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EMERGING TRENDS IN TECHNOLOGY: INSIGHTS ACROSS MACHINE LEARNING, DIGITALIZATION, AND INDUSTRY APPLICATIONS

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Abstract

This study aimed to explore and analyse the emerging trends in technology, focusing on the applications of machine learning, digital transformation, and blockchain across various industries, with an emphasis on addressing key challenges, fostering innovation, and promoting sustainable solutions in business, education, and environmental conservation. This study employed various methodologies such as literature reviews, systematic analyses, and case-based designs. Key findings highlighted the application of machine learning techniques to predict cryptocurrency market trends despite its volatile nature, the potential of WebGIS technology in advancing environmental conservation efforts, and the role of blockchain in enhancing e-commerce security. The discussions also explored how these technologies are driving greater business efficiency, promoting environmental sustainability, and revolutionizing educational methods. Notably, this study emphasized the significance of adopting emerging technologies to tackle contemporary challenges, improve digital accessibility, and optimize both organizational and societal outcomes. Lastly, this study provided a comprehensive perspective on how technological advancements are shaping progress and delivering solutions across diverse industries.

Keywords: Artificial intelligence, Bibliometric, Digitalization, Industry application, Machine learning.

1. Introduction

The rapid evolution of technology has profoundly influenced various sectors, driving remarkable advancements across multiple domains. The integration of cutting-edge technologies such as the Internet of Things (IoT), Machine Learning (ML), Virtual Reality (VR), Augmented Reality (AR), and Artificial Intelligence (AI) has transformed industries by offering innovative solutions to complex challenges (see Tables 1-5). This collection of research studies provides an in-depth examination of these developments, covering key topics such as cryptocurrency price prediction using machine learning, emotion recognition powered by deep learning, cybersecurity measures like phishing detection, and the use of GIS and web-based systems for environmental and spatial management. Additional studies explore the digital transformation of Small and Medium Enterprises (SMEs), advancements in educational technology, and innovations in sustainable logistics, underscoring the adaptability of emerging technologies in addressing real-world problems.

Table 1. Research on IoT.

No.	Title	Ref.
1	A systematic review of the IoT in smart university: model and contribution	[1]
2	Mesh network based on MQTT broker for smart home and IoT factory	[2]
3	Easy-mushroom mobile application using the Internet of Things (IoT)	[3]
4	Greening the internet of things: a comprehensive review of sustainable IoT solutions from an educational perspective	[4]
5	Water quality monitoring in Citarum river (Indonesia) using IoT (Internet of Thing)	[5]
6	A systematic literature review of internet of things for higher education: architecture and implementation	[6]
7	Greening internet of things for greener and smarter cities: a survey and future prospects	[7]

Table 2. Research on AI.

No.	Title	Ref.
1	Trends in the use of Artificial Intelligence (AI) technology in increasing physical activity	[8]
2	Bibliometric analysis of research trends in conceptual understanding and sustainability awareness through Artificial Intelligence (AI) and digital learning media	[9]
3	The future of learning: ethical and philosophical implications of Artificial Intelligence (AI) integration in education	[10]
4	University students' awareness of, access to, and use of artificial intelligence for learning in Kwara State	[11]
5	Bibliometric analysis on artificial intelligence research in Indonesia vocational education	[12]
6	Primary education undergraduates' competency in the use of artificial intelligence for learning in Kwara State	[13]
7	Unravelling the layers of email phishing threats	[14]

Table 2 (continue). Research on AI.

No.	Title	Ref.
8	Exploring the nexus of User Interface (UI) and User Experience (UX) in the context of emerging trends and customer experience, human-computer interaction, applications of artificial intelligence	[15]
9	Future trends in pharmaceuticals: Investigation of the role of AI in drug discovery, 3D printing of medications, and nanomedicine	[16]
10	Artificial intelligence as human behavior detection for auto-personalization function in social media marketing	[17]

Table 3. Research on ML.

