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Navigating the ethical and privacy concerns of big data and machine learning in decision making

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Abstract: In recent years, the fields of big data and machine learning have gained significant attention for their potential to revolutionize decision-making processes. The vast amounts of data generated by various sources can provide valuable insights to inform decisions across a range of domains, from business and finance to healthcare and social policy. Machine learning algorithms enable computers to learn from data and improve their performance over time, thereby enhancing their ability to make predictions and identify patterns. This article provides a comprehensive overview of how big data and machine learning can improve decision-making processes between 2017–2022. It covers key concepts and techniques involved in these tools, including data collection, data preprocessing, feature selection, model training, and evaluation. The article also discusses the potential benefits and limitations of these tools and explores the ethical and privacy concerns associated with their use. In particular, it highlights the need for transparency and fairness in decision-making algorithms and the importance of protecting individuals' privacy rights. The review concludes by highlighting future research opportunities and challenges in this rapidly evolving field, including the need for more robust and interpretable models, as well as the integration of human decision making with machine learning algorithms. Ultimately, this review aims to provide insights for researchers and practitioners seeking to leverage big data and machine learning to improve decision-making processes in various domains.

Key words: privacy; big data; machine learning; cybersecurity; decision making

1 Introduction

The decision-making process holds significant importance in both personal and professional domains, as it entails selecting the most optimal course of action from a range of available alternatives[1]. The ability to make effective decisions is crucial in attaining personal and organizational objectives, enhancing productivity, and upholding competitiveness in the current dynamic corporate landscape[2]. Conventional methods of decision making rely on subjective judgment, practical knowledge, and non-numerical information to arrive at well-informed decisions[3]. Nevertheless, the efficacy of these techniques may be constrained in their capacity to furnish precise and all-encompassing perspectives, particularly when confronted with voluminous datasets or intricate predicaments.

By offering a more data-driven and objective approach to decision making, big data analytics can solve some of the drawbacks of conventional decision-making methods[4]. Big data analytics can assist in resolving decision-making issues by improving visibility, arranging and filtering data, locating crucial insights, and producing more precise predictions[5]. While big data analytics can provide valuable insights to inform decision making, there are also several issues that organizations should be aware of when using big data for decision making[6]. Making decisions can be difficult when using big data because of problems with data quality, bias, privacy concerns, complexity, expense, and security hazards. To ensure the efficient and moral application of big data for decision making, it is critical for enterprises to be aware of these

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problems and take action to overcome them.

Big data availability and machine learning technology development have significantly increased in daily life[7], which has sparked an explosion in interest in applying these tools to help decision making across a variety of sectors. In contrast to machine learning, which uses algorithms that can learn from data and make predictions or judgments based on that learning[8], big data refers to datasets that are too massive and complicated to be processed using conventional data processing techniques[9]. Machine learning can help address some of the issues associated with big data and decision making by improving data quality, reducing bias, addressing privacy concerns, simplifying complexity, lowering costs, and enhancing security.

The utilization of big data and machine learning algorithms for decision-making purposes holds the capacity to bring about a significant transformation in various domains such as healthcare[10], finance and marketing[11], and transportation[12], among several others. Esteva et al.[13] suggested that medical data can be analyzed using machine learning algorithms to detect patterns that may signify the presence of a disease. These patterns can then be utilized to provide personalized treatment recommendations. Although big data and machine learning have the potential to offer significant advantages in decision making, there exist numerous challenges that require attention. The collection and utilization of vast amounts of data raise ethical and privacy concerns, especially when such data comprises sensitive personal information[14]. Furthermore, there exist apprehensions regarding the precision and dependability of machine learning algorithms, particularly when they are employed in situations that involve decision making[15].

The role of big data and machine learning in decision making has become increasingly important in recent years. These technologies have allowed organizations to extract insights from vast amounts of data and make better decisions in a timely manner. The goal of a scoping review on the application of big data and machine learning in decision making is to map the body of existing literature and pinpoint essential ideas, knowledge gaps, and areas in need of further investigation. Scoping reviews help combine many pieces of information and give a broad perspective on the breadth and depth of a subject. The existing research on how big data and machine learning are used in decision making will be summarized in this scoping review. It will examine the numerous ways in which these technologies are used in diverse fields, point out the advantages and difficulties of doing so, and highlight emerging trends and lines of inquiry. The review will address the following research questions:

(1) What approaches and techniques are used for leveraging big data and machine learning in decision making?

(2) What are the ethical and privacy concerns associated with the use of big data and machine learning in decision making?

(3) What are the key challenges and opportunities for future research in this field?

This scoping review will provide a comprehensive overview of the current state of research on the role of big data and machine learning in decision making. It will first present the concepts and relationships between decision making, machine learning, and big data. After outlining the methodology of the review, the results of included article will be presented, and three research questions will be discussed. The conclusion will be the final part.

2 Decision making

Industry 4.0 requires data-driven decision making, which has sparked the development of novel techniques and algorithms to assist engineers in choosing the best course of action for maintenance and operational tasks[16]. Making decisions effectively is crucial to the success of any business or organization. The decision-making process is challenging since numerous criteria can be used to decide whether or not to take action. Numerous decisions that affect their professional and personal lives are made by people every day. Making decisions is essential for organizations and businesses to accomplish their strategic goals and maintain their competitiveness in a market that is always changing. Making decisions can

be difficult and complex, and it calls for thorough consideration of many different elements.

Organizations continue to witness an explosion[17] in the volume, velocity, and variety of data created each year. This includes the diversity of data types, the velocity of data creation, and the volume of data[18]. Big data[19] has been characterized as a game-changer in how businesses operate across many industries. This can be attributed to the increased use of structured data and unstructured data, such as videos and images[20]. Moreover, people are using desktops, laptops, smartphones, tablets, and other smart devices that produce a variety of large datasets by their very nature[21]. Big data is another name for these various kinds of enormous datasets. Big data consists of massive amounts of data from data sharing, analysis, and mining[22, 23], manufacturing data from cyber-physical systems[24], and other applications related to Industry 4.0, such as digital twin systems[25]. Data visualization, advanced data analytics, data storage, data acquisition, data generation, and decision making for value creation are the six primary components that comprise the related field of big data analytics[26].

In the age of digital transformation, organizations recognize the value and significance of making the right decisions at the right time, which is only possible by relying on the relevant and timely accessibility of information and data that are processed as a component of the decision-making process[27]. The process of making choices is supported at all organizational levels by data that can be meaningfully processed[28]. The sequence of visualizing, processing, and accumulating big data can assist an organization's management function in making informed decisions regarding the operations and approach of the organization. In a business environment that is constantly evolving, organizations around the world strive to gain a competitive advantage by employing the most recent technologies to process data and improve strategic decision making.

Big data has revolutionized decision making by granting organizations access to vast quantities of data that may be analyzed to obtain valuable insights[29]. Multiple studies have highlighted the use of big data in decision making[30], with big data analytics tools playing an essential part[31]. By utilizing these tools and analyzing massive amounts of data, decision-makers can make more informed decisions that contribute to the success of their businesses. From the general literature on the role of big data in the organizational decision-making process, it can be seen that organizations that consider the capabilities of big data can make more informed decisions that help them increase their bottom line, improve overall performance, and gain a competitive advantage[32]. In addition, big data may be used to automate processes, acquire knowledge about target audiences, and improve performance through an in-depth market understanding based on past events. Big data is the ability of a business to utilize the data accumulated during daily operations[33].

