

ADVANCED ANALYTICS FOR INDUSTRY 4.0

An overview of the application of
advanced analytics in industry



Aim

This book aims to provide a reference for industry executive managers, R&D specialists, advanced data analyzers, professors, and students working in advanced data analytics and digital transformation.

Digital solutions are needed to develop advanced analytics applications in different industries. Advanced analytics has gained massive momentum in the industrial sector. Its evolution and conquest of the markets are unstoppable, with its presence and importance as an essential tool.

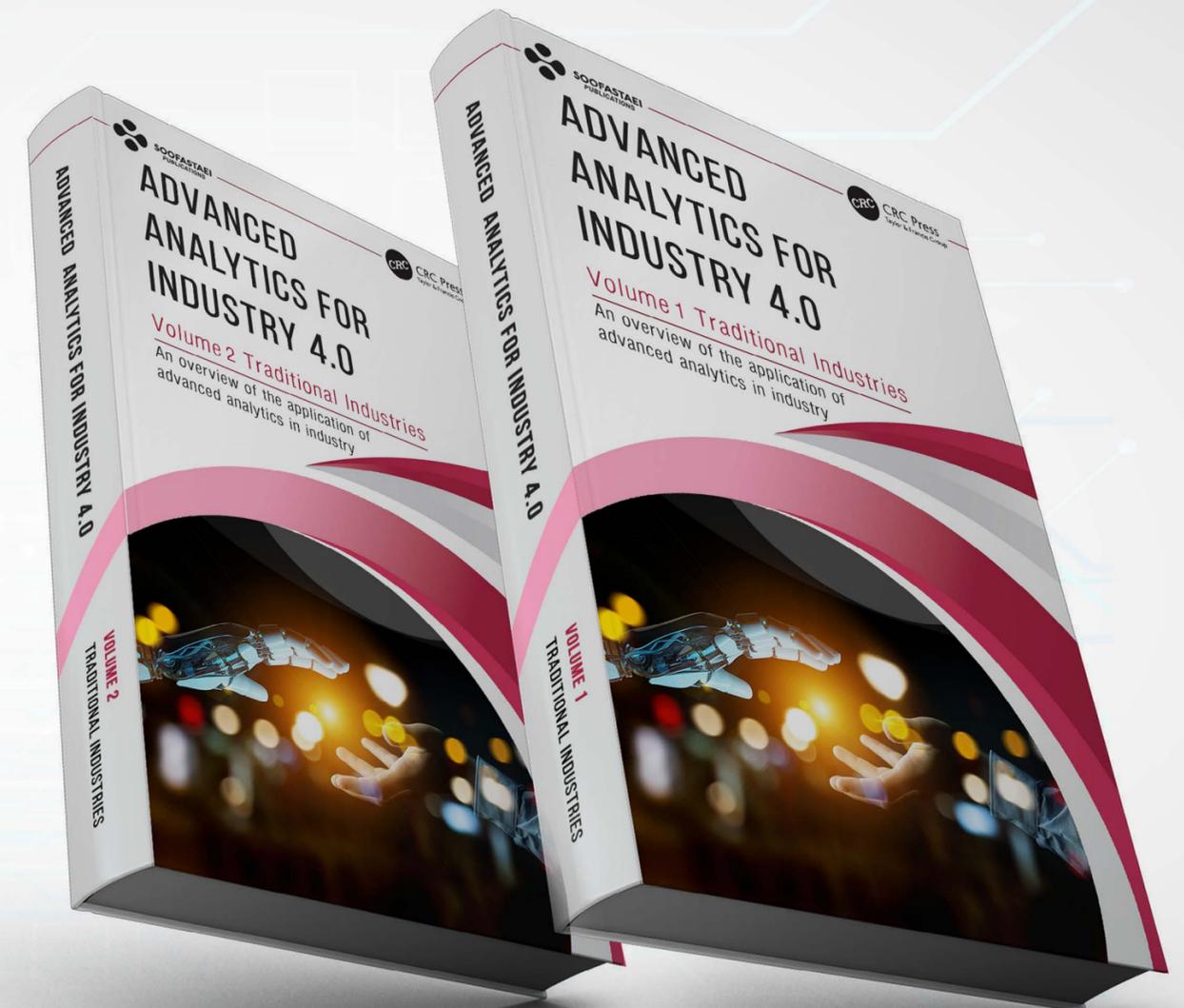
The book is aimed at providing (I) industry executives with an understanding of the business value and applicability of different analytic approaches, and (II) data analytics leads with a business framework in which to assess the value, cost, and risk of potential analytic solutions as well and (III) undergraduate and graduate student of engineering with an understanding of data analytics applied to the different industries.

