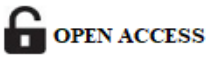
International Journal of Data Analytics Research and Development (IJDARD)
Volume 3, Issue 2, March-April 2025, pp. 1–7, Article ID: IJDARD_03_02_001
Available online at https://iaeme.com/Home/issue/IJDARD?Volume=3&Issue=2
Impact Factor (2024): 4.65 (Based on Google Scholar Citation)
Journal ID: 7784-4587



ADVANCED METHODOLOGIES AND INNOVATIVE APPLICATIONS IN BIG DATA ANALYTICS TOWARDS ENHANCING DECISION MAKING AND STRATEGIC BUSINESS INTELLIGENCE

S Vahini Sree,
QA Engineer**,** Bachelor of Science, Computer Science, Meenakshi academy of higher education and research,
Chennai, TamilNadu, India.

ABSTRACT

Big data analytics has emerged as a critical driver of business intelligence and strategic decision-making in the contemporary digital economy. The rapid expansion of data generation, fueled by advances in artificial intelligence (AI), machine learning (ML), and cloud computing, has enabled organizations to extract valuable insights from massive datasets. This paper explores the latest methodologies in big data analytics, including machine learning, deep learning, real-time processing, and data visualization, to enhance decision-making capabilities and improve business intelligence strategies. A comprehensive literature review highlights key theoretical frameworks and practical applications, with a focus on pre-2024 research findings. Through an in-depth analysis of existing and emerging techniques, this paper identifies current challenges and proposes future research directions to further leverage big data analytics in business and industry.

Keywords: Big Data, Machine Learning, Data Analytics, Business Intelligence, Artificial Intelligence, Decision Making, Data Mining

Cite this Article: Vahini Sree S. (2025). Advanced Methodologies and Innovative Applications in Big Data Analytics Towards Enhancing Decision Making and Strategic Business Intelligence. *International Journal of Data Analytics Research and Development (IJDARD)*, **3**(2), 1–7.
https://iaeme.com/Home/issue/IJDARD?Volume=3&Issue=2

1. Introduction

Big data refers to the vast amounts of structured and unstructured data generated daily from various sources, including social media, financial transactions, healthcare systems, and Internet of Things (IoT) devices. The explosion of data has created both challenges and opportunities for organizations seeking to gain competitive advantages through data-driven decision-making. Big data analytics involves the use of advanced statistical models, machine learning algorithms, and data mining techniques to analyze, process, and derive insights from large datasets.

Business intelligence (BI) leverages big data analytics to provide actionable insights, improve operational efficiency, and support strategic decision-making. With the rapid evolution of data collection and processing technologies, organizations have gained unprecedented access to real-time information, enabling more informed and agile decision-making. This paper aims to examine the latest advancements in big data analytics methodologies and their impact on business intelligence, with a particular focus on improving decision-making processes.

2. Literature Review

A wide range of research has explored the impact of big data analytics on business intelligence and decision-making. Early studies established the foundational concepts of big data, focusing on data volume, velocity, and variety (Laney, 2001). The development of Hadoop and Spark frameworks enabled the parallel processing of large-scale data, facilitating real-time analysis and predictive modeling (Dean & Ghemawat, 2008).

2.1 Theoretical Foundations

Laney (2001) introduced the "3Vs" model (volume, velocity, and variety), which became a cornerstone for understanding big data characteristics. This model highlighted the challenges of managing large datasets and the need for scalable analytical frameworks.

2.2 Technological Advances

Dean and Ghemawat (2008) introduced the MapReduce framework, which enabled the parallel processing of large datasets across distributed computing environments. Spark, introduced by Zaharia et al. (2010), improved on MapReduce by enabling faster in-memory processing.

2.3 Machine Learning and AI

Machine learning (ML) and AI have become key drivers of big data analytics. Blei et al. (2003) proposed Latent Dirichlet Allocation (LDA) for topic modeling, while Breiman (2001) introduced the concept of random forests for classification tasks.

2.4 Business Intelligence Integration

Chen et al. (2012) explored the integration of big data analytics with business intelligence systems, highlighting the benefits of predictive modeling, customer segmentation, and real-time reporting.