3 Big data's role in decision making

In the age of big data, the manufacturing sector generates enormous amounts of large data, much of which has an ultra-high dimension[34]. A difficult topic is how to handle these ultra-high dimension data, unlock their potential, and create a data flow model appropriate for the current manufacturing environment[35]. The industrial sector will currently profit more optimally from big data-driven analysis thanks to the cooperation of associated new technologies against the backdrop of Industry 4.0. The goal of the data analysis process is to increase decision-making openness[36].

Big data starts the digital revolution in the age of intelligent information linkage and knowledge drive[37]. The complexity and cognitive load of processing vast amounts of data are being gradually reduced through methods based on intelligent computing and big data analysis[38]. To increase its competitiveness, the organization is increasingly implementing solid data-driven strategies[39]. Modern manufacturing has a great chance to make the switch from traditional production to intelligent manufacturing thanks to big data-driven technology. Big data analysis has recently been the primary motivator for businesses to create industrial value, pushing the intelligent growth of industrial

facilities and increasing industrial production. Research on industrial output has made use of the data gathered from numerous sources. Data-driven production research has replaced analytical model-based production research[40].

Big data analysis represents a fundamental improvement over traditional data analysis. Big data systems' distinctive traits in the industrial sector's big data era are real-time, dynamic, and adaptive[41]. The data controlled by a big data platform comes from the physical entity world or the virtual digital world, as opposed to the traditional data analysis system. The ability to handle data effectively emphasizes a more outstanding possibility because of the number of data sources. Revolutionary informational and intelligent transformation is taking place in the manufacturing sector[42]. For manufacturing systems to operate with high reliability, solid scalability, and availability, on-demand communication services are essential.

One of the difficult problems for practitioners and researchers to solve is the decision-making process for massive data using several criteria. Researchers are discovering novel ways to create decision support systems for the issues of various big data application domains by using multiple criteria in integration with artificial intelligence (AI) and machine learning. This allows decision-making based on appropriate numbers of choices, effectiveness, and potentiality. Several decision support systems can help in decision-making processes[43, 44]. Making decisions effectively is crucial to the success of any business or organization. The decision-making process is challenging since numerous criteria can be used to decide whether or not to take action.

Decision support systems are enabled by the inclusion of deep learning algorithms in current approaches for handling large data challenges to give a more intelligent decision support system[45, 46]. Numerous applications for the decision support system can be found in a variety of industries, including agriculture[47], energy industry[48], and business[49]. Theories and techniques that range from basic to more sophisticated and intelligent models for decision making are explained in several disciplines[50].

4 Machine learning and big data: Empowering decision making

Big data and its newly developed tools and methodologies, such as big data analytics, have completely changed how organizations and businesses work, opening up new, promising opportunities for academia, professionals, and corporations[51]. Governmental and non-governmental entities now routinely produce huge amounts of unique scope and complexity data, in addition to corporations and research institutions[52]. Consequently, gathering useful information and advantageous advantages from these big data sources is now crucial for enterprises all over the world. But as the research demonstrates, it can be difficult to swiftly and skillfully extract useful insights from big data[53]. Big data analytics is now unavoidably necessary to fulfill big data's full potential for boosting company performance and expanding market share for the majority of enterprises. Although the majority of machine learning and AI algorithms and the platforms that support them for performing big data analytics are free, they call for a new skill set that is unusual for most practitioners in this sector and the IT departments of organizations[54].

Machine learning and big data have become integral components of modern decision-making processes. With the advent of advanced computing technologies, vast amounts of data can now be collected, analyzed, and utilized to inform decision making in a variety of contexts. Machine learning is a subfield of AI that focuses on the development of algorithms and statistical models that enable computer systems to learn from data and make predictions or decisions without being explicitly programmed[55]. Machine learning algorithms are particularly well-suited to processing large amounts of data, and as such, they have become a key tool for analyzing big datasets.

Big data refers to large and complex datasets that are difficult to process using traditional data processing techniques[56]. The size, variety, and complexity of big data make it challenging to extract meaningful insights, but machine learning algorithms can help identify patterns, correlations, and relationships that would be

difficult to discern using manual analysis[57]. Machine learning algorithms can also be used to automate decision-making processes, enabling organizations to make faster and more accurate decisions[58]. In finance, for example, machine learning algorithms can analyze market data to identify trends and patterns that can inform investment decisions. In healthcare, machine learning algorithms can be used to analyze patient data to identify risk factors and develop personalized treatment plans. In marketing, machine learning algorithms can be used to analyze customer data to identify trends and preferences, enabling companies to target their advertising and marketing efforts more effectively[59].

Machine learning and big data have become essential tools for decision-making in a variety of domains. By analyzing large and complex datasets, machine learning algorithms can identify patterns and correlations that can inform decision-making and automate decision-making processes, enabling organizations to make faster and more accurate decisions[60]. Table 1 highlights some of the key characteristics of machine learning and big data as they relate to decision-making.

5 Methodology

Scoping literature reviews give an overall idea of the size and nature of the literature in specific fields[61]. In this case, a scoping study is conducted to assess the extent to which big data and machine learning are used in decision-making.

5.1 Search strategy

The study utilizes the Scopus database, formulates research questions, and employs various techniques to gather and analyze information. To ensure a comprehensive evaluation of the research subjects, a specific set of reporting elements required for scoping reviews was selected.

5.2 Inclusion and exclusion criteria

Studies are considered if they meet the following requirements: final published papers, published between 2017 and 2022, published in English, source and document type being journal and article. Studies that are book chapters, conference papers, review articles, or letters to the editor are not included.

5.3 Selection

Throughout the investigation, the sources from Scopus are utilized and relevant databases are evaluated to ensure the accuracy of the information presented. However, certain exceptional works of literature are not included in the search criteria for various reasons. This section reviews several research studies conducted in the past 5 years (2017–2022) to gather information on big data and machine learning in decision making. A total of 1109 Scopus results are examined until April 13th, 2023, out of which only 30 are considered significant (see Fig. 1). The search string is created based on the search of “big data” and “machine

Table 1 Key features of machine learning and big data in decision-making

Feature	Machine learning	Big data
Data processing	Uses algorithms to infer conclusions or predictions from data without being explicitly programmed	Focuses on handling huge, complicated datasets that are challenging to process using conventional data processing methods.
Data analysis	Finds in data patterns, correlations, and linkages that are challenging to find through manual analysis	Aids in the extraction of insightful information from vast and complex datasets
Application	Used to assist in decision-making across a range of industries, such as banking, healthcare, marketing, and more	Utilized throughout a variety of sectors, including healthcare, finance, retail, and entertainment
Automation	May automate decision-making procedures, enabling businesses to take judgments more quickly and accurately	Can be used to automate a variety of tasks, such as data gathering, processing, analysis, and visualization
Benefit	Gives businesses the ability to make data-driven decisions, which improves accuracy and efficiency	Gives businesses insightful data they can utilize to expand, optimize processes, and enhance customer experiences
Challenge	Requires large amounts of high-quality data and expertise to develop and implement effective algorithms	Requires substantial resources, as well as knowledge of data management and analysis, to store, process, and analyze enormous amounts of data

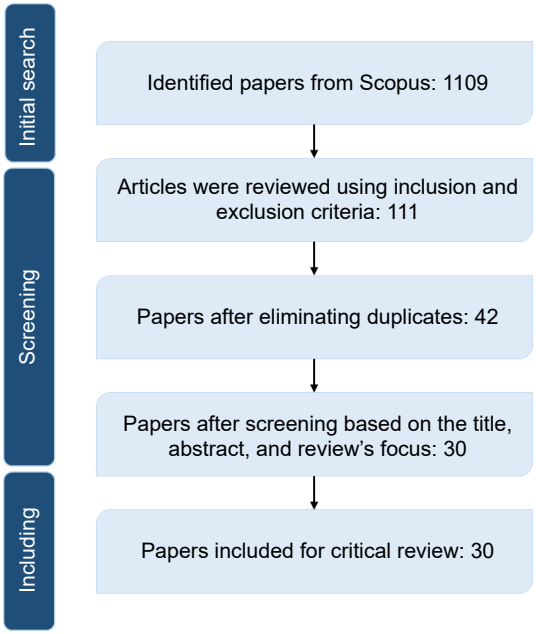

Fig. 1 Flowchart depicting the procedure for selecting papers for a scoping review.

learning" in the title and "decision making", and inclusion and exclusion criteria are developed.

6 Result

This scoping review encompasses 30 publications. The selected papers and an explanation of the overall categorization results are provided below. Organizations are gaining interest in this field as they recognize the potential advantages of utilizing big data and machine learning to make better decisions. There has been an increase in the research and development of machine learning and big data tools and algorithms that can be applied to decision-making duties in a variety of industries and domains. Moreover, the growing availability of data and the increasing power of computing systems have made it possible to analyze large and complex datasets in real time, allowing decision-makers to make more informed and precise decisions.

Between 2017 and 2022, the quantity of included articles is depicted in Fig. 2. In recent years, the field of decision making with big data and machine learning has grown significantly due to three primary factors. Firstly, the exponential growth in the amount of data generated by the internet and digital technologies has necessitated the development of tools and methods for

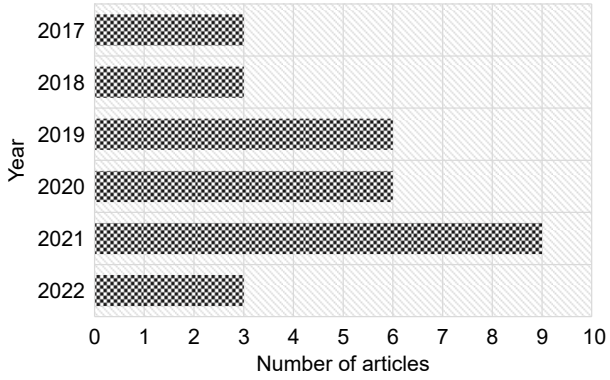

Fig. 2 Several included articles based on year.

managing and analyzing this immense quantity of data. Secondly, advances in machine learning algorithms and computing power have enabled more sophisticated data analysis and prediction, enabling organizations to make more informed decisions and enhance their operations. Thirdly, the availability of open-source tools and cloud computing platforms has facilitated the access and utilization of big data and machine learning technologies by businesses of all sizes.

Nevertheless, this development appears to have plateaued between 2021 and 2022 for a variety of reasons. It is conceivable that the field has reached its saturation point, with the majority of companies having adopted these technologies and investing less in their further development. It is also possible that this is a temporary lull, with growth anticipated to recommence in the coming years as new applications and use cases for big data and machine learning are discovered. In addition, global events such as the COVID-19 pandemic may have temporarily diverted resources and attention away from this discipline. Despite this, the potential benefits of big data and machine learning in decision making are substantial, and the field will likely continue to expand and develop in the future.

Figure 3 depicts the number of articles in various categories. Due to the abundance of data, the potential for enhanced patient outcomes, and the need for ethical considerations in a highly regulated industry, there are more articles in healthcare and medicine (10 articles) on decision making using big data and machine learning. The analysis of healthcare data by machine learning algorithms has the potential to substantially improve patient outcomes and decrease healthcare

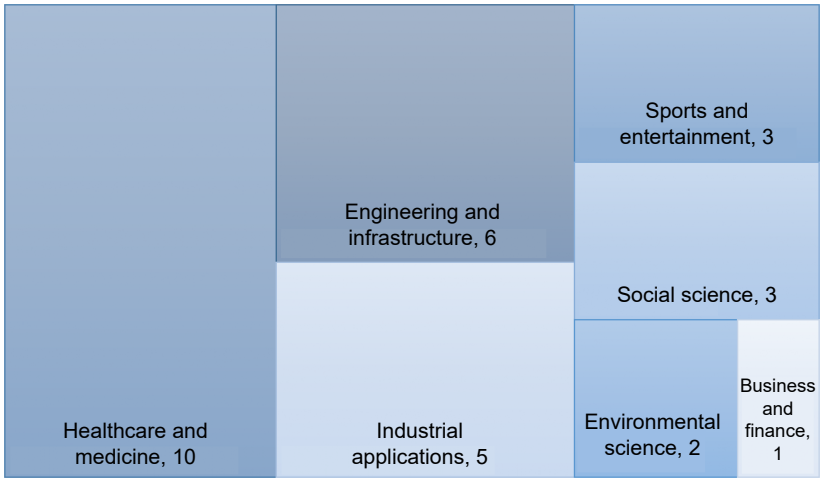

Fig. 3 Number of articles in different areas.

costs. The broad applicability of big data and machine learning has led to the publication of articles on their function in decision making in a variety of fields, including infrastructure and engineering (6 articles), industrial applications (5 articles), sports and entertainment (3 articles), environmental science (2 articles), social science (3 articles), and business and finance (1 article). In each of these domains, these methods can provide valuable insights and facilitate improved decision making.

The current state of decision making about big data and machine learning is characterized by continuous growth and innovation, with new techniques and tools being developed and applied to a variety of applications. This trend is likely to continue as the quantity of available data continues to increase and as new technologies emerge to assist with making sense of this data.

7 Discussion

This section aims to answer several important questions related to the use of big data and machine learning in decision making. By addressing these questions, this section hopes to contribute to a better understanding of the potential and limitations of big data and machine learning in decision making, and to inform future research and practice in this rapidly evolving field.

(1) What approaches and techniques are used for leveraging big data and machine learning in decision making?

Organizations are finding it difficult to make sense of the vast volumes of information at their disposal because of the volume and variety of data that is being generated daily. Businesses and industries have begun to use big data and machine learning approaches to extract insights and make data-driven choices to address this challenge. The way of gathering, storing, processing, and evaluating data has been completely changed by big data and machine learning. Big data and machine learning are employed in decision making using a variety of strategies and methods. These innovations have given businesses and organizations new ways to use data-driven insights to make wise decisions.

Predictive modeling is one method for leveraging large data and machine learning in decision-making. For instance, Wang et al.[62] used machine learning to predict sports performance and analyze influencing factors based on statistics derived from big data. Similarly, Soffer et al.[63] utilized machine learning to predict in-hospital mortality at medical ward admission using big data. In addition, Xie et al.[64] used an optimized machine learning approach to forecast the demand for Chinese cruise tourism based on big data. Another optimization method is the use of machine learning and large data. For example, Hosseini et al.[65] utilized machine learning and big data to optimize medication prescriptions for complex diseases such as diabetes. Similarly, Venkatesh et al.[66] developed a

predictive analytics model for disease prediction using machine learning techniques and massive amounts of data. In addition, Nallaperuma et al.[67] developed an online incremental machine learning platform for big data-driven intelligent traffic management.