Objectives

The main objectives of this book are presenting the scientific concepts and providing industrial case studies for different applications of advanced analytics, which can be grouped into four main areas:

1. Descriptive Analytics; Its function is to describe, diagnose, and discover trends and patterns that occur in a given process, thanks to the real-time study of historical data. The most significant descriptive analytics applications are:

- Real-time visualization of data;
- Advanced visualization of data (e.g., creation of benchmark tables offering flexibility in terms of variables, generation of ad hoc reports, etc.); and
- Descriptive statistics of processes and detection through PCA (e.g., detection of production anomalies).



2. Predictive Analytics; Based on more advanced mathematical methods that include statistical analyses, data mining, predictive models, and machine learning, among others. Its function consists of predicting events that can occur in the future, thanks to developing the predictive models. The major applications of predictive analytics are:

- Prediction of anomalies and alerts;
- Demand estimation; and
- Forecasting process outcomes based on the values of variables (e.g., model for detecting product quality issues).

3. Prescriptive analytics; Its function consists of defining the actions to obtain the best results in a process. It relies on predictive models, scenario simulations, localized rules, and technical optimization to transform data and recommend obtaining the desired result. This level of analytics is complete and more robust. It uses complex event processing, neural networks, heuristic learning, and "machine learning," among others. The most significant applications of prescriptive analytics are:

- Generation of scenarios to recommend actions;
- Identification of the best results in an autonomous way; and
- Proactive updating of recommendations for action due to changing events.

4. Optimization; Optimization is one of the most important categories of advanced analytics.

The most significant applications of optimization are:

- Process and scenario simulations; and
- Analysis of the evolution and search for maximum and minimum key values.

Applications

Of the many applications of Industry 4.0 (robotics, 3D printing, automation, synchronization of supply chains in real-time, etc.), advanced analytics has some of the best prospects in terms of applicability and impact.

A few years ago, it would have been unthinkable to regard complex algorithms and analytics (in general) as the fundamental pillar of digital transformation companies. Today, however, there are multiple opportunities for high-impact applications in different sectors, including manufacturing, thanks to the availability of a massive amount of data generated along the industry's value chain, storage capacities, new analysis possibilities, and data processing through more powerful and complex algorithms. Advanced analytics use has only captured a small part of the forecasted potential, which means that there are still plenty of opportunities to deploy analytics in the industry.

"Analytics" applications are generally divided into three groups: descriptive, predictive, and prescriptive analytics. In addition, optimization should also be included in the analytics applications to make a sustainable and applicable solution for the industries. These applications can take the form of different use cases depending on each stage of the industrial value chain (e.g., product design optimization, planning optimization, predictive maintenance, etc.)

Each one of the industries in the sector has different preferences when it comes to using analytics. However, the sectors with greater potential to apply advanced analytics are the chemical industry, pharmaceutical and biotechnological industry, automotive industry, food, and beverage industry, metallurgical industry, aeronautics industry, packaging, and healthcare industry.

Volume I: Traditional Industries

Modern technology is growing very fast, and it affects all industries' dimensions. Traditional industries play a critical role in providing the initial materials for other industries, and a small improvement in these industries can make a big change in other ones. There is plenty of room to use advanced analytics and artificial intelligence to improve the business decisions that aim to increase the quality and quantity of traditional industries' products. This book's volume (V.I) covers the analytics revolution in Industry 4.0 for main industries to open a new way in front of researchers and industrial managers. This new vision can help the research and development teams design and implement digital transformation strategies to exceed customer expectations, link their supply chains, and increase margins.

Volume II: Technological Industries

Advanced analytics has gained massive momentum in the industrial sector. Its evolution and conquest of the markets are unstoppable, with its presence and importance as an essential tool. Technology enterprises consolidate using online data sources to deliver analytics and intelligence that inform everything from operations process automation to customer experiences.

