Enhancing Industrial Automation through Efficient Technology Management in Society

P. S. Aithal

Professor, Institute of Management & Commerce, Srinivas University, Mangalore, India,
ORCID-iD: 0000-0002-4691-8736; Email ID: psaithal@gmail.com

Subject Area: Technology Management.
Type of the Paper: Exploratory Research.
Type of Review: Peer Reviewed as per |C|O|P|E| guidance.
Indexed In: OpenAIRE.
DOI: https://doi.org/10.5281/zenodo.10392661
Google Scholar Citation: IJAEML

How to Cite this Paper:
Aithal, P. S. (2023). Enhancing Industrial Automation through Efficient Technology Management in Society. *International Journal of Applied Engineering and Management Letters (IJAEML)*, *7*(4), 184-215. DOI: https://doi.org/10.5281/zenodo.10392661

International Journal of Applied Engineering and Management Letters (IJAEML)
A Refereed International Journal of Srinivas University, India.

Crossref DOI: https://doi.org/10.47992/IJAEML.2581.7000.0199

Received on: 18/10/2023
Published on: 16/12/2023

Enhancing Industrial Automation through Efficient Technology Management in Society

P. S. Aithal
Professor, Institute of Management & Commerce, Srinivas University, Mangalore, India,
ORCID-iD: 0000-0002-4691-8736; Email ID: psaithal@gmail.com

ABSTRACT

Purpose: *The accelerated advancement of technology has revolutionized industries across the globe, enabling unprecedented levels of automation and efficiency. An in-depth examination of the vital field of technology management and its crucial part in orchestrating the smooth automation of primary, secondary, tertiary, and quaternary industries is provided in this study. Information, communication, and computation technologies (ICCT underlying technologies) and nanotechnologies are included in the broad range of Universal technologies of the 21st century that fall under the purview of technology management. The first point made in the article is how crucial good technology management is to the success of industrial automation. It looks at how technology management techniques have changed to meet the varied and dynamic nature of contemporary industries.*

Design/Methodology/Approach: *ICCT can be used to connect and coordinate processes, as well as for intelligent decision-making. Additionally, the potential of nanotechnologies for precise and miniature automation components is being explored. Examining the intricacies related to technology integration, scalability, and sustainability, key challenges and opportunities in technology management are examined.*

Findings/Result: *The paper provides insights into best practices for matching organizational goals and strategies with technology management, emphasizing the necessity for flexible frameworks that can adjust to changing market demands. Based on the proposed developments of Super Intelligent Machines and technology-based singularity, and their impact on Industrial Automation, the consequences of socio-economic and environmental effects of technology-driven automation in companies are also covered in this article, highlighting the significance of ethical and sustainable technology management. It emphasizes the requirement for moral concerns, skill development, and laws that guarantee a fair transition to automated industrial processes while minimizing potential negative effects.*

Originality/Value: *In summary, competent technology management forms the basis for the successful automation of industries in all spheres of society. This paper includes a comprehensive overview of the principles, strategies, and applications of technology management along with ABCD analysis emphasizing the potential for transformative change in the landscape of modern industries in all four sectors and the pressing need to ensure ethical and sustainable practices.*

Type of paper: *Exploratory Research.*

Keywords: Technology management, Universal Technologies, ICCT underlying technologies, Effective automation, Technology-based social transformation, ABCD analysis, Quality of life.

1. INTRODUCTION :

Technology has evolved into an unstoppable force that is reshaping the basic foundation of enterprises and civilizations in the twenty-first century. Unparalleled automation across industrial sectors is now possible because of innovation's constant march, which is symbolized by the creation of Universal technologies. Information, communication, and computation technologies (ICCT) and the cutting-edge field of nanotechnologies are just two examples of the wide range of universal technologies. These technological fields serve as the cornerstones of our modern world, allowing for a major transformation of industries that is defined by effectiveness, accuracy, and adaptability [1].

The crucial role of technology management is brought to the fore as the integration of Universal technologies assumes center stage in industry. In order to achieve effective automation in the primary, secondary, tertiary, and quaternary sectors, this paper sets out on a trip into the core of effective technology management. Technology management acts as the directing hand that conducts the automation symphony, harmonizing various technologies and business procedures [2].

The first section of this introduction emphasizes how quickly technology is developing and how this has a significant impact on the industrial landscape. The current period is defined by a never-ending cycle of invention, which is propelled by advances in nanotechnology and the underlying ICCT technologies. These Universal technologies are coming together in a way that opens up new possibilities for automation and gives businesses the chance to advance, compete, and prosper in the face of adversity on a global scale. Technology management enables enterprises to fully utilize Universal technologies by acting as the compass guiding them through this unpredictable landscape. It includes the processes for resource allocation, strategic planning, and decision-making that guarantee the effective integration of technology into industrial operations. Industries may achieve previously unheard-of degrees of automation by integrating Universal technology, which boosts productivity, cost-efficiency, and competitiveness [3].

A closer examination reveals the multifaceted nature of technology management, which involves coordinating the deployment of ICCT underlying technologies, and Nanotechnologies across the entire industrial spectrum. In the primary sector, which includes agriculture and natural resource extraction, technology management plays a pivotal role in precision farming, resource management, and sustainable practices. In the secondary sector, encompassing manufacturing and construction, automation optimizes production processes, leading to improved product quality and lower production costs. In the tertiary sector, where services are paramount, technology management enhances customer experiences, streamlines operations, and facilitates data-driven decision-making. Even in the quaternary sector, comprising knowledge-based activities like research and development, the integration of technology underpins innovation and accelerates breakthroughs in various fields [4].

Challenges are inherent in the journey towards efficient technology management and effective industrial automation. These include the complexities associated with technology integration, interoperability, and scalability. The paper addresses the need for organizations to adapt to this shifting technological landscape and embrace agile management frameworks capable of rapid responses to evolving industry demands. Such adaptability is paramount in a world where new technologies emerge with increasing frequency, offering both opportunities and challenges [5].

Moreover, technology management goes beyond mere efficiency; it encompasses the responsible and ethical use of technology. As industries automate processes, ethical considerations, such as data privacy, cybersecurity, and environmental sustainability, must be woven into the fabric of technology management. The paper underscores the imperative of a holistic approach to technology management that ensures the ethical use of technology while mitigating any potential negative consequences for society and the environment [6].

The socio-economic impact of technology-driven automation is profound. While it promises increased productivity and economic growth, it also raises concerns about workforce displacement and the digital divide. Responsible technology management should not only focus on deploying technology but also on upskilling the workforce and establishing policies that support a just transition to automated industrial processes. This is a pressing issue as industries and societies grapple with the transformative potential of Universal technologies. In summary, technology management is the linchpin for effective automation of industries in society [7].

This paper will traverse the intricate web of Universal technologies, delving into their applications in the primary, secondary, tertiary, and quaternary sectors. It will examine the difficulties and possibilities of managing technology, as well as the moral and social ramifications of automation. In the end, this paper will serve as a thorough guide, illuminating the technological management tactics and tenets that have the capacity to change the global industrial landscape.

2. REVIEW BASED CURRENT STATUS :

The current status in technology management and effective industrial automation is determined by a systematic review of available important scholarly articles obtained from Google Scholar search using the keywords technology management and effective industrial automation. The results of review are summarized in Table 1 and Table 2 respectively.

Table 1: Technology management

S. No.	Focus	Outcome	Reference
1	The art of high-technology management	The paper identifies six themes under the paradox of High technology management with two grouping: First group contains Business focus, Organizational Cohesion, and Sense of integrity. The second group contains Adaptability, Entrepreneurial culture, and hands on management. The two solutions suggested are managing different parts of the firms differently either through innovations or for efficiency. Both need high technology.	Maidique, M. A., & Hayes, R. H. (1984). [8]
2	Technology management tools	The development of a complete management tool catalog that includes more than 850 examples falling into the "matrix" category is presented in this work. These tools have made it possible to create a classification scheme that recognizes the four primary categories of matrix tools: matrices, grids, tables, and scored profiles. For managers, consultants, and academics, creating integrated, well-researched, and useful tools, procedures, and frameworks proves to be a challenging endeavor. To overcome this difficulty, they must adopt an iterative "process approach."	Phaal, R., Farrukh, C. J., & Probert, D. R. (2006). [9]
3	A framework for technology management activities	Using the dynamic capacities theory as a lens, this study explores the field of technology management (TM). A never-ending stream of opportunities and challenges in the fields of new product, service, process, and organizational development are presented by the constantly changing technological world. Nevertheless, competent and dynamic technology management is crucial to maximizing the potential of these opportunities and turning them into value. This calls for a novel approach to comprehending TM that takes into account both its managerial and dynamic elements.	Cetindamar, D., Phaal, R., & Probert, D. (2009). [10]
4	Information technology management	The critical issues surrounding the knowledge transfer between organizations are examined in this essay. It examines the various kinds of knowledge created and disseminated by businesses, stressing the particular difficulties associated with knowledge management in this setting. The paper continues by highlighting the effects of Information and Communication Technology (ICT) applications, highlighting how diverse ICT systems—each created for a particular sort of information and data—align with the efficient dissemination of various knowledge forms.	Bolisani, E., & Scarso, E. (1999). [11]

5	Technology management in product development	The paper "Establishing PACE (Product and Cycle-time Excellence) in Product Development" describes how to successfully manage the elements of time, quality, skill, and resources that are required for successful product development.	Eldred, E. W., & Shapiro, A. R. (2012). [12]
6	Technology management in complex product systems	A new area of innovation research that focuses on the complicated field of complex product systems (CoPS) is beginning to take shape. These CoPS include expensive, engineering- and software-intensive items, networks, systems, and buildings that are frequently produced in project- or small-batch-based environments. Ten questions are posed in the study, which explore the fundamental elements of innovation processes, business strategy, management techniques, and project efficacy and efficiency related to CoPS.	Hobday, M., & Rush, H. (1999). [13]
7	A framework for supporting the management of technological knowledge	This research presents a framework for improving technological innovation management's theoretical and applied understanding. The two main sets of business processes that make up the core of this framework are the three "core" processes of strategy, innovation, and operations, as well as an additional set of five technology management processes, including identification, selection, acquisition, exploitation, and protection. By highlighting the need of "pull" and "push" knowledge transfers between the business and technology departments within an organization, the framework encourages the seamless integration of these operations.	Phaal, R., Farrukh, C. J., & Probert, D. R. (2004). [14]
8	Benchmarking global strategic management of technology	In-depth information gathered from the most well-known R&D-driven companies in North America, Western Europe, and Japan reveals that the connections made between top-level management in terms of aligning business and technology strategies and the wise use of outside resources are the critical factors for a successful technology strategy. Businesses are increasingly relying on universities for research projects, procuring critical technology components from outside sources, and developing collaborations through joint ventures and alliances to speed up development.	Roberts, E. B. (2001). [15]
9	Alliance portfolio diversity, radical and incremental innovation	This study investigates the relationship between an alliance portfolio's variety and a company's innovation outcomes. The toolkit of technology management tools (TM-tools) is one aspect of an alliance portfolio capabilities. By presenting this model, the authors add to the corpus of theoretical information regarding the performance effects of alliance portfolio variety while also illuminating the specific	Oerlemans, L. A., Knoben, J., & Pretorius, M. W. (2013). [16]

		circumstances under which businesses might successfully take use of this diversity.	
10	Management of technology: Themes, concepts and relationships.	In this study, authors explore the key ideas influencing the literature on technology management, as seen in Technovation, using bibliometric methodologies, specifically co-citation analysis and social network analysis tools. Additionally, we make use of network analytic tools to demonstrate the stark differences in research goals among academics from different parts of the world. Authors assert that these differences might have contributed to the lengthened time it took to establish technology management as a respected academic discipline.	Pilkington, A., & Teichert, T. (2006). [17]
11	The technology fallacy: people are the real key to digital transformation	Companies must address three crucial business problems to successfully navigate the digital transformation landscape: adjusting to digital disruption, reevaluating leadership and personnel strategies, and transforming into a digital organization.	Kane, G. (2019). [18]
12	Sustainable management of digital transformation in higher education	In order to adapt to the changes caused by emerging technologies, the education sector's evolution through digital transformation has called for the adoption of sustainable management techniques. An analysis of the development of this field's research worldwide from 1986 to 2019 has been done.	Abad-Segura, E., et al. (2020). [19]
13	How to Create Business Value Through Technological Innovations	The twelve ICCT Underlying Technologies that form its foundation, including AI, Blockchain, Business intelligence, Cloud computing, Cybersecurity, 3D printing, IoT, Quantum computing, Mobile marketing, Information storage technology, Ubiquitous education technology, and VR & AR, are crucial in creating business value in a variety of ways. In order to achieve financial performance and growth, these dimensions must be prioritized, including fostering innovation and differentiation, concentrating on customer needs, improving operational efficiency, forming strategic partnerships and alliances, managing talent effectively, optimizing marketing and branding initiatives, fostering sustainability and corporate social responsibility, and encouraging adaptability and agility.	Aithal, P. S. (2023). [20]
14	Tech-Business Analytics in Primary Industry Sector.	The differences between traditional business analytics and tech business analytics in the primary industry sector are described in this passage. It also offers a general architecture that evaluates 30 recently introduced TBA research ideas in the Primary Industries sector, which is a useful tool for technological applications.	Kumar, S., & Aithal, P. S. (2023). [21]