No.	Title	Ref.
1	XBRL open information model for risk-based tax audit using machine learning	[18]
2	Face emotion recognition based on machine learning: a review	[19]
3	Healthcare diseases classification based on machine learning algorithms: a review	[20]
4	Detection of SQL injection attacks based on supervised machine learning algorithms: a review	[21]
5	Phishing website detection using several machine learning algorithms: a review paper	[22]
6	Harnessing machine learning for cryptocurrency price prediction: a review	[23]
7	Machine learning approaches for heart disease detection: a comprehensive review	[24]
8	Implementation of management information system using machine learning technology	[25]
9	Early detection of cardiovascular disease utilizing machine learning techniques: evaluating the predictive capabilities of seven algorithms	[26]
10	Implementation of management information system using machine learning technology	[27]
11	Comparative analysis of machine learning techniques for cryptocurrency price prediction	[28]
12	Prediction of cryptocurrency price using time series data and deep learning algorithms	[29]
13	Machine learning algorithms: a review	[30]
14	Supervised machine learning algorithms: classification and comparison	[31]
15	Exploring the applications of machine learning in healthcare	[32]
16	Survey of machine learning algorithms for disease diagnostic	[33]

Table 4. Research on AR.

No.	Title	Ref.
1	How to create Augmented Reality (AR) applications using Unity and Vuforia engine to teach basic algorithm concepts: step-by-step procedure and bibliometric analysis	[34]
2	Augmented reality for cultivating computational thinking skills in mathematics completed with literature review, bibliometrics, and experiments to students	[35]

Table 4 (continue). Research on AR.

No.	Title	Ref.
3	Development of augmented reality application for exercise to promote health among elderly	[36]
4	Application of augmented reality technology with the fuzzy logic method as an online physical education lecture method in the new normal era	[37]
5	Utilization of augmented reality technology as an interactive learning media	[38]
6	Utilization of augmented reality as a solution for vernacular language approaches to recognize an object through speech recognition	[39]

Table 5. Research on VR.

No.	Title	Ref.
1	Immersive intelligent tutoring system for remedial learning using virtual learning environment	[40]
2	The use of virtual reality as a substitute for the pre-school students' field trip activity during the learning from home period	[41]
3	Colleges of education lecturers' attitude towards the use of virtual classrooms for instruction	[42]
4	Students' learning experiences and preference in performing science experiments using hands-on and virtual laboratory	[43]
5	The effectiveness of using a virtual laboratory in distance learning on the measurement materials of the natural sciences of physics for junior high school students	[44]
6	Perception of early childhood education lecturers on the use of virtual learning	[45]
7	Lecturers perceived proficiency in the use of virtual classrooms for instruction in colleges of education	[46]

State-of-the-art technologies showcased in these studies highlight their transformative potential across various domains. For example, machine learning has shown remarkable effectiveness in financial forecasting, particularly in predicting cryptocurrency prices [23]. Similarly, blockchain technology enhances the security of e-commerce transactions [6], while WebGIS platforms support conservation initiatives such as mangrove forest management [47]. Advances in deep learning have driven significant progress in facial emotion recognition, with far-reaching implications for mental health interventions and user experience design [23]. Furthermore, the integration of digital tools into SMEs streamlines operations and enhances marketing strategies, underscoring the critical role of adopting cutting-edge solutions across industries [48].

This body of research underscores the increasing focus on leveraging technology to address domain-specific challenges. SMEs, for instance, benefit from digital accounting applications and online systems that optimize their processes [49]. In the agricultural sector, hydroponic farming incorporates advanced digital marketing strategies to reach broader markets. Similarly, in education, digital transformation is reshaping traditional learning methodologies to meet the demands of the Fourth Industrial Revolution. Additionally, research on logistics and tourism

in Vietnam highlights how digitalization drives economic growth while promoting environmental sustainability [50].

2.Method

In this study, bibliographic data was gathered from articles published between 2022 and 2024, indexed in Scopus, and centred on key themes such as machine learning, digitalization, and their industrial applications. Bibliometric analysis, as shown in Table 6, is a robust method for examining research trends in these domains.

Table 6. Research on bibliometric analysis.