In technology companies, lower costs and democratized data increase access and management speed, enable dynamic forecasting and complete visibility into supply chains, and improve security measures that ensure ongoing privacy compliance-like remote work. Advanced analytics and artificial intelligence can help the technology industries maximize their throughput, but they are also reliable and strong tools to sustain the application of new technologies in other related industries. The second volume of this book (V.II) clarifies the benefits of using advanced analytics in technology industries and highlights the potential challenges and risks of the Industry 4.0 revolution. This volume aims to reference industry executive managers, R&D specialists, advanced data analyzers, professors, and students working in advanced data analytics and digital transformation.

Advanced Analytics for Industry 4.0

Volume I
Traditional Industries



Chapter 1

DIGITAL TRANSFORMATION FOR TRADITIONAL INDUSTRIES

Modern technology is growing very fast, and it affects all industries' dimensions. Traditional industries play a critical role in providing the initial materials for other industries, and a small improvement in these industries can make a significant change in other ones. There is plenty of room to use advanced analytics and artificial intelligence to improve the business decisions that aim to increase the quality and quantity of traditional industries' products. This new vision can help the research and development teams design and implement digital transformation strategies to exceed customer expectations, link their supply chains, and increase margins.

Chapter 2

MINING INDUSTRY

The unprecedented demand for natural resources drives mining companies to strive for a step-change in optimizing their business processes. Advanced analytics techniques are being applied in other industries to enable significant improvements in strategic and operational business processes by optimizing decision-making. This chapter looks at how these advanced analytics techniques can be used to the mining industry's fundamental challenges. Today, decisions are usually locally optimized but do not achieve optimum capability for the mine value chain. Although mining operations now collect more information than ever before, it is difficult to bring all this information to bear to make better decisions. For example, plant history, maintenance, mine planning, logistics, and engineering data are rarely all bought together, in real-time, to make better operational decisions. Complex data analysis is time-consuming and requires specialist skills and knowledge, and is often neglected in the decision-making process. By contrast, advanced analytics will close the loop between analyzing data and taking action. Using analytics to make better decisions will not require specialist skills or be time-consuming. Analytics will become embedded in the business and routinely applied to improve decision-making across all organization levels, from senior management to operations and maintenance workers. Embedding analytics in the business processes drives better decisions supported by data, integrated in real-time from many sources. Ultimately, predictive tools will help suggest, or even in some cases automate, courses of action. The main opportunities for analytics exist where the enterprise requires supporting technology to continue evolving to a higher maturity level. This will be in asset management, rapid reconciliation and adaptive planning, and the inbound and outbound supply chains. Advanced analytics is also a key enabler for increasing the effectiveness and realizing Remote Operations Centers' actual value to safely and efficiently support operations in remote locations with smaller workforces. This chapter focuses on using advanced analytics to develop prediction, optimization, and decision technics through the mine value chain.

Chapter 3

OIL AND GAS INDUSTRY

Advanced analytics is one of the critical components in the digitalization of the oil and gas (O&G) industry. Its focus is managing and processing a high volume of data to improve operational efficiency, enhance decision-making, and mitigate workplace risks. Enhanced processing of seismic data also provides the industry with a better understanding of advanced analytics applications. However, this industry still exercises caution in adopting new technologies.

Although the oil and gas industry has recently become more interested in utilizing advanced analytics, there are still challenges mainly due to a lack of business support and awareness about the industry's advanced analytics. Furthermore, the quality of the data and understanding the complexity of the problem are also among the challenging parameters facing advanced analytics.

This chapter examines the potential for advanced analytics in the upstream and midstream oil and gas industry sectors.



Chapter 4

STEEL INDUSTRY

With an increasingly competitive environment, global steel companies are searching for ways to gain a competitive advantage. For years, steel companies have employed analytics from process simulation to laboratory management systems to computerized maintenance management systems integrated with real-time production data. However, companies can sharpen their view to make better decisions in different business areas using advanced analytics, including product costs and margins, customer insights and demand, risk management, capital investments, production, operations safety, suppliers, and global supply chain. A gradual but pervasive evolution of analytics techniques in the worldwide steel industry is expected over the next few years. Analytics has the potential to influence all major areas of the steel manufacturing value chain. Manufacturing companies can gain a margin increase by applying a more holistic approach to using analytics. Many of the steel industry's first and most significant advanced analytics applications will likely be in the supply chain operations. Advanced analytics represents a step-change in capabilities. Steel companies have the opportunity to expand the use of analytics in managing their businesses and for strategic decision-making. It is the early days for advanced analytics in the steel industry. There are opportunities for first-mover advantage, exploiting lessons from the application of analytics in other sectors.

