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AI-Driven Real-Time Decision-Making in Business Intelligence: Techniques and Challenges

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Abstract: ***In the contemporary business landscape, the integration of Artificial Intelligence (AI) and Machine Learning (ML) into data-driven strategies has emerged as a pivotal factor for organizational success and competitive advantage. A comprehensive framework for leveraging AI and ML to enhance business analytics, improve decision-making processes, and foster organizational growth. The framework proposed herein serves as a strategic guide for businesses seeking to harness the transformative potential of these technologies.***

AI and ML technologies have revolutionized the domain of business analytics by providing sophisticated tools for data processing, pattern recognition, and predictive modelling. The application of AI algorithms facilitates the extraction of actionable insights from vast and complex datasets, enabling organizations to make informed decisions with unprecedented accuracy. Machine learning models, with their capacity for adaptive learning and iterative refinement, offer dynamic analytical capabilities that are crucial for navigating the rapidly evolving business environment.

The integration process is further elaborated upon, highlighting the role of system architecture and infrastructure in supporting AI and ML applications. This includes considerations for computational resources, data storage solutions, and real-time processing capabilities. The framework also addresses the necessity of cross-functional collaboration between data scientists,ITprofessionals,andbusinessstakeholderstoensurethatAI-driveninsightsalign with organizational objectives and strategic goals.

Furthermore,thepaperinvestigatestheethicalandregulatoryimplicationsassociatedwith AI and ML in business contexts. Ensuring transparency, fairness, and accountability in AI systemsiscrucialf ormaintaining stake holdertrust andcomplyingwithregulatorystandards.

Keywords: business strategy, Machine Learning, dataintegration.

I. INTRODUCTION

The ascent of Artificial Intelligence (AI) and Machine Learning (ML) represents a profound shift in the landscape of business strategy and analytics. Historically, business decision- makinghasbeenunderpinned bytraditionaldata analysismethods, which, whileeffectiveto acertainextent,havebeenconstrainedbytheirrelianceonmanualinterpretationandstatic analytical tools. The advent of AI and ML, however, has introduced a new paradigm, characterized by advanced computational techniques and adaptive algorithms that significantly enhance the capacity for data processing and predictive analytics [1].

In the era of digital transformation, the exponential growth of data has necessitated advanced analytical approaches to extract meaningful insights for informed decision-making. Artificial Intelligence (AI) and Machine Learning (ML) have emerged as powerful enablers in this domain, revolutionizing the way organizations process, analyze, and utilize data for strategic advantage. The ability to generate real-time insights from vast and complex datasets has become a key differentiator for businesses striving to maintain competitiveness and agility in an increasingly dynamic marketplace.

AI-enhanced data analytics represents a paradigm shift from traditional statistical methods and rule-based decision-making models. Unlike conventional approaches, which rely on static algorithms and predefined logic, AI-driven analytics leverage adaptive learning, predictive modelling, and pattern recognition to provide intelligent insights. By continuously analysing real-time data, AI can identify trends, forecast outcomes, detect anomalies, and optimize decision-making processes across various business functions. This capability is particularly valuable in industries such as finance, healthcare, manufacturing, retail, and supply chain management, where timely and accurate decisions are critical for operational success.

AI encompasses a broad range of technologies, including neural networks, natural language processing, and computer vision, all of which have become integral to modern business operations.

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MachineLearning,asubsetofAI,focusesonthedevelopmentofalgorithmsthatenablesystemstolearnfromdataandimprovetheirperfo rmanceovertimewithoutexplicit programming [6]. The sheer scale of data now available demands the deployment of advanced AI and ML techniques to extract actionable insightsanddrivestrategicdecisions [11].AI-drivenanalytics notonlyfacilitatest heidentification of patterns and trends that are not immediately apparent but also enhances predictive accuracy, thereby supporting more informed and timely decision-making.

II. AI AND MACHINE LEARNING IN BUSINESS ANALYTICS CORE CONCEPTS AND TECHNOLOGIES

ArtificialIntelligence(AI)andMachineLearning(ML)representaparadigmshiftinthefield of business analytics, driven by their ability to perform complex computations, learn from data, and generate actionable insights with a high degree of accuracy. At the core of this technological evolution are several key concepts and techniques that are essential for understanding how AI and ML can be applied to enhance business analytics.

