Chapter 1
Deep Learning in IoT:
Introduction, Applications, and Perspective in the Big Data Era

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ABSTRACT

The internet of things (IoT), big data analytics, and deep learning (DL) applications in the mechanical internet are expanding. The current digital era has various sensory devices for a wide range of fields and applications, which all generate various sensory data. DL is being applied for handling big data and has achieved great success in the IoT and other fields. The applications for data streams to discover new information, predict future insights, and make control decisions are crucial processes that make the IoT a worthy paradigm for businesses and a quality-of-life improving technology. This chapter provides a detailed account of the IoT domain, machine learning, and DL techniques and applications. The IoT that consists of DL with intelligence backgrounds is also discussed. Recent research on DL in the IoT within the big data domain is also discussed. Current challenges and potential areas for future research are discussed.

INTRODUCTION

The era of the IoT and big data is creating and acquiring an interest in diverse research disciplines, which can be seen in the amount of recently published articles, surveys, and tutorials on the topic (Chen, 2014; Gheisari, 2017; Horidi, 2017; Najafabadi, 2015). According to McKinsey's report on the global economic impact of the IoT (Najafabadi, 2015), the annual economic impact of the IoT in 2025 will be in the range of $2.7 to $6.2 trillion. Healthcare applications contribute about 41% of the share in the IoT market, followed by industry and energy with 33% and 7%, respectively. Other fields make up about

15% of the IoT market. Deep learning (DL) implies a tremendous and sudden growth in the market in the coming years (Horidi, 2017) since DL is suitable for most of the real-time applications. This has led to increased demand for DL products and tasks, and experts are looking forward to designing these new products. McKinsey's report also mentions that advances in DL algorithms are the main enablers of knowledge work automation. Over a decade, IoT applications have become spread across many fields (health, transportation, smart home, smart city, agriculture, education, and others) that consider key design elements as intelligent learning behaviors such as prediction, mining data, and pattern recognition. DL, which is a part of the machine learning (ML) approach, is actively utilized in IoT applications compared to other methods. DL is getting prominence by its intrinsic behavior of analytics, as it is easier to integrate big data when compared to traditional ML. Based on the learning and hierarchical representation of deep architecture, DL consists of supervised and unsupervised learning techniques for the design structure of neural networks. The functioning of DL imitates human brain neurons in the transformation of data. The IoT and big data are inter-related. IoT directly or indirectly generates big data and the IoT is an important target for big data analytics, which mainly aims to improve IoT services (Goodfello, 2016). Searching trends in Google demonstrates the popularity of DL compared to the other

Table 1. Definitions of deep learning, IoT, and big data from different organizations

Deep Learning	
Wikipedia	Deep learning is a class of machine learning algorithms which - uses a cascade of many layers of nonlinear processing; are part of the broader machine learning field of learning representations of data facilitating end-to-end optimization; learn multiple levels of representations that correspond to hierarchies of concept abstraction
Techopedia	DL is a collection of algorithms used in machine learning, used to model high-level abstractions in data through the use of model architectures, which are composed of multiple nonlinear transformations
Data science	DL conjures up images of sentient robots staging a hostile takeover. DL is just another way to describe large neural networks
Microsoft	DL is a set of algorithms in machine learning that attempt to learn in multiple levels, corresponding to different levels of abstraction.
MIT	DL is a branch of machine learning based on a set of algorithms that attempt to model high-level abstractions in data.
IoT	
IBM	IoT is the concept of connecting any devices to the Internet and to other connected devices.
IEEE	A network of items, each embedded with sensors that are connected to the Internet.
CCSA	A network, which can collect information from the physical world or control the physical world objects through various deployed devices with the capability of perception, computation, execution and communication and support communication between things by transmission; classify and process information.
ITUT	A global infrastructure for the information society, enabling advanced services by interconnecting things based on existing and evolving interoperable information and communication technologies.
Big Data	
Oracle	Big data is data of greater variety arriving in increasing volumes and with ever-higher velocity
SAS	Big data is a term that describes both structured and unstructured that inundates a business on day-to-day basics.
Techopedia	Big data refers to a process that is used when trade handling techniques cannot uncover the insights an underlying data.
EMC	All data in any form that is used for gaining insights and generating value is considered big data

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