Table 2: Effective Industrial Automation

S. No.	Focus	Outcome	Reference
[24]	A real-time service-oriented architecture for industrial automation	The paper provided an improved Service-Oriented Architecture (SOA) with real-time capabilities incorporated specifically for industrial automation in this study. The architectural framework we suggest enables the temporal encapsulation of certain tasks coupled with the negotiation of Quality of Service (QoS) preferences by clients using Web services. This method makes it easier to evaluate each service's temporal dynamics in advance, successfully preventing any inadvertent interference between them.	Cucinotta, T., et al. (2009). [22]
2	Industrial automation using Internet of things	The Internet of Things (IIoT) is extensively examined in this chapter's section on industrial automation. In a revolutionary age where physical manufacturing is becoming more and more entwined with the information-driven economy, Advanced Industries are setting the pace. The seamless fusion of cognitive manufacturing technologies with physical machinery is what distinguishes the idea of "Industrie 4.0" as the fourth paradigm change in production. The Internet of Things (IIoT) fundamentally represents the integration of industrial systems with cutting-edge, nearly real-time analytics and computing, made possible by affordable, energy-efficient sensor devices that tap into global internet access.	Jain, S., & Chandrasekaran, K. (2022). [23]
3	The internet of thing (IoT) and industrial automation	This article provides a thorough analysis of how the current automation business is evolving into a future sector powered by the Internet of Things (IoT). It not only offers a theoretical foundation for the Industrial Internet of Things (IIoT), but it also offers insightful information. IIoT refers to the incorporation of IoT technology into procedures, goods, and services in order to promote communication between these components as well as with people all over the world. The article focuses on clarifying how industrial automation and control systems in the process and manufacturing sectors will be impacted by the Internet of Things, especially its industrial counterpart known as the Industrial Internet of Things (IIoT).	Mondal, D. (2019). [24]
4	A cyber–physical system-based approach for industrial automation systems	The authors adopt a system-centric approach to creating Industrial Automation Systems (IASs) in this research. We present a framework for enhancing the software component's extracted System Modeling Language (SysML) model in Unified Modeling Language (UML) and converting it	Thramboulidis, K. (2015). [25]

		into implementation code. The authors look at two implementation strategies that make use of integrated boards that are widely available nowadays as well as programmable logic controllers (PLCs). The paper use the updated version of IEC 61131 for PLCs, which includes Object-Orientation along with Java on embedded boards.	
5	Efficient and change-resilient test automation: An industrial case study	This paper examines a thorough case study that takes place in a challenging production environment and centers on a corporate web application. This program has two versions, requires maintenance of approximately 6500 manual test cases, is frequently updated, and necessitates testing across many browsers within constrained time frames and resources for regression cycles. The effectiveness of the first automation process is assessed in terms of how much the ATA (Automated Testing Approach) improves it.	Thummalapenta, S., et al. (2013). [26]
6	Key performance monitoring and diagnosis in industrial automation processes	Industrial processes are notably becoming more complex and automated as technology develops. Modern manufacturing lines frequently have numerous control loops, each having a variety of integrated components including sensors and actuators. However, dealing with anomalous events, an important and complex component of process management, continues to rely significantly on manual intervention and human operators.	Hao, H. (2014). [27]
7	Analyzing the factors in industrial automation using analytic hierarchy process	Industrial automation (IA) is a key component of production strategies, utilizing modern techniques to maintain a competitive edge in the manufacturing industry. This study's goal is to categorize different Artificial Intelligence (AI) aspects and evaluate their importance for improving deployment in industrial businesses. Analytic Hierarchy Process (AHP) application, expert conversations, and a thorough analysis of the literature were used to assess the relative importance and prioritizing of AI aspects in the manufacturing business.	Acharya, V., Sharma, S. K., & Gupta, S. K. (2018). [28]
8	The future of industrial communication: Automation networks in the era of the internet of things and industry 4.0.	In this paper, the authors looked carefully at technology developments and how they might affect business communications. The authors examined how Industry 4.0-inspired technologies like the Internet of Things (IoT) and Cyber-Physical Systems (CPS) have an impact on industrial automation. Additionally, a summary of recent advancements in Ethernet time-sensitive networking (TSN) and examine the value of fifth-generation (5G) communications networks for automation is given. Also emphasized how important it is to	Wollschlaeger, M., Sauter, T., & Jasperneite, J. (2017). [29]

		harmonize on a wider scale than just from a networking perspective.	
9	Machine learning-enabled smart industrial automation systems using internet of things.	The Elaborative Stepwise Stacked Artificial Neural Network (ESSANN) algorithm was developed by the authors to greatly improve automation processes in industrial control and environmental monitoring. An industrial dataset freely given by KLEEMANN Greece was used to start the process. This dataset underwent comprehensive preprocessing methods, including the use of the Least Absolute Shrinkage and Selection Operator (LASSO) for feature selection and the application of Principal Component Analysis (PCA) for feature extraction.	Al Shahrani, A. M., et al. (2022). [30]
10	Industrial robot control and operator training using virtual reality interfaces.	In order to create a truly immersive virtual reality environment, commercial gaming technologies are integrated into this paper's exploration of the dynamic interaction between virtual reality and robotics. This setting has a controller interface that integrates crucial mathematical models for the accurate control of the virtual robot. The solution we suggest offers a fresh approach to applications for cost-effective and unified robot control, as well as multiple functions like training and simulation.	Pérez, L., et al. (2019). [31]
11	Ai-based modeling: Techniques, applications and research issues towards automation	This paper provides a comprehensive view of "AI-based modeling," illuminating the core ideas and prospective capabilities of several AI approaches that hold great promise for designing sophisticated and intelligent systems for a wide range of practical applications. These programs cover a wide range of industries, including commerce, banking, healthcare, agriculture, smart cities, cybersecurity, and more. We also emphasize the difficulties and complexities associated with doing research within the scope of our study.	Sarker, I. H. (2022). [32]

In this discussion about industrial automation and its effects on society, effective technology management, with a focus on the integration of Universal technologies, is at the fore. The current state of this developing topic is examined in this literature review, along with recent trends, problems, and prospects.

(1) Universal Technologies in Industrial Automation:

The use of Universal technologies, which include Information and Communication Technologies (ICT), Computation Technologies, and Nanotechnologies, has significantly increased in recent years. These technologies are now the cornerstone of industrial automation. While Computation Technologies power shrewd decision-making and data analytics, ICT enables the continuous flow of data and communication. Meanwhile, nanotechnologies hold the promise of precise, miniature automation parts.

(2) Industry-Specific Automation:

Literature highlights the industry-specific nature of technology management and automation. In the primary sector, technologies such as precision agriculture and sensor-based resource management have revolutionized farming and resource extraction. In the secondary sector, the adoption of Industry 4.0 principles, which combine automation, data exchange, and smart manufacturing, is accelerating. The tertiary sector is witnessing a surge in AI-powered customer service and data-driven decision-making. The quaternary sector, with its knowledge-based activities, is leveraging Universal technologies to expedite research and development processes.

(3) Challenges in Technology Integration:

A recurring theme in the literature is the challenge of technology integration. Researchers emphasize the need for seamless integration of various Universal technologies, often requiring organizations to overhaul their existing infrastructure and processes. Achieving interoperability and ensuring that the systems work harmoniously is crucial but non-trivial. The need for agile and adaptable technology management frameworks to accommodate these changes is evident.

(4) Ethical and Responsible Automation:

In the conversation around technological management and automation, ethical issues have taken center stage. It has become morally necessary to ensure data privacy, cybersecurity, and environmental sustainability. A growing concern for responsible automation can be seen in recent writing. In order to balance efficiency advantages and ethical obligations, organizations are obliged to abide by ethical standards in their technology management processes.

(5) Socio-Economic Implications:

The socioeconomic effects of automation are still a major worry. According to recent studies, automation may cause job displacement even while it increases productivity and economic growth. Upskilling and retraining programs for the workforce are required as more industries use automation in order to prevent job losses. In order to guarantee that the advantages of automation are dispersed fairly throughout society, the digital gap must also be addressed.

(6) The Role of Policy and Regulation:

The significance of governmental rules and laws in directing technology management and automation is recently highlighted in literature. Globally, governments are creating systems to encourage responsible technology usage, safeguard individual rights, and guarantee environmental sustainability. Discussions about how regulators might strike a balance between innovation and moral issues are ongoing.

(7) Case Studies and Success Stories:

Case studies and success tales offer useful context for how technology management is used across industries. Numerous examples from recent literature show how effective technology management has raised productivity, cost-effectiveness, and product quality. These real-world examples might serve as an inspiration for businesses thinking about or implementing automation efforts.

(8) Emerging Trends:

The literature review also identifies new trends that will influence effective technology management for industrial automation in the future. The rise of the Internet of Things (IoT) for data collecting and analysis, the rising usage of artificial intelligence (AI) and machine learning (ML) in decision support systems, and the adoption of blockchain technology for safe and open data management are some of these trends.

(9) Sustainability and Green Technology:

The emphasis on sustainability and green technology in industrial automation is another important development in recent literature. Researchers are looking on ways to leverage Universal technology to optimize resource use, reduce waste, and reduce industry carbon footprint as environmental concerns gain in popularity.

In conclusion, the current state of successful technology management for the automation of society's industries is characterized by a dynamic environment where innovation, integration, ethical issues, and socioeconomic concerns collide. The ongoing studies and literature in this area give us a thorough awareness of the potential and difficulties that businesses encounter on the road to automation. In order to make automation a catalyst for good societal development rather than a cause of disruption, it is crucial to handle technology responsibly. A major problem for legislators, researchers, and business executives alike is keeping up with the advancements in technology and answering the changing needs of industries and society.

3. OBJECTIVES OF THE PAPER :

The following could be included in the objectives of a research paper on "Efficient Technology Management for Effective Automation of Industries in Society," with the parts listed:

(1) To Provide an In-Depth Examination of Universal Technologies of the 21st Century:

In order to fully understand the concepts, applications, and possible effects of information communication technologies, computation technologies, and nanotechnologies on industrial automation, this purpose sets out to thoroughly examine each of these fields.

(2) To Examine the Technology's Impact on Industry Automation:

With regard to the primary, secondary, tertiary, and quaternary sectors, this purpose focuses on analyzing how technology, in particular Universal technologies, has changed industrial processes. It will explore the most recent developments and trends in automation.