No.	Title	Ref.
1	A bibliometric analysis of management bioenergy research using Vosviewer application	[51]
2	Oil palm empty fruit bunch waste pretreatment with benzotriazolium-based ionic liquids for cellulose conversion to glucose: experiments with computational bibliometric analysis.	[52]
3	Research mapping in the use of technology for fake news detection: Bibliometric analysis from 2011 to 2021.	[53]
4	Management information systems: bibliometric analysis and its effect on decision making	[54]
5	Sustainable production-inventory model with multimaterial, quality degradation, and probabilistic demand: from bibliometric analysis to a robust model.	[55]
6	Phytochemical profile and biological activities of ethylacetate extract of peanut (*Arachis hypogaea L.*) stems: in-vitro and in-silico studies with bibliometric analysis.	[56]
7	Biomass-based supercapacitors electrodes for electrical energy storage systems activated using chemical activation method: a literature review and bibliometric analysis	[57]
8	Antiangiogenesis activity of Indonesian local black garlic (*Allium sativum 'Solo'*): experiments and bibliometric analysis	[58]
9	Characteristics of tamarind seed biochar at different pyrolysis temperatures as waste management strategy: experiments and bibliometric analysis	[59]
10	The Compleat Lextutor application tool for academic and technological lexical learning: review and bibliometric approach.	[60]
11	How eyes and brain see colour: definition of colour, literature review with bibliometric analysis, and inquiry learning strategy for teaching colour changes to students with mild intelligence barriers	[61]
12	Corncob-derived sulfonated magnetic solid catalyst synthesis as heterogeneous catalyst in the esterification of waste cooking oil and bibliometric analysis	[62]
13	Prototype of greenhouse effect for improving problem-solving skills in Science, Technology, Engineering, and Mathematics (STEM) Education for Sustainable Development (ESD): literature review, bibliometric, and experiment	[63]

The data collection process utilized Scopus' advanced search functionality to identify relevant publications. Articles were selected based on their alignment with the specified keywords-"machine learning," "digitalization," and "industry"-and their inclusion in the Scopus index. The collected data was exported in two formats: *.ris for streamlined reference management and *.csv for data analysis in Microsoft Excel. This approach provided a comprehensive dataset, enabling an in-depth exploration of emerging trends and advancements in these pivotal technological areas. Unlike traditional tools such as Publish or Perish, this study exclusively relied on Scopus for data extraction and filtering. By doing so, it ensured the inclusion of only peer-reviewed articles that adhered to the rigorous standards of the Scopus database, thereby enhancing the quality and reliability of the research.

After capturing the bibliographic data, we conducted an in-depth analysis to identify trends, research productivity, and the interconnections among machine learning, digitalization, and industry. Instead of employing tools like VOSviewer, commonly used for network visualization, we leveraged Scopus' built-in citation analysis features to derive insights into the scholarly impact and citation patterns of the selected articles. This approach facilitated the construction of a scientometric network that illustrates the evolution of research within these domains, providing a clearer understanding of how these technologies intersect and influence various industries. Our study emphasized the growing significance of machine learning and digitalization in transforming industrial practices, while also identifying emerging research topics and key contributors within the field. The findings from this bibliometric analysis offer valuable insights into the current state and potential future directions of research in these areas. A detailed explanation of the research methodology, including data processing and visualization techniques, is provided.

3. Results and Discussion

3.1. Results data

The collected data provided a comprehensive visual representation of the "Documents by Year" trend, offering valuable insights into this research. The graph (see Fig. 1) highlights a clear upward trajectory in the number of documents published during this period, signifying a steady increase in the volume of research and information generated within the technological domain. This surge aligns closely with the rapid advancements and widespread adoption of emerging technologies, such as machine learning and digitalization, across diverse industries. Notably, the graph also projects a decline in document production from 2022 onward, potentially indicating a shift in research priorities or a temporary slowdown in specific technological areas. Analysing this data in the broader research context provides a deeper understanding of temporal trends and the underlying factors driving these changes. Such an analysis informs discussions on the current state of technological advancements, identifies emerging focus areas, and assesses the implications for industry applications and societal impact.

Figure 2 shows a comprehensive visual representation of the distribution of documents across various subject areas, providing critical context for this research. The pie chart effectively highlights the relative proportions of documents within different subject domains, shedding light on thematic focuses and research priorities within the broader technological landscape.