Artificial Intelligence, broadly defined, refers to the capability of machines to perform tasks that would normally require human intelligence.[9] These tasks include reasoning, learning, problem-solving, and decision-making. Within the domain of AI, Machine Learning is a subsetthatspecificallyfocusesonthedevelopmentandapplicationofalgorithmsthatenable systems to learn from and make predictions based on data.

AnotherpivotalconceptinMLisreinforcementlearning,whichischaracterizedbythe learning of optimal actions through trial and error. In reinforcement learning, an agentinteracts with an environment and receives feedback in the form of rewards or penalties based on its actions. This feedback is used to update the agent's policy for selecting actions that maximize cumulative rewards [15]. Reinforcement learning has significant applications in areassuch as operational optimization and strategic decision-making, where the objective is to determinethebestcourseofactionindynamicanduncertainenvironments.

Deep learning, a subfield of ML, employs neural networks with multiple layers—known as deepneuralnetworks—tomodelcomplexpatternsandrelationshipsindata.Convolutional NeuralNetworks(CNNs)areparticularlyeffectiveforimageandspatialdataanalysis,while Recurrent Neural Networks (RNNs) and their variants, such as Long Short-Term Memory (LSTM)networks ,aredesignedtohand lesequentialdataan dtemporaldependencies.Deep learningmodelshaved emonstratedsuperior performanceint askssuchasnaturallanguage processingandcomputervision,furtherextendingthecapabilitiesofAIinbusinessanalytics [2].

III. DATA MANAGEMENT USING AI AND ML

In addition to these core concepts, the implementation of AI and ML in business analytics necessitatesanunderstandingofdatamanagementpractices.Datapreprocessing,including cleaning, normalization, and feature extraction, is critical for ensuring the quality and relevance of input data. The integration of AI and ML models into business processes also requires a robust system architecture capable of handling large volumes of data and performing real-time analytics. This includes considerations for computational resources, data storage solutions, and infrastructure for deploying machine learning models at scale.

IV. IMPORTANCE OF DATA QUALITY

In the realm of AI and Machine Learning, the quality of data is paramount to the success of analytical models and decision-making processes. High-quality data is characterized by its accuracy, completeness, consistency, and timeliness, all of which are essential for developing reliable and effective AI solutions.

Accuratedataensuresthattheinformationusedintrainingmodelsreflectsthetruestateoftheunderlyingphenomena.Inaccuraciesindata,whet herduetomeasurementerrors,data entry mistakes, or other anomalies, can lead to misleading insights and suboptimal model performance.Completenessreferstotheextenttowhichthedatacoversallnecessaryaspects of the problem domain. Missing or incomplete data can result in biased or incomplete analyses, undermining the reliability of the derived conclusions. Consistency involves maintaining uniformity across data sources and records, which is critical for avoiding discrepancies that can disrupt model training and analysis.

V. DATA GOVERNANCE

Effective data governance establishes a framework for managing data quality, ensuring compliance with standards, and implementing best practices in data management. Data governance encompasses policies, procedures, and responsibilities that govern data collection, storage, usage, and sharing within an organization.

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It is integral to maintaining data integrity, ensuring privacy, and supporting regulatory compliance.Awell-defineddatagovernancestrategyinvolvesestablishingdataownershipand stewardship roles, defining data standards, and implementing data quality metrics. Data stewardsareresponsibleforoverseeingdatamanagementpracticesandensuringadherence to governance policies [5]. Data standards set guidelines for data formats, definitions, and documentation, facilitating consistency and interoperability across systems. Data quality metrics, such as accuracy, completeness, and timeliness, are used to assess and monitor data quality,enablingorganizationstoidentifyandaddressissuespromptly.

VI. PREPROCESSING TECHNIQUES

DatapreprocessingisacriticalstepintheAIandMLworkflow,aimedatpreparingrawdataforanalysisbyaddressingissuesrelatedtodataqualityandrelevance.Preprocessinginvolves a series of techniques designed to clean, transform, and organize data, ensuring that it issuitable for model training and analysis.One of the primary preprocessing tasks is data cleaning, which involves identifying and correcting errors or inconsistencies in the dataset. This may include handling missing values through imputation or exclusion, correcting inaccuracies, and resolving inconsistenciesbetweendifferentdatasources. Techniquessuchas meanimputation, medianimputation, and interpolation are commonly used to address missing values, while outlier detectionmethods help identify and mitigate anomalies.

Datatransformationisanothercrucialpreprocessingstepthatinvolvesconvertingdatainto formats suitable for analysis. This may include encoding categorical variables, aggregating data,orcreatingnewderivedfeatures.

VII. INTEGRATION CHALLENGES

The integration of Artificial Intelligence (AI) and Machine Learning (ML) technologies into existing business processes and systems is fraught with a variety of challenges. These challenges arise from the complexities inherent in adapting advanced technologies to traditional organizational frameworks, each of which can significantly impact the effectiveness and efficiency of AI and ML applications.

The integration of AI in data analytics facilitates real-time data processing, which allows organizations to respond proactively to emerging opportunities and challenges. AI-powered tools can analyse structured and unstructured data from diverse sources, including transactional databases, IoT sensors, social media platforms, and customer interactions, to derive actionable intelligence. Machine Learning algorithms play a central role in this transformation by continuously refining their predictions based on historical data patterns, thereby enhancing accuracy and reliability over time. This adaptability makes AI-driven analytics an indispensable asset for businesses aiming to improve efficiency, reduce risks, and personalize customer experiences.

One prominent challenge is **system compatibility**. Existing business systems, including legacysoftwareanddatabases, maynotbedesignedtohandlethedataformatsorprocessing requirements of modern AI and ML technologies [6]. Integrating these technologies often necessitates substantial modifications to existing systems or the development of intermediary solutions that bridge the gap between legacy systems and new AI-driven tools. This compatibility issue can lead to significant technical debt, increased costs, and extended timelines for implementation [10].

Anothercriticalchallengeis**dataintegrationandqualitymanagement**.AIandMLmodels require high-quality, well-integrated data to function effectively. Despite its immense potential, the deployment of AI-enhanced data analytics is not without challenges.

However, many organizationsfacedifficultiesinaggregatingdatafromdisparatesources,whichmayinclude variousdatabases, cloud services, andoperationalsystems.Ensuringthatdataisconsistently formatted, cleansed, and synchronized across these sources is essential for accurate model training and analysis. Moreover, the data integration process often involves overcoming issuesrelatedtodatasilos,inconsistentdataschemas,andincompletedatasets.

1) *Scalability:* Itis also a significant concern when integrating AI and ML technologies. The deployment of AI models often involves scaling up computational resources to handle large volumes of data and complex algorithms. This requirement can strain existing IT infrastructureandnecessitatetheadoptionofadvancedcomputingsolutions,suchascloud-basedservicesordistributedcomputingenvironments.Ensuringthattheinfrastructurecan support the demands of AI and ML applications without compromising performance or reliability is a key challenge.
2) *Change management:* Itpresents another hurdle in the integration process. The introduction ofAIandMLtechnologiescanleadtosubstantialchangesinbusinessprocessesandworkflows. Organizationsmustmanagethetransitioncarefullytominimizedisruptionsandensurethat employees are adequately prepared for the new technologies. This includes providing training and support to staff, addressing resistance to change, and aligning organizational culture with the adoption of AI-driven methodologies.

3) *Security and privacy concerns:* They are paramount when integrating AI and ML technologies, especially in industries dealing with sensitive information. Ensuringrobustsecuritymeasures,includingencryption,accesscontrols,anddata anonymization, is crucial for safeguarding data and maintaining regulatory compliance.
4) *Algorithmic transparency and interpretability*: It pose significant challenges in the context ofAIintegration.ManyadvancedAImodels,particularlythosebasedondeeplearning;operate as "black boxes" with limited visibility into their internal decision-making processes. This lackof transparency can make it difficult for organizations to understand and trust the results producedbyAIsystems.Addressingtheseconcernsrequiresthedevelopmentofexplainable AI techniques that provide insights into model behavior and decision-making, enhancing the interpretability and accountability of AI solutions.

Lastly, cost considerations play a crucial role in the integration of AI and ML technologies. The development, deployment, and maintenance of AI models can be expensive, involving costsrelatedtodataacquisition ,computationa lresources, softwarelicenses,andspecializedtalent.Organizationsmustcarefullyevaluatethereturnoninvestment(ROI)andconsiderthe long-term financial implications of AI integration to ensure that the benefits outweigh the costs.

VIII. BEST PRACTICES

Implementing AI and ML solutions effectively requires adherence to best practices that ensure successful deployment and optimal performance. Collaboration among data scientists, IT professionals, and business stakeholders is critical to achieving these goals.

