor networks (WSN).

A. Sobehy et al. the authors of *Generalization aspect of accurate Machine Learning models for CSI based localization*, extended a previous work by combining classical (based on *K*-nearest neighbors (KNN)) and deep learning (multi-layer perceptron neural network (MLP NN)) methods in an attempt to improve the localization accuracy using channel state information (CSI) to achieve localization given its temporal stability and rich information.

The second theme deals with the detection of intrusions and anomalies in networks, whether to disrupt their behavior or to study them for a future attack. The type of attack studied in the context of this special issue concerns embedded systems, 4G networks, the DNS, and more generally the Internet. At a time when cyber-attacks are more and more numerous and taking place on a larger scale, this theme seemed important to us. Here is a brief summary of the articles that are related to this second aspect.

S. Ajila et al. proposed *Experimental Analysis of Error-based Machine Learning Accuracy in Network Anomaly Detection and Categorization* where error-based learning methods are compared to non-error-based learning methods on the UNSW-NB15 data set.

In the paper entitled *Multi-Layer Perceptron for Network Intrusion Detection: From a study on two recent data sets to deployment on automotive processor*, A. Rosay et al. propose an end-to-end methodology allowing a neural network–based intrusion detection system to outperform traditional machine learning algorithms while testing the proposed solution on two different datasets, namely, CIC-IDS2017 and CSE-CIC-IDS2018.

O. Salman et al. the authors of *Mutated Traffic Detection and Recovery: an Adversarial Generative Deep Learning Approach*, proposed a deep learning (DL) model to detect mutated traffic and recover the original, as traffic mutation can be used by malicious attackers to hide their attack traffic and avoid detection.

M. Panza et al. the authors of *Extracting Human Behavior Patterns from DNS Traffic*, used machine learning techniques on real DNS data to detect and extract human patterns by applying network traffic retrieved from an authoritative DNS server from the country code top-level domain (ccTLD) for Chile.

D. Ferreira et al. the authors of *Prediction of Low Accessibility in 4G Networks*, analyzed the probable root causes of reduced accessibility in 4G networks, taking into account the information of important key performance indicators (KPIs) and considering their evolution in previous time frames.

T. Wakui et al. the authors of *GAMPAL: An Anomaly Detection Mechanism for Internet Backbone Traffic by Flow Size Prediction with LSTM-RNN*, proposed a general purpose anomaly detection mechanism for Internet backbone traffic named GAMPAL. The validity of GAMPAL is evaluated using real traffic information, BGP RIBs exported from the WIDE backbone network (AS2500), and the dataset of an Internet service provider (ISP) in Spain.

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