The largest segment of the chart represents the "Conference Paper" category, comprising nearly 44% of the total documents. This indicates that a substantial portion of research and literature in this field is disseminated through conference proceedings, a widely recognized platform for presenting and sharing findings in technology and engineering. The second-largest segment, "Article," accounts for approximately 33% of the documents, emphasizing the pivotal role of peer-reviewed journal articles in shaping technological discourse and advancing knowledge in areas like machine learning, digitalization, and industry applications. The remaining document types, including "Book Chapter," "Review," "Conference Review," "Book," "Note," and "Short Survey," collectively constitute smaller portions of the chart. These categories likely offer complementary perspectives and specialized insights that enrich the overall understanding of emerging trends and developments in the field of technology.

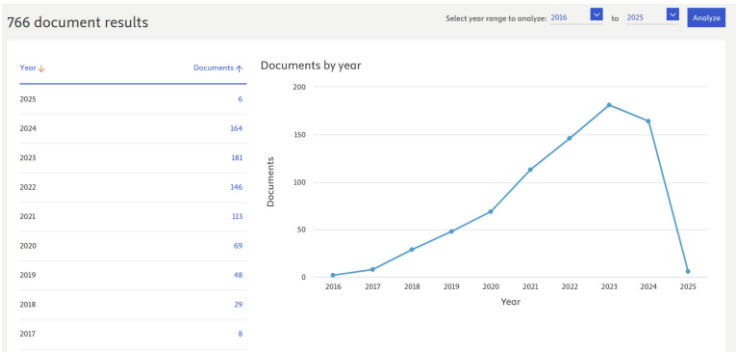

Fig. 1. Document result by terms machine learning, digitalization, industry application.

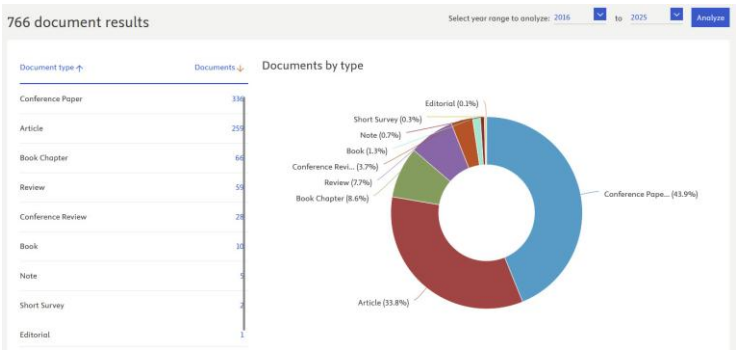

Fig. 2. Document by type.

Figure 3 shows a compelling visual representation of the distribution of documents across various subject areas, directly supporting this research. The pie chart effectively highlights the relative proportions of documents within different subject domains, providing valuable insights into thematic emphases and research priorities within the technological landscape.

The largest segment of the pie chart corresponds to the "Engineering" category, representing nearly 23% of the total documents. This indicates that a substantial

portion of research in this domain revolves around engineering topics, which serve as foundational elements of technological innovation and industry applications. The second-largest segment, "Computer Science," accounts for approximately 19% of the documents. This highlights the pivotal role of computer science research in shaping technological progress and advancing knowledge in areas such as machine learning, digitalization, and industry applications. The remaining subject areas, including "Energy," "Business, Management and Accounting," "Mathematics," "Decision Sciences," "Social Sciences," "Environmental Science," and "Earth and Planetary Sciences," collectively constitute smaller portions of the chart. These domains likely offer complementary perspectives and specialized contributions that enhance the overall understanding of emerging trends and innovations in technology.

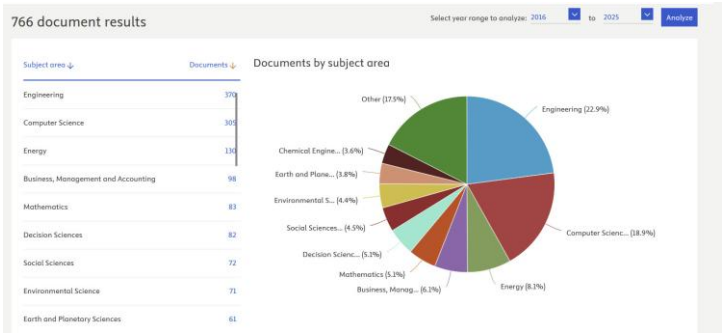

Fig. 3. Document by subject area.

Figure 4 shows a clear visual representation of the distribution of documents across various years, providing key insights for this research. The line graph effectively highlights the trend in document numbers over time, offering a deeper understanding of the temporal dynamics in research output within this field.