In addition, several studies have recommended the use of machine learning and big data for decision making and risk assessment in a variety of fields. Zhong et al.[68] proposed a pipeline risk big data intelligent decision-making system based on machine learning and situational awareness. Using big data and machine learning, Jamil et al.[69] developed a decision-based model for real-time Internet of Things (IoT) analysis. To restore accountability, de Laat[70] developed an algorithmic decision-making model based on machine learning and big data.

Several studies have applied machine learning and big data to environmental management and sustainability. Using machine learning, Ji et al.[71] proposed a big data approach for constructing life-span predictions for life cycle assessment and life cycle cost. Similarly, Choi et al.[72] developed the engineering machine-learning automation platform, a big-data-driven AI instrument for contractors' sustainable plant project management solutions. In addition, Liu et al.[73] used machine learning ensemble and satellite big data to map large-scale, high-resolution mangrove forests throughout West Africa. In addition, some studies have proposed the application of machine learning and big data to the management of health care. For instance, Moorthy and Gandhi[74] utilized machine learning algorithms to analyze medical large data. Similarly, Ephzibah and Sujatha[75] developed big data management with machine learning and domain knowledge for the healthcare industry in their study. In addition, Segura-Bedmar et al.[76] investigated machine learning approaches for predicting anaphylaxis in electronic medical record large data.

However, there are also challenges associated with the use of machine learning and big data, as highlighted in the studies by Ning and You[77] and Wang et al.[78]. These articles emphasize the need to consider uncertainty and potential biases in the development and implementation of these technologies. Overall, machine learning and big data have the potential to significantly impact decision making in a wide range of industries and applications. However, it is important to consider ethical and accountability issues, as well as potential biases and uncertainties, when using these technologies. By doing so, it can be ensured that machine learning and big data are used to improve outcomes and make more accurate predictions. Table 2 provided all 30 included articles related to the intersection of big data, machine learning, and decision making. Each title represents a unique study or application of these fields, with a focus on various industries such as healthcare, transportation, sports, etc.

(2) What are the ethical and privacy concerns associated with the use of big data and machine learning in decision making?

Big data and machine learning are being used more and more frequently across a wide range of industries, including healthcare, transportation, athletics, and finance. Although these technologies have many advantages, they also raise ethical and privacy issues that should be considered when making decisions. This section examines the ethical and privacy issues related to the use of big data and machine learning in decision making, as indicated by the titles provided.

The potential for bias is a significant ethical concern associated with the use of big data and machine learning in decision making. Wang et al.[62] used machine learning to predict sports performance and discovered that the athlete's age, weight, and training time have a substantial effect on their performance. However, race, gender, and socioeconomic status were not considered in the analysis, which may have resulted in biased predictions. Similarly, Soffer et al.[63] developed a big data machine learning model to predict in-hospital mortality, but the model did not take race or ethnicity into consideration. The omission of such crucial factors could result in discrimination against certain patient groups, raising ethical concerns.

Privacy concerns are also prevalent in the decision-making use of big data and machine learning. Xie et al.[64] used big data to predict the demand for Chinese cruise tourism but acknowledged that the collection

Table 2 Studies driving machine learning and big data in decision making across industries.

Study	Year	Area	Big data	Machine learning	Decision-making feature
Zhong et al.[68]	2022	Risk management	√	√	Intelligent decision-making
Wang et al.[62]	2022	Sports analytics	√	√	Performance prediction
Sassite et al.[79]	2022	Smart cities	√	√	Automated analytics
Jamil et al.[69]	2021	IoT	√	√	Real-time decision-making
Ji et al.[71]	2021	Life cycle assessment	√	√	Life-span prediction
Choi et al.[72]	2021	Engineering	√	√	Sustainable management
Bertoni et al.[80]	2021	Agriculture	√	√	Estimation
Soffer et al.[63]	2021	Healthcare	√	√	Mortality prediction
Xie et al.[64]	2021	Tourism	√	√	Demand forecasting
Opperhuizen and Schouten[81]	2021	Media	√	√	Issue attention analysis
Liu et al.[73]	2021	Environmental monitoring	√	√	Mapping
Sharma and Gupta[82]	2021	Healthcare	√	√	Predictive analysis
Kovacs-Györi et al.[83]	2020	Urban planning	√	√	Geospatial analysis
Nibareke and Laassiri[84]	2020	Healthcare, aviation	√	√	Prediction
Hosseini et al.[65]	2020	Healthcare	√	√	Medication optimization
Wang et al.[78]	2020	Data analysis	√	√	Tension analysis
López-Martínez et al.[85]	2020	Healthcare	√	√	Medical decision support
Subha Seethalakshmi et al.[86]	2020	Energy	√	√	Stability analysis
Nallaperuma et al.[67]	2019	Transportation	√	√	Smart traffic management
Moorthy and Gandhi[74]	2019	Healthcare	√	√	Medical data analytics
Gu et al.[87]	2019	Gaming	√	√	Game prediction
Venkatesh et al.[66]	2019	Healthcare	√	√	Disease prediction
Ning and You[77]	2019	Optimization	√	√	Uncertainty handling
Kalpana et al.[88]	2019	Data analysis	√	√	Feature selection
de Laat[70]	2018	Ethics and accountability	√	√	Transparency
Segura-Bedmar et al.[76]	2018	Healthcare	√	√	Early detection
Syafrudin et al.[89]	2018	Manufacturing	√	√	Real-time monitoring
Achiron et al.[90]	2017	Healthcare	√	√	Accurate prediction
Ephzibah and Sujatha[75]	2017	Healthcare	√	√	Data management
Chi et al.[91]	2017	Healthcare	√	√	Treatment optimization

and use of personal data could pose significant privacy risks. As discussed by Hosseini et al.[65], when machine learning is used to optimize medication prescriptions for complex diseases, patients' privacy is also at risk. Medical records contain sensitive information that need to be handled with care, and their confidentiality needs to be protected.

The use of big data and machine learning also raises concerns regarding decision-making transparency and accountability. de Laat[70] discusses how algorithmic decision making based on machine learning from massive amounts of data could reduce transparency and accountability. This concern is especially pertinent when the decision-making process is wholly automated, as in the case of an intelligent decision-making system for pipeline risk big data[68]. In addition, the use of big data and machine learning in decision making may raise ethical concerns regarding the possible misuse of data. For example, Jamil et al.[69] developed a decision-based model for real-time IoT analysis using big data and machine learning, which could be used to monitor the activities of individuals, causing privacy concerns.

Big data and machine learning are increasingly being used in decision making, which creates serious ethical and privacy issues such as bias, privacy violations,

transparency, accountability, and potential data exploitation. It is essential to make sure that moral guidelines govern the creation and application of these technologies to allay these worries. Additionally, to protect people's privacy, adequate security measures should be put in place and the collecting, storage, and use of personal data should be transparent. Before using algorithms in decision-making processes, it is crucial to assess the algorithms' ethical implications and any biases.

(3) What are the key challenges and opportunities for future research in this field?

Big data and machine learning can provide a potent decision-making toolkit. By analyzing large datasets, machine learning algorithms can identify insights and trends that are difficult or impossible for humans to detect. This can aid enterprises and organizations in making more informed decisions, reducing costs, and enhancing results. However, the field of big data and machine learning presents prospective researchers with both challenges and opportunities[62–64]. Given the potential benefits and problems of employing big data and machine learning in decision making, there is a need for continued study in this area.