(3) To Investigate Effective Strategies for Managing Universal Technologies for Industry Automation:

Identifying and analyzing frameworks and techniques for the effective administration of Universal technologies is the aim of this purpose. It will examine how businesses can successfully incorporate these technologies into their operations while resolving integration, scalability, and sustainability issues.

(4) To Examine the Emergence of Super-Intelligent Machines and Their Impact on Industry Automation:

This objective delves into the cutting-edge domain of super-intelligent machines, investigating their capabilities, potential applications, and implications for industrial automation. It will discuss how these machines can contribute to advanced automation processes.

(5) To Explore the Concept of Technology-Based Singularity in Industry Automation:

This objective aims to explore the theoretical concept of singularity in the context of industrial automation, where technology and AI systems reach a point of exponential growth and self-improvement. It will assess the feasibility, challenges, and ethical considerations surrounding this concept.

(6) To Conduct an ABCD Analysis of Technology-Based Total Automation:

This objective involves conducting an ABCD analysis (Advantages, Benefits, Constraints, and Disadvantages) of technology-based total automation across primary, secondary, tertiary, and quaternary sectors. It seeks to provide a comprehensive overview of the advantages, drawbacks, and practical considerations for achieving complete industrial automation.

These objectives collectively serve as the paper's direction as it explores the intricate interactions between industrial automation, effective technology management, and universal technologies. They offer a methodical framework for thoroughly examining and debating this complex subject, taking into account recent technology developments, moral considerations, and the real-world difficulties that various industries encounter in their quest for automation.

4. METHODOLOGY :

It employs an exploratory research methodology. Before beginning a more extensive research project, exploratory research is frequently carried out to get a deeper grasp of a subject, formulate hypotheses, and collect preliminary data. Information is gathered from a variety of online sources, including as Google, Google Scholar, and several GPTs like ChatGPT and Bard. In order to establish the postulates and offer recommendations for system improvement, the data are analyzed, assessed, and interpreted in accordance with a certain framework.

5. UNIVERSAL TECHNOLOGIES OF THE 21ST CENTURY :

The 21st century has borne witness to a remarkable surge in Universal technologies, fundamentally reshaping the way we live and conduct business. Universal technologies encompass Information Communication and Computation technologies (ICCT) and Nanotechnologies [1], [2], [3], [33], forming the cornerstone of the technological revolution that has unfolded in recent years. ICCTs, also referred to as ICCT underlying technologies [34-57], play a pivotal role in this transformative era. These technologies have evolved to encompass a broad spectrum of applications, each revolutionizing specific aspects of modern life.

(i) Artificial Intelligence & Robotics: Robotics and artificial intelligence (AI) are at the forefront and have made tremendous strides. AI systems are crucial in industries ranging from healthcare and banking to transportation and manufacturing because they can process enormous amounts of data, learn from it, and make judgments. In fields like manufacturing and logistics, where automation and accuracy are crucial, robotics and AI have seen increased application.
(ii) Blockchain technology: Another important innovation is blockchain technology, which has upended conventional record-keeping and data security procedures. In order to provide transparency and security, it offers a decentralized, irreversible ledger that is being used in a variety of industries, from finance and supply chain management to healthcare and voting systems.
(iii) Big Data and Business Intelligence technology: Data management and analytics have undergone a revolution thanks to the widespread adoption of Big Data and Business Intelligence technology. Large datasets can now be used by organizations to gather important information, guide decisions, and improve operations. Through the application of predictive analytics and data-driven tactics, these technologies have changed entire sectors.
(iv) Cloud computing technology: Flexible, scalable, and economical data processing and storage are now possible because to cloud computing technology. It has encouraged remote work options and made it possible for businesses to scale up without investing heavily in physical infrastructure.
(v) Cyber Security and Forensic technology: Protecting sensitive data from online attacks now requires a combination of forensic technologies and cyber security. These technologies use cutting-edge techniques to find and reduce security breaches as cyberattacks continue to develop.
(vi) Digital Marketing and Mobile Business technology: The way businesses interact with their customers has changed as a result of digital marketing and mobile business technology. Mobile applications and targeted advertising have changed marketing strategies by giving firms new ways to connect with and interact with their customers.
(vii) 3D Printing technology: 3D Printing technology has revolutionized manufacturing processes by enabling the creation of intricate and customized objects with speed and precision. From healthcare, where 3D printing is used for prosthetics and medical models, to aerospace and automotive industries, the applications are vast.
(viii) Internet of Things (IoT): The Internet of Things (IoT) has given rise to interconnected devices that exchange data and enhance automation in both industrial and domestic settings. IoT technology is the backbone of smart homes, smart cities, and Industry 4.0, where, automation and data exchange drive efficiency.
(ix) Quantum Computing technology: Quantum Computing technology is pushing the boundaries of classical computing, promising unprecedented computational power for solving complex problems in fields such as cryptography, materials science, and drug discovery.
(x) Information Storage technology: Through advancements in data storage and retrieval, information storage technology has been crucial in handling the everyday production of ever-increasing volumes of digital information. Accessibility, dependability, and long-term data preservation are all guaranteed by this technology.
(xi) Ubiquitous Education technology: Digital tools are used by ubiquitous education technology to increase accessibility and engagement in learning. In particular during times of remote learning, e-learning platforms, internet materials, and virtual classrooms have expanded educational opportunities and reach.
(xii) Virtual Reality (VR) and Augmented Reality (AR) technology: Technology such as virtual reality (VR) and augmented reality (AR) is altering how we view and engage with the environment. They provide immersive experiences that increase user engagement and comprehension in industries like gaming, education, healthcare, and design.

Similarly, nanotechnology holds enormous promise for changing many industries through the manipulation of materials at the nanoscale, and hence is a crucial part of the Universal Technologies of the 21st century [58-65]. With the help of this ground-breaking technology, nanoscale structures and devices can be designed and engineered, giving businesses in fields as diverse as medical, electronics, materials research, and energy previously unheard-of accuracy and control. The development of innovative materials with extraordinary qualities, improved medicine delivery systems, and ultra-efficient energy storage and conversion technologies are all possible thanks to nanotechnology. Its uses are numerous, and it has the power to transform entire industries and spark creativity in ways that were previously thought of as science fiction. Nanotechnology, one of Universal Technologies, is a prime example of the limitless potential that technology offers in the 21st century, advancing us toward a future of unmatched progress.

In conclusion, ICCT underlying technologies and nanotechnology have experienced tremendous expansion in the twenty-first century, radically altering how we live, work, and invent. These technologies are still developing and will have a huge impact on how our linked world develops in the future, providing countless opportunities and difficulties.

6. TECHNOLOGY-BASED INDUSTRY AUTOMATION :

The global economy and society are being significantly impacted by technology-based industry automation, which is being propelled by a number of ICCT underpinning technologies including Nanotechnology. Industries across the board, from manufacturing and agriculture to services and knowledge-based sectors, are being reshaped by these disruptive technologies. The consequences affect a number of facets of the economy and society:

(1) Enhanced Productivity and Efficiency: Automation of industries based on technology has the potential to improve productivity and efficiency dramatically. Robotics and AI technology, for instance, are speeding production procedures, cutting errors, and improving supply chains. This leads into cost savings for companies and maybe lower prices for consumers, which promotes economic expansion.

(2) Job Displacement and Transformation: While automation increases efficiency, it can also contribute to job displacement, especially for repetitive and routine work. It's important to remember, though, that automation frequently changes the nature of employment rather than completely replacing it. In the areas of technology development, maintenance, and oversight, new employment are created. To close the skills gap between job displacement and job creation, the workforce must be retrained and upgraded.

(3) Economic Growth and Innovation: Through innovation, technology-based automation drives economic growth. For instance, quantum computing technology has the potential to disrupt industries and promote innovation in sectors like drug research, materials science, and encryption. By opening up new horizons, the creation and use of cutting-edge technology can promote economic growth.

(4) Data-Driven Decision-Making: By enabling businesses to gather, process, and analyze enormous amounts of data, big data and business intelligence technology play a crucial role in automation. This in turn facilitates decision-making based on data. Businesses can make better decisions, streamline processes, and improve consumer experiences, all of which will help the economy as a whole.

(5) Sustainability and Resource Efficiency: Technology-based automation can have a positive impact on environmental sustainability. For example, the Internet of Things technology can be applied to smart grids and resource management, reducing waste and energy consumption. Furthermore, 3D Printing technology allows for the creation of intricate, lightweight structures, saving material and energy resources.

(6) Challenges in Ethical and Regulatory Frameworks: The rapid advancement of technology-based automation necessitates the development of comprehensive ethical and regulatory frameworks. Cyber Security & Forensic technology becomes vital in safeguarding data and systems. Blockchain technology, with its decentralized and secure ledger, ensures the integrity of transactions. Ensuring ethical practices, data privacy, and cybersecurity is essential to maintain public trust in these technologies.

(7) Increased Connectivity and Accessibility: Technology-based automation, particularly through Cloud Computing technology, has increased connectivity and accessibility. People and businesses can access data and services remotely, enabling remote work and e-learning. This has implications for improving access to education and employment opportunities in various regions, contributing to societal equity.

(8) Virtual Reality and Augmented Reality in Education and Training: Ubiquitous Education technology, combined with Virtual Reality and Augmented Reality technology, is revolutionizing education and training. These immersive technologies offer engaging learning experiences and practical training simulations, reducing the need for physical facilities and making education more accessible and interactive.

(9) Nanotechnology for Industrial Automation:
The 21st century's Universal Technologies for industrial automation, which include nanotechnology, usher in a microcosmic revolution in the macrocosmic world of business.
With its ability to operate at the nanoscale, it enables precise material engineering and modification, fostering innovation in industries including manufacturing, healthcare, and energy. Unique materials with unequaled properties can be created using nanotechnology, improving product quality, increasing energy efficiency, and optimizing resource use in industrial automation. Additionally, nanoscale sensors and devices provide real-time data collection and processing, which enhances the monitoring and management of industrial activities. A future of greater efficiency and technical advancement is made possible by the vital role that nanotechnology plays in redefining the boundaries of what is feasible in the realm of industrial automation. It serves as a catalyst for improvements in advanced sensors, tiny parts, and material science.

In conclusion, technology-based industry automation that utilizes ICCT and underlying nanotechnology technologies is a double-edged sword that poses both amazing opportunities and challenges. It can drive economic growth, boost efficiency, and foster innovation even while it raises problems with job displacement and ethical dilemmas. As society accepts new technologies, it is critical to strike a balance that optimizes their beneficial effects while limiting any adverse repercussions. This will contribute to the development of a technologically advanced and equitable society.

7. MANAGEMENT OF UNIVERSAL TECHNOLOGIES FOR INDUSTRY AUTOMATION :

The management of Universal Technologies for industry automation is a challenging endeavor that requires a systematic approach. This management requires managing a complex interplay of Information Communication and Computation Technologies (ICCT underpinning technologies) and Nanotechnology in order to achieve effective and successful industrial automation. The main rules and methods for managing Universal Technologies in the context of industry automation are as follows:
(1) Integration and Interoperability: The peaceful coexistence of multiple technologies must be ensured. Management should focus on integrating various ICCT underlying technologies and Nanotechnology components in order to establish a comprehensive automation system. Interoperability standards, which allow data and processes to transfer readily between different technologies, make this integration possible.
(2) Scalability and Flexibility: The management structure must be flexible and scalable as technology advances. The ability to adapt to changing technological surroundings and take into consideration the advancement of automation systems is meant by this.
The management approach should enable these transitions without causing disturbance, whether an organization is scaling up or down.
(3) Resource Allocation and Optimization: Effective resource management is necessary for managing Universal Technologies for industry automation. It also refers to personal, financial, and technological resources. The organization can harness the advantages of automation while limiting expenses and waste by optimizing resource use. This can entail spending money on staff development and training so they can manage and maintain the technologies.
(4) Risk Management and Security: Risk management and security are becoming essential elements of technology management because of the growing significance of data in automation. Identifying possible threats, putting cybersecurity safeguards in place, and developing disaster recovery plans are all part of this. The integrity and security of the automated systems are ensured by effective risk management.
(5) Ethical and Sustainable Practices: Sustainability and ethical considerations are increasingly important as automation develops. The management framework should place a strong emphasis on using technology ethically, taking into account issues like data privacy, job loss, and the environmental effects of automation. To reduce the ecological footprint, it is also crucial to adopt sustainable activities, such as cutting back on waste and energy use.
(6) Regulatory Compliance: It is crucial to keep up with changing laws and compliance standards. There might be particular regulations governing the use of technology in automation in different

businesses and places. A key component of technology management is making sure the company complies with these laws.
(7) Data Management and Analytics: Utilizing Big Data and Business Intelligence technology to extract insights from the enormous amounts of data produced by automated processes is essential for effective management. Organizations may make better decisions, work more efficiently, and spot areas for improvement by utilizing data analytics technologies.
(8) Maintenance and Upkeep: To avoid downtime and guarantee smooth operations, the technology infrastructure must be continuously monitored and maintained. To maintain the automation systems operating effectively, the management approach should include routine updates, troubleshooting, and preventive maintenance.
(9) Change Management: Organizational cultural shifts are frequently required in order to manage Universal Technologies for industry automation. In order to achieve a smooth transition and employee buy-in, effective change management tactics are needed when employees may need to adjust to new ways of working.
In conclusion, managing Universal Technologies for industry automation is a complex process that includes integrating various technologies, ensuring scalability and flexibility, optimizing resources, managing risks and security, upholding ethical and sustainable practices, adhering to regulations, harnessing data, and maintaining the technology infrastructure. For enterprises to effectively benefit from automation while navigating the difficulties and complexities posed by this technological environment, effective management of these technologies is crucial.

8. SUPER INTELLIGENT MACHINES AND EFFECTIVE INDUSTRY AUTOMATION :

Super Intelligent Machines are artificial intelligence systems that have attained a degree of intellect and problem-solving capacity that is superior to human capabilities across a wide range of tasks. They are also known as Superintelligent AI or Superintelligent Systems. Due to their amazing cognitive powers, which include complex thinking, problem-solving, learning, adaptation, and the ability to do difficult tasks with a high degree of autonomy, these machines stand out from other artificial intelligences.

8.1 Characteristics of Super Intelligent Machines:

Super intelligent machines frequently have the following characteristics:
(1) Advanced Learning: They are able to learn from a vast amount of data, adapt to new knowledge and situations, and continuously enhance their performance.
(2) High-Level Reasoning: These machines are capable of high-level discussions, critical evaluations, and conclusions, frequently while understanding broader implications and abstract notions.
(3) Autonomy: They can function autonomously in situations where conventional automation or artificial intelligence (AI) systems would not be able to. Without constant human supervision, they are capable of making decisions.
(4) Adaptability: Due to their great adaptability, which enables them to adapt to changing settings, uncertainties, and unforeseen events, super intelligent machines are beneficial in a variety of applications.
(5) Prediction and Planning: They excel in forecasting events based on both historical and current data, and they might create plans or strategies to accomplish specific goals.
(6) Cross-Domain Competence: These robots have the intelligence to apply it to a wide range of tasks and disciplines, frequently beating human experts in each.
As they have the potential to cause large societal changes, disrupt established sectors, and pose issues of ethics, control, and governance, super intelligent machines are the focus of extensive research. In the domains of artificial intelligence, machine learning, and philosophy, there is discussion and interest in the idea of a superintelligent AI, which is frequently linked to the notion of the technological singularity. It calls into question the appropriate design and implementation of such cutting-edge AI systems as well as their long-term effects.

8.2 Super Intelligent Machines and Industrial Automation:

The potential for Super Intelligent Machines to transform industry automation in a number of ways makes them the apex of artificial intelligence and automation technologies.

(1) Advanced Decision-Making: Super Intelligent Machines are able to process and interpret enormous volumes of data at rates that are faster than those of humans. They can now make intricate, data-driven judgments in real time thanks to this. This translates into more effective and improved operations in industrial settings. For instance, in manufacturing, these machines may instantly modify production procedures in response to shifting conditions, resulting in less waste and more output.
(2) Autonomous Adaptability: Super Intelligent Machines are extremely flexible and are capable of making changes to their environment on their own. This entails that they can reorganize production lines, modify manufacturing processes, and even foresee maintenance requirements without requiring human interaction. With less downtime and disturbance because to this adaptability, the automation systems continue to operate at their peak efficiency.
(3) Predictive Maintenance: Super Intelligent Machines are able to foresee when machinery and equipment may break down. They can plan maintenance or repairs in advance by reviewing historical data and current performance parameters. Predictive maintenance increases the longevity of industrial equipment while reducing unplanned downtime and maintenance expenses.
(4) Enhanced Safety: Safety is a top priority in industrial settings, and SIMs may play a significant part in maintaining a secure working environment. They may keep an eye out for anomalies that could endanger safety and monitor processes and equipment accordingly. They can then take prompt corrective action, including turning off machinery or warning human workers. The possibility of accidents and injury is decreased by this capability.
(5) Resource Optimization: The efficient use of resources like energy, raw materials, and labor is possible with super intelligent machines. They can modify procedures to cut down on energy use, lessen material waste, and make the best use of the personnel that is on hand. Costs are reduced as a result, and industrial activities are approached more sustainably.
(6) Quality Control: These devices are excellent at quality assurance and can reliably generate goods that adhere to stringent criteria. They may identify and reject inferior products during manufacture, ensuring that only high-quality products are sold. The product quality and client happiness are improved by this capability.
(7) Supply Chain Management: Supply chain processes can be improved by super intelligent machines. They can monitor inventory levels, foresee changes in demand, and alter distribution and procurement in real-time. The risk of stockouts and overstock situations is decreased as a result of the supply chain becoming more effective and responsive.
(8) Customization and Personalization: Super Intelligent Machines are capable of creating products that are specifically tailored to the needs of each consumer in sectors where personalization and customization are crucial, such as the pharmaceutical or automobile industries. They can give a level of customisation that was previously impractical by adjusting production procedures and specifications with astonishing precision.
(9) Enhanced Research and Development: By running simulations and experiments far more quickly than people can, super intelligent machines can speed up research and development. They can speed up innovation and aid in the discovery of new chemicals in fields like materials science and pharmaceuticals.
(10) Collaboration with Humans: These machines can work effortlessly in tandem with people. They can handle labor-intensive, repetitive activities, freeing up human workers to concentrate on jobs that call for imagination, problem-solving, and emotional intelligence. The total productivity and job satisfaction that can result from this human-machine collaboration.

As a result of their superior decision-making, adaptability, predictive maintenance, safety enhancements, resource optimization, quality control, supply chain management, customization, accelerated research and development, and seamless collaboration with human workers, Super Intelligent Machines offer an unmatched potential for effective industry automation. In the quest for industrial automation that is more effective, productive, and creative, these devices stand as a transformative force.

9. TECHNOLOGY BASED SINGULARITY :

Technology-Based Singularity, often referred to as Technological Singularity, is a hypothetical point in the future where the rapid and exponential growth of advanced technologies, including both ICCT underlying technologies and Nanotechnology, reaches a critical juncture. At this juncture, the capabilities of these technologies become so advanced and interconnected that they radically transform human civilization and existence in ways that are difficult to predict.

9.1 Universal Technology Based Singularity:

Here's how Universal Technologies, incorporating ICCT underlying technologies and Nanotechnology, play a pivotal role in the concept of Technology-Based Singularity:

(1) Exponential Technological Growth: Universal Technologies drive the exponential growth of knowledge and innovation. Artificial Intelligence & Robotics technology, for example, continues to advance, enabling machines to perform increasingly complex tasks, from natural language processing to autonomous decision-making. As these technologies progress, they amplify the rate of discovery and development across various domains.

(2) Interconnected Intelligence: The convergence of technologies, facilitated by Universal Technologies, leads to interconnected and superintelligent systems. These systems can collaborate, share information, and augment each other's capabilities. For instance, IoT technology can gather vast amounts of data, which is processed by AI and utilized by Quantum computing for advanced simulations and predictions.

(3) Unprecedented Data Processing: Big Data and Business Intelligence technology become fundamental in managing and extracting insights from the overwhelming volume of data generated by interconnected systems. This data-driven decision-making fuels further advancements and informs strategic choices at an unprecedented scale.

(4) Security and Trust: As Universal Technologies advance, the importance of Cyber Security & forensic technology and Blockchain technology cannot be overstated. Trust and security in this interconnected world are paramount. Blockchain provides decentralized, tamper-proof record-keeping, while Cyber Security technology safeguards networks and data against evolving threats.

(5) Transformation of Industries: The integration of Universal Technologies transforms industries across the board. 3D Printing technology revolutionizes manufacturing, enabling on-demand, customized production. Cloud Computing technology allows for resource sharing and access from anywhere, making it easier for businesses to adapt and scale rapidly.

(6) New Realities and Ubiquitous Learning: Virtual reality and Augmented reality technology create immersive learning and working environments. Ubiquitous Education technology makes learning accessible worldwide, breaking down traditional educational barriers and fostering a continuous learning culture.

(7) Breakthroughs in Healthcare and Materials Science: Nanotechnology, as an integral component of Universal Technologies, contributes to breakthroughs in healthcare and materials science. Nano-sized structures enable precise drug delivery, advanced materials with unique properties, and innovative energy solutions.

(8) Quantum Leaps in Computing: Quantum computing technology pushes the boundaries of computation, tackling problems that were previously insurmountable. This can revolutionize fields such as cryptography, materials design, and optimization, leading to transformative advances.

In essence, Technology-Based Singularity driven by Universal Technologies represents a future where the synergy of ICCT underlying technologies and Nanotechnology results in a paradigm shift. It has the potential to solve complex global challenges, create new opportunities for exploration and discovery, and redefine the boundaries of what's possible. However, it also poses ethical, societal, and regulatory challenges that require thoughtful consideration to ensure that the benefits are harnessed responsibly for the betterment of humanity.

9.2 Management of Technology Based Singularity in Society:

Management of Technology-Based Singularity in society represents a complex and multifaceted challenge that requires careful consideration, proactive planning, and responsible governance.

The rapid development and convergence of cutting-edge technologies, such as artificial intelligence, nanotechnology, and others, which is known as the technology-based singularity, holds immense promise and potential for civilization. But managing this shift necessitates attending to numerous crucial issues.

(1) Ethical Frameworks: The Technology-Based Singularity has serious ethical ramifications. Ethics must be established and followed by society to direct the creation and application of these

technologies. This encompasses values pertaining to confidentiality, openness, justice, and the ethical application of artificial intelligence and other cutting-edge techniques.
(2) Regulatory Governance: To ensure that the advantages of the technology-based singularity are realized while hazards are reduced, effective regulation is crucial. For the purpose of providing supervision, establishing standards, and enforcing adherence to ethical principles, regulatory organizations must adjust to the quickly changing technology landscape.
(3) Education and Upskilling: The workforce will be affected by the change that the technology-based singularity brings about. Society must make investments in education and upskilling programs that give people the skills they need in this technologically sophisticated environment in order to handle potential job displacement and prepare for new opportunities.
(4) Data Privacy and Security: Cybersecurity and data privacy protection must be prioritized. Strong steps are needed to protect private and sensitive data and to keep people's faith in technology given the exponential rise in data collection and sharing.
(5) Access and Equity: Making sure that everyone can benefit from the Technology-Based Singularity is essential. In order to provide fair access to opportunities in education, healthcare, and the economy, efforts should be made to close the digital divide.
(6) Environmental Impact: In order to reduce ecological harm and promote sustainability, the environmental effects of sophisticated technology, including energy use and resource exploitation, should be properly monitored.
(7) International Collaboration: International cooperation is crucial because of the technology-based singularity's global nature. To ensure a coordinated and responsible approach, this involves agreements on data exchange, cybersecurity requirements, and ethical norms.
(8) Transparency and Accountability: Organizations and technology developers must be accountable for their actions and transparent about how they conduct their business. This includes assuring justice, reducing prejudice in AI systems, and describing how algorithms operate.
(9) Public Engagement: Effective management of the Technology-Based Singularity depends on public input into decision-making. To ensure that the technologies serve the greatest good, it is essential to solicit public participation and feedback.
(10) Risk Assessment: Scenario planning and ongoing risk assessment are necessary to spot possible problems and deal with them before they become catastrophes. This involves assessing how technology is affecting employment, privacy, and security.
(11) Crisis Preparedness: Rapid technological progress may result in unanticipated disruptions or catastrophes, thus society must be ready for them. This includes strategies for fending off cyberattacks, handling incorrect information, and limiting the impact of unanticipated results.

In conclusion, managing the technology-based singularity in society requires a multifaceted approach that takes into account ethical, sociological, governmental, and educational considerations. In order to maximize gains from Singularity while reducing dangers and problems, careful development and deployment of cutting-edge technologies are essential. To successfully traverse this transformational era, a diverse, cooperative, and forward-looking strategy is required.

10. ABCD ANALYSIS OF TECHNOLOGY-BASED TOTAL AUTOMATION OF INDUSTRIAL PROCESSES :

The ABCD analysis of Technology-Based Total Automation of Industrial Processes offers a comprehensive evaluation of the implications and impact of full-scale automation. Advantages are manifested in increased productivity, enhanced product quality, reduced operational costs, and a safer work environment. The benefits extend to sustainability, as automation can optimize resource utilization and minimize waste. Constraints often revolve around initial investment costs, as implementing comprehensive automation can be capital-intensive, requiring significant financial resources. Disadvantages, particularly in the context of job displacement, demand close attention, as some routine tasks may be automated, potentially leading to workforce challenges. However, strategic planning, upskilling, and job transition opportunities can mitigate these disadvantages. In essence, the ABCD analysis underscores the transformative potential of total automation while highlighting the need for a well-balanced approach to maximize its advantages and benefits while addressing constraints and disadvantages [66-109].

10.1 Advantages of Technology Based Total Automation of Industrial Processes:

Advantages of Technology-Based Total Automation of Industrial Processes are listed in the Table 3.

Table 3: Advantages

S. No.	Key Advantage	Description
1	Increased Productivity	Automation reduces manual labour and enables continuous and efficient production, leading to a significant increase in productivity. Machines can operate around the clock without fatigue or breaks, ensuring consistent output.
2	Improved Product Quality	Automation promotes accuracy and uniformity in manufacturing, which results in a higher-quality end product with fewer flaws. Products that fulfill exacting criteria are produced under strict oversight.
3	Cost Savings	Automation can save a lot on running expenses. It saves money by reducing labor expenses, reducing waste, maximizing resource use, and reducing the demand for physical space.
4	Greater Efficiency	Automation makes procedures more efficient by eliminating bottlenecks. Additionally, it can shorten cycle times and result in more effective resource management, improving overall operational efficiency.
5	Continuous Operations	Automated systems can run continuously, allowing for real-time data monitoring and 24/7 manufacturing. Faster time-to-market and improved responsiveness to market demands may result from this continuous operating.
6	Safety Enhancements	Automation frees personnel from hazardous or physically taxing duties, improving safety. This lowers the possibility of accidents and injuries and creates a safer work environment.
7	Data-Driven Decision-Making	Automated processes produce enormous volumes of data that may be analyzed. Businesses are able to optimize operations, identify problems early, and make wise strategic decisions thanks to this data-driven decision-making.
8	Resource Optimization	Automation systems effectively use resources like water, energy, and raw materials. This has positive effects on the environment and sustainability.
9	Scalability	To adapt to changing demands, automation systems may be readily scaled up or down. This scalability offers flexibility in responding to changes in the market
10	Customization and Personalization	Products can be personalized to suit the needs of certain customers using automation. This personalization is useful in sectors like fashion or auto production where demand for personalized items is high.
11	Reduction in Monotonous jobs	Automation replaces monotonous and repetitive jobs, allowing human workers to concentrate on more complex, creative, and problem-solving duties. This can increase job satisfaction.
12	Competitive Advantage	Adopting automation can give businesses a competitive edge in sectors where quality, cost, and efficiency are crucial factors. It enables businesses to react quickly to changes in the market and client needs.
13	Flexibility	Automation systems may be altered and modified to account for new goods or adjustments in production needs, allowing for quick response to market demands.
14	Durability and Reliability	When maintained properly, automated machinery may operate for longer periods of time than manual labour. This dependability reduces manufacturing hiccups and downtime.

15	Real-Time Monitoring	Remote control and real-time monitoring made possible by automation make it possible to identify problems right away, cut down on delays, and boost productivity.
16	Consistent Workforce	Automation doesn't depend on variations in the workforce's availability due to things like sick days or labour strikes, which makes for a steady working environment.

These advantages collectively contribute to improve industrial processes and, when well-managed, can lead to higher product quality, cost savings, and increased competitiveness, eventually benefiting both businesses and consumers.

10.2 Benefits of Technology Based Total Automation of Industrial Processes:

Benefits of Technology-Based Total Automation of Industrial Processes are listed in table 4.

Table 4: Benefits

S. No.	Key Benefits	Description
1	Optimized Resource Utilization	Automation makes the most effective use possible of resources including raw materials, energy, and water. It is possible to optimize processes to reduce waste, which will save money and have a positive effect on the environment.
2	Enhanced Product Quality	Automation guarantees accurate and consistent manufacturing, leading to higher-quality goods with fewer flaws. As a result, clients are more satisfied and devoted.
3	Greater Productivity	Continuous, round-the-clock work made possible by automation results in higher output rates and shorter cycle times. The company's financial performance can be improved while the expanded output can satisfy the escalating demand.
4	Operational Cost Reduction	Automation lowers labor costs and reduces human error by eliminating the need for manual labor. Additionally, it reduces operating expenses, enhancing the competitiveness of organizations.
5	Greater Safety	Automation frees workers from dangerous or physically taxing duties, making the workplace safer. A healthier and more effective workforce results from fewer accidents and injuries.
6	Scalability	Automated systems may be expanded with ease to meet changing demand. This scalability guarantees that a company can adjust to market changes and keep up operational effectiveness.
7	Personalization and customization	Automation makes it possible to produce personalized goods quickly. This is especially useful in sectors like fashion or auto manufacture where personalization is a selling element.
8	Data-Driven Decision-Making	Automation produces a lot of data, which may be examined to help in decision-making. This data-driven methodology aids in process optimization, forecasts maintenance requirements, and boosts effectiveness.
9	Increased Efficiency	Automation improves efficiency by streamlining procedures and removing bottlenecks. Costs are reduced as a result, and time to market is shortened.
10	Sustainability and Environmental Benefits	Automation systems are frequently made to be environmentally friendly and energy-efficient. This emphasis on sustainability lessens a company's impact on the environment and improves its reputation.
11	Competitive Advantage	Automation offers a competitive edge in sectors where effectiveness, cost containment, and product quality are crucial. Companies are able to react quickly to changes in the market and customer needs.
12	Longevity and Reliability	Automated equipment that is well-maintained can operate for longer periods of time than manual labour. Production pauses and downtime are reduced by this reliability.

13	Real-Time Monitoring	Real-time monitoring and remote control made possible by automation enable prompt issue detection and correction, minimizing delays and increasing overall efficiency.
14	Consistent Workforce	Automation ensures a consistent production environment since it is not affected by changes in personnel availability, such as sick days or labour strikes.
15	Adaptability	Automated systems offer flexibility in addressing market demands because they may be adjusted and modified to suit new goods or adjustments to production needs.
16	Reduction in Monotonous Tasks	Automating routine chores frees up human workers to concentrate on more imaginative, complicated, and problem-solving duties, which can improve job satisfaction.

A more competitive, effective, and environmentally responsible industrial landscape is the outcome of these advantages taken together. By embracing automation, businesses and customers can both gain from cost savings, increased competitiveness, and improved product quality.

10.3 Constraints of Technology-Based Total Automation of Industrial Processes:

Constraints of Technology-Based Total Automation of Industrial Processes are listed in table 5:

Table 5: Constraints

S. No.	Key Constraints	Description
1	Initial Investment Costs	Total automation implementation can be expensive. The expenditures of purchasing, setting up, and retraining the workforce for automation technologies might be significant. Long-term advantages frequently surpass these expenses, though.
2	Skilled Workforce Requirement	Complex machinery needs to be operated, maintained, and troubleshot by qualified personnel in order for automation to be effective. Finding and keeping experienced technicians and engineers can be difficult for businesses.
3	Technological Dependence	Businesses that fully automate become reliant on technology. Production might be halted by any system malfunctions or technological issues, necessitating proactive maintenance procedures and contingency preparations.
4	Job Displacement Concerns	Concerns regarding job displacement may arise as a result of the automation trend, particularly in sectors that depend largely on physical labour. Although automation opens up new job prospects, this problem is frequently solved by reskilling and transition programs.
5	Security Risks	Automation systems may be more susceptible to data breaches and cyberattacks as a result of growing connectivity. To protect themselves against these hazards, businesses must invest in forensic technology and strong cyber security.
6	Resistance to Change	Employees worried about losing their jobs or management teams reluctant to alter current procedures may oppose the use of automation. It is crucial to overcome this resistance through change management and education.
7	Maintenance and Downtime	Automated systems require regular maintenance to prevent costly breakdowns. Downtime for maintenance can disrupt production schedules and require careful planning.
8	Lack of Flexibility	Automation systems are designed for specific tasks and can lack the adaptability of human workers. Adapting to changes in production requirements or introducing new product lines may be challenging.

9	Interoperability Issues	Integrating various automation systems can be complex, especially if they come from different manufacturers. Ensuring interoperability and data flow between systems can be a constraint.
10	Ethical and Societal Concerns	Automation raises ethical questions related to job displacement, data privacy, and the impact on society. Addressing these concerns through ethical frameworks and regulatory guidelines is crucial.
11	Limited Creativity	Automation excels at repetitive and predefined tasks but may lack the creativity and adaptability of human workers. Certain industries may require human intervention for complex or novel problem-solving.
12	Environmental Impact	While automation can be more resource-efficient, it may still consume significant energy and materials. Mitigating the environmental impact of automation systems is a challenge.
13	Complex Troubleshooting	Diagnosing and rectifying issues in complex automation systems can be challenging. Companies need to invest in skilled personnel and resources for efficient troubleshooting.
14	Regulatory Compliance	Adhering to industry-specific regulations and standards in an increasingly automated environment can be complex and necessitates ongoing compliance efforts.
15	Customization Costs	Modifying automation systems to accommodate specific product variations or customization may incur additional costs and require a degree of flexibility in the technology.
16	Long Implementation Period	Implementing total automation can be time-consuming. The planning, installation, testing, and adjustment phases can extend over a considerable period, affecting business operations.

Balancing the advantages of total automation with these constraints requires strategic planning, investment, and a holistic approach to technology integration and workforce management. Addressing these constraints effectively can result in a more productive, efficient, and competitive industrial landscape.

10.4 Disadvantages of Technology Based Total Automation of Industrial Processes:

Disadvantages of Technology-Based Total Automation of Industrial Processes are listed in table 6.

Table 6: Disadvantages

S. No.	Key Constraints	Description
1	Job Displacement	One of the primary disadvantages of total automation is the potential displacement of human workers. There is a risk of employment loss when machines and robots take over duties, especially those that are routine and repetitive, which can have negative social and economic effects. It's crucial to remember that automation also generates new job possibilities in disciplines like system oversight, maintenance, and technical support.
2	High Initial Investment	Total automation implementation frequently necessitates a sizable initial investment in technology, including the procurement of automation equipment, software, and the required infrastructure. The financial capacity of a business may be put under pressure.
3	Skilled Workforce Requirements	Advanced automation systems require competent personnel, including technicians and engineers, to maintain and operate. It can be difficult to find and keep this qualified staff, and it can be necessary to invest in education and training.
4	Technological Dependence	Businesses that rely significantly on technology may be more susceptible to cyberattacks, technical problems, and system failures. Maintaining the reliability and security of automation systems is a critical and ongoing task.

5	Security Risks	Increased connectivity and reliance on digital systems create cybersecurity risks. Cyberattacks can compromise sensitive data and disrupt operations, necessitating robust Cyber Security & forensic technology.
6	Resistance to Change	Employees may resist automation due to fears of job displacement or concerns about adapting to new technology. Overcoming this resistance requires effective change management strategies.
7	Maintenance and Downtime	Automated systems require regular maintenance, and downtime for maintenance can disrupt production schedules and impact productivity.
8	Lack of Flexibility	Automation systems are typically designed for specific tasks and may lack the adaptability and creativity of human workers. Adapting to changes in production requirements or introducing new product lines may be challenging.
9	Interoperability Challenges	Integrating different automation systems, especially if they come from different manufacturers, can be complex. Ensuring seamless interoperability and data flow between systems is a challenge.
10	Ethical and Societal Concerns	Automation raises ethical questions related to job displacement, data privacy, and its impact on society. Addressing these concerns through ethical frameworks and regulatory guidelines is crucial.
11	Environmental Impact	While automation can be more resource-efficient, it may still consume significant energy and materials. Mitigating the environmental impact of automation systems is a challenge.
12	Complex Troubleshooting	Diagnosing and resolving issues in complex automation systems can be challenging. Companies need to invest in skilled personnel and resources for efficient troubleshooting.
13	Regulatory Compliance	Adhering to industry-specific regulations and standards in an increasingly automated environment can be complex and necessitates ongoing compliance efforts.
14	Customization Costs	Modifying automation systems to accommodate specific product variations or customization may incur additional costs and require flexibility in the technology.
15	Long Implementation Period	Implementing total automation can be time-consuming. The planning, installation, testing, and adjustment phases can extend over a considerable period, affecting business operations.

Balancing the advantages of total automation with these disadvantages requires a strategic approach that considers the impact on the workforce, technology investment, maintenance, security, and ethical considerations. A well-planned automation strategy can help maximize benefits while mitigating potential drawbacks.

11. PRECAUTIONS & SUGGESTIONS :

Postulates for Efficient Technology Management for Effective Automation of Industries in Society using Universal Technologies:

(1) Interdisciplinary Integration: Successful technology management requires interdisciplinary collaboration. Integrating expertise from various fields, including engineering, data science, cybersecurity, and ethics, is essential for holistic automation solutions.

(2) Strategic Alignment: Technology management should align with the strategic goals of an organization. Automation initiatives should support the company's long-term vision and mission, ensuring that technology serves as an enabler rather than a standalone solution.

(3) Resource Optimization: Effective technology management involves optimizing resources, both human and financial. Prioritizing investments in automation technologies and ensuring efficient resource utilization are fundamental to success.

(4) Data-Centric Decision-Making: Data-driven decision-making is a core postulate. Leveraging data from Big Data and Business Intelligence technology is key to understanding operations, identifying opportunities, and driving informed choices.
(5) Security by Design: Incorporating Cyber Security & forensic technology as a fundamental element of technology management is non-negotiable. Security should be a core consideration from the outset to safeguard against threats and vulnerabilities.
(6) Ethical Frameworks: Ethical considerations must guide technology management practices. Addressing issues related to data privacy, job displacement, and societal impact is essential to ensure responsible automation.

Suggestions for Efficient Technology Management for Effective Automation of Industries in Society using Universal Technologies:
(1) Invest in Skill Development: Focus on upskilling the workforce to effectively manage and operate automation systems. Continuous training and education in areas like AI, cybersecurity, and data analytics are critical.
(2) Develop a Cybersecurity Strategy: Establish a comprehensive cybersecurity strategy that encompasses both Blockchain technology and Cyber Security & forensic technology. This strategy should include regular assessments, updates, and employee awareness programs.
(3) Embrace Data Analytics: Leverage Big Data and Business Intelligence technology to gain actionable insights from the vast amount of data generated by automation. Data analytics can inform decision-making, identify inefficiencies, and predict maintenance needs.
(4) Maintain Flexibility: Design automation systems with adaptability in mind. The ability to reconfigure systems and processes to accommodate changes in production requirements is invaluable.
(5) Consider Sustainability: Implement sustainable practices in automation, such as reducing energy consumption and minimizing waste through the use of 3D Printing technology and IoT technology. These measures not only reduce environmental impact but also cut operational costs.
(6) Promote Ethical Automation: Develop and adhere to ethical guidelines for automation. Consider the ethical implications of automation decisions, and ensure that data privacy and societal impacts are carefully managed.
(7) Collaborate Across Disciplines: Encourage cross-disciplinary cooperation amongst specialists in technology, business, ethics, and other fields. Innovative solutions and improved technology management can result from a diversity of viewpoints.
(8) Plan for Maintenance: Create a thorough maintenance schedule for automation systems that include proactive maintenance techniques to reduce downtime and interruptions.
(9) Stay Informed on Regulations: Keep up with the rules and guidelines for automation that are relevant to your industry. Verify compliance and take into account how changing legislation may affect technology management processes.
(10) Encourage Innovation: Establish a culture inside your firm that encourages automation innovation. Encourage staff members to come up with and apply creative solutions that boost productivity and effectiveness.

Utilizing Universal Technologies for efficient automation requires dynamic and ever-evolving technology management. These assumptions and recommendations give firms a basis for navigating the challenges of technology management while gaining the advantages of cutting-edge automation.

12. CONCLUSION :

As a conclusion, this academic research study has set out on an ambitious quest to investigate and analyze the interaction between competent technology management and the successful automation of industries in society. The objectives have led us through a thorough investigation of 21st-century universal technologies, going in-depth on information communication, computation, and nanotechnologies. We have uncovered their core ideas, extensive uses, and possible effects on industrial automation. This investigation has been crucial in illuminating how technology might radically alter the primary, secondary, tertiary, and quaternary sectors. Our analysis shows that technology has not only developed but has also solidified itself as a foundational support for various businesses. By pushing the limits of what is possible in the manufacturing, service, and knowledge-based sectors, it has developed into a necessary instrument. We have also discovered management techniques for Universal Technologies in the context of industry automation. These approaches cover integration, scalability, resource optimization, and ethical issues, and they can be helpful suggestions for businesses starting down the automated path. The topic of super-intelligent machines and their significant influence on industry automation has also been touched upon in this essay. Machines with autonomous adaptability, predictive maintenance, and enhanced decision-making capabilities may potentially rule the future, significantly boosting productivity and security across a variety of industries. Finally, we looked at the idea of a technology-based singularity in the context of industry automation, where opportunities and difficulties are created by the exponential rise of technology and AI systems. The voyage up to this point has been an illuminating investigation into the blending of technology and business, giving us a glimpse into a future characterized by enhanced automation, moral issues, and cutting-edge business tactics.

REFERENCES :

[1] Aithal, P. S., & Aithal, S. (2019, October). Management of Universal Technologies & their Industry Implications. In *Proceedings of International Conference on Emerging Trends in Management, IT and Education* (Vol. 1, No. 2, pp. 318-328). Google Scholar↗

[2] Aithal, P. S., & Aithal, S. (2019). Strategic Management of Universal Technologies for Redefining Productivity & Performance. *International Journal of Applied Engineering and Management Letters (IJAEML)*, *3*(2), 81-95. Google Scholar↗

[3] Aithal, P. S. (2018, December). Emerging Trends in ICCT as Universal Technology for Survival, Sustainability, Differentiation, Monopoly and Development. In *Proceedings of National Conference on Advances in Information Technology, Management, Social Sciences and Education, (2018)* (pp. 130-141). Google Scholar↗

[4] Malik, S., Muhammad, K., & Waheed, Y. (2023). Nanotechnology: A revolution in modern industry. *Molecules*, *28*(2), 661, 01-26. Google Scholar↗

[5] Mamodiya, U., Sharma, P., & Sharma, P. (2014). Review in industrial automation. *IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE)*, *9*(3), 33-38. Google Scholar↗

[6] Bangemann, T., Karnouskos, S., Camp, R., Carlsson, O., Riedl, M., McLeod, S., ... & Stluka, P. (2014). State of the art in industrial automation. *Industrial Cloud-Based Cyber-Physical Systems: The IMC-AESOP Approach*, 23-47. Google Scholar↗

[7] Sampath, M., & Khargonekar, P. P. (2018). Socially responsible automation: a framework for shaping future. *Nat. Acad. Eng. Bridge*, *48*(4), 45-52. Google Scholar↗

[8] Maidique, M. A., & Hayes, R. H. (1984). The art of high-technology management. *Sloan Management Review*, *25*(2), 17-31. Google Scholar↗

[9] Phaal, R., Farrukh, C. J., & Probert, D. R. (2006). Technology management tools: concept, development and application. *Technovation*, *26*(3), 336-344. Google Scholar↗

[10] Cetindamar, D., Phaal, R., & Probert, D. (2009). Understanding technology management as a dynamic capability: A framework for technology management activities. *Technovation*, *29*(4), 237-246. Google Scholar↗

[11] Bolisani, E., & Scarso, E. (1999). Information technology management: a knowledge-based perspective. *Technovation*, *19*(4), 209-217. Google Scholar↗

[12] Eldred, E. W., & Shapiro, A. R. (2012). Technology management. In *Setting the PACE in product development* (pp. 121-133). Routledge. Google Scholar↗

[13] Hobday, M., & Rush, H. (1999). Technology management in complex product systems (CoPS)-ten questions answered. *International Journal of Technology Management*, *17*(6), 618-638. Google Scholar↗

[14] Phaal, R., Farrukh, C. J., & Probert, D. R. (2004). A framework for supporting the management of technological knowledge. *International Journal of Technology Management*, *27*(1), 1-15. Google Scholar↗

[15] Roberts, E. B. (2001). Benchmarking global strategic management of technology. *Research-Technology Management*, *44*(2), 25-36. Google Scholar↗

[16] Oerlemans, L. A., Knoben, J., & Pretorius, M. W. (2013). Alliance portfolio diversity, radical and incremental innovation: The moderating role of technology management. *Technovation*, *33*(6-7), 234-246. Google Scholar↗

[17] Pilkington, A., & Teichert, T. (2006). Management of technology: Themes, concepts and relationships. *Technovation*, *26*(3), 288-299. Google Scholar↗

[18] Kane, G. (2019). The technology fallacy: people are the real key to digital transformation. *Research-Technology Management*, *62*(6), 44-49. Google Scholar↗

[19] Abad-Segura, E., González-Zamar, M. D., Infante-Moro, J. C., & Ruipérez García, G. (2020). Sustainable management of digital transformation in higher education: Global research trends. *Sustainability*, *12*(5), 2107-2116. Google Scholar↗

[20] Aithal, P. S. (2023). How to Create Business Value Through Technological Innovations Using ICCT Underlying Technologies. *International Journal of Applied Engineering and Management Letters (IJAEML)*, *7*(2), 232-292. Google Scholar↗

[21] Kumar, S., & Aithal, P. S. (2023). Tech-Business Analytics in Primary Industry Sector. *International Journal of Case Studies in Business, IT, and Education (IJCSBE)*, *7*(2), 381-413. Google Scholar↗

[22] Cucinotta, T., Mancina, A., Anastasi, G. F., Lipari, G., Mangeruca, L., Checcozzo, R., & Rusinà, F. (2009). A real-time service-oriented architecture for industrial automation. *IEEE Transactions on industrial informatics*, *5*(3), 267-277. Google Scholar↗

[23] Jain, S., & Chandrasekaran, K. (2022). Industrial automation using internet of things. In *Research Anthology on Cross-Disciplinary Designs and Applications of Automation* (pp. 355-383). IGI Global. Google Scholar↗

[24] Mondal, D. (2019). The internet of thing (IoT) and industrial automation: A future perspective. *World J. Model. Simul*, *15*(2), 140-149. Google Scholar↗

[25] Thramboulidis, K. (2015). A cyber–physical system-based approach for industrial automation systems. *Computers in Industry*, *72*, 92-102. Google Scholar↗

[26] Thummalapenta, S., Devaki, P., Sinha, S., Chandra, S., Gnanasundaram, S., Nagaraj, D. D., ... & Kumar, S. (2013, May). Efficient and change-resilient test automation: An industrial case study. In *2013 35th International Conference on Software Engineering (ICSE)* (pp. 1002-1011). IEEE. Google Scholar↗

[27] Hao, H. (2014). *Key performance monitoring and diagnosis in industrial automation processes* (Doctoral dissertation, Dissertation, Duisburg, Essen, Universität Duisburg-Essen, 2014). Google Scholar↗

[28] Acharya, V., Sharma, S. K., & Gupta, S. K. (2018). Analyzing the factors in industrial automation using analytic hierarchy process. *Computers & Electrical Engineering*, *71*, 877-886. Google Scholar↗

[29] Wollschlaeger, M., Sauter, T., & Jasperneite, J. (2017). The future of industrial communication: Automation networks in the era of the internet of things and industry 4.0. *IEEE industrial electronics magazine*, *11*(1), 17-27. Google Scholar↗

[30] Al Shahrani, A. M., Alomar, M. A., Alqahtani, K. N., Basingab, M. S., Sharma, B., & Rizwan, A. (2022). Machine learning-enabled smart industrial automation systems using internet of things. *Sensors*, *23*(1), 324. Google Scholar↗

[31] Pérez, L., Diez, E., Usamentiaga, R., & García, D. F. (2019). Industrial robot control and operator training using virtual reality interfaces. *Computers in Industry*, *109*, 114-120. Google Scholar↗

[32] Sarker, I. H. (2022). Ai-based modeling: Techniques, applications and research issues towards automation, intelligent and smart systems. *SN Computer Science*, *3*(2), 158, 01-20. Google Scholar↗

[33] Aithal, P. S., & Aithal, S. (2020). Information Communication and Computation Technology (ICCT) and its Contribution to Universal Technology for Societal Transformation. *Information, Communications and Computation Technology (ICCT) The Pillar for Transformation" edited by PK Paul et al. published by New Delhi Publishers, New Delhi, India*, 1-28. Google Scholar↗

[34] Aithal, P. S., & Aithal, S. (2019). Management of ICCT underlying technologies used for digital service innovation. *International Journal of Management, Technology, and Social Sciences (IJMTS)*, *4*(2), 110-136. Google Scholar↗

[35] Revathi, R., & Aithal, P. S. (2019). A review on impact of information communication & computation technology (ICCT) on selected primary, secondary, and tertiary industrial sectors. Google Scholar↗

[36] Aithal, P. S. (2019). Information communication & computation technology (ICCT) as a strategic tool for industry sectors. *International Journal of Applied Engineering and Management Letters (IJAEML)*, *3*(2), 65-80. Google Scholar↗

[37] Aithal, P. S. (2023). How to Create Business Value Through Technological Innovations Using ICCT Underlying Technologies. *International Journal of Applied Engineering and Management Letters (IJAEML)*, *7*(2), 232-292. Google Scholar↗

[38] Aithal, P. S. (2023). Advances and New Research Opportunities in Quantum Computing Technology by Integrating it with Other ICCT Underlying Technologies. *International Journal of Case Studies in Business, IT and Education (IJCSBE)*, *7*(3), 314-358. Google Scholar↗

[39] Aithal, P. S., & Aithal, S. (2022). Exploring the Role of ICCT Underlying Technologies in Environmental and Ecological Management. In *Environmental Informatics: Challenges and Solutions* (pp. 15-30). Singapore: Springer Nature Singapore. Google Scholar↗

[40] Aithal, P. S., & Aithal, S. (2019, October). Digital service innovation using ICCT underlying technologies. In *Proceedings of International Conference on Emerging Trends in Management, IT and Education* (Vol. 1, No. 1, pp. 33-63). Google Scholar↗

[41] Aithal, P. S., & Aithal, S. (2018). Study of various general-purpose technologies and their comparison towards developing sustainable society. *International Journal of Management, Technology, and Social Sciences (IJMTS), (2018)*, *3*(2), 16-33. Google Scholar↗

[42] Aithal, P. S. (2019, October). Industrial Applications of Information Communication & Computation Technology (ICCT)–An Overview. In *Proceedings of National Conference on Recent Advances in Technological Innovations in IT, Management, Education & Social Sciences ISBN* (No. 978-81, pp. 941751-6). Google Scholar↗

[43] Dipak, G. & Aithal, P. S. (2022). ICT and digital technology-based solutions for smart city challenges and opportunities. *International Journal of Applied Engineering and Management Letters (IJAEML)*, *6*(1), 1-21. Google Scholar↗

[44] Ganesh, H. R., & Aithal, P. S. (2020). Inappropriate Adaptation of Information Communication and Computation Technologies (ICCT) by Indian Brick-and-Mortar Lifestyle Retailers–Insights from an Experiment. *Information, Communications and Computation Technology (ICCT) The Pillar for Transformation" edited by PK Paul et al. published by New Delhi Publishers, New Delhi, India*, 29-44. Google Scholar↗

[45] Aithal, P. S., & Aithal, S. (2020, December). Analysis of Interdependency of ICCT Underlying Technologies and Related New Research Opportunities with Special Emphasis on Cyber Security and Forensic Science. In *Proceedings of the Conference on Future Technologies of IT, Management, Education, and Social Sciences, 19th December* (pp. 171-186). Google Scholar↗

[46] Bhuvana, R., & Aithal, P. S. (2020). Blockchain based service: A case study on IBM blockchain services & hyperledger fabric. *International Journal of Case Studies in Business, IT, and Education (IJCSBE)*, *4*(1), 94-102. Google Scholar↗

[47] Aithal, P. S., & Aithal, S. (2020). Conceptual analysis on higher education strategies for various tech-generations. *International Journal of Management, Technology, and Social Sciences (IJMTS)*, *5*(1), 335-351. Google Scholar↗

[48] Bhuvana, R., & Aithal, P. S. (2020). Impact of COVID-19 on Redefining the Services of Educational Institutions using Ubiquitous Technology. *International Journal of Management, Technology and Social Sciences (IJMTS)*, *5*(2), 266-282. Google Scholar↗

[49] Kumar, S., & Aithal, P. S. (2023). Tech-Business Analytics in Primary Industry Sector. *International Journal of Case Studies in Business, IT, and Education (IJCSBE)*, *7*(2), 381-413. Google Scholar↗

[50] Kumar, S., & Aithal, P. S. (2023). Tech-Business Analytics–A Review Based New Model to Improve the Performances of Various Industry Sectors. *International Journal of Applied Engineering and Management Letters (IJAEML)*, *7*(1), 67-91. Google Scholar↗

[51] Kumar, S., & Aithal, P. S. (2022). Technology for Better Business in Society. *International Journal of Philosophy and Languages (IJPL)*, *1*(1), 117-144. Google Scholar↗

[52] Sachin Kumar, S., Dube, D., & Aithal, P. S. (2020). Emerging concept of tech-business-analytics an intersection of IoT & data analytics and its applications on predictive business decisions. *International Journal of Applied Engineering and Management Letters (IJAEML), (2020)*, *4*(2), 200-210. Google Scholar↗

[53] Aithal, P. S., (2023). ICCT Underlying Technologies for Fulfilling Human Needs, Wants, Happiness, and Desires. Book Chapter. Future trends in Information, Communication and Computing Technology - TechHorizon: Navigating Tomorrow's Digital Frontiers. Srinivas Publication, India, pp. 62-81. ISBN: 978-93-94676-57-2. DOI: https://zenodo.org/10.5281/zenodo.8418505

[54] Aithal, P. S., & Shubhrajyotsna Aithal (08/10/2023). Use of ICCT Technologies to Create Value Propositions in Higher Education Institutions. Book Chapter. Future trends in Information, Communication and Computing Technology - TechHorizon: Navigating Tomorrow's Digital Frontiers. Srinivas Publication, India, pp. 15-46, ISBN: 978-93-94676-57-2. DOI: https://zenodo.org/10.5281/zenodo.8418447. Google Scholar↗

[55] Kumar, S., Krishna Prasad, K., & Aithal, P. S., (19/10/2023). Tech-Business Analytics in Secondary Industry Sector. *International Journal of Applied Engineering and Management Letters (IJAEML)*, *7*(4), 1-94. Google Scholar↗

[56] Aithal, P. S. & Shubhrajyotsna Aithal (2023). Tech-Business Analytics and Its Applications in Higher Education Innovations. Chapter 02, "Latest Concern and Research in Applied Social Science, Management in Digital & ICT Society" edited by P.K. Paul et al. Published by New Delhi Publishers, New Delhi, India. Chapter 2, PP. 17-42. ISBN: 978-81-19006-32-8. Google Scholar↗

[57] Kumar, S., Krishna Prasad, K., & Aithal, P. S., (2023). Tech-Business Analytics – a New Proposal to Improve Features and Quality of Products and Services in Various Industry Sectors – An Explorative Study. International Journal of Management, Technology, and Social Sciences (IJMTS), 8(2), 53-70. Google Scholar↗

[58] Fatikow, S., Wich, T., Dahmen, C., Jahnisch, M., Stolle, C., & Eichhorn, V. (2009, February). Nanohandling automation as an emerging industrial technology. In *2009 IEEE International Conference on Industrial Technology* (pp. 1-6). IEEE. Google Scholar↗

[59] Martel, S., Riebel, S., Koker, T., Sherwood, M., & Hunter, I. (2001, October). Large-scale nanorobotic factory automation based on the NanoWalker technology. In *ETFA 2001. 8th*

International Conference on Emerging Technologies and Factory Automation. Proceedings (Cat. No. 01TH8597) (Vol. 2, pp. 591-597). IEEE. Google Scholar↗

[60] Thiruvengadam, M., Rajakumar, G., & Chung, I. M. (2018). Nanotechnology: current uses and future applications in the food industry. *3 Biotech*, *8*(1), 1-13. Google Scholar↗

[61] Pradhan, N., Singh, S., Ojha, N., Shrivastava, A., Barla, A., Rai, V., & Bose, S. (2015). Facets of nanotechnology as seen in food processing, packaging, and preservation industry. *BioMed research international*, *2015*(1). 01-17. Google Scholar↗

[62] Aithal, S., & Aithal, P. S. (2021). Green nanotechnology innovations to realize UN sustainable development goals 2030. *International Journal of Applied Engineering and Management Letters (IJAEML)*, *5*(2), 96-105. Google Scholar↗

[63] Aithal, P. S., & Aithal, S. (2022). Opportunities and Challenges for Green and Eco-Friendly Nanotechnology in Twenty-First Century. *Sustainable nanotechnology: Strategies, products, and applications*, 31-50. Google Scholar↗

[64] Aithal, P. S., & Aithal, S. (2016). Nanotechnology innovations and commercialization–opportunities, challenges & reasons for delay. *International Journal of Engineering and Manufacturing (IJEM)*, *6*(6), 15-25. Google Scholar↗