This chapter aims to examine the opportunities and challenges of advanced analytics in the steel industry.

Chapter 5

MANUFACTURING INDUSTRY

Advanced analytics can enable manufacturing engineers to improve product quality and achieve equipment and resource efficiency gains using large amounts of data collected during manufacturing. Manufacturing engineers, however, often lack the expertise to apply advanced analytics, relying instead on frequent consultations with data scientists. Furthermore, collaborations between manufacturing engineers and data scientists have resulted in highly specialized applications not relevant to broader use cases. The manufacturing industry can benefit from the techniques applied in these collaborations if they can be generalized for a wide range of manufacturing problems without requiring a strong knowledge of analytical models.

Advanced analytics has the potential to redefine manufacturing. However, practical implementation is in its infancy. One reason is a lack of management tools that enable decision-makers to choose suitable techniques from advanced analytics for domain-specific manufacturing problems.

This chapter addresses manufacturing service transformation trends in a Big Data environment, thereby achieving transparency and productivity.

Chapter 6

FOOD INDUSTRY

Food Industries have to cater to a plethora of consumers having a variety of tastes. For sustaining in such an environment, companies create their unique selling point, and Big Data helps them analyze the market situation for such purpose. Using advanced analytics can allow the food industries to reduce food loss and gain better returns on investment by going for a digital transformation. Companies combine Big Data with machine learning and artificial intelligence to get faster and more personalized experiences.

This chapter focuses on applying advanced analytics to improve food products' quality and reduce the food industry's costs.

Chapter 7

CONSTRUCTION INDUSTRY

The construction industry deals with large volumes of heterogeneous data, which is expected to increase exponentially as technologies such as sensor networks and the Internet of Things (IoT) are commoditized. This chapter presents a detailed survey of the literature, investigating the application of advanced analytics techniques in the construction industry. While the application of data analytics in the construction industry is not new, the adoption of advanced analytics technologies in this industry remains at a nascent stage and lags the broad uptake of these technologies in other fields. The chapter fills the void and presents a wide-ranging interdisciplinary literature review of areas such as statistics, data mining and warehousing, machine learning, and Big Data Analytics in the construction industry. We discuss the current state of adopting advanced analytics in the construction industry and discuss the future potential of such technologies across the construction industry's multiple domain sub-areas.

Chapter 8

TRANSPORT AND LOGISTICS INDUSTRY



To face the worldwide competition and meet the new information technologies era's recent requirements, digitalization and adoption of new information techniques have become a must for all transport and logistics companies and organizations to improve their activities. This digital transformation of transport and logistics sectors gives birth to huge and increasingly growing sets of voluminous data with high velocity and varied data sources, also known as advanced analytics. With new manipulation and management infrastructures and more real-time analysis and techniques, these enormous datasets can be efficiently harvested to carry out valuable operational improvements and create new business values in the transport and logistics domains. This chapter reviews the advanced analytics in the transport and logistic fields, discusses the current research challenges, and identifies promising future research directions.

Chapter 9

CHEMICAL INDUSTRY

Data and analytics are playing a revolutionary role in the chemical industry. This chapter provides an overview of the chemical industry's challenges and the opportunities to transform the industry by aligning data analytics and strategy. We look at various facets of the chemical industry and outline data analytics's role in production and research strategies and marketing and customer service strategies. The chemical industry is also successfully implementing analytical techniques used by various other industries such as retailing and finance to create value through differentiation and rethinking customer offerings. We also describe Big Data and analytics opportunities to offer the industrial Internet of Things (IoT) strategy and industry 4.0 to drive performance and growth. Finally, we outline the limitations of data analytics and opportunities for future research in this area.



Chapter 10

AGRICULTURE INDUSTRY

The surge in the global population is compelling a shift toward smart agriculture practices.

This coupled with the diminishing natural resources, limited availability of arable land, increase in unpredictable weather conditions, makes food security a primary concern for most countries. As a result, the Internet of Things (IoT) and advanced analytics enhance operational efficiency and productivity in the agriculture sector. As a result, there is a paradigm shift from the use of wireless sensor networks (WSN) as a significant driver of smart agriculture to the use of IoT and advanced analytics. The IoT integrates several existing technologies, such as WSN, radio frequency identification, cloud computing, middleware systems, and end-user applications. In this chapter, several benefits and challenges of advanced analytics have been identified. Finally, we present the advanced analytics ecosystem and how the combination of IoT and advanced analytics enables smart agriculture.