The need for efficient data processing and analysis methods[65] is one of the primary obstacles to utilizing big data and machine learning. This can be especially challenging in sectors such as healthcare, where concerns about data privacy and data quality can also arise[74]. Another difficulty is the development of effective machine learning models capable of accurately predicting outcomes and providing insights[69]. This requires a comprehensive comprehension of the underlying data as well as the creation of suitable algorithms and models[66].

Despite obstacles, there are numerous opportunities to utilize big data and machine learning in a variety of fields. For instance, machine learning models can be utilized in sports to predict athlete performance and assess influencing factors[78]. Online incremental machine learning platforms can be developed for big data-driven intelligent traffic management in the transportation sector[67]. In the healthcare industry, machine learning, and big data can be used to optimize medication prescriptions for complex diseases like diabetes[65]. Additionally, they can be used to enhance medical decision support and population health management[85]. Other opportunities include the creation of big data predictive analytics models for disease prediction[66], the estimation of the common agricultural policy (CAP) greening effect utilizing machine learning techniques[80], and the creation of machine learning and multi-agent models to automate big data analytics in smart cities[79].

Data privacy and security is some crucial considerations in big data and machine learning research. As more data is collected and analyzed, there is a possibility that sensitive information will be disclosed. Researchers need to develop methods for anonymizing data and preserving the privacy of individuals while ensuring that the algorithms they employ are not biased or discriminatory. Future research in big data and machine learning for decision making faces extensive and intricate challenges and opportunities. Researchers can continue to develop innovative solutions that have the potential to transform a variety of industries and enhance outcomes for individuals and society if they carefully consider these issues. Figure 4 provides a summary of the challenges and opportunities presented by big data and machine learning in decision-making, highlighting the key concepts and ideas discussed in the text.

Making smarter decisions is the ultimate aim of employing big data and machine learning. As a result, improving decision-making abilities is a crucial research field. This entails creating decision support systems that can efficiently use big data and machine learning to give decision-makers useful insights. Scalability also becomes a significant problem as data complexity and volume increase. Future research should concentrate on creating new systems and architectures that are capable of meeting the requirements of big data and machine learning applications. Overall, it is expected that future research in this area will concentrate on creating novel methods and techniques for data processing and analysis, resolving ethical and privacy issues, boosting decision-making skills, and providing scalable solutions.

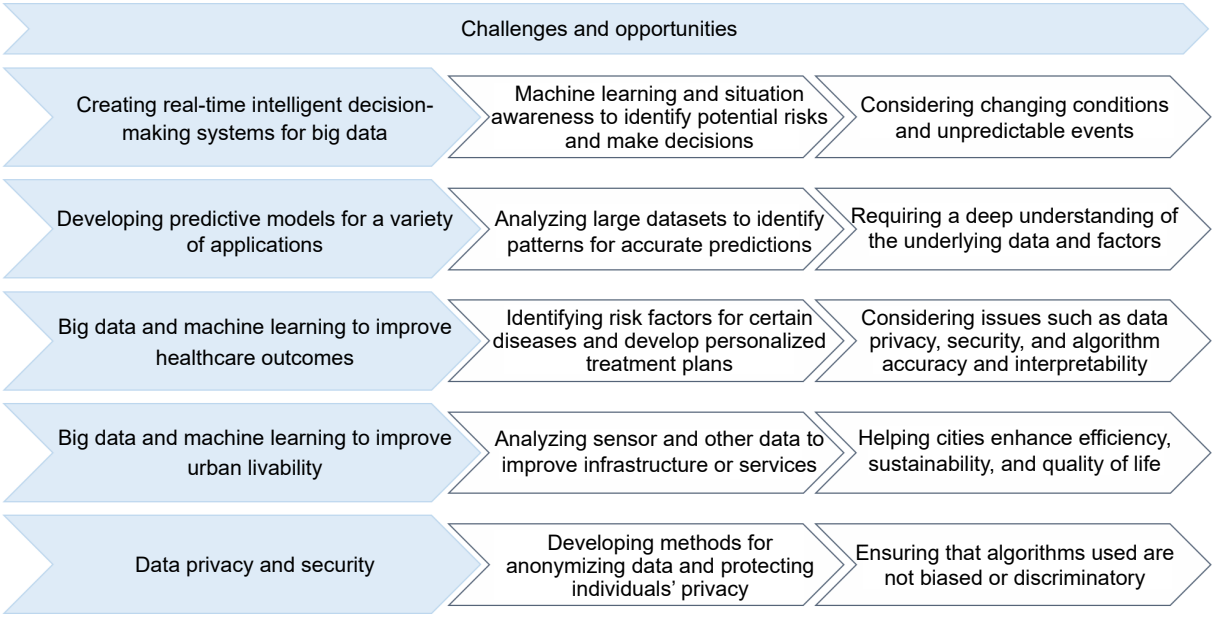

Fig. 4 Machine learning and big data in decision-making issues and possibilities.

8 Conclusion

The volume of data produced by companies and organizations has increased dramatically in recent years. Decision-makers need to figure out how to efficiently process and analyze this massive amount of data. Big data provides a solution to this issue by giving decision-makers the tools and technologies they need to conclude from sizable and complicated information. This scoping review covers publications that were published between 2017 and 2022 that examined the use of big data and machine learning in decision-making processes. According to the review, big data can offer insightful information and aid in the discovery of patterns that might not be immediately evident using conventional approaches. On the other hand, machine learning algorithms can assist in automating and improving decision making.

Marketing is one industry where big data and machine learning are having a large impact. Businesses can find trends and patterns that can be utilized to guide marketing campaigns and product development by studying massive databases of consumer behavior. The practice of automating the targeting of particular clients with customized offers and promotions uses machine learning algorithms. Big data and machine learning are being used in the healthcare sector to enhance patient outcomes. Doctors and researchers can find trends and risk factors that can be used to create more effective therapies and preventative measures by examining massive datasets of patient health records. To intervene early and achieve better results, machine learning algorithms can also be used to detect patients who are at risk of contracting particular disorders.

Big data and machine learning have the potential to significantly improve decision-making processes, but it is critical to carefully consider the benefits and dangers associated with their use. To ensure that judgments are ethical, accurate, and fair, businesses need to exercise caution when dealing with issues such as bias and privacy concerns. With the proper safeguards in place, big data and machine learning can be useful tools for improving decision making across a wide range of sectors and applications.

9 Future study

One important area of future research is the development of more interpretable machine learning models that can provide insights into how they arrive at their decisions. Besides, despite the potential benefits of machine learning in decision-making processes, human expertise and judgment are still essential for making complex decisions in many domains. Recent research has shown that combining human and

machine decision making can lead to better decision outcomes than either alone. Additionally, there is a need for more research on the ethical and social implications of big data and machine learning in decision-making processes. As the use of these technologies becomes more widespread, it is important to ensure that they are used in ways that align with societal values and norms. This includes ensuring that decision-making algorithms are transparent and accountable, protecting individuals' privacy rights, and ensuring that they do not reinforce existing biases and discrimination. Finally, as big data and machine learning research expands, data privacy and security are crucial considerations. Researchers need to ensure that data is anonymized, and individuals' privacy is preserved, while avoiding bias and discrimination. Future research faces complex challenges, but innovative solutions have the potential to transform industries and enhance outcomes.