The graph reveals a consistent increase in document numbers from 2016 to 2022, peaking in 2022 with approximately 200 documents. This upward trend suggests a significant rise in research activity and publication output within machine learning, digitalization, and industry applications, reflecting growing attention and investment in these emerging technological areas. However, the sharp decline in document numbers from 2022 to 2025 is notable, as it may signal shifts in research priorities, funding availability, or other external factors affecting the publication landscape. These observations provide valuable insights for strategic planning, resource allocation, and identifying emerging research trends and opportunities in the fields of machine learning, digitalization, and industry applications.

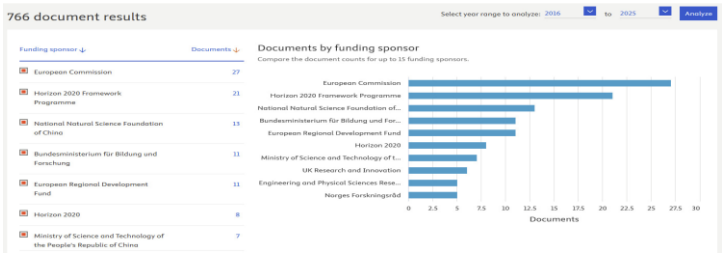

Fig. 4. Documents by funding sponsor.

Table 7 shows the most frequently cited research on machine learning, digitalization, and their industrial applications, providing valuable insights into the foundational works in these fields. These studies represent significant contributions that have fuelled technological advancements and offer a glimpse into current research trends and the dynamic evolution of these disciplines.

Table 7. Top cited articles.

No.	Document title	Source	Year	Citation
1	Artificial intelligence in sustainable energy industry: status quo, challenges, and opportunities [64].	Journal of cleaner production	2021	525
2	Towards leveraging the role of machine learning and artificial intelligence in precision agriculture and smart farming [65]	Computers and electronics in agriculture	2022	296
3	Digitalisation and intelligent robotics in value chain of circular economy-oriented waste management: a review [66].	Waste management	2019	288
4	A review of machine learning for the optimization of production processes [67].	International journal of advanced manufacturing technology	2019	241
5	Digital transformation in healthcare: architectures of present and future information technologies [68].	Clinical chemistry and laboratory medicine	2019	183
6	A review of further directions for artificial intelligence, machine learning, and deep learning in smart logistics [69].	Sustainability (Switzerland)	2020	180
7	Big data for healthcare industry 4.0: applications, challenges, and future perspectives [70].	Expert systems with applications	2022	152
8	Digital twin and internet of things: current standards landscape [71]	Applied sciences (Switzerland)	2020	136
9	Integrating BIM and AI for smart construction management: current status and future directions [72]	Archives of computational methods in engineering	2023	131
10	Industry 4.0 based process data analytics platform: a waste-to-energy plant case study [73].	International journal of electrical power and energy systems	2020	130

3.2. Trends in technology

3.2.1. Machine learning

Machine Learning (ML) has emerged as a transformative technology in recent years, driving innovation across a variety of sectors. At its core, ML refers to systems that learn from data to make predictions or decisions without being explicitly programmed. Research in this area has focused on refining algorithms such as supervised learning, unsupervised learning, and reinforcement learning to achieve higher accuracy and efficiency in tasks like image recognition, natural language processing, and predictive analytics [74]. Recent developments have introduced hybrid models that combine neural networks with traditional statistical methods, enhancing generalization and interpretability.

A key focus of ML research is optimizing model training and deployment for scalability and performance. Techniques such as transfer learning and federated learning have gained significant attention, allowing models to adapt across domains while preserving data privacy. For example, federated learning has been used in healthcare to train models on sensitive patient data without compromising individual privacy [75]. Likewise, autoML systems now automate the design of ML pipelines, reducing the need for manual intervention and enabling non-experts to effectively use these technologies.

Another important area of research is improving model transparency and reducing bias. Explainable AI (XAI) frameworks have been developed to clarify decision-making processes in complex models, thereby increasing user trust. Methods like SHAP (SHapley Additive exPlanations) and LIME (Local Interpretable Model-agnostic Explanations) offer insights into model predictions, making them more interpretable for stakeholders. The integration of XAI into ML workflows has become particularly crucial in critical applications such as finance and law enforcement.

Despite notable advancements, challenges remain, including the substantial computational resources required and the ethical considerations surrounding ML applications. Research focused on these issues is geared towards developing more efficient models for edge computing and establishing ethical frameworks to guide responsible AI development. These ongoing efforts highlight the growing significance of ML in addressing complex problems across various fields.

3.2.2. Digitalization

Digitalization, which involves harnessing digital technologies to transform processes and systems, has brought about a global revolution in industries. By integrating technologies such as cloud computing, IoT, and blockchain, digitalization has enabled businesses to improve efficiency, reduce costs, and drive innovation in their services. For instance, the implementation of digital supply chain management systems has optimized logistics and inventory control, leading to fewer operational delays [76].

One of the most profound effects of digitalization is its role in enabling data-driven decision-making. Advanced analytics platforms now offer real-time insights into market trends, customer behavior, and operational performance, empowering organizations to stay competitive. A key example of this is predictive maintenance,

where IoT sensors gather equipment data to anticipate potential failures, reducing both downtime and repair costs [77]. This application has been extensively adopted in the manufacturing and energy sectors.

Digitalization has significantly transformed customer engagement, enabling businesses to leverage digital platforms for enhanced user experiences. For example, e-commerce platforms employ personalized recommendation systems powered by machine learning algorithms, which not only improve customer satisfaction but also drive sales. Similarly, digital marketing tools allow for precise audience targeting, maximizing the effectiveness of advertising campaigns.

However, the rapid pace of digital transformation also presents challenges, such as cybersecurity risks and skill gaps within the workforce. Research in this field has focused on developing robust security protocols and offering digital literacy training to employees. Furthermore, governments and organizations are collaborating to create regulatory frameworks that strike a balance between fostering innovation and ensuring consumer protection, thus ensuring that digitalization benefits society as a whole.

3.2.3. Industry applications

The convergence of machine learning and digitalization has given rise to transformative applications across various industries. In manufacturing, for instance, smart factories utilize machine learning-powered systems to optimize production processes, minimize waste, and enhance quality control. Technologies like computer vision are employed for defect detection on assembly lines, while predictive analytics ensure the timely maintenance of machinery [78-80]. These innovations have played a crucial role in advancing the vision of Industry 4.0.

In healthcare, the convergence of digitalization and ML has led to significant advancements in patient care and medical research. From early disease detection using diagnostic algorithms to personalized treatment plans based on genomics, ML models analyse vast amounts of medical data to enhance outcomes. For example, Convolutional Neural Networks (CNNs) have shown exceptional accuracy in identifying diseases like cancer through image analysis. Telemedicine platforms also expand healthcare access to remote areas, helping to reduce disparities in medical services.

The financial sector has similarly benefited from these technologies. ML-powered fraud detection systems can identify anomalous transaction patterns in real time, helping to protect assets. Additionally, robo-advisors offer personalized investment advice by analysing market trends and individual risk profiles. Digital banking platforms continue to evolve, providing seamless user experiences while maintaining rigorous security standards.

In the transportation industry, ML and digitalization have transformed logistics and mobility solutions. Autonomous vehicles rely on ML algorithms for navigation and decision-making, while digital platforms enhance route planning and fleet management. Likewise, ride-hailing services utilize dynamic pricing models to effectively match supply with demand. These innovations are improving efficiency and promoting sustainability in urban transportation systems.

The integration of machine learning, digitalization, and industry applications highlights the potential of these technologies to address complex challenges and create new opportunities. Ongoing research and collaboration across sectors are crucial to fully realizing their potential, while also addressing the ethical and societal implications they bring.

4. Conclusion

This research highlights the synergy between machine learning and digitalization in driving industrial transformation. Machine learning facilitates advanced analytics and predictive capabilities, while digitalization enhances connectivity and fosters innovation within operational processes. Together, they have revolutionized key sectors by boosting productivity and enabling the development of innovative solutions. However, addressing challenges such as data privacy concerns, ethical issues, and technical limitations are crucial to ensuring sustainable progress. Future research should focus on interdisciplinary approaches to overcome these challenges and fully harness the potential of these transformative technologies.

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