Furthermore, we provide future trends and opportunities categorized into technological innovations, application scenarios, business, and marketability.

Advanced Analytics for Industry 4.0

Volume II
Technological Industries



Chapter 1

DIGITAL TRANSFORMATION FOR TECHNOLOGY INDUSTRIES

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In technology companies, lower costs and democratized data increase access and management speed, enable dynamic forecasting and complete visibility into supply chains, and improve security measures that ensure ongoing privacy compliance-like remote work. Advanced analytics and artificial intelligence can help the technology industries maximize their throughput and are reliable and robust tools to sustain new technologies in other related industries. This book clarifies the benefits of using advanced analytics in technology industries and highlights the potential challenges and risks of the Industry 4.0 revolution. This book, the second volume of the Advanced Analytics for Industry 4.0 book, aims to help industry executive managers, research and development specialists, advanced data analyzers, professors, and students working in advanced data analytics and digital transformation.

Chapter 2

COMPUTER INDUSTRY



In recent years "Big Data" has become a buzzword in business, computer science, information studies, information systems, statistics, and many other fields. As technology continues to advance, we continuously generate an ever-increasing amount of data. This growth does not differentiate between individuals and businesses, private or public sectors, institutions of learning, and commercial entities. It is nigh universal and therefore warrants further study. This review aims to provide a brief overview of Big Data and its use in analytics. After reviewing the methodology of research used in creating the review, the investigation of Big Data will begin by attempting to craft a satisfying definition of the term. Many of the relevant technologies and techniques used in advanced analytics will be covered briefly, and the benefits of advanced analytics across various sectors will be explored. The presented review in this chapter will also show several of the challenges and barriers faced by purveyors of Big Data analytic tools and attempt to determine if the analytics results offset the costs of overcoming these challenges sufficiently to make them a wise investment. The review concludes with recommendations for the future at the end of the chapter.

Chapter 3

TELECOMMUNICATION INDUSTRY

Data is one of the most strategic assets for Telecom Operators today. With the rampant adoption of smartphones and growth in mobile internet, Telecom Operators today have access to unprecedented amounts of data sources, including—customer profiles, device data, network data, customer usage patterns, location data, apps downloaded, clickstream data, etc.

Given the abundance of data at their fingertips, Telecom Operators are virtually sitting on a goldmine of information and are in a great position to capitalize on these valuable data sets. To gain insights into the avalanche of data they have at their disposal, Telecom Operators are increasingly starting to adopt Hadoop & Big Data analytics solutions to turn their data into valuable business insights and practical information.

Operators believe Big Data will play a critical role in meeting business objectives, promoting growth, and driving efficiencies and profitability across the entire telecom value chain.

This chapter facilitates advanced analytics architectures, platforms, and infrastructures to the telecommunications (telecom) industrial sector.

Chapter 4

AEROSPACE INDUSTRY



The aerospace industry is poised to capitalize on Big Data and machine learning, which excels at solving the types of multi-objective, constrained optimization problems that arise in aircraft design and manufacturing. Indeed, emerging methods in machine learning may be thought of as data-driven optimization techniques that are ideal for high-dimensional and multi-objective optimization problems, improving with increasing volumes of data. This chapter will explore the opportunities and challenges of integrating data-driven science and engineering into the aerospace industry. This chapter will include a retrospective, an assessment of the current state-of-the-art, and a forward roadmap. Recent algorithmic and technological trends will be explored in the context of critical challenges in aerospace design, manufacturing, verification, validation, and services.

Chapter 5

ELECTRONICS INDUSTRY

Advanced analytics with Big Data has been widely used in the lifecycle of electronic products, ranging from the design and production stages to the service stage. Comprehensive, advanced analytics with Big Data and a review of its application in its lifecycle steps will help researchers develop strong research themes, identify gaps in the field, and help practitioners develop an advanced analytics application system. A brief clarification of advanced analytics-related topics is presented in this chapter, and the current challenges and potential opportunities will be explained.