References

[1] H. Taherdoost and M. Madanchian, Multi-criteria decision making (MCDM) methods and concepts, *Encyclopedia*, vol. 3, no. 1, pp. 77–87, 2023.

[2] B. H. Sparks and J. T. McCann, Factors influencing business intelligence system use in decision making and organisational performance, *Int. J. Sustain. Strateg. Manag.*, vol. 5, no. 1, pp. 31–54, 2016.

[3] N. Elgendy, A. Elragal, and T. Päivärinta, DECAS: a modern data-driven decision theory for big data and analytics, *J. Decis. Syst.*, vol. 31, no. 4, pp. 337–373, 2022.

[4] N. Tantalaki, S. Souravlas, and M. Roumeliotis, Data-driven decision making in precision agriculture: The Rise of big data in agricultural systems, *J. Agric. Food Inf.*, vol. 20, no. 4, pp. 344–380, 2019.

[5] S. Ren, Y. Zhang, Y. Liu, T. Sakao, D. Huisingh, and C. M. V. B. Almeida, A comprehensive review of big data analytics throughout product lifecycle to support sustainable smart manufacturing: A framework, challenges and future research directions, *J. Clean. Prod.*, vol. 210, pp. 1343–1365, 2019.

[6] H. Chen, R. H. L. Chiang, and V. C. Storey, Business intelligence and analytics: From big data to big impact, *MIS Q.*, vol. 36, no. 4, p. 1165, 2012.

[7] J. Guedalia, M. Lipschuetz, M. Novoselsky-Persky, S. M. Cohen, A. Rottenstreich, G. Levin, S. Yagel, R. Unger, and Y. Sompolinsky, Real-time data analysis using a machine learning model significantly improves prediction of successful vaginal deliveries, *Am. J. Obstet. Gynecol.*, vol. 223, no. 3, pp. 437.e1–437.e15, 2020.

[8] J. C. Peterson, D. D. Bourgin, M. Agrawal, D. Reichman, and T. L. Griffiths, Using large-scale experiments and machine learning to discover theories of human decision-making, *Science*, vol. 372, no. 6547, pp. 1209–1214, 2021.

[9] M. Mohammadpoor and F. Torabi, Big Data analytics in oil and gas industry: An emerging trend, *Petroleum*, vol. 6, no. 4, pp. 321–328, 2020.

[10] T. Lysaght, H. Y. Lim, V. Xafis, and K. Y. Ngiam, AI-assisted decision-making in healthcare: The application of an ethics framework for big data in health and research, *Asian Bioeth. Rev.*, vol. 11, pp. 299–314, 2019.

[11] W. M. S. Yafooz, Z. B. Abu Bakar, S. K. Ahammad Fahad, and A. M Mithun, Business intelligence through big data analytics, data mining and machine learning, in Proc. 8th Int. Conf. Data Management, Analytics and Innovation, Vellore, India, 2019, pp. 217–230.

[12] A. Mohamed, M. K. Najafabadi, Y. B. Wah, E. A. K. Zaman, and R. Maskat, The state of the art and taxonomy of big data analytics: View from new big data framework, *Artif. Intell. Rev.*, vol. 53, no. 2, pp. 989–1037, 2020.

[13] A. Esteva, A. Robicquet, B. Ramsundar, V. Kuleshov, M. DePristo, K. Chou, C. Cui, G. Corrado, S. Thrun, and J. Dean, A guide to deep learning in healthcare, *Nat. Med.*, vol. 25, no. 1, pp. 24–29, 2019.

[14] V. Chang, An ethical framework for big data and smart cities, *Technol. Forecast. Soc. Change*, vol. 165, p. 120559, 2021.

[15] C. Rudin, Stop explaining black box machine learning models for high stakes decisions and use interpretable models instead, *Nat. Mach. Intell.*, vol. 1, no. 5, pp. 206–215, 2019.

[16] N. Amruthnath and T. Gupta, A research study on unsupervised machine learning algorithms for early fault detection in predictive maintenance, in *Proc. 2018 5th Int. Conf. Industrial Engineering and Applications* (*ICIEA*), Singapore, 2018, pp. 355–361.

[17] L. H. Son and N. D. Tien, Tune up fuzzy C-means for big data: Some novel hybrid clustering algorithms based on initial selection and incremental clustering, *Int. J. Fuzzy Syst.*, vol. 19, no. 5, pp. 1585–1602, 2017.

[18] A. McAfee and E. Brynjolfsson, Big data: The management revolution, *Harv. Bus. Rev.*, vol. 90, no. 10, pp. 60–68, 2012.

[19] M. Favaretto, E. De Clercq, C. O. Schneble, and B. S. Elger, What is your definition of Big Data? Researchers' understanding of the phenomenon of the decade, *PLoS One*, vol. 15, no. 2, p. e0228987, 2020.

[20] I. Lee, Big data: Dimensions, evolution, impacts, and challenges, *Bus. Horiz.*, vol. 60, no. 3, pp. 293–303, 2017.

[21] P. Russom, Big data analytics, *TDWI Best Pract. Rep.*, vol. 19, no. 4, pp. 1–34, 2011.

[22] W. Y. C. Wang and Y. Wang, Analytics in the era of big data: The digital transformations and value creation in industrial marketing, *Ind. Mark. Manag.*, vol. 86, pp. 12–15, 2020.

[23] Z. Wang, S. Zaman, S. F. Rasool, Q. U. Zaman, and A. Amin, Exploring the relationships between a toxic workplace environment, workplace stress, and project success with the moderating effect of organizational support: Empirical evidence from Pakistan, *Risk Manag. Healthc. Policy*, vol. 13, pp. 1055–1067, 2020.

[24] Y. Cui, S. Kara, and K. C. Chan, Manufacturing big data ecosystem: A systematic literature review, *Robot. Comput. Integr. Manuf.*, vol. 62, p. 101861, 2020.

[25] J. Cheng, H. Zhang, F. Tao, and C. F. Juang, DT-II: Digital twin enhanced Industrial Internet reference framework towards smart manufacturing, *Robot. Comput. Integr. Manuf.*, vol. 62, p. 101881, 2020.

[26] M. K. Saggi and S. Jain, A survey towards an integration of big data analytics to big insights for value-creation, *Inf. Process. Manag.*, vol. 54, no. 5, pp. 758–790, 2018.

[27] J. Joseph and V. Gaba, Organizational structure, information processing, and decision-making: A retrospective and road map for research, *Acad. Manag. Ann.*, vol. 14, no. 1, pp. 267–302, 2020.

[28] H. Kościelniak and A. Puto, BIG DATA in decision making processes of enterprises, *Procedia Comput. Sci.*, vol. 65, pp. 1052–1058, 2015.

[29] H. Taherdoost, An overview of trends in information systems: Emerging technologies that transform the information technology industry,*Cloud Comput. Data Sci.*, pp. 1–16, 2022.

[30] F. Provost and T. Fawcett, Data science and its relationship to big data and data-driven decision making, *Big Data*, vol. 1, no. 1, pp. 51–59, 2013.

[31] T. H. Davenport, Analytics 3.0, *Harv. Bus. Rev.*, vol. 91, no. 12, pp. 64–72, 2013.

[32] Talaoui, Y. and M. Kohtamäki, 35 years of research on business intelligence process: A synthesis of a fragmented literature, *Manag. Res. Rev.*, vol. 44, no. 5, pp. 677–717, 2021.

