

## REVIEW

# Data, Analytics, and Intelligence

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## ABSTRACT

We are living in an age of big data, analytics, and artificial intelligence (AI). After reviewing a dozen different books on big data, data analytics, data science, AI, and business intelligence (BI), there are the current questions: 1) What are the relationships between data, analytics, and intelligence? 2) What are the relationships between big data and big data analytics? 3) What is the relationship between BI and data analytics? This article first discusses the heuristics of the Greek philosopher Plato and French mathematician Descartes and how to reshape the world. Then it addresses the above questions based on a Boolean structure, which destructs big data, data analytics, data science, and AI into data, analytics, and intelligence as the Boolean atoms. Data, analytics, and intelligence are reorganized and reassembled, based on the Boolean structure, to data analytics, analytics intelligence, data intelligence, and data analytics intelligence. The research will analyse each of them after examining the system intelligence. The proposed approach in this research might facilitate the research and development of big data, data analytics, AI, and data science.

**Keywords:** Big data; Big analytics; Business intelligence; Artificial intelligence; Data science

## 1. Introduction

Big data, artificial intelligence (AI), and data science have been critical for academia and industries. We are living in an age of big data, data analytics, and AI. Big data has become one of the most important frontiers for innovation, research, and development in the computer industry and business <sup>[1-4]</sup>.

Big data has also been a key enabler in exploring business insights, business intelligence (BI), and the economics of services. This has drawn an unprecedented interest in industries, universities, governments, and organizations <sup>[5,6]</sup>. Data analytics has also played a vital role in BI and management activities <sup>[7,8]</sup>. Market-oriented AI, big data-based AI, and BI have

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become the fiercest competition in the world <sup>[9,10]</sup>, such as chips, 5G and 6G. ChatGPT, driverless cars, TikTok, the Internet of Things (IoT), and artificial drones have made us immerse in the era of big data and AI. However, the following fundamentals of data, analytics, and intelligence are still open for comprehending and exploring big data, AI, and data science:

1) What are the relationships between data, analytics, and intelligence?

2) What are the relationships between big data, big knowledge, and big intelligence?

3) What is the relationship between business intelligence and analytics, as well as data intelligence?

This research will use the Boolean structure to address each of the issues based on the graduality of data, analytics, and intelligence as well as a systematic analysis. The Boolean structure deconstructs big data, data analytics, data science, and AI into data, analytics, and intelligence as the Boolean atoms. Data, analytics, and intelligence are then reorganized and reassembled, based on the Boolean structure, to data analytics, analytics intelligence, data intelligence, and data analytics intelligence.

The rest of this article is structured as follows: Section 2 reviews a dozen different books on big data, analytics, data science, and artificial intelligence. Section 3 looks at the heuristics of Aristotle and Descartes. Section 4 discusses how to reshape the world by shaping the wood based on a story. Section 5 explores data, analytics, and intelligence using a Boolean structure. Section 6 provides related work and discussion. The final section ends this article with some concluding remarks and suggestions for future work.

## 2. Book reviews for data, analytics, and intelligence

There are many books on each of the topics, using the research of Google books and Amazon's books. A dozen different books the author has used for his teaching and research recently are illustrated in **Table 1**.

**Table 1.** Book reviews for data, analytics, and intelligence.

Items	Books
Data	[6], [10], [11], [12]
Analytics	[6], [11], [12], [13], [14], [15], [16], [17], [18], [19]
Intelligence	[6], [10], [11], [13], [14], [15], [20], [21]
Data analytics	[6], [11], [12], [17], [18], [22], [23]
Data intelligence	[9], [11], [22], [23]
Analytics intelligence	[6], [13], [14], [15].
Data analytics intelligence	1. Analytics: Business Intelligence, Algorithms and Statistical Analysis <sup>[19]</sup> . 2. Artificial Intelligence, Analytics and Data Science: Volume 1 Core Concepts and Models <sup>[24]</sup> .

In what follows, we will examine each of them:

*Database Systems: Design, Implementation, and Management* is a classic textbook in the world that focuses on data (including big data), database systems, and management <sup>[6]</sup>. However, it lacks the investigation into analytics and intelligence, data intelligence, and data analytics intelligence.

Laudon & Laudons look at management information systems by investigating data and intelligence <sup>[10]</sup>. However, they lack investigation on relationships between data intelligence and data analytics intelligence from data, analytics and intelligence.

*Artificial Intelligence: A Modern Approach* is a classic textbook <sup>[9]</sup>. In the past AI was a knowledge-based intelligence, it is also a data-driven intelligence technique. However, it investigates the AI using an agent approach. The book has not investigated analytics and intelligence, as well as analytics intelligence and much more. Further, the agent approach in the book can be also replaced by other approaches like a multi-industry approach.

Arora, et al. investigate data and analytics <sup>[18]</sup>. From a structural viewpoint, Arora, et al, have not classified the principles, tools, and practices for mentioned topics such as database management

systems, data warehouse, BI, data visualization, big data, machine learning, and data analytics. In other words, their book has not really discussed data analytics, although the book is titled *Principles, Tools, and Practices for Data Analytics*. This book is similar to the book of Sharda, et al. [6] and the book of Weber [11], because Chapters 4 and 5 of the book are similar to Chapter 2 of the book of Sharda, et al. [6]. Chapter 2 of this book is similar to Chapter 3 of the book of Sharda, et al. [6]. The feature of this book is that it provided more techniques for big data; Chapters 6 and 7 look at the introduction to big data and Hadoop, NoSQL and MapReduce. It also provided more applications of big data and machine learning. Even so, Arora, et al. have not detailed an investigation into data analytics, data intelligence, and analytics intelligence.