Chapter 6

ROBOTICS INDUSTRY

Robotic Process Automation (RPA) is going into a "maturity market." The leading vendors surpassed billion dollars in the evaluation, and the research they are launching these days on the market will radically change the business landscape. It can be seen already what is coming next to RPA: intelligent optical character recognition (IOCR), chat-bots, machine learning, Big Data analytics, cognitive platforms, anomaly detection, pattern analysis, voice recognition, data classification, and many more. As a result, the top vendors developed partnerships with the primary leading artificial intelligence providers, such as IBM Watson, Microsoft Artificial Intelligence, Microsoft Cognitive Services, Blockchain, Google, etc. On the business part, the consulting companies implementing the RPA solution are moving from developing Proofs-of-Concept (POCs) and Pilots to helping clients with RPA global roll-outs and developing Centre of Excellences (CoE). As a result, the experiences gathered so far on this kind of project will also be tackled in this chapter. In addition, this chapter will also present some data related to automation for different business areas (e.g., Accounts Payable, Accounts Receivable, etc.) and how an assessment can be done correctly to decide if a process can be automatized and, if yes, up to which extent (i.e., percent).

Moreover, the chapter will provide how now the RPA is integrated with Artificial Intelligence and Cloud, interpret data, and what savings these technologies can bring to the organizations. All the services mentioned above made RPA a potent tool. A process that was mainly not recommended for automation or was partially automated can be now fully automated with more advantages, such as money, non-FTE savings, and fulfillment time

Chapter 7

ECOMMERCE INDUSTRY

E-commerce start-ups have ventured into emerging economies and are growing at a significantly faster pace. Advanced analytics has acted as a catalyst in their growth story. Advanced analytics has attracted e-commerce firms to invest in the tools and gain a cutting edge over their competitors. The process of adoption of these advanced analytics tools by e-commerce start-ups has been an area of interest as successful adoption would lead to better results.

Typically a large e-commerce site offers thousands of products and services for sale. Therefore, navigating and searching for a product out of thousands on a website could significantly setback consumers. However, with the recommender system's invention, an E-Commerce site/application can quickly identify/predict products that closely suit the consumer's taste—one solution in advanced analytics.

Advanced analytics is the use of historical data to forecast consumer behavior and trends. In addition, it is the use of past/historical data to predict future trends. This analysis uses statistical models and machine learning algorithms to identify patterns and learn from historical data. Advanced analytics can also be defined as a process that uses machine learning to analyze data and make predictions.

This chapter presents an interpretive framework that explores the definitional aspects, distinctive characteristics, types, business value, and challenges of advanced analytics in the e-commerce landscape.

Chapter 8

INSURANCE INDUSTRY



Advances in Big Data analytics, artificial intelligence, and the Internet of Things transform the insurance industry, and data play a critical role in insurance strategy decisions. New digital data sources reveal information about behaviors and lifestyle habits that allow insurers to assess individual risks much better than before. However, the emergence of Big Data raises several concerns regarding privacy, personalization of insurance, and competition, which require intricate and complex value judgments.

Digitization and the application of Big Data analytics can considerably reduce insurance costs by automating processes along the entire insurance value chain. They could mitigate informational asymmetries, a key driver of inefficiency in insurance. Moreover, they allow for new usage-based insurance propositions and coverage for risks that so far have been considered uninsurable. Great societal benefits can ensue from better data and increased potential to reduce risks. Big Data facilitates new approaches to encourage prudent behavior. More and better data also allows for early intervention and risk prevention based on predictive analytics. Ultimately, these technologies will enable the role of insurance to evolve from pure risk protection towards predicting and preventing risks.

This chapter aims to review the opportunities and challenges of advanced analytics in the insurance industry.

Chapter 9

INFORMATION TECHNOLOGY INDUSTRY

Nowadays a Big Data analytics is an extensive area for both academia and industry.

Big Data analytics has attracted intense interest from all academia and industry recently for its attempt to extract knowledge, information, and wisdom from Big Data. Big Data and cloud computing are two of the most important trends defining the new emerging analytical tools. Big Data analytical capabilities using cloud delivery models could ease adoption for many industries, and the most crucial thinking to cost-saving could simplify useful insights that could provide them with different kinds of competitive advantage. Many companies offer online Big Data analytical tools, some of the top companies like Amazon Big Data Analytics Platform, HIVE web-based Interface, SAP Big Data Analytics, IBM InfoSphere BigInsights, Cloudera Big Data Solution, etc. Those companies analyze vast amounts of data with different tools and provide a straightforward user interface for analyzing data.

