Chapter 10
Optimizing WSNs for CPS Using Machine Learning Techniques

Mehmet Akif Cifci
https://orcid.org/0000-0002-6439-8826
Istanbul Aydin University, Turkey

ABSTRACT

Progress in wireless systems has enabled the creation of low-cost, ergonomic, multi-functional, miniature sensing devices. These devices come together in large numbers creating wireless sensor networks (WSNs), which serve for sensing, collecting, analyzing, and sending detected data to a base station. Problems arise, however, due to the limitations of sensor nodes (SNs), incorrect aggregation of data, redundant and similar data problems, data security and reliability, and some others related to WSN topology. This chapter proposes a novel method for solving WSNs problems to improve cyber-physical systems (CPS). As WSN is of increasing interest in CPSs, the authors put forward an approach for reconstructing WSNs. For traditional methods are not able to cope with such problems, this study takes up rendering WSNs more functional through artificial intelligence (AI) techniques which are considered to develop smart SNs through "intelligent computing," "deep learning," "self-learning," and "swarm learning" ability on the network to improve functionality, utility, and survivability of WSNs.

INTRODUCTION

Wireless Sensor Networks (WSNs) and Cyber-Physical Systems (CPSs) are currently two significant technical fields that are closely interlinked. There are various types of specific applications introduced for CPSs. For this reason, wireless communication and networking have been one of the fastest-growing fields over the last two decades. Significant progress has been achieved in the field of WSNs. More recently, the CPS has emerged as a promising tool to enhance human-to-human, human-to-object, and object-to-object interactions (Ahmadi & Bouallegue, 2017). CPSs will be more reliable and secure with the help of smart WSNs since more sensor inputs and richer network connectivity is required to minimize the burden optimization becomes necessary. It is, therefore, important to examine what has been learned in these fields to predict what can happen in the field of CPS and to determine what needs to be further

DOI: 10.4018/978-1-7998-5101-1.ch010

researched. Besides, recent technical advancements in CPS have verged computing to a wide variety of devices, including toys, home appliances, and tablets. In addition to increasing their computing capabilities, advancements are also allowing these devices to communicate with each other to accomplish individual or shared objectives via smart WSNs (Ahn et al., 2016). CPS is an intelligent system that includes both computational and physical components integrated seamlessly and interacting very closely to control and monitor the necessary area. Reliability and integrity of data is also an important attribute of CPS. For certain fields of application with high-reliability demands, it is particularly important to ensure the WSNs' reliability. Most researchers are currently searching WSNs' reliability for network topology, protocol reliability, and failure correction of the application layer while the latter being the traditional method. However, a new solution can be offered to WSNs' problems by using Artificial Intelligence (AI) methods (Kaur et al., 2018). The key CPS infrastructure that allows the device to get and distribute real-world data is the WSN. Today, most CPSs need a WSN infrastructure for sensing, communication, and actuation. However, studies show that the poor battery life of current WSNs is becoming a critical factor affecting the prospects of these emerging CPSs. The optimization of WSNs with AI methods is, therefore, necessary to prolong battery life and to cope with WSNs' emerging problems since they are generally known to be unreliable, stationary while mostly viewed as an extension of the existing network or the internet that collects data cost-effectively. Because of their resource limitations, WSNs do not have a pivotal role in common networks. While several examples demonstrate how sensor nodes can be deployed, it is aimed to solve coverage-related issues.

In contrast, others aim to solve network compatibility problems to prolong the overall network life-cycle. All in all, this study aims to solve most of these problems by using AI via which the WSNs will be optimized to be more secure and have a long battery life. In this study, the WSNs are aimed to be optimized by using AI algorithms for better CPSs. In particular, the smart WSNs in the integration of the physical and virtual environments of the CPS will be quite beneficial. Last but not least, another aim is to improve some insights about WSNs' optimization problem. The main objective of this study is to highlight the use of AI algorithms on WSNs for CPSs to demonstrate progress achieved so far by applying AI techniques to CPSs. Moreover, this study highlights concerns over future progress by examining the current conditions of AI on WSNs.

The remainder of this chapter is organized as follows: In the Background section, we present related work studied from the literature and the method underlying the research. The details about CPS is introduced in the Cyber-Physical Systems section. In the Wireless Sensor Network Issues section, we present an overview of the problems arising from WSNs. We present how AI approaches can be applied to WSNs in Using Artificial Intelligence Techniques in Wireless Sensor Networks section. Sensor Nodes System Architecture section introduces SNs system architecture while a new architectural enhancement is proposed. In the Proposed Architecture section, an overview of the SNs system with the AI techniques is offered as well as a model encapsulating the evolution pattern of AI solutions. The proposed model is reviewed in the Evaluation section, where finally, the study is finalized by the Conclusions section.

BACKGROUND

This section summarizes the existing studies on applied AI on WSNs optimization for CPSs. The comparison is provided by considering the studies in the literature. It is noted that a study by (Antonopoulos et al., 2016) benefit from AI techniques in which the WSNs aim to improve their abilities to adapt to the