International Journal on Recent and Innovation Trends in Computing and Communication
ISSN: 2321-8169 Volume: 11 Issue: 9
Article Received: *25 July 2023* ***Revised:*** *12 September 2023* ***Accepted:*** *30 September 2023*

A Comprehensive Insight into Cloud Robotics, Digital Transformation, Automation, and Technological Innovation.

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Abstract:

Cloud robotics is the integration of cloud computing technology and robotics. Digital transformation is defined as the process of implementing technology in various fields of industry and automation is defined as the process of automating a task using technology. Technological innovation defines the improvements in technology that can be used in industries and other aspects of life. From the study, it can be seen that all these concepts are associated closely and their implementation will help in the development of various industries and fields. The aim of the study is to provide a comprehensive overview of cloud robotics, digital transformation automation and technological innovation which can serve as a repository to researchers. For this study, the systematic literature review methodology was adopted to gather the necessary studies from the years 2015 to 2021. Using this study, researchers can gather various details without having to search the vast collection of studies, books, journals etc. The study also provides additional information like advantages, challenges, applications, etc associated with the topics.

1. Introduction

1.1 Cloud Robotics

The innovative cloud technology is said to benefit a wide range of other technologies like automation and robotics. Cloud robotics can be defined as the robotic system that relies on cloud technology for its operations. This includes mobile robots like UAVs as well as warehouse robots. Home automation systems, advanced processing plants and assembly lines also come under cloud robotics. The term 'cloud robotics' was initially coined by James Kuffner in 2010. Other examples of cloud robotics are self driving cars wich uses data from the clouds to carry out its operations (Kehoe, B., Patil, S., Abbeel).

By combining the computational power of the cloud computing and the availability of internet-connected devices in robotics, the term ''Cloud Robotics''. As a newly emerging type of robotic systems, the cloud robotics introduces the architecture of''back-end cloud'' together with ''front-end robots''. Robots simply connect to the cloud and deliver information to the cloud as needed, without having to store a large amount of information or having superb computing capabilities. Compared with conventional robotic systems, cloud robotics can significantly improve the storage capability and learning capability of the robots. The resource sharing among the robots is also enhanced. More importantly, in cloud robotics, the computing-intensive tasks can be offloaded from the robots to the cloud, and hence the robots can have less pressure on energy consuming and enjoy a better computing performance. At the cloud side, a computing service platform helps the robots to handle these computing tasks. Moreover, the information transmissions from the robots to the cloud do not occur periodically as in a time-triggered manner. Instead, an information transmission is only performed when a robot has a task to be handled and sends a service request to the cloud, and this is considered as an event-triggered model (Liu et al., 2018).

1.2 Digital Transformation and Automation

Digital transformation, defined as transformation 'concerned with the changes digital technologies can bring about in a company's business model, … products or organizational structures', is perhaps the most pervasive managerial challenge for incumbent firms of the last and coming decades. However, digital possibilities need to come together with

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skilled employees and executives in order to reveal its transformative power. Thus, digital transformation needs both technology and people (Nadkarni and Prügl, 2021).

The increasing digitalization of economies has highlighted the importance of digital transformation and how it can help businesses stay competitive in the market. However, disruptive changes not only occur at the company level; they also have environmental, societal, and institutional implications. This is the reason why during the past two decades the research on digital transformation has received growing attention, with a wide range of topics investigated in the literature. Globalization in recent decades has placed increasing pressure on businesses to change. This requires businesses to efficiently integrate to not only stay alive, but thrive in competitive environments. Efficient integration can only be achieved through digital processes and collaborative tools. With this being the case, the importance of digital transformation (DT) has increased. Research emphasizes that DT should be included into the existing business perspectives, as this topic addresses much more than just technological shifts, and affects many or all segments of business: Successful business transformation is achieved by simultaneously exploiting and exploring what it offers to achieve organizational agility (Kraus et al., 2021; Gong and Ribiere, 2021).

Automation represents one of the major trends of the 20th century. The drive to provide increased levels of control to electro-mechanical systems, and with it a corresponding distancing of the human from direct system control, has grown out of the belief that automated systems provide superior reliability, improved performance and reduced costs for the performance of many functions. Through the auspices of the technological imperative, automation has steadily advanced as means have been found for automating physical, perceptual, and, more recently, cognitive tasks in all kinds of systems. In many cases automation has provided the desired benefits and has extended system functionality well beyond existing human capabilities. Along with these benefits, however, a certain price has been extracted. The role of the human operator has changed dramatically. Instead of performing tasks, the human's job has become that of monitor over an automated system — a role people are not ideally suited to. Contrary to the implication of the term "automated", humans have remained a critical part of most automated systems. They must monitor for failures of the automated system and the presence of conditions the is not designed to handle. Furthermore, as most automation has been piece-meal, covering certain functions but not others, humans have remained in the system as integrators — monitoring the automation for some functions and performing others themselves (Endsley, 2018).

1.3 Technological Innovation

Innovations play a decisive role in the country's economy, as they allow making scientific discoveries, improving production, and creating a fundamentally new product (Pasholikov and Dudakov, 2020). Technological innovation, a complex and multidimensional construct, refers to innovations associated with an organization's operations, such as the introduction of new/improved products or processes. Scholars and practitioners recognize the importance of technological innovation in a firm's ability to obtain a sustainable competitive advantage (Singhal et al., 2020).