Brooks investigates BI and analytics from concepts, techniques, and applications [13]. This book consists of five chapters: Chapter 1 Introduction to BI; Chapter 2 Understanding of Business Analytics; Chapter 3 Data for BI and Analytics; Chapter 4 Operational Intelligence, and Chapter 5 Role of Analytics for business decision making. However, this book lacks a detailed investigation into BI and analytics. This book also lacks related topics on various kinds of BI and business analytics at a deep level. Even so, Brooks investigates BI but also more intelligence on business, that is, market intelligence and location intelligence are important. This leads to significant questions:

- 1) What is the difference between BI and other intelligence such as market intelligence?
- 2) What is the interrelationship between intelligence and analytics?
- 3) What is the minimum intelligence and maximum intelligence?

Thompson & Rogers focus on analytics based on their understanding of how to win with intelligence [15]. They first provide the competitive advantage stemming from analytics in Chapter 1, understanding advanced analytics in Chapter 2, the age of the algorithm economy in Chapter 3, the modern data systems in Chapter 4, and then study a few business

cases. Their discussion on operational analytics (in Chapter 7) is similar to Chapter 4, Operational Intelligence of Brooks's book [13]. However, they have not investigated BI and analytics, as well as data intelligence. The challenging question for these two books is: What is the relationship between analytics and intelligence?

EMC provides big data analytics, data analytics lifecycle, and advanced analytical theory and methods using R [17]. From a research methodological perspective, this book classifies the advanced analytical theory and methods into clustering, association rules, regression, classification, visualization and report of data and more; the latter has been considered as the functions of data mining [25]. However, EMC has no interest in implementing data intelligence and analytics intelligence and their interrelationships.

Sharda, et al. focus on BI, analytics, and data science [6,14]. They look at data, big data, BI, and analytics. In particular, they investigated techniques and tools in analytics (descriptive, predictive, and prescriptive analytics). The good strength of the book is that the techniques and tools in analytics have been structured excellently. This is the first book for processing analytics using this structure. However, they have not processed diagnostic analytics [26]. They also have not investigated the relationship between BI and analytics.

Ghavami investigated big data analytics methods: analytics techniques in data mining, deep learning, and natural language processing [16]. Ghavami first looks at Part 1: big data analytics, consisting of a data analytics overview in Chapter 1, basic data analysis in Chapter 2, and data analytics process in Chapter 3, and then Part 2: advanced analytics methods, consisting of natural language processing in Chapter 4, qualitative analysis in Chapter 5, advanced analytics and predictive modelling in Chapter 6, ensemble of models in Chapter 7, machine learning and deep learning in Chapter 8, and model and optimization in Chapter 9. The book also provides case studies. Therefore, from a methodological perspective, Ghavami used models and methods to discuss data and big data. He also classifies big data

analytics and then advanced analytics methods. This book is a detailed data/analytics method for BI and analytics<sup>[14,6]</sup>. Even so, this book has a good structure from a structuralist and modelling viewpoint.

From a technique and application viewpoint, Wade looks at advanced analytics in Power BI with R and Python<sup>[22]</sup>, and Pittman uses Google Analytics and GA4 to improve online sales by better understanding customer data<sup>[23]</sup>. Both can be considered a technique and applications for understanding data, analytics, and intelligence. Both have an impact on the techniques of data analytics and BI.

There are two books on intelligence. Hawkins provides a new theory on intelligence<sup>[21]</sup>. Bostrom looks at paths, dangers, and strategies towards super-intelligence, which is a kind of meta intelligence<sup>[20]</sup>. Both books will be useful for investigating data, analytics, and intelligence, for example, Hawkins's human intelligence<sup>[21]</sup>, Bostrom's collective super-intelligence and digital intelligence<sup>[20]</sup> are vital for intelligence.

*Artificial Intelligence (AI), Analytics, and Data Science* written by Chee Chew Hua in 2020 focuses on real data and real problems instead of purely mathematical constructs, although AI, analytics and data science use mathematics to solve real problems<sup>[24]</sup>. The main chapters of this book encompass The main chapters of this book encompass chapter 3: data exploration and summaries, chapter 4: data structures and visualisation, chapter 5: data cleaning and preparation, chapter 6: linear regression, chapter 7: logistic regression, chapter 8: classification and regression Tree (CART), chapter 9: neural network, chapter 10: strings and text mining. In other words, this book mainly covers data structures, data cleaning and preparation, and visualization as the first part: data organization and visualization. The book covers linear regression, logistic regression, classification and regression tree as the second part: statistics, and this book covers neural network and text mining as a part of machine learning. Relatively, this book focuses on computations over mathematical proof, statistics are the basis for this book, because it is a textbook for students in the areas, maybe not for

students of AI, overall, this book is a theory-flavored different from other books mentioned next<sup>[11,18,19]</sup>. All these mentioned books are not related to statistics, because they are free from mathematics and mathematical formulas.

