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Technology, Communications and Computing

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Data Science and Internet of Things

Research and Applications at the Intersection of DS and IoT

Springer

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Foreword

The immersive ecosystem of the Internet of Things, with its capillary sensor streams, is flooding information systems, and consequently business processes, with huge amounts of heterogenous real-time raw data.

Such huge data flows truly represent the most precious IoT innovation and at the same time the most complex challenge as Big IoT Data often requires real-time processing and fusion to turn into actionable and smart insights.

Here, Data Science, by means of dedicated methodologies, machine learning techniques, and tools, can unleash the full potential of IoT allowing it to translate raw, fragmented data into meaningful, smart information. The picture that arises is a two-faced coin with IoT representing the ubiquitous data generation infrastructure and Data Science, the first consumer of such data to uncover information and eventually knowledge.

This book, often through the presentation of practical innovative IoT applications spanning from health care to agriculture, investigates how Data Science methods, algorithms, and tools can effectively complement the IoT infrastructure.

Catania, Italy — Min Chen

Preface

In everyday life, the Internet of Things (IoT) paradigm fosters the idea of interconnected entities as computers, humans, objects, devices and sensors, all capable of exchanging data to collaborate and provide unforeseen services, spanning various domains as industrial manufacturing, livelihood resources management (agriculture, water and waste), sustainable and eco-friendly economy, logistics, transportation, smart cities, health care, social networks, nanotechnologies frontiers and others. Like most of the modern technologies, IoT relies on advanced hardware and high-speed networks for its purposes, but these are only the means that endorse the massive underlying stream of data, the real core of IoT.

On the other hand, Data Science (DS) meets IoT with its methodologies, techniques and tools to translate data into information, enabling the effectiveness and usefulness of new services offered by IoT stakeholders. If IoT can indeed be considered the infrastructure of a new world full of amazing possibilities, DS is the key that can really lead to a significant improvement of human life.

It is known, however, that generating data is much easier than extracting something useful from it, even in the presence of high-end performance computer systems. The rate of (even real-time) data creation, especially when considering IoT, is unequivocally higher than the rate of increasing in machine processing capabilities. To complete (and complicate) the picture, the huge amount of data coming from IoT sensors and devices may differ in type, format and semantics, therefore this also demands for a significant effort to compare, discriminate and/or integrate distinct sources of information; researchers tried to condensate all these issues into the term "Big data" that features the evolution of DS.

This book investigates the combination of IoT and DS, specifically how methods, algorithms, and tools from DS can effectively support IoT; the aim is also to present innovative IoT applications as well as ongoing research that exploit modern DS approaches. Readers are offered new issues and challenges in a cross-disciplinary context that involves both IoT and DS fields. In particular, the book spans the following scenarios: (1) smart home architectures; (2) mobile edge computing for health care; (3) centrality measures in complex networks; (4) Low-Power WAN; (5) hydroponic agriculture; (6) collaborative body sensor

networks; (7) Unmanned Aerial Vehicles; (8) criminal networks analysis; and (9) indoor navigation systems. These research areas correspond to authored chapters briefly introduced below.

"IoT Aided Smart Home Architecture for Anomaly Detection" by Ibrahim Arif and Nevena Ackovska presents a system for the discovering of unusual events inside homes through the comparison of past versus present behaviors as revealed by data from IoT nodes. The chapter in particular starts reviewing the existing models in the field of anomaly detection in smart homes, then considers fire detection/prediction and fall detection of elderly people as the two most significant anomalies and discusses how the proposed system can effectively detect them and which countermeasures can be carried out to save lives.

"Evolutionary Dynamics and Multiplexity for Mobile Edge Computing in a Healthcare Scenario" by Barbara Attanasio, Alessandro Di Stefano, Aurelio La Corte and Marialisa Scata proposes a framework to conceive cognitive ambient assisted living (AAL) of people with frailty syndromes. The chapter considers how mobile edge computing (MEC) can endorse the shifting of health care from a traditional approach to a distributed patient-centric one, specifically exploiting the cognitive and evolutionary dynamics of complex networks to extract collective knowledge from the AAL of frail people viewed as a social network. In the chapter, the evolution of cooperation between MEC nodes with a low blocking probability is explored to prevent inefficiency in the proposed smart AAL.