[33] J. Vidal-García, M. Vidal, and R. H. Barros, Computational business intelligence, big data, and their role in business decisions in the age of the Internet of Things, in *Web Services*: *Concepts, methodologies, tools, and applications*, Information Resources Management Association Ed. Hershey, PA, USA: IGI Global, 2019. pp. 1048–1067.

[34] D. Sen, M. Ozturk, and O. Vayvay, An overview of big data for growth in SMEs, *Procedia Soc. Behav. Sci.*, vol. 235, pp. 159–167, 2016.

[35] S. Kumar and K. K. Mohbey, A review on big data based parallel and distributed approaches of pattern mining, *J. King Saud Univ. Comput. Inf. Sci.*, vol. 34, no. 5, pp. 1639–1662, 2022.

[36] M. Hammer, K. Somers, H. Karre, and C. Ramsauer, Profit per hour as a target process control parameter for manufacturing systems enabled by big data analytics and industry 4.0 infrastructure, *Procedia CIRP*, vol. 63, pp. 715–720, 2017.

[37] F. Chiheb, F. Boumahdi, and H. Bouarfa, A new model for integrating big data into phases of decision-making process, *Procedia Comput. Sci.*, vol. 151, no. C, pp. 636–642, 2019.

[38] R. Iqbal, F. Doctor, B. More, S. Mahmud, and U. Yousuf, Big Data analytics and Computational Intelligence for Cyber-Physical Systems: Recent trends and state of the art applications, *Future Gener. Comput. Syst.*, vol. 105, pp. 766–778, 2020.

[39] F. Tao, Q. Qi, A. Liu, and A. Kusiak, Data-driven smart manufacturing, *J. Manuf. Syst.*, vol. 48, pp. 157–169, 2018.

[40] Y. H. Kuo and A. Kusiak, From data to big data in production research: The past and future trends, *Int. J. Prod. Res.*, vol. 57, nos.15&16, pp. 4828–4853, 2019.

[41] Y. Cheng, K. Chen, H. Sun, Y. Zhang, and F. Tao, Data and knowledge mining with big data towards smart production, *J. Ind. Inf. Integr.*, vol. 9, pp. 1–13, 2018.

[42] Y. Liu, A. Soroka, L. Han, J. Jian, and M. Tang, Cloud-based big data analytics for customer insight-driven design innovation in SMEs, *Int. J. Inf. Manag.*, vol. 51, p. 102034, 2020.

[43] S. Nazir, S. Shahzad, Z. Hussain, M. Iqbal, and A. Keerio, Evaluating student grades using analytic network process, *Sindh Univ. Res. J.* (*Sci. Ser.*), vol. 41, no. 1, pp. 97–102, 2016.

[44] S. Nazir, S. Anwar, S. A. Khan, S. Shahzad, M. Ali, R. Amin, M. Nawaz, P. Lazaridis, and J. Cosmas, Software component selection based on quality criteria using the analytic network process, *Abstr. Appl. Anal.*, vol. 2014, pp. 1–12, 2014.

[45] S. Safdar, S. Zafar, N. Zafar, and N. F. Khan, Machine learning based decision support systems (DSS) for heart disease diagnosis: a review, *Artif. Intell. Rev.*, vol. 50, no. 4, pp. 597–623, 2018.

[46] I. Aouadni and A. Rebai, Decision support system based on genetic algorithm and multi-criteria satisfaction analysis (MUSA) method for measuring job satisfaction, *Ann. Oper. Res.*, vol. 256, no. 1, pp. 3–20, 2017.

[47] I. Petkovics, J. Simon, Á. Petkovics, and Z. Čović, Selection of unmanned aerial vehicle for precision agriculture with multi-criteria decision making algorithm, in *Proc. 2017 IEEE 15th Int. Symp. on Intelligent Systems and Informatics* (*SISY*), Subotica, Serbia, 2017, pp. 000151–000156.

[48] A. Schwenk-Ferrero and A. Andrianov, Nuclear waste management decision-making support with MCDA, *Sci. Technol. Nucl. Install.*, vol. 2017, pp. 1–20, 2017.

[49] C. Fleig, D. Augenstein, and A. Maedche, Designing a process mining-enabled decision support system for business process standardization in ERP implementation projects, in *Proc. 16th Int. Conf. Business Process Management*, Sydney, Australia, 2018, pp. 228–244.

[50] L. S. R. Supriadi and L. Sui Pheng, Knowledge based decision support system (KBDSS), in *Business Continuity Management in Construction*, L. S. R. Supriadi and L. S. Pheng Eds. Singapore: Springer, 2018, pp. 155–174.

[51] Z. Sun, L. Sun, and K. Strang, Big data analytics services for enhancing business intelligence, *J. Comput. Inf. Syst.*, vol. 58, no. 2, pp. 162–169, 2018.

[52] B. K. Sarkar, Big data for secure healthcare system: A conceptual design, *Complex Intell. Syst.*, vol. 3, no. 2, pp. 133–151, 2017.

[53] J. Zakir, T. Seymour, and K. Berg, Big data analytics, *Issue Inf. Syst.*, vol. 16, no. II, pp. 81–90, 2015.

[54] G. Kaur, P. Tomar, and P. Singh, Design of cloud-based green IoT architecture for smart cities, in *Internet of things and big data analytics toward next-generation intelligence*, N. Dey, A. E. Hassanien, C. Bhatt, A. S. Ashour, and S. C. Satapathy Eds. Cham, Switzerland: Springer, 2018, pp. 315–333.

[55] P. Ongsulee, V. Chotchaung, E. Bamrungsi, and T. Rodcheewit, Big data, predictive analytics and machine learning, in *Proc. 2018 16th Int. Conf. ICT and Knowledge Engineering* (*ICT&KE*), Bangkok, Thailand, 2019, pp. 1–6.

[56] M. Chen, S. Mao, and Y. Liu, Big data: A survey, *Mob. Netw. Appl.*, vol. 19, no. 2, pp. 171–209, 2014.

[57] P. Domingos, The Master Algorithm: How the Quest for the Ultimate Learning Machine Will Remake Our World. New York, NY, USA: Basic Books, 2015.

[58] Y. R. Shrestha, S. M. Ben-Menahem, and G. von Krogh, Organizational decision-making structures in the age of artificial intelligence, *Calif. Manag. Rev.*, vol. 61, no. 4, pp. 66–83, 2019.

[59] F. Provost and T. Fawcett, Data Science for Business: What You Need to Know about Data Mining and Data-Analytic Thinking. Sebastopol, CA, USA: O'Reilly Media, 2013.

[60] X. Wu, X. Zhu, G. Q. Wu, and W. Ding, Data mining with big data, *IEEE Trans. Knowl. Data Eng.*, vol. 26, no. 1, pp. 97–107, 2014.

[61] H. Taherdoost, Towards nuts and bolts of conducting literature review: A typology of literature review, *Electronics*, vol. 12, no. 4, p. 800, 2023.

[62] P. Wang, J. Liu, and B. Liao, Prediction of sports performance and analysis of influencing factors based on machine learning and big data statistics, *J. Sens.*, vol. 2022, pp. 1–9, 2022.

[63] S. Soffer, E. Klang, Y. Barash, E. Grossman, and E. Zimlichman, Predicting In-hospital mortality at admission to the medical ward: A big-data machine learning model, *Am. J. Med.*, vol. 134, no. 2, pp. 227–234.E4, 2021.