This book, titled *Big Data Analytics: Applications in Business and Marketing*, covers 4 parts below after its introduction<sup>[27]</sup>:

1) Applications of business analytics consists of chapter 2: big data analytics and algorithms, chapter 3: market basket analysis: An effective data mining technique for anticipating consumer purchase behavior, chapter 4: customer view variation in shopping patterns, chapter 5: big data analytics for market intelligence, chapter 6: advancements and challenges in business applications of SAR images, and chapter 7: exploring quantum computing to revolutionize big data analytics for various industrial sectors.

2) Business intelligence consists of 2. Business Intelligence consists of chapter 8: evaluation of green degree of reverse logistic of waste electrical appliances, chapter 9: nonparametric approach of comparing company performance: a Grey relational analysis, chapter 10: applications of big data analytics in supply chain management, chapter 11: evaluation study of churn prediction models for business intelligence.

3) Analytics for marketing decision-making consists of Analytics for marketing decision making consists of chapter 12: big data analytics for market intelligence, chapter 13: data analytics and consumer behavior, chapter 14: marketing mode and survival of the entrepreneurial activities of nascent entrepreneurs, chapter 15: the responsibility of big data analytics in organization decision-making, chapter 16: decision making model for medical diagnosis based on some new interval neutrosophic Hamacher power choquet integral operators.

4) Digital marketing consists of Digital Marketing consists of chapter 17: prediction of marketing by consumer analytics; chapter 18: web analytics for digital marketing., chapter 19: smart retailing: a novel approach for retailing business, chapter 20: leveraging web analytics for optimizing digital mar-

keting strategies, chapter 21: smart retailing in digital business, and chapter 22: business analytics and performance management in India.

The last two books can be considered as a new type of publishing, open free publishing, different from traditional publishers. Weber looks at data and big data, data science, intelligence, AI, advanced AI, machine learning, analytics and cyber security<sup>[11]</sup>, although he does not discuss analytics intelligence. His book is an introduction to all the mentioned topics. There are also a lot of good ideas in his discussion, although he contributed a number of good ideas in this book on big data, data science, AI and cyber security. However, the lack of references damaged the quality of this book.

Blatt provides each of the elements for analysis, BI, algorithms, and statistical analysis<sup>[19]</sup>. He understands that analysis has become an extremely important aspect to consider when you are thinking of starting any new line of business or even when it comes to purchasing a new house in today's world, although his book focuses on analytics rather than analysis: BI, Algorithms, and Statistical Analysis. At least, what is the relationship between analysis and analytics? It is still an issue for the author and many other readers. There are not any references in the book, which also damaged this book<sup>[19]</sup>. Even so, his discussion on descriptive, predictive, and prescriptive analytics<sup>[19]</sup> can provide a bitter understanding of data analytics as a classification of analytics.

Overall, all these books have not processed data, analytics, intelligence and their relationships properly or logically. For example, how to generalize and specialize their topics based on the research methodology is still a topic. All these books ignore the relationships between data, information, knowledge, intelligence and wisdom. They also ignore analytics and intelligence, and intelligent analytics with applications in business and other fields including management and decision-making. All these books' thoughts, technologies, and methods need a systematic integration based on a Boolean structure (see later) and our existing research sections. Therefore, the following research issues should be addressed:

- 1) What is the relationship between data, analytics, and intelligence?
- 2) What is the relationship between BI and Analytics?
- 3) What is the relationship between BI, Analytics, and data intelligence?
- 4) How to generalize and specialize data science, big data, BI and AI based on the Boolean research methodology?

### 3. The heuristics of Plato and Descartes

*The Republic* was written by an ancient Greek philosopher Plato<sup>[28]</sup> about justice, order, character and the man of the republic. A few years ago, my friend told the author that he would like to build a republic and become a president. As a scholar, the author cannot create a republic. However, the author can write an article and publish a book. In fact, writing an article and publishing a book, similar to creating a republic, must follow a set of rules, referencing rules, writing rules, publishing rules, formatting rules, templating rules, and communicating rules. Some articles and books are also required to have a research methodology consisting of a set of research rules.

Descartes is a great French mathematician. It is he who introduced analytical geometry that let the author know how to integrate algebra and geometry. It is he who gave the author a better understanding of analytics. Descartes is a great man not only because of his profound knowledge of analytical geometry, but his book on his research methodology titled *Discourse on the Methods*<sup>[29]</sup>. The author does not have a lot of knowledge and skill in data science, AI, or computer science although he has been working in these areas for a few decades. However, this research tries to use a new research methodology and ideas, just like Descartes, to create a new research methodology for a new article and a new book.

### 4. Reshaping the world

When the author was very young. His dream was to become a carpenter. He bought a very expensive

saw, plane, chisel, nail, axe and ruler to make a table, similar to the existing table around him. His idea was to reshape wood although he could not reshape the world. Yes, he was very happy that he made a table, which made his parents also very happy. His neighbors and villagers helped him to become a master of reshaping wood. However, he did not continue this way, and instead, he continued to study and took the national examination for universities and changed his way completely.

Now, he became a scholar and drove to an Australian furniture shop to buy a box of tables made in China. After he came back to his home, he opened the box and reassembled the table based on the instruction: how to reassemble the table using a provided screwdriver.

The author asked the boss of the table factory how to make a table. The boss told him that this was a reshaping of wood by:

- 1) Design a table and draw a table blueprint.
- 2) Disassemble the table into a table plate, table leg, nails, furniture cam lock and nut.
- 3) Procure a table plate, table leg, furniture cam lock and nut, nails, and booklet for reassembling the table from different factories using the Internet and putting them into a box.
- 4) Advertise the information of the table to all the world using the Internet.
- 5) Sell all the boxes of tables to the world using the Internet.

Therefore, disassembling, procuring, and selling are important tasks of the table factory.

This is a kind of reshaping wood towards mass production based on big data, business analytics, and the Internet. In fact, more than 40% of the furniture is made in China in 2022 by these furniture factories. The Internet and big data have been playing an important role in meeting the furniture requirements of the world.

We cannot destroy the existing world. However, we must smash and reorganize human living conditions and everything such as commodities, organizational structures, design and art, education and development in the world. The rules of the world

and new algorithms are about to change the world completely, to reorganize things accordingly based on advanced technologies such as AI, big data, and digital technology. They will basically overturn the foundation of the whole world that has been established for half a century since the inception of digital computers in 1946. The computer infrastructure is based on chips for CPUs (a central processing unit) and AI GCUs of NVIDIA (<https://www.wired.co.uk/article/nvidia-ai-chips>), and big data as the core of AI computing. This article aims to smash and reorganize AI, big data, data analytics, and business intelligence and reorganize them using first a Boolean structure and then reorganize the new atoms and internal components of this Boolean structure using a new algorithm to smash and reorganize computing such as data computing, information computing, knowledge computing, intelligence computing, and wisdom computing.

## 5. Overview on data, analytics, and intelligence

What is intelligence? It is related to patterns, knowledge discoveries, and insights for decision-making. Even so, wisdom is still more important than intelligence. We are at the trinity age of data, analytics, and intelligence.

We are in the age of AI and big data. AI including its natural language processing (NLP) and big data has been applied to almost every sector and has been revolutionizing our work, lives and societies <sup>[30]</sup>. ChatGPT is an example of NLP.

Big data does not have very big value without big data analytics, just as oil without the significant progress of the petrochemical industry <sup>[31]</sup>. However, the commercial value of big data becomes bigger and bigger with the processing, deep processing, smart processing, and intelligent processing of big data. Big data analytics is behind processing, deep processing, second-time processing, and multi-processing... of big data. Therefore, big data analytics is more important than big data, and intelligent big data analytics is at the core of this age of trinity and will become a disruptive technology for the age of Trinity

in terms of healthcare, web services, service computing, cloud computing, IoT (the Internet of Things) computing, and social networking computing<sup>[2]</sup>.

## 6. Big data, analytics, and intelligence: A Boolean structure

This research will use the Boolean structure to address each of the issues based on the graduality of data, analytics, and intelligence as well as a systematic analysis of related books and journal articles and the research methodology such as a meta-processing, systematic generalization and specialization of existing publications, as illustrated in **Figure 1**. It will provide multi-industry applications in business, management and decision-making based on the Boolean structure. All these are treated using an integrated approach. This Boolean structure destructs the existing world of the books mentioned in section 2. For example, AI, BI, big data analytics, and data science<sup>[14,6]</sup> are destructed into data, analytics and intelligence as the three atoms of Boolean structure. The data, analytics, and intelligence are reorganized and reassembled based on Boolean structure to data analytics, analytics intelligence, and data intelligence and then data analytics intelligence. In such a way, some of the mentioned books have ignored some of

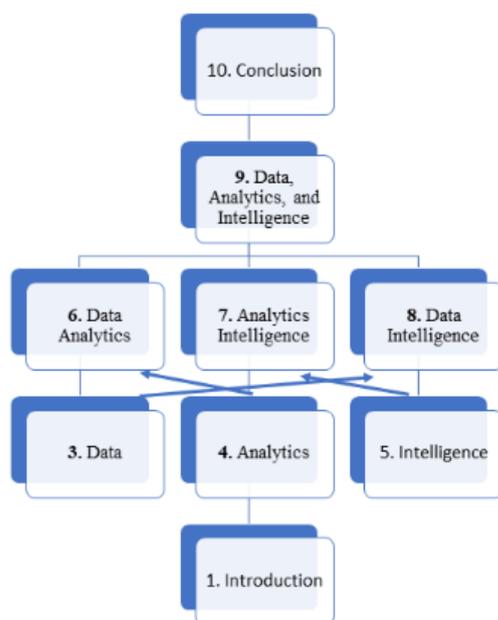
them, for example, analytics intelligence and data analytics intelligence, technologically. Accordingly, big data analytics intelligence has not been discussed in the mentioned books.

Based on the Boolean structure, the introduction is the basis. The three atoms of the Boolean structure are composed of data, analytics, and intelligence. Data, analytics, and intelligence will be represented as three composite Boolean expressions, that is, data analytics, analytics intelligence, and data intelligence. Finally, data, analytics and intelligence have been represented as the Boolean expression: data analytics intelligence. In other words, this research (as a book under contract with CRC Press and Talyer Francis in the USA), based on a Boolean structure, is composed of the following chapters<sup>[32]</sup>:

- 1) Introduction
- 2) Data
- 3) Analytics
- 4) Intelligence
- 5) Data analytics
- 6) Analytics intelligence
- 7) Data intelligence
- 8) Data, analytics and intelligence
- 9) Conclusions

In what follows, we will explore each of them (except for the introduction and conclusion), corresponding to a chapter in the book, based on an integrated approach.

This research uses computing, science, technology, systems, management, services, and applications to explore each of the above terms listed in the Boolean structure. For example, it will explore data computing, data science, data engineering, data technology, data systems, data management, data services, and data applications<sup>[33]</sup>. It will demonstrate that data engineering aims to use data science and data technology to develop and manage data systems to provide data intelligence with data system products and services<sup>[33]</sup>.



**Figure 1.** Data, analytics and intelligence: A Boolean structure.

### 6.1 Data

All data and big data are important for ruling the world. Data have become an important element

of the economy <sup>[32]</sup>. One hundred years ago, big companies dominated steel, oil, and manufacturing companies. Recently, big data companies have ruled the whole world. Apple, Alphabet, Meta (formerly Facebook), Amazon, Microsoft, Tencent, and Alibaba have dominated the whole world. Big data as a disruptive technology is transforming how we live, study, work, and think <sup>[32]</sup>. Therefore, this research first looks at data, and then big data. It identifies and examines ten big characteristics of big data with an example for each: big volume, big velocity, big variety, big veracity, big data technology, big data systems, big Infrastructure, big value, big services, and big market <sup>[31]</sup>. It also explores a service-oriented foundation of big data and calculus of big data. Besides data and big data, this research also explores not only data, but also information, knowledge, and intelligence (DIKI) are important for ruling the world. Then it explores DIKI computing, science, Engineering, technology, systems, management, and services <sup>[33]</sup>. For example, data computing = data science + data engineering + data technology + data systems + data Management + data service. Finally, this research provided big trends in the era of big data, that is, we are embracing the era of big data. Countries around the world have drawn increasing attention to the research and development of big data since 2012 <sup>[26]</sup>. Big data industries have been booming in the world. These six big trends consist of the informatization of big data, mining big data for big knowledge, mining big data for big intelligence, networking of big data, socialization of big data, and commercialization of big data <sup>[32]</sup>. This research also discusses the interrelationships of data from three different viewpoints: data science, big data and artificial intelligence (AI). The research demonstrates that big data is the raw material that will be transformed into information, knowledge, intelligence, networking, society and big market using ICT and digital technology, data science, and AI. These six big trends will bring about big industries, smarter cities, smarter societies and smarter countries. Overall, data in general and big data in particular are a foundation

of big information, big knowledge, big intelligence and big analytics. Therefore, we are still at the foundational stage, and enter the emerging age of big information, big knowledge, big intelligence, and big analytics.

## 6.2 Analytics

We are in the age of analytics although it has been around us for about a century <sup>[15,34]</sup>. Analytics is a science and technology of using mathematics, AI, computer science, data science and operations research to provide practical applications to business, management, research and development, economic and societal problems. Analytics can be defined as a process of understanding and exploring data by creating meaningful patterns and insights <sup>[19]</sup>. Analytics is one area that requires complex algorithms <sup>[15,9]</sup>. One of the most important parts of analytics is data visualization <sup>[19,18]</sup>. After discussing the evolution of analytics, this research looks at analysis  $\neq$  analytics, and examines mathematical analytics, a system process of analytics. This research provided types of analytics based on a few perspectives, one of them is that analytics can be classified into descriptive statistics, diagnostic statistics, predictive statistics, and predictive statistics (DDPP analytics) based on cyclic business operations. This research explores analytics algorithms and models, and analytics computing, for example, analytics computing = analytics science + analytics engineering + analytics technology + analytics systems + analytics management + analytics services + analytics intelligence. Analytics engineering aims to use analytics science and analytics technology to create and manage analytics systems to provide analytics services with analytics intelligence <sup>[33]</sup>. Finally, this research analyzes three major trends of analytics, that is, the rise of analytics scientists, and algorithms becoming more and more important for the Algorithm industry, and the blossoming analytics industry and then all analytics including analytical approach, analytical modelling, analytical analysis, analytical metrics are central for ruling the world.

### 6.3 Intelligence

All data, big data, and analytics are all for intelligence [32]. Intelligence is not only a lasting topic for computer science, AI, intelligence computing, BI, and intelligent analytics, but also an exciting topic for industries, organizations, and businesses [35]. AI has facilitated the development of intelligent services, intelligent manufacturing, intelligent systems [9], and intelligent analytics [34]. BI has promoted the improvement of competitiveness of business and marketing performance, supported management decision-making of organisations, and produced trillion level enterprises such as Google, Amazon, and Meta [3,36]. However, the current AI is a very mixed intelligence, and very market-driven. A lot of companies brand their products as AI products. Many social media brands do a lot of things as AI products and services. Even so, this research looks at the fundamentals of intelligence including basic intelligence, how can calculate intelligence? Then it explores Intelligence 1.0, Intelligence 2.0, and Meta AI with six levels of intelligence. It examines multi-intelligence and intelligence of the five senses. This research provides a meta-approach to a hierarchy of data and intelligence including meta (DIKI) and a meta-approach to intelligent systems. This research demonstrates that, meta (data) = information; meta (information) = knowledge, meta (knowledge) = Meta<sup>3</sup> (data) = intelligence; Meta<sup>4</sup> (data) = meta (intelligence) = mind, Meta<sup>5</sup> (data) = meta (mind) = wisdom. After overviewing intelligence in AI, this research explores wisdom and mind, from AI to artificial mind, cloud intelligence, data intelligence, and similarity intelligence. It provides an integrated framework of intelligence to a DIKW Intelligence where DIKW is the abbreviated form of data, information, knowledge and wisdom. This research also examines the age of meta intelligence as competing in the digital world.

### 6.4 System intelligence

This leads to a new question, that is, how can we calculate system intelligence? This research explores

temporality, expectability, and relativity of intelligence as three system intelligences [35].

#### Temporality of intelligence

There are two meanings for temporal intelligence. 1) Temporal intelligence is the ability to adapt to change. This has motivated the development of temporal logic and evolutionary computing including genetic algorithms [9]. 2) Temporality of intelligence means that intelligence is related or limited to a time interval [35]. For example, at the time of writing this section, few people consider floppy disks as intelligent storage devices. However, a few decades ago floppy disks were considered intelligent in comparison to paper tape for data storage. In what follows, we limit ourselves to the meaning of item 2.

#### Expectability of intelligence

Intelligence can be referred to as a substitution for easier, faster, smarter, friendlier, more efficient, more satisfactory. This is the expectability of intelligence. We denote them using the degree of satisfaction. All these related concepts are a set of expectations of humans, as parts of human intelligence. Some aim to become billionaires. Some like to become the president of a country to provide services to the people of the country. Others aim to become a CEO of top companies in the world. Different people have really different expectations. We denote these expectations for a system or product  $P$ , as  $E_p = \{e_i | e_i \text{ is an expected performance for function } i \text{ of a product}\} = \{e_i | i \in \{1, 2, \dots, n-1, n\}\}$ , where  $n$  is a given integer. For every  $i \in \{1, 2, \dots, n-1, n\}$ , there is a perceived performance of the customer for function <sub>$i$</sub> ,  $p_i$ , then a product  $P$  is intelligent if and only if there exists at least one  $i \in \{1, 2, \dots, n-1, n\}$  such that [35]:

$$S_i = \frac{p_i}{e_i} \geq 0 \quad (1)$$

where  $s_i$  is the satisfaction degree of the customer to the  $i^{\text{th}}$  function of system  $P$ .

For example, a Huawei Mate 60 Pro smartphone, cost CN¥6,599 (\$923.99) as a launch price in August, 2023, with BDS satellite calling and message and 5G telecommunication is smarter. “Smarter” is what the

customer perceived,  $p_1 = 1.5$ , while “smart” is an expected performance,  $e_1 = 1$ , for Huawei Mate 60 Pro from a customer, based on Equation (1), we have the satisfaction degree of the customer  $s_i = 1.5 > 0$ . Then a Huawei Mate 60 Pro smartphone is intelligent.

### Relativity of intelligence

If one lives in the data world, one will find information = metadata (i.e., meta (data)) is a result of meta intelligence. However, if one lives in the information world, one cannot have such knowledge. Further, if one lives in the information world, one will find knowledge = meta (information) (i.e., meta (information)) is a result of meta intelligence. However, if one lives in the knowledge world, one cannot have such a vision. Therefore, one has relativity of intelligence and relativity of meta intelligence. This also means that meta is relative.

Generally speaking, let  $X$  and  $Y$  be two systems.  $X$  is intelligent if  $X$  is better than  $Y$  with respect to  $E$ , where  $E$  is a set of human expectations. “Better” is a relativity concept. For example, a new microwave is intelligent because it displays the temperature when microwaving food. A user believes that displaying the temperature is better than not displaying it. This example reflects the relativity of intelligence. Displaying temperature belongs to the set of expectations  $E$ . The set of human expectations can be considered as a set of demands. The expectation of human beings and society promotes intelligence and social development. Therefore, it is significant to define the intelligence of systems with respect to the set of human expectations or demands.

In summary, system intelligence can be measured through three dimensions: temporality, expectability, and relativity. In other words, there are three characteristics of system intelligence: temporality, expectability, and relativity. The degree of intelligence of a system product or service can be measured using this triad, that is:

$$\begin{aligned} \text{degree of system intelligence} = & \text{temporality} \\ & + \text{expectability} \\ & + \text{relativity} \end{aligned} \quad (2)$$

Equation (2) is more useful for system intelligence

and big data intelligence, because they are based on performance, business advantages, competitive advantages of systems products or services. All of these are closely associated with temporality, expectability, and relativity of system intelligence. This formula can be realized by using big data analytics and big data, in other words, big data and big data analytics can generate big data intelligence, for short,

$$\text{big data intelligence} = \text{big data} + \text{big data analytics} \quad (3)$$

Equation (3) indicates that increases in either big data or big data analytics can improve big data intelligence. This is partially proved by what Professor Peter Norvig, Google’s Director of Research, said: “We don’t have better algorithms; we just have big data”<sup>[37]</sup>.

Temporality, expectability, and relativity of system intelligence can be considered fundamental for BI including organization intelligence, enterprise intelligence, marketing intelligence, big data intelligence, analytics intelligence, and data analytics intelligence<sup>[13]</sup>. We will explore them in the next subsection.

### 6.5 Data analytics

Data analytics might be the oldest among all types of analytics. Data have become the new oil and gold of the 21st century. Data analytics mines the data from data sources such as data warehouses and data lakes for new knowledge and meaningful insights<sup>[16]</sup>. Data analytics is at the heart of business and decision-making<sup>[6]</sup>, just as data analysis is at the heart of decision-making in almost real-world problem-solving<sup>[38]</sup>. This research first discusses the fundamentals of data analytics. Then it explores the classification of data analytics. It explores the fundamentals of big data analytics and advanced analytics platforms. The research examines big analytics covering big information analytics, big knowledge analytics, big wisdom analytics, and big intelligence analytics. Then this research discusses data science covering database systems, data warehousing, data mining, data computing and data analytics computing. Finally, this subsection will explore data analytics and big data analytics with applications in busi-

ness, management, and decision-making.

## 6.6 Analytics intelligence

Analytics intelligence is about how to use analytics to win intelligence<sup>[15]</sup>. Strategically, analytics intelligence is an intelligence that is derived from analytics systems. This research looks at analytics intelligence and intelligence analytics, as well as DIKW analytics intelligence and big DIKW analytics intelligence. It overviews generative intelligence. The research explores analytical intelligence as the core of AI and generative intelligence not only in academia and the market. The research demonstrates that the earlier analytical intelligence was from logical AI, and then symbolic AI. This period has lasted till the inception of the Internet. However, big data has been booming from 2012 and onwards. Data analytics and big data analytics have become an important part of business analytics, BI, and intelligent analytics. What is the key to data analytics? It is analytic. How can we use analytic methods and techniques to process data and big data, information and big information, knowledge and big knowledge intelligently? This is the analytical intelligence underpinned by data analytics, big data analytics, and big analytics. Therefore, we can work on intelligent data analytics and intelligent big data analytics, both are used to develop analytical intelligence in terms of business and society.

Mathematically<sup>[35]</sup>,

$$\text{Analytics} = \text{analysis} + \text{SM} + \text{DM} + \text{DW} + \text{ML} + \text{visualization} \quad (4)$$

where SM, DM, DW, and ML are abbreviated forms of statistical modeling, data mining, data warehouse, and machine learning. Therefore, using intelligence as a right operation to both sides of the above equation, we have:

$$\begin{aligned} \text{Analytics intelligence} = & \text{analysis intelligence} \\ & + \text{SM intelligence} \\ & + \text{DM intelligence} \\ & + \text{DW intelligence} \\ & + \text{ML intelligence} \\ & + \text{visualization intelligence} \end{aligned} \quad (5)$$

The research examines big data analytics intel-

ligence with applications. Finally, the research discusses the spectrum of intelligent analytics.

## 6.7 Data intelligence

Data intelligence is the analysis of various forms of data in such a way that it can be used by companies to expand their services or investments future<sup>[39]</sup>. This research introduces data intelligence by addressing the following research questions: What is the fundamental of data intelligence? What are the applications of data intelligence? After reviewing backgrounds and related work, this research analyzes data as an element of intelligence, and looks at data and knowledge perspective on intelligence including information intelligence and knowledge intelligence. It examines big intelligence not only with data, but DIKW intelligence through proposing an integrated framework of intelligence. This research presents the fundamentals, impacts, challenges, and opportunities of data intelligence in the age of big data, AI, and data science. This research also presents a unified framework for not only data intelligence. This research also looks at the age of meta intelligence for competing in the digital world. Finally, this research explores big data 4.0 as the era of big intelligence we are living in. There are at least two contributions to the academic communities. 1) The research demonstrates that data intelligence is the basis for knowledge intelligence, which is a core of artificial intelligence. 2) Big data 4.0 = big intelligence will play a critical role in our organisations, economies, and societies.

## 6.8 Data, analytics, and intelligence

Google Web and Google Scholar search and summarize their popularity for each of analytics on data, information, knowledge, and wisdom. This is a kind of analytics on data, information, knowledge, and wisdom (retrieved on July 26, 2023).

From **Table 2**, Google Scholar implies that data analytics and information analytics are similar in academia, while Google Web means that information analytics plays a more important role than data

analytics in academia and industry although data analytics are very popular in the big data and business intelligence world <sup>[6,26]</sup>. Knowledge analytics and wisdom analytics have also played an important role in academia and industry although they are not popular in the business intelligence world <sup>[10,13]</sup>. This implies that not only data analytics but also information analytics, knowledge analytics, and wisdom Analytics (DIKW analytics) have played a critical role in computer science, AI, and data science as well as business and management. Therefore, this research looks at data analytics intelligence and big data analytics intelligence. It explores DIKW computing, analytics, and intelligence. The research presents a cyclic model for big data analytics and intelligence. The research provides the calculus of intelligent data analytics: elements, principles, techniques, and tools for business analytics and business intelligence. Finally, the research provides fundamentals of business analytics and discusses the relationships of business analytics, digital analytics, and business intelligence and applications of big data analytics intelligence.

