Chapter 78
The Role and Applications of Machine Learning in Future Self-Organizing Cellular Networks

Paulo Valente Klaine
University of Glasgow, UK

Oluwakayode Onireti
University of Glasgow, UK

Richard Demo Souza
Federal University of Santa Catarina (UFSC), Brazil

Muhammad Ali Imran
University of Glasgow, UK

ABSTRACT

In this chapter, a brief overview of the role and applications of machine learning (ML) algorithms in future wireless cellular networks is presented, more specifically, in the context of self-organizing networks (SONs). SON is a promising and innovative concept, in which future networks are expected to analyze and use historical data in order to improve and adapt themselves to the network conditions. For this to be possible, however, algorithms that are capable of extracting patterns from data and learn from previous actions are necessary. This chapter highlights the utilization and possible applications of ML algorithms in future cellular networks. A brief introduction of ML and SON is presented, followed by an analysis of current state of the art solutions involving ML in SON. Lastly, guidelines on the utilization of intelligent algorithms in SON and future research trends in the area are highlighted and conclusions are drawn.

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INTRODUCTION

In the last couple of years, mobile wireless networks have become an essential part of our lives, due to a broad range of applications and services that are available. Nowadays, people are able to do business on the go, by performing teleconferences whenever and wherever needed, watch or listen to their favorite videos and music on the fly, talk to distant relatives, stream audio/video whenever a special event happens, instantly upload photos or videos about their daily lives in social media, and many more (Aliu, Imran, Imran, & Evans, 2013).

In the future, however, this demand is expected to be much larger, with the advents of new technologies being developed, such as ultra-high definition videos, Virtual Reality (VR) applications, the Internet of Things (IoT); Machine-to-Machine (M2M) communications; cloud computing, and various other services that are unimaginable today. In addition, not only new technologies will need to be addressed by the Next Generation of Mobile Networks (NGMN), but also the ever increasing demand of users in terms of both capacity and better services (Huawei, Technologies Co., 2016), (Samsung Electronics Co., 2015). Some of the requirements that are present in the current state-of-the-art literature of NGMNs are (P. Fettweis, 2012), (G. Andrews, et al., 2014) (Huawei, Technologies Co., 2016):

- Address the exponential growth required in both coverage and capacity;
- Provide better Quality of Service and Experience (QoS and QoE) to end users;
- Support the coexistence with other radio technologies;
- Provide peak data rates higher than 10Gbps;
- Support latency lower than one millisecond (enabling the concept of tactile internet);
- Support ultra-high reliability and network energy efficiency.

From these requirements, it is clear that NGMNs are under a heavy pressure in order to address current limitations of present mobile networks and to push their performance to a next level, allowing all these requirements and new technologies to become a reality in the near future. In order to address the expected exponential growth required in both coverage and capacity, one major shift that will probably occur in NGMNs is the network densification process, in which operators are expected to deploy a wide range of small cells in order to cover a relatively small area (G. Andrews, et al., 2014), (Alsedairy, Qi, Imran, Imran, & Evans, 2015). Although the densification process is probably going to solve some of the future cellular network problems, this process will require an even bigger change in paradigm on how future cellular networks are organized. The dense deployment of small cells will result in an exponential increase in terms of network complexity, while also increasing the total network CAPital and OPerational EXpenditures (CAPEX and OPEX), affecting the whole network in terms of configuration, optimization and healing (Valente Klaine, Imran, Onireti, & Demo Souza, 2017).

In order to address these issues created by the densification process, one possible solution is the addition of more intelligence in the network, by using algorithms that rely on data collected by operators and traffic patterns, such as Machine Learning (ML) algorithms. In addition, ML solutions would also address other network issues by simplifying the coordination, configuration and optimization procedures of the network, minimizing the network complexity, energy consumed and expenditures, while also enabling autonomous network healing (Imran, Zoha, & Abu-Dayya, 2014), (Aliu, Imran, Imran, & Evans, 2013). Furthermore, ML algorithms would also be a key enabler to new types of applications that today are unimaginable, ranging from the autonomous configuration of a new Base Station (BS)