[64] G. Xie, Y. Qian, and S. Wang, Forecasting Chinese cruise tourism demand with big data: An optimized machine learning approach, *Tour. Manag.*, vol. 82, p. 104208, 2021.

[65] M. M. Hosseini, M. Zargoush, F. Alemi, and R. E. Kheirbek, Leveraging machine learning and big data for optimizing medication prescriptions in complex diseases: A case study in diabetes management, *J. Big Data*, vol. 7, no. 1, pp. 1–24, 2020.

[66] R. Venkatesh, C. Balasubramanian, and M. Kaliappan, Development of Big Data Predictive Analytics Model for Disease Prediction using Machine learning Technique, *J. Med. Syst.*, vol. 43, no. 8, pp. 1–8, 2019.

[67] D. Nallaperuma, R. Nawaratne, T. Bandaragoda, A. Adikari, S. Nguyen, T. Kempitiya, D. De Silva, D. Alahakoon, and D. Pothuhera, Online incremental machine learning platform for big data-driven smart traffic management, *IEEE Trans. Intell. Transport. Syst.*, vol. 20, no. 12, pp. 4679–4690, 2019.

[68] X. Zhong, X. Zhang, and P. Zhang, Pipeline risk big data intelligent decision-making system based on machine learning and situation awareness, *Neural Comput. Appl.*, vol. 34, no. 18, pp. 15221–15239, 2022.

[69] H. Jamil, T. Umer, C. Ceken, and F. Al-Turjman, Decision based model for real-time IoT analysis using big data and machine learning, *Wirel. Pers. Commun.*, vol. 121, no. 4, pp. 2947–2959, 2021.

[70] P. B. de Laat, Algorithmic decision-making based on machine learning from big data: Can transparency restore accountability, *Philos. Technol.*, vol. 31, no. 4, pp. 525–541, 2018.

[71] S. Ji, B. Lee, and M. Y. Yi, Building life-span prediction for life cycle assessment and life cycle cost using machine learning: A big data approach, *Build. Environ.*, vol. 205, p. 108267, 2021.

[72] S. W. Choi, E. B. Lee, and J. H. Kim, The engineering machine-learning automation platform (EMAP): A big-data-driven AI tool for contractors' sustainable

management solutions for plant projects, *Sustainability*, vol. 13, no. 18, p. 10384, 2021.

[73] X. Liu, T. E. Fatoyinbo, N. M. Thomas, W. W. Guan, Y. Zhan, P. Mondal, D. Lagomasino, M. Simard, C. C. Trettin, R. Deo, et al., Large-scale high-resolution coastal mangrove forests mapping across West Africa with machine learning ensemble and satellite big data, *Front. Earth Sci.*, vol. 8, pp. 560933, 2021.

[74] U. Moorthy and U. D. Gandhi, Medical big data analytics using machine learning algorithms, *Int. J. Innov. Technol. Explor. Eng.*, vol. 9, no. 1, pp. 3517–3526, 2019.

[75] E. P. EPhzibah and R. Sujatha, Big data management with machine learning inscribed by domain knowledge for health care, *Int. J. Eng. Technol.*, vol. 6, no. 4, p. 98, 2017.

[76] I. Segura-Bedmar, C. Colón-Ruíz, M. Á. Tejedor-Alonso, and M. Moro-Moro, Predicting of anaphylaxis in big data EMR by exploring machine learning approaches, *J. Biomed. Inform.*, vol. 87, pp. 50–59, 2018.

[77] C. Ning and F. You, Optimization under uncertainty in the era of big data and deep learning: When machine learning meets mathematical programming, *Comput. Chem. Eng.*, vol. 125, pp. 434–448, 2019.

[78] H. Wang, Y. Yao, and S. Salhi, Tension in big data using machine learning: Analysis and applications, *Technol. Forecast. Soc. Change*, vol. 158, p. 120175, 2020.

[79] F. Sassite, M. Addou, and F. Barramou, A machine learning and multi-agent model to automate big data analytics in smart cities, *Int. J. Adv. Comput. Sci. Appl.*, vol. 13, no. 7, pp. 441–451, 2022.

[80] D. Bertoni, G. Aletti, D. Cavicchioli, A. Micheletti, and R. Pretolani, Estimating the CAP greening effect by machine learning techniques: A big data ex post analysis, *Environ. Sci. Policy*, vol. 119, pp. 44–53, 2021.

[81] A. E. Opperhuizen and K. Schouten, Dynamics and tipping point of issue attention in newspapers: Quantitative and qualitative content analysis at sentence level in a longitudinal study using supervised machine learning and big data, *Qual. Quant.*, vol. 55, no. 1, pp. 19–37, 2021.

[82] S. Sharma and Y. K. Gupta, Predictive analysis and survey of COVID-19 using machine learning and big data, *J. Interdiscip. Math.*, vol. 24, no. 1, pp. 175–195, 2021.

[83] A. Kovacs-Györi, A. Ristea, C. Havas, M. Mehaffy, H. H. Hochmair, B. Resch, L. Juhasz, A. Lehner, L. Ramasubramanian, and T. Blaschke, Opportunities and challenges of geospatial analysis for promoting urban livability in the era of big data and machine learning, *ISPRS Int. J. Geo-Inf.*, vol. 9, no. 12, p. 752, 2020.

[84] T. Nibareke and J. Laassiri, Using Big Data-machine learning models for diabetes prediction and flight delays analytics, *J. Big Data*, vol. 7, no. 1, pp. 1–18, 2020.

[85] F. López-Martínez, E. R. Núñez-Valdez, V. García-Díaz, and Z. Bursac, A case study for a big data and machine learning platform to improve medical decision support in population health management, *Algorithms*, vol. 13, no. 4, p. 102, 2020.

[86] V. Subha Seethalakshmi, R. Karthigaivel, N. Vengadachalam, and S. Selvakumaran, RETRACTED: Application of Machine Learning and Big Data in Doubly Fed Induction Generator based Stability Analysis of Multi Machine System using Substantial Transformative Optimization Algorithm, *Microprocess. Microsyst.*, vol. 73, p. 102971, 2020.

[87] W. Gu, K. Foster, J. Shang, and L. Wei, A game-predicting expert system using big data and machine learning, *Expert Syst. Appl.*, vol. 130, pp. 293–305, 2019.

[88] K. Kalpana, G. S. V. Kumar, and K. Madhavi, Feature selection for machine learning in big data, *Int. J. Innov. Technol. Explor. Eng.*, vol. 8, no. 6S4, pp. 332–335, 2019.

[89] M. Syafrudin, G. Alfian, N. L. Fitriyani, and J. Rhee, Performance analysis of IoT-based sensor, big data processing, and machine learning model for real-time monitoring system in automotive manufacturing, *Sensors*, vol. 18, no. 9, p. 2946, 2018.

[90] A. Achiron, Z. Gur, U. Aviv, A. Hilely, M. Mimouni, L. Karmona, L. Rokach, and I. Kaiserman, Predicting refractive surgery outcome: Machine learning approach with big data, *J. Refract. Surg.*, vol. 33, no. 9, pp. 592–597, 2017.

[91] C. L. Chi, J. Wang, T. R. Clancy, J. G. Robinson, P. J. Tonellato, and T. J. Adam, Big data cohort extraction to facilitate machine learning to improve statin treatment, *West. J. Nurs. Res.*, vol. 39, no. 1, pp. 42–62, 2017.

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