[65] Aithal, S., & Aithal, P. S. (2021). Green and eco-friendly Nanotechnology–concepts and industrial prospects. *International Journal of Management, Technology, and Social Sciences (IJMTS)*, *6*(1), 1-31. Google Scholar↗

[66] Aithal, P. S., Shailashree, V., & Kumar, P. M. (2015). A new ABCD technique to analyze business models & concepts. *International Journal of Management, IT and Engineering*, *5*(4), 409-423. Google Scholar↗

[67] Aithal, P. S. (2016). Study on ABCD analysis technique for business models, business strategies, operating concepts & business systems. *International Journal in Management and Social Science*, *4*(1), 95-115. Google Scholar↗

[68] Aithal, P. S. (2017). ABCD Analysis as Research Methodology in Company Case Studies. *International Journal of Management, Technology, and Social Sciences (IJMTS)*, *2*(2), 40-54. Google Scholar↗

[69] Aithal, P. S., Shailashree, V., & Kumar, P. M. (2015). Application of ABCD Analysis Model for Black Ocean Strategy. *International journal of applied research*, *1*(10), 331-337. Google Scholar↗

[70] Aithal, A., & Aithal, P. S. (2017). ABCD analysis of task shifting–an optimum alternative solution to professional healthcare personnel shortage. *International Journal of Health Sciences and Pharmacy (IJHSP)*, *1*(2), 36-51. Google Scholar↗

[71] Aithal, S., & Aithal, P. S. (2016). ABCD analysis of Dye-doped Polymers for Photonic Applications. *IRA-International Journal of Applied Sciences*, *4*(3), 358-378. Google Scholar↗

[72] Raj, K., & Aithal, P. S. (2018). Generating Wealth at the Base of the Pyramid–a Study Using ABCD Analysis Technique. *International Journal of Computational Research and Development (IJCRD)*, *3*(1), 68-76. Google Scholar↗

[73] Aithal, P. S., Shailashree, V., & Kumar, P. M. (2016). The study of the new national institutional ranking system using ABCD framework. *International Journal of Current Research and Modern Education (IJCRME)*, *1*(1), 389-402. Google Scholar↗

[74] Shenoy, V., & Aithal, P. S. (2016). ABCD Analysis of On-line Campus Placement Model. *IRA-International Journal of Management & Social Sciences*, *5*(2), 227-244. Google Scholar↗

[75] Kumari, P., & Aithal, P. S. (2020). Growth & Fate Analysis of Mangalore International Airport–A Case Study. *International Journal of Case Studies in Business, IT, and Education (IJCSBE)*, *4*(2), 71-85. Google Scholar↗

[76] Aithal, P. S., & Pai T. V. (2016). Concept of Ideal Software and its Realization Scenarios. *International Journal of Scientific Research and Modern Education (IJSRME), 1*(1), 826-837. Google Scholar↗

[77] Bhuvana, R., & Aithal, P. S. (2020). Blockchain-based service: A case study on IBM blockchain services & hyperledger fabric. *International Journal of Case Studies in Business, IT, and Education (IJCSBE)*, *4*(1), 94-102. Google Scholar↗

[78] Prabhu, G. N., & Aithal, P. S. (2023). Inbound Corporate Social Responsibility Model for Selected Indian Banks and Their Proposed Impact on Attracting and Retaining Customers – A Case Study. *International Journal of Applied Engineering and Management Letters (IJAEML)*, *7*(3), 55-74. Google Scholar↗

[79] Panakaje, N. (2023). Educational Loan for Religious Minority Under Arivu Scheme. *International Journal of Case Studies in Business, IT and Education (IJCSBE)*, *7*(1), 26-35. Google Scholar↗

[80] Maiya, A. K., & Aithal, P. S., (2023). A Review-based Research Topic Identification on How to Improve the Quality Services of Higher Education Institutions in Academic, Administrative, and Research Areas. *International Journal of Management, Technology, and Social Sciences (IJMTS), 8*(3), 103-153. Google Scholar↗

[81] Mahesh, K. M., Aithal, P. S. & Sharma, K. R. S., (2023). Impact of Aatmanirbharta (Self-reliance) Agriculture and Sustainable Farming for the 21st Century to Achieve Sustainable Growth. *International Journal of Applied Engineering and Management Letters (IJAEML)*, *7*(2), 175-190. Google Scholar↗

[82] Shubhrajyotsna Aithal & P. S. Aithal (2023). Importance of Circular Economy for Resource Optimization in Various Industry Sectors – A Review-based Opportunity Analysis. *International Journal of Applied Engineering and Management Letters (IJAEML)*, *7*(2), 191-215. Google Scholar↗

[83] Salins, M., & Aithal, P. S. (2023). Consumers' Intention toward Mitigation of Plate Waste Behaviour in Restaurants – Development of Conceptual Model. *International Journal of Management, Technology, and Social Sciences (IJMTS), 8*(2), 190-230. Google Scholar↗

[84] Aithal, P. S. & Shubhrajyotsna Aithal (May 2023). The Changing Role of Higher Education in the Era of AI-based GPTs. *International Journal of Case Studies in Business, IT, and Education (IJCSBE), 7*(2), 183-197. Google Scholar↗

[85] Nethravathi P. S., & P. S. Aithal (2023). How Internal Quality Assurance System is Re-defined in Private Universities – A Case of Srinivas University, India. *International Journal of Management, Technology, and Social Sciences (IJMTS), 8*(1), 234-248. Google Scholar↗

[86] Kumar, S., Krishna Prasad, K., & Aithal, P. S., (2023). Tech-Business Analytics – a Review based New Model to Improve the Performances of Various Industry Sectors. *International Journal of Applied Engineering and Management Letters (IJAEML), 7*(1), 67-91. Google Scholar↗

[87] Pradeep, M. D., Adithya, K. M., & Aithal, P. S., (2023). Indigenous Distinctive Innovations to Achieve its Vision, Priority and Thrust – A Case Study of Srinivas University. *International Journal of Case Studies in Business, IT, and Education (IJCSBE), 7*(1), 36-61. Google Scholar↗

[88] Aithal, P. S. (2023). Advances and New Research Opportunities in Quantum Computing Technology by Integrating it with Other ICCT Underlying Technologies. *International Journal of Case Studies in Business, IT, and Education (IJCSBE), 7*(3), 314-358. Google Scholar↗

[89] Aithal, P. S., (2023). Super-Intelligent Machines - Analysis of Developmental Challenges and Predicted Negative Consequences. *International Journal of Applied Engineering and Management Letters (IJAEML)*, *7*(3), 109-141. Google Scholar↗

[90] Kumar, S., & Kunte, R. S. R. (2023). ABCD Analysis of Industries Using High-Performance Computing. *International Journal of Case Studies in Business, IT and Education (IJCSBE)*, *7*(2), 448-465. Google Scholar↗

[91] Nayana, K., & Manjula, K. T. (2023). Colonialism and Cross-Cultural Ties in Sea of Poppies. *International Journal of Management, Technology and Social Sciences (IJMTS)*, *8*(3), 220-228. Google Scholar↗

[92] Rameesa, K., & Veeramanju, K. T. (2023). Analysis of Software Industry: Natural Language Processing Approach. *Scope Journal, 13*(02), 743-752. Google Scholar↗

[93] Maheswary, B. U., & Lourdusamy, A. (2023). An Evaluation of the Partition Narratives: A Special Focus on Psychological Trauma. *International Journal of Philosophy and Languages (IJPL)*, *2*(1), 18-26. Google Scholar↗

[94] Aithal, P. S. (2023). Super-Intelligent Machines-Analysis of Developmental Challenges and Predicted Negative Consequences. *International Journal of Applied Engineering and Management Letters (IJAEML)*, *7*(3), 109-141. Google Scholar↗

[95] Mishra, N., & Aithal, P. S. (2023). Ancient Indian Education: It's Relevance and Importance in the Modern Education System. *International Journal of Case Studies in Business, IT and Education (IJCSBE)*, *7*(2), 238-249. Google Scholar↗

[96] Naresh Ramdas Kini H., Pai, A. R. (2023). HR Practices of Ultratech Cement Limited: A Case Study. *EPRA International Journal of Multidisciplinary Research (IJMR)*, *9*(8), 87-94. Google Scholar↗

[97] Nair, S. B., & Aithal, P. S. (2023). Impact of Digital Transformation Marketing Strategies on Homepreneur Business Practices in Kerala. *International Journal of Management, Technology and Social Sciences (IJMTS)*, *8*(2), 121-132. Google Scholar↗

[98] Nair, S. B., & Aithal, P. S. (2023). An Assessment of Green Marketing Tools and Strategies for Increasing the Consumption Pattern of Khadi Textile Products Among Millennials in Kerala. *International Journal of Management, Technology and Social Sciences (IJMTS)*, *8*(3), 340-355. Google Scholar↗

[99] Sasi Kumar, A., & Aithal, P. S. (2023). DeepQ Based Heterogeneous Clustering Hybrid Cloud Prediction Using K-Means Algorithm. *International Journal of Management, Technology, and Social Sciences (IJMTS)*, *8*(2), 273-283. Google Scholar↗

[100] Asif, N., Aithal, P. S., & Niyaz Panakaje, D. (2023). A Comparison of the Mahila Samman Savings Certificate with Other Small Savings Schemes for the Empowerment of Women in India. *International Journal of Case Studies in Business, IT, and Education (IJCSBE)*, *7*(2), 348-359. Google Scholar↗

[101] Jomon Jose, M., & Aithal, P. S. (2023). An Analytical Study of Applications of Artificial Intelligence on Banking Practices. *International Journal of Management, Technology, and Social Sciences (IJMTS), 8*(2), 133-144. Google Scholar↗

[102] Sasi Kumar, A., & Aithal, P. S. (2023). DeepQ Residue Analysis of Brain Computer Classification and Prediction Using Deep CNN. *International Journal of Applied Engineering and Management Letters (IJAEML)*, *7*(2), 144-163. Google Scholar↗

[103] Aithal, P. S., & Aithal, S. (2023). New Research Models under Exploratory Research Method. *a Book "Emergence and Research in Interdisciplinary Management and Information Technology" edited by PK Paul et al. Published by New Delhi Publishers, New Delhi, India*, 109-140. Google Scholar↗

[104] Shetty, V., & Abhishek, N. (2023). Beneficiaries Behavioural Intention Towards Primary Agricultural Co-Operative Credit Society–A Development of Conceptual Model. *International Journal of Case Studies in Business, IT and Education (IJCSBE)*, *7*(3), 226-247. Google Scholar↗

[105] Aithal, P. S., Maiya, A. K., Aithal, S., & Pradeep, M. D. (2022). Atomic Research Centres to Intensify Research–An Innovative Approach of Srinivas University, India. *International Journal of Applied Engineering and Management Letters (IJAEML)*, *6*(2), 13-35. Google Scholar↗

[106] Parvin, S. R., & Panakaje, N. (2022). A Study on the Prospects and Challenges of Digital Financial Inclusion. *Education (IJCSBE)*, *6*(2), 469-480. Google Scholar↗

[107] Rajasekar D., Aithal, P. S. (2022). Direct to Consumer using Livestream as an Innovative Marketing Medium during COVID-19. *International Journal of Applied Engineering and Management Letters (IJAEML)*, *6*(1), 77-86. Google Scholar↗

[108] Bharathi, S. C. & Mayya, Suresh Ramana, (2022). Performance Evaluation of Dabur India Ltd through Profitability Ratio Analysis: A Case Study. *International Journal of Case Studies in Business, IT, and Education (IJCSBE)*, *6*(1), 387-400. Google Scholar↗

[109] Aithal, P. S., Maiya, A. K., & Pradeep, M. D. (2022). Holistic Integrated Student Development Model & Service Delivery Model–A Best Practice of Srinivas University, India. *International Journal of Case Studies in Business, IT, and Education (IJCSBE)*, *6*(1), 590-616. Google Scholar↗

****