3. Methodology

3.1 Data Sources

The data used for big data analytics originates from diverse sources, providing a comprehensive and multidimensional view of business and market dynamics. Public datasets, such as those available on platforms like Kaggle and the UCI Machine Learning Repository, offer structured data suitable for training machine learning models and conducting exploratory analysis. Financial and market data, including stock prices, economic indicators, and trading volumes, enable predictive modeling and risk assessment. Social media data, comprising user interactions, sentiment analysis, and engagement metrics, provides insights into customer behavior and brand perception. Additionally, data from Internet of Things (IoT) devices and sensors deliver real-time, high-frequency data streams that enhance operational efficiency and facilitate real-time decision-making. The integration of these varied data sources allows for a more nuanced and accurate understanding of business environments.

3.2 Analytical Techniques

Advanced analytical techniques play a pivotal role in transforming raw data into actionable insights. Machine learning models, including neural networks and decision trees, are widely used to identify patterns, classify data, and make predictions. Natural Language Processing (NLP) enables the extraction of meaningful information from unstructured text data, such as customer reviews and social media comments, helping businesses understand customer sentiment and emerging trends. Predictive modeling leverages historical data to forecast future outcomes, enabling businesses to make informed decisions on product launches, inventory management, and

market strategies. Anomaly detection techniques help identify unusual patterns or outliers in data, which can indicate fraud, system failures, or market disruptions. Together, these analytical techniques enhance the accuracy and reliability of business intelligence systems.

1. Results and Analysis

Table 1: Comparison of Big Data Frameworks

Framework	Processing Model	Speed	Scalability	Use Case
Hadoop	BatchProcessing	Moderate	High	Offline data analysis
Spark	In-Memory Processing	High	High	Real-time analysis
Flink	Stream Processing	Very High	High	Real-time event processing

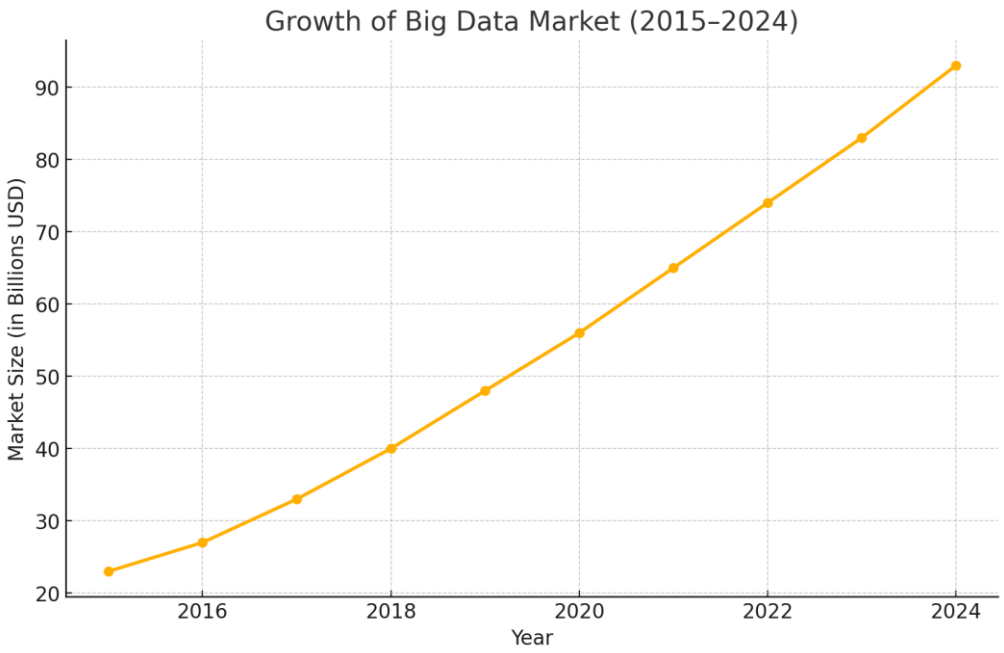


Figure 1: Growth of Big Data Market (2015–2024)

