Preface

An accurate virtual representation of a physical object is called a digital twin. A wind turbine, for instance, is equipped with various sensors connected to critical functional regions. These sensors generate information on the performance of the physical thing in multiple areas, including energy output, temperature, environmental conditions, and more. Afterward, a processing system transfers this information and applies it to the digital copy. The market for digital twins is proliferating, suggesting that even if they are already used in many different industries, demand will continue to rise for a long time.

This book will be the guidelines for professionals working with industry, institutions, postgraduates, and graduate students taking courses in any engineering field like computer, electronics, mechanical, etc. It will also be the guide for research scholars, researchers doing interdisciplinary research, industrialists, and scientists learning techniques and technologies related to the intelligence industry.

Each chapter reflects various application fields and methodologies. Chapter 1 presents the concept of the Digital Twin and its architecture. This chapter explains that digital twins are physical models that can accurately translate into virtual versions. With the help of digital twins, it is possible to understand better the performance characteristics of substantial parts, processes, or systems. The performance of a system, a method, or a process can be remotely visualised, predicted, and optimised by industrial operators using digital twins.

Chapter 2 covers the benefits of digital twin modelling. The chapter explains the significance, challenges, and advantages of digital twins – explanation of how digital twin benefits manufacturing in the Industry 4.0 era. It mentions the Industrial Revolution and how it changed how goods are produced and how consumers interact with the manufacturing process, enabling more sophisticated requests for various consumer items. It also focuses on the goal of the fourth Industrial Revolution, called Industry 4.0, which combines the advantages of mass production with individualisation and virtual product models, referred to as "Digital Twins".

Chapter 3 provides an overview of the end-to-end conceptual model of a digital twin, which reflects its complementary physical item from the ground cloud. An explanation of the multiple layers of the digital twin model, including the overlapping security layer and the physical, communication, virtual space, data analytic and visualisation, and application layers – the comprehensive review of the hardware and software techniques utilised in constructing the digital twin model. A use case is shown to demonstrate how the layers gather, exchange, and process the physical object data from the ground to the cloud, and indicate how the layers collect, exchange, and process the physical object data from the ground to the cloud.

Chapter 4 covers IoT and Digital Twin. It mentions a network of digitally connected items known as the Internet of Things (IoT). There are numerous shapes and sizes for IoT. These devices may be an intelligent virtual assistant in your living room, an innovative home security system, or your garage-parked car. They appear in the

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form of traffic lights in smart cities that are connected to the internet. A "digital twin" is the term used to describe a system's virtual representation of a physical component. The IoT device's sensors collect data and transmit it to its digital duplicate. IoT researchers and developers use the data to generate new logic and schemas, which they test against the digital twin. The tested code is then uploaded via over-the-air updates into the IoT device. A digital twin is a representation of an actual object in cyberspace.

Chapter 5 explains how machine learning and IoT are used to construct digital twin and how system builders should approach the development of digital twins that use artificial intelligence. What are the biggest hardware challenges regarding artificial intelligence/machine learning? The Internet of Things system transmits real-time data via edge computing and smart gateways. The digital twin model is fed the preprocessed data that is readily available online. Additionally, offline data is processed and used as input for the digital twin after some data mining methods have been used. Modelling and analytics techniques can be combined to achieve a model with a specified purpose. With the aid of IoT sensors and machine learning algorithms, the entire workflow is maintained in order to obtain accurate, precise predictions.

Chapter 6 presents intelligent and smart manufacturing with AI solution. It discusses about current artificial intelligence opportunities which allow manufacturing to become smarter, with a focus on research and development, procurement, and assembly line processes. Smart manufacturing refers to a group of technologies and solutions, including artificial intelligence (AI), robotics, cyber security, the Industrial Internet of Things (IIoT), and blockchain, which are integrated into a manufacturing ecosystem to optimise manufacturing processes through data generation and/or acceptance.

Chapter 7 presents an overview of various literature on the data fusion, such as different methodologies of data fusion, and the challenges and opportunities are discussed under each method. It focuses on information and data fusion for decision-making. Techniques of data fusion integrate relevant information and data from multiple sensors to draw conclusions that are more accurate than those that might be drawn from a single, independent sensor. Even though the idea of data fusion is not new, real-time data fusion has become more and more practical as a result of the addition of additional sensors, enhanced processing techniques, and upgraded hardware. Data fusion technology has quickly advanced from being a hastily put together set of related concepts to a comprehensive engineering profession with standardised language, established system design principles, and libraries of trustworthy mathematical operations or procedures.

Chapter 8 presents digital twin use cases in industries. The chapter tells the prominent and dominant use cases of the fast-evolving digital twin, as well as a number of industry use cases and benefits for unambiguously substantiating the varied claims on the future of this unique and sustainable discipline.

Chapter 9 is about the security in digital twin. The chapter identifies the ways and means of collecting, organising, and storing the data in a secured cloud environment. The data is filtered according to the use and priority and pushed into the cloud. It is determined to implement an exclusive algorithm for a secured cloud which would greatly benefit the users and the providers to handle and process it effectively. It also explains that cyber security and protection are ongoing concerns for every business, and the digital twin technology may hold the key for stronger online defence.

Chapter 10 describes the modelling and the subsequent implementation of an integrated system that consists of a real material handling system and its digital twin, based on physics simulation. Digital actual creation frameworks offer flexibility and adaptation while producing different goods in small batches. Due to altering paths and a wide range of task components, material streams in digital actual production frameworks can get extremely difficult. This can result in genuinely induced annoyances that can result in accidents, poorer yield, and expensive costs. This problem can be solved by using a physical science motor. Recreate the real-world interaction between the tools of the trade and the equipment used for material maintenance.

Chapter 11 offers an architecture for information flow between digital twins and virtual reality software before offering a use case on designing and assessing design and assessment of a collaborative workplace involving humans and robots. Furthermore, it focuses on a hybrid discrete-continuous simulations architecture created specifically for digital twin applications. The framework's base is provided by SimPy, a well-known Python discrete-event simulation library. First, provide a step-by-step guide for integrating continuous process simulations into SimPy's event-stepped engine.

Chapter 12 gives the case study of smart city based on digital twin. The smart twins provide a clear understanding of the bright city. It can actually steer the city, from metropolitan seeking to land-use enhancement. Computerised twins enable the demonstration of plans prior to their execution, revealing flaws before they materialise. Using computerised techniques, engineering components such as lodging, remote organisation receiving cables, solar-powered chargers, and public transit can be planned and focussed on. It also covers the objectives met through the development of digital twin-based smart cities.