**Table 2.** Data analytics, information analytics, knowledge analytics, and wisdom analytics.

Analytics	Google Web	Google Scholar
Data analytics	1,970,000,000	4,390,000
Information analytics	2,630,000,000	4,560,000
knowledge analytics	894,000,000	3,170,000
Wisdom analytics	36,400,000	114,000

## 7. Discussion

This section will discuss the related work on data, analytics, and intelligence. It also examines the limitations of this research.

A Google Scholar search for “data, analytics, and intelligence” found about 11,000,000, 4,980,000, and 4,500,000 results, respectively (retrieved on December 2, 2023). This implies that data, analytics, and intelligence have become significant topics for the research of scholars and researchers. A Google search for “data, analytics, and intelligence” found about 18,600,000,000, 5,650,000,000, and 2,780,000,000 results respectively (retrieved on December 2, 2023).

This means that data, analytics, and intelligence have significantly influenced our lives, communities, economies, and societies. Therefore, data, analytics, and intelligence are still a topic for us to explore and develop in the age of digital technology.

This article first reviewed a dozen different books on big data, data analytics, data science, artificial intelligence, and business intelligence that have been used for the author’s teaching and research in the past few years. Some authors use textbooks such as *Database Systems: Design, Implementation, and Management* <sup>[40]</sup>, *Management Information Systems: Managing the Digital Firm* <sup>[10]</sup>, *Business Intelligence, Analytics, and Data Science: A Managerial Perspective* <sup>[14]</sup>, and *Artificial Intelligence: A Modern Approach* <sup>[9]</sup> to apprehend data, analytics and intelligence. Other authors use *Big Data and Artificial Intelligence: Complete Guide to Data Science, AI, Big Data, and Machine Learning* <sup>[11]</sup>; *Business Intelligence and Analytics: Concepts, Techniques and Applications* <sup>[13]</sup>; *Analytics: Business Intelligence, Algorithms and Statistical Analysis* <sup>[19]</sup> and *Data Analytics: Principles, Tools and Practices* <sup>[18]</sup> to look at the relationships of data, analytics, and intelligence. Some authors also provide case studies for how to data and analytics to win with intelligence <sup>[15]</sup>. Other authors use *Google Analytics and GA4: Improve Your Online Sales by Better Understanding Customer Data and How Customers Interact with Your Website* in order to understand data, analytics, and intelligence <sup>[23]</sup>. Different from above mentioned books and related publications, this article uses the motivation of the heuristics of Greek philosopher Plato and French mathematician Descartes, a story for reshaping the world and the Boolean structure to destroy big data, data analytics, data science, AI into data, analytics, and intelligence as the Boolean atoms. Then data, analytics, and intelligence are reorganized and reassembled, based on the Boolean structure, to data analytics, analytics intelligence, data intelligence, and data analytics intelligence. Then this article examines each of the eight Boolean elements in depth.

A limitation of this research is that it should pro-

vide a deeper investigation into data, analytics, and intelligence in order to provide more rationales for each of them with multi-industry applications. Another limitation of this research is that connecting (or connection) should be another component of human intelligence. Connectivity should be another element of system intelligence. Advanced communication technologies and tools such as mail, telephone, email, social media, and information sharing on the Web aim to develop the skill of connecting as a form of system intelligence<sup>[32]</sup>. For example, the current advanced ICT technology and systems (have brought about social networking services such as Facebook, LinkedIn, and WeChat<sup>[10]</sup>). All these have developed the skill of connecting as a part of system intelligence. we will add connectivity intelligence as the fourth of human intelligence and system intelligence in future work.

## 8. Conclusions

This research first reviews a dozen different books on big data, data analytics, data science, artificial intelligence, and business intelligence and discusses the heuristics of Greek philosopher Plato and French mathematician Descartes and how to reshape the world. The key scientific methodology and tool is destructing, reorganizing, and reassembling to reshape the world of big data, data analytics, data science, artificial intelligence, and business intelligence. This article uses the Boolean structure as a scientific tool to destruct big data, data analytics, data science, AI into data, analytics, and intelligence as the three Boolean atoms. Then data, analytics, and intelligence are reorganized and reassembled, based on the Boolean structure, to data analytics, analytics intelligence, data intelligence, and data analytics intelligence. The article analyses each of them after examining the system intelligence. Corresponding to the above key scientific methodology and tool, this article and book will use engineering method to discuss each of the chapters. For example, one of the key contributions of this article is that data (analytics) engineering aims to use data science and data technology to develop and manage data systems to

provide data intelligence with data system products and services<sup>[32]</sup>.

This research is based on the early book publication proposal submitted to CRC Press Florida and Tayler Francis Delaware, USA. The book has been under contract with the mentioned company. This article and this book hope that ideas, methods, and techniques with applications help readers prepare critical data, analytics, and intelligence for the changing uncertainties ahead, not only to understand the knowledge of them.

In future work, as an extension of future research directions and our research of this article, we will delve into real world cases such as the IoT including the Internet of People (IoP) and the Internet of Services (IoS), and ChatGPT to further verify big intelligence where we are living in. We will also develop a unified framework for analytics thinking and analytics intelligence to support big intelligence.

## Conflict of Interest

There is no conflict of interest.

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