One of the fundamental best practices is establishing a clear alignment between AI and ML initiatives and business objectives. This involves defining specific use cases and desired outcomes that align with organizational goals. Business stakeholders should be actively involved in identifying the problems to be addressed and setting performance metrics that reflect the impact of AI and ML solutions on business processes.

Effective communication and collaboration between data scientists, IT professionals, and business stakeholders are essential for successful AI and ML implementation. Regular meetingsandupdatesshould beconducted toalignproject objectives,addressanytechnical challenges,andensurethatbusinessrequirementsaremet.Cross-functionalteamsshould worktogether toidentifypotentialrisks,developmitigationstrategies,andensurethatAIand ML solutions are aligned with the overall business strategy.

IX. THE ROLE OF AI IN REAL-TIME DATA ANALYSIS

Artificial Intelligence (AI) plays a transformative role in real-time data analysis by efficiently processing vast amounts of structured and unstructured data. Unlike traditional data analysis methods, which often involve manual processing and delays, AI-powered systems can instantly analyze data, detect anomalies, and identify emerging patterns. This capability is particularly beneficial in areas like finance, healthcare, and cybersecurity, where rapid decision-making is critical. AI-driven analytics enable organizations to respond to potential issues proactively, enhance operational efficiency, and optimize business strategies in real time.

The selection of appropriate AI and ML techniques, tailored to specific business needs, is pivotal for achieving desired outcomes. The framework incorporates a broad range of methods, from supervised and unsupervised learning to reinforcement learning, each with distinct applications and advantages. Understanding these techniques allows organizations to leverage AI and ML effectively, aligning them with strategic goals and operational requirements [17].

X. EVOLUTION OF AI IN BUSINESS

AI's impact on business has evolved significantly over the decades. The journey began with automation in the early 1960s when Unimate, the first industrial robot, was deployed in manufacturing. In the late 1960s, ELIZA, an early chatbot, demonstrated AI's potential in human interaction. The 1980s witnessed the rise of expert systems, which mimicked human decision-making in specialized domains. The advent of machine learning and neural networks in the 2000s revolutionized AI applications, making them more adaptive and intelligent. Today, with deep learning, cloud computing, and big data integration, AI has become a core component of business strategies, enhancing productivity and driving innovation.

AI brings numerous advantages to real-time data analysis, making it an indispensable tool for businesses. One of the primary benefits is enhanced efficiency and accuracy, as AI can process vast amounts of data much faster than humans while reducing errors. AI-powered systems enable faster decision-making by providing real-time insights, which helps businesses adapt to market fluctuations and changing customer demands. AI-driven personalization enhances customer experiences, offering tailored recommendations and automated support through chatbots and virtual assistants.

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Additionally, AI contributes to increased profitability by optimizing resource allocation, reducing operational costs, and ensuring business continuity through round-the-clock operations.

XI. REAL-TIME ANALYTICS

Real-time analytics is defined as the ability for users to see, analyse and assess data as soon as it appears in a system. In order to provide users with insights (rather than raw data), logic, mathematics and algorithms are applied [18]. The output is a visually cohesive and understandable dashboard and/or report.

Real-Time Analytics Technology

Real-time analytics encompasses the technology and processes that quickly enables users to leverage data the second it enters the database. It includes data measurement, management, and analytics.

For businesses, analytics that is real time can be used to meet a variety of needs including enhancing workflows, boosting the relationship between marketing and sales, understanding customer behavior, finalising financial close procedures and more [8].

Understanding live analytics is best done by breaking down the terms:

- Real-time: operations are performed milliseconds before it becomes available to the user
- Analytics: a software capability to pull data from various sources and interpret, analyse and transform it into a format that is comprehensible by humans

XII. CHALLENGES OF REAL-TIME ANALYTICS AND AI IMPLEMENTATION

Despite its advantages, AI adoption comes with significant challenges that businesses must address. One major challenge is the integration of AI with existing business systems, which often requires technical expertise and infrastructure upgrades. Scalability is another issue, as AI models must be designed to handle growing data volumes efficiently. Data quality is crucial for AI effectiveness—poor or biased data can lead to inaccurate predictions and flawed decision-making. Ethical concerns such as data privacy, algorithmic bias, and lack of transparency pose serious risks, raising questions about accountability and fairness in AI-driven processes. Furthermore, AI's potential to automate tasks and replace human jobs raises concerns about workforce displacement, making ethical AI implementation essential.

When implementing real-time analytics into your organisation, you may face the following:

(a)Meet Expectations: Real-time data analytics require that everyone within your team and stakeholders of the business agree on what "real-time" means so you can integrate a solution that meets expectations (in terms of timing)

(b) System architecture: After defining the meaning of "real-time," you must be sure to select a tool that can process data at high speeds. The tool should also be able to grow and scale, as data does.

(c) Implementation: Implementing a real-time analytics tool may require technical know-how or an IT team to make sure that the system works well with existing tools. It can also be used as an out-of-the-box, no code required automation solution.

XIII. BENEFITS OF REAL-TIME DATA ANALYTICS

Using real-time data analytics allows your business to thrive and reach optimal productivity. You can minimise risks, reduce costs, and understand more about your employees, customers, and overall financial health of the business with the aid of real-time data.

Here are some of the key benefits:

(a) Data visualisation: With historical data, you can get a snapshot of information displayed in a chart. However, with real-time data, you can use data visualisations that reflect changes within the business as they occur in real-time. This means that dashboards are interactive and accurate at any given moment. With custom dashboards, you can also share data easily with relevant stakeholders so that decision-making never gets put on hold.

(b) Competitive advantages: Compared to a company that is focused on historical, stale data, your business can gain a competitive advantage by accessing real-time data analytics. You can easily understand benchmarks and view trends to make the wisest choices to boost your business.

(c) Precise information: Since real-time data analytics is focused on creating outcomes, there is no wasted effort. Rather than spending resources, time and money collecting data that's unnecessary, the software is set up to capture only the data you need.

(d) Testing: With the ability to test how changes will affect your business' processes in real-time, you can take calculated risks. As you make changes, you can gauge if there's any issues or negative effects and be able to revert and try again without undergoing too much damage.

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(e) Monitor customer behaviour: With knowledge and insights about customer behavior, you can dive deep into customer behaviors and be able to monitor what is and isn't working to your business' advantage.
(f) Lower costs: Big data used to require extensive mathematical understanding and IT support. With SolveXia, you can leverage all the benefits of real-time data analytics. This means that you can lower the costs of hiring coding experts to take advantage of business data, reduce bottlenecks within processes and ensure team members have what to pull insights from the data.
(g) Apply machine learning: Machine learning improves as more data enters the system. Rather than requiring a human to update algorithms and spend time on tedious tasks, the machine manages to become more efficient as time goes on. [13]
(h) Drive better decision making: Ultimately, one of the biggest benefits of real-time data analytics is the ability to move forward on both small and big decisions in a timely and productive manner. Through accurate insights, you can strip, update and introduce new business ideas and processes to your organisation with little risk as the analytics provides you with all the necessary information to make sound business decisions. [16]

XIV. REAL-WORLD APPLICATIONS OF AI IN BUSINESS

AI is already transforming various industries through real-world applications that improve efficiency, customer engagement, and profitability. For example, Amazon Go leverages AI-powered computer vision, sensor fusion, and deep learning to create a checkout-free shopping experience, allowing customers to walk out with their purchases without standing in line. Netflix uses AI algorithms to analyze user preferences, viewing habits, and content engagement patterns to offer personalized recommendations, enhancing user experience and retention. Uber utilizes AI-driven demand prediction and dynamic pricing models, adjusting ride fares based on factors such as traffic conditions, rider demand, and availability of drivers, thereby optimizing service efficiency.
Examples of real-time analytics are:

- Providing the customer with an offer or a piece of information that matches their needs and inclinations based on a real-time analysis of their behavior.
- Application monitoring to prevent downtime and improve performance.
- Real-time blocking of fraudulent transactions.
- Chatbots that automate conversations with customers.

Real-Time Analytics Working
To get a better understanding of the term real-time analytics, let's break it down into its components:Real-time: Data is collected and processed rapidly and continuously.
Analytics: Actionable insights are extracted by applying a set of algorithms to the data.We can now see that real-time analytics is a process, not just a technology. To "make real-time analytics work," all components should operate in real time.[7]

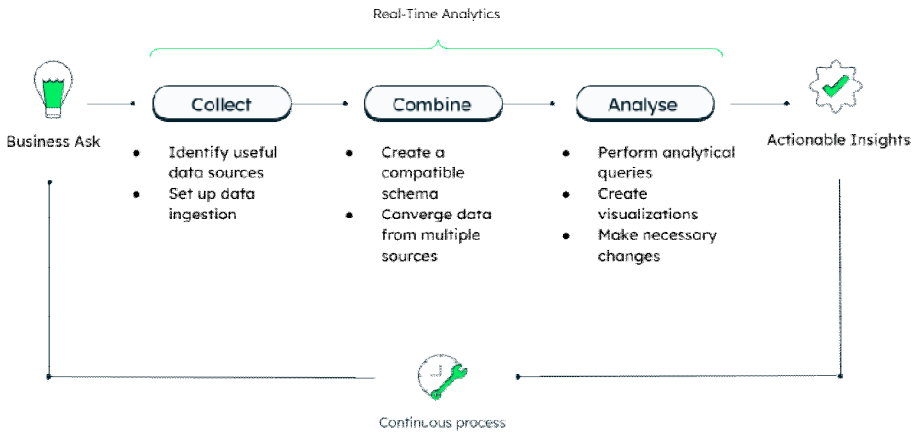


Figure 1.5: Real-time analytics process

XV. AI TECHNOLOGIES FOR REAL-TIME ANALYTICS

- Machine Learning (ML): ML algorithms detect patterns in continuously incoming data, predict outcomes, and flag anomalies, all in real-time.

- Deep Learning and Neural Networks: These are used to process complex unstructured data—like images or sensor signals—quickly for applications such as cybersecurity or logistics.[4]
- Edge AI: By running AI models directly on edge devices (rather than in the cloud), organizations cut decision latency dramatically, important for IoT systems and scenarios where delays are unacceptable.

Common Applications

- Healthcare: AI-powered IoT and Edge systems analyze patient sensor data, support diagnosis, and trigger timely responses, while also enhancing cybersecurity through anomaly detection.
- Business Intelligence: Real-time AI analytics create interactive dashboards and alert systems, supporting agile responses to market or operational changes and optimizing forecasting.
- Cybersecurity: Big data AI analyzes network activity, detects threats instantly through behavioral/anomaly analysis, and enables quick mitigation.
- Logistics: AI drives dynamic routing, scheduling, resource allocation, and predictive maintenance based on live sensor and operational data.

How AI Drives Real-Time Decisions

- Data Integration: AI platforms ingest data from multiple sources (sensors, online feeds, transactions) and harmonize it for rapid analysis.[3]
- Automated Action: Algorithms trigger alerts, updates, or physical actions automatically when set thresholds or conditions are met.
- Human-AI Collaboration: Systems present insights to people via natural language summaries or decision support dashboards for quicker, more informed choices.[14]

Benefits and Challenges

- Benefits:
- Faster and more accurate decisions due to automation and predictive modeling.
- Scalability across massive data volumes, even in distributed networks.
- Reduced latency crucial for safety, efficiency, and competitive advantage.
- Challenges:
- Ensuring data privacy and secure processing, especially at the network edge.
- Integrating diverse, high-velocity data sources and maintaining model accuracy.
- Balancing automation with human oversight to avoid errors and bias.

AI is a critical enabler for data analytics and real-time decision making across modern industries, transforming operations with speed, precision, and adaptability [12].

XVI. FUTURE IMPACT OF AI ON BUSINESS

The future of AI in business is poised for even greater advancements, driven by continuous improvements in machine learning, natural language processing (NLP), and Internet of Things (IoT) integration. AI-powered predictive analytics will become more accurate, allowing businesses to anticipate customer needs, market trends, and operational risks with greater precision. Enhanced NLP capabilities will enable AI to understand human language more effectively, improving sentiment analysis, chatbots, and voice assistants. AI-driven IoT sensors will further automate industries such as healthcare, manufacturing, and logistics, enabling real-time monitoring and process optimization. As AI technology evolves, businesses that strategically adopt AI will gain a competitive advantage, ensuring long-term growth and innovation.

AI is revolutionizing real-time data analysis and decision-making by enabling faster, smarter, and more accurate insights. While AI presents challenges such as integration complexity, data quality issues, and ethical concerns, its benefits in improving efficiency, personalization, and profitability make it an invaluable asset for businesses. By adopting best practices and staying ahead of AI advancements, organizations can harness AI's full potential to drive innovation, enhance customer experiences, and maintain a competitive edge in the evolving digital landscape.

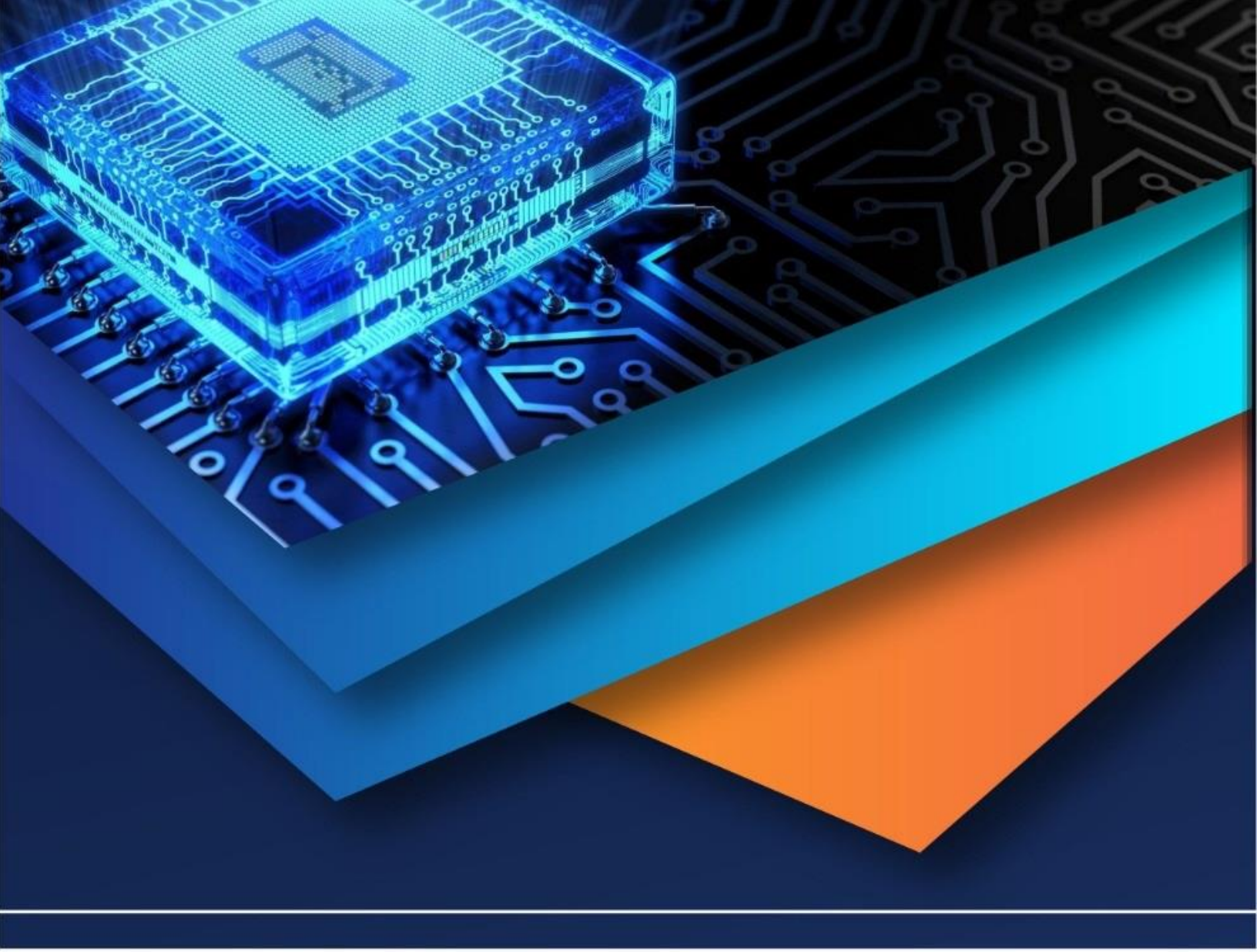
XVII. CONCLUSION

Real-time analytics is an essential process for successful businesses. To put it simply, real-time analytics is a process that requires you to be able to collect data as it becomes available and analyze it in real time. The importance of extracting insights quickly and accurately from data is ubiquitous to industry and can be achieved by using the right tools.While there are a lot of tools promising to help you with analytics, choosing an integrated data platform is the best way to go.

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