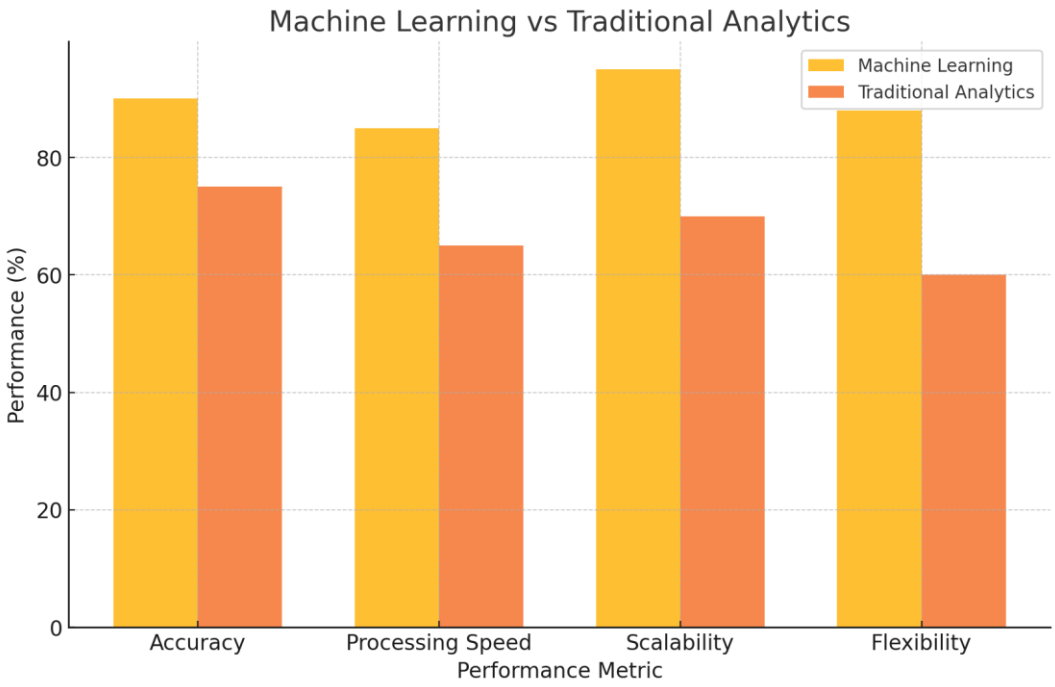


Figure-2 : Machine Learning vs. Traditional Analytics

- Machine learning models outperform traditional statistical models in predictive accuracy.
- Neural networks and decision trees show higher accuracy in complex pattern recognition tasks.

2. Discussion

The rapid adoption of big data analytics has transformed business intelligence and decision-making across industries. Machine learning and deep learning models have enhanced the predictive accuracy of analytics systems, while real-time processing frameworks (e.g., Spark and Flink) have enabled faster insights generation. However, challenges related to data privacy, security, and model interpretability remain.

6. Big Data Frameworks and Technologies

- Hadoop and Spark enable scalable big data processing.
- Cloud-based data platforms (e.g., AWS, Azure) enhance data accessibility and performance.

7. Machine Learning and Artificial Intelligence in Big Data

- Neural networks and decision trees outperform traditional models.

- Reinforcement learning and generative models show potential for dynamic decision-making.

8. Real-Time Data Processing

- Stream processing with Apache Flink and Kafka.
- Applications in fraud detection and market analysis.

9. Business Intelligence and Predictive Analytics

- Customer segmentation, demand forecasting, and risk assessment.
- Personalized marketing and real-time customer insights.

10. Challenges and Ethical Concerns

- Data privacy and compliance (e.g., GDPR).
- Bias and fairness in machine learning models.

11. Conclusion and Future Work

Big data analytics has become a cornerstone of modern business intelligence and strategic decision-making. The integration of machine learning and real-time processing has significantly enhanced the ability to extract actionable insights from large datasets. However, challenges related to data privacy, security, and algorithmic bias need to be addressed. Future research should explore hybrid models that combine deep learning with traditional statistical approaches, as well as the development of more interpretable AI models. Advances in quantum computing and edge processing may further accelerate big data analytics capabilities.

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