"Correlations Among Game of Thieves and Other Centrality Measures in Complex Networks" by Annamaria Ficara, Giacomo Fiumara, Pasquale De Meo and Antonio Liotta investigates how the Game of Thieves (GoT) can be used to compute nodes' and links' centrality in complex network. The GoT is a new algorithm that executes in polylogarithmic time with respect to the state-of-the-art methods that need at least a quadratic time. The chapter illustrates recent literature and discusses several experiments on three correlation metrics in networks differing for nature (artificial and real), type (scale-free, small-world and Erdös-Rényi) and size.

"A LPWAN Case Study for Asset Tracking" by Fabrizio Formosa, Michele Malgeri and Marco Vigo describes a smart application aiming at tracking livestocks using a Low-Power Wide-Area Network (LPWAN), a widely adopted technology within IoT for its low power, long range and low-cost features. The chapter provides the state of the art in industrial IoT platforms useful for tracking applications, then briefly discusses asset tracking, its key features and main use cases, finally introducing the case study together with a discussion on functionalities and performance assessment.

"Implementing an Integrated Internet of Things System (IoT) for Hydroponic Agriculture" by Georgios Georgiadis, Andreas Komninos, Andreas Koskeris and John Garofalakis concerns modern trends in IoT-based agriculture, in particular, how the adoption of Wireless Sensor Networks (WSNs) to measure soil properties, environmental and ambient light conditions enables precision agriculture, allowing the reduction of energy, water, fertilizer and chemicals used for plant growth. After an overview of the current literature, the chapter analyzes the use of IoT in

hydroponic agriculture, where plants are placed over a substrate material and continuously watered with nutrient solutions, an innovation leading to very high-quality products although more expensive than other farming approaches.

"A Collaborative BSN-Enabled Architecture for Multi-user Activity Recognition" by Qimeng Li, Raffaele Gravina, Congcong Ma, Weilin Zang, Ye Li and Giancarlo Fortino considers Body Sensor Networks (BSN) used to support the shifting toward human-centric IoT services, and combines them with multi-user Activity Recognition (AR) to analyze the interaction of individuals in a shared environment, a research area in embryonic stage. After a brief discussion on related work on recent multi-user AR, the chapter presents a novel BSN-enabled architecture to support collaborative multi-user AR achieving better responsiveness, latency reduction and higher scalability.

"Collaborative Solutions for Unmanned Aerial Vehicles" by Francisco Fabra, Julio A. Sanguesa, Willian Zamora, Carlos T. Calafate, Juan-Carlos Cano and Pietro Manzoni is a chapter where Unmanned Aerial Vehicles (UAVs), a.k.a. drones, are the main topic. Several issues are outlined, from battery lifetime challenge to privacy, security, and safety, to their social applications, as human transportation and indoor navigation systems, to legal related questions. The chapter then focuses on collaborative solutions for UAVs, joining them into a swarm to carry out a cooperative task; different scenarios are presented, and for each of them a proper protocol to manage all swarm UAVs as a whole is introduced in terms of its finite state machine, together with performance metrics coming from real experiments.

"Graph and Network Theory for the Analysis of Criminal Networks" by Lucia Cavallaro, Ovidiu Bagdasar, Pasquale De Meo, Giacomo Fiumara and Antonio Liotta explores network science tools to investigate criminal networks, also in order to assist law enforcement agencies. To this purpose, the chapter considers the Sicilian Mafia scenario, in particular the set of theoretical tools used to analyze such a criminal network is discussed, the social network analysis is briefly reviewed and finally a study on two real criminal networks related to Sicilian Mafia is presented, showing the dataset extracted from juridical acts, the weights distribution analysis useful to understand suspected interactions and the shortest path analysis that allows to identify trusted affiliates inside the clan who can spread confidential and illegal messages.

"A Data Mining Approach for Indoor Navigation Systems in IoT Scenarios" by Mahbubeh Sattarian, Javad Rezazadeh, Reza Farahbakhsh and Omid Ameri Sianaki considers indoor navigation systems (INS) and discusses the role of data mining techniques in allowing the prediction of what actions INS devices will take, based on past history. After a deep overview on existing related works, the chapter illustrates a navigation model based on the data of a real-world scenario adapted from the emergency ward of a large hospital, and discusses how such previous experiences can be effectively used to suggest better routes; results show improvement both for traveled distance and elapsed time by decreasing the number of turns and obstacles encountered.

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