This chapter deals with Big Data definition, Analysis requirements, tools, frameworks, and different types of cloud-based Big Data analytics tools.

Chapter 10

BIOMECHANICS INDUSTRY



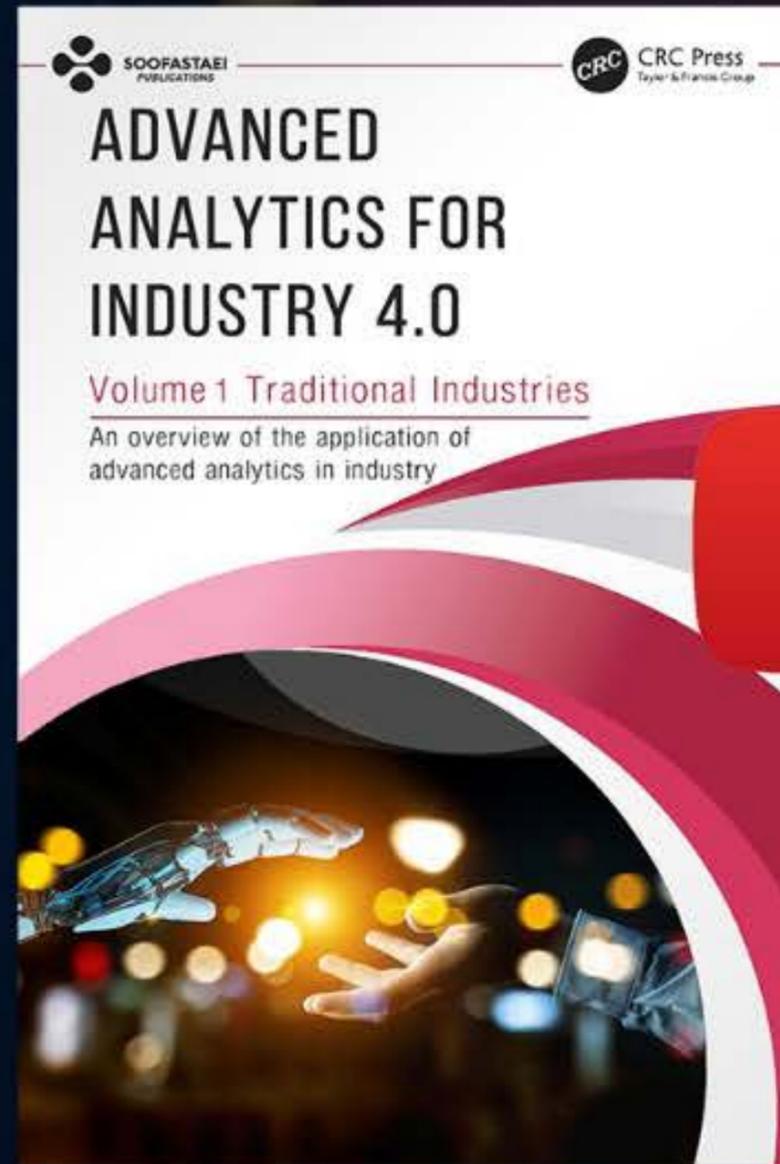
Much of the biomechanical research over the past 20 years has investigated the influence of potential injury risk factors in isolation. More likely, multiple biomechanical and clinical variables interact with one another and operate as combined risk factors to the point that traditional biomechanical analysis techniques (that is, using discrete variables, such as peak angles, together with a statistical hypothesis test, such as analysis of variance) cannot capture the complexity of these relationships.

To identify these complex associations, advanced analytics and machine learning methods are necessary. However, an adequate number of samples is needed to build accurate classification and prediction models, which grow exponentially with the number of variables used in the analysis. Similarly, traditional data analytics may not be able to handle these large volumes of data. The increasing amount of data in biomechanics research has dramatically increased the

importance of developing advanced multivariate analysis and machine learning techniques, which can better handle "Big Data." Consequently, advances in data science methods will expand the knowledge for testing new hypotheses about biomechanical risk factors.

This chapter begins with a brief introduction to the application of advanced analytics in the biomechanics industry, followed by a discussion of existing multivariate and machine learning methods that can be applied to Big Data analytics. Finally, fundamental challenges and future research directions are presented.

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