Organizational innovation is a necessary precondition for technological innovation to be fully implemented and exploited. Lam (2005, p. 115) states that "the ability of an organization to innovate is a precondition for successful utilization of ... new technologies." Organizational innovations, in terms of structural improvements and organizational changes (e.g., policies, practices and communication) lead to enhanced intra-organizational coordination and cooperation, which, in turn, create an appropriate environment for the adoption and utilization of technological innovations. According to Damanpour et al. (1989), the successful implementation of technological innovations depends on adopting changes in the administrative components of the organization (i.e., organizational innovations). Moreover, Teece (2010) argues that, to profit from technological innovations, enterprises must adopt new organizational forms, new organizational methods, and new business models that are of equal (if not greater) importance to the business enterprise (Azar and Ciabuschi, 2017).

Cloud robotics, digital transformation, automation, and technological innovation are inextricably linked. Cloud robotics is a powerful force driving digital transformation and automation, leading to significant advancements in various industries. They, reinforce and enhance each other, collectively driving the modernization of industries and creating new opportunities for growth and efficiency. The main aim of this study is to provide a comprehensive overview of these topics. The topics of the study will be briefly explained and the advantages, applications and challenges associated with their implementation will also be provided. The aim of this study is to make researchers quickly understand the current state of knowledge in a field without

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needing to consult multiple sources. This synthesis provides a foundation for new research, helping scholars identify gaps, trends, and key findings that can guide future studies.

2. Review of Literature

The below Table 1 contains a list of all the articles selected for this study using the systematic literature review. There are three major topics and the necessary details like author names, year of publication and the name of the publication as well as the titles of the study is also added in the below table.

Table 1. List of Articles selected for the study

S.no	Topic	Title	Author	Year of Publication	Publication name
1		A comprehensive survey of recent trends in cloud robotics architectures and applications	Saha and Dasgupta,	2018	MDPI
2		Network offloading policies for cloud robotics: a learning-based approach	Chinchali et al.,	2021	Springer
3		Robot web tools: Efficient messaging for cloud robotics	Toris et al.,	2015	IEEE
4		cloud: Bridging the power of robotics and cloud computing	Du et al.,	2017	Science Direct
5		Cloud robotics: Current status and open issues	Wan et al.,	2016	IEEE
6		A reinforcement learning-based resource allocation scheme for cloud robotics	Liu et al.,	2018	IEEE
7		Cloud robotics: a review of technologies, developments and applications	Bogue	2017	Emerald
8		A pricing mechanism for task oriented resource allocation in cloud robotics	Wang et al.,	2016	Springer
9		Cloud-controlled autonomous mobile robot platform	Balogh et al.,	2021	IEEE
10		A self-aware and scalable solution for efficient mobile-cloud hybrid robotics	Akbar et al.,	2020	Frontiers
11	**Cloud Robotics**	The economic case for cloud-based computation for robot motion planning	Ichnowski et al.,	2020	Springer
12		Digital twin-based industrial cloud robotics: Framework, control approach and implementation	Xu et al.,	2021	Science Direct
13		Cooperative cloud robotics architecture for the coordination of multi-AGV systems in industrial warehouses	Cardarelli et al.,	2017	Science Direct

14		Digital transformation. Practical guide.	Rogers,	2017	-
15		Digital transformation of business	Schwertner,	2017	Semantic Scholar
16		The IoT and digital transformation: toward the data-driven enterprise.	Pflaum and Gölzer,	2018	IEEE
17		Internet of Things and Big Data as enablers for business digitalization strategies.	Sestino et al.,	2020	Science Direct
18		Big data and business analytics ecosystems: paving the way towards digital transformation and sustainable societies.	Pappas et al.,	2018	Springer
19		Challenges and risks of digital transformation: global and Ukrainian contexts.	Sidenko,	2021	-
20		Digital transformation challenges in the manufacturing industry	Abdallah et al.,	2021	IOS press
21		Digital Transformation: Opportunities & Challenges.	SOBOLIEVA and HOLIONKO,	2021	-
22	**Digital transformation and automation**	The challenges of instructors' and students' attitudes in digital transformation: A case study of Saudi Universities.	Alhubaishy and Aljuhani,	2021	Springer
23		Challenges of the digital transformation–Comparing nonprofit and industry organizations.	Vogelsang et al.,	2021	Springer
24		A survey of research on cloud robotics and automation	Kehoe et al.	2015	IEEE
25		Intelligent process automation: The future of digital transformation.	Kholiya et al.,	2021	IEEE
26		From here to autonomy: lessons learned from human–automation research.	Endsley,	2017	Sage Journals
27		Automation is all you need: Faster Earth system models with AI/ML	Ball et al.,	2021	-
28		Automation in radiation oncology-cautionary considerations in the push for planning efficiency	Harris et al.,	2018	Europe PMC
29		Role of automation in waste management and recent trends.	Desai, and Parimala,	2017	Inder Science
30		Addressing challenges in data collection: The role of automation in complex translational research	Quintana and Plätzer,	2015	Science
31		Technological innovation systems in contexts: Conceptualizing contextual structures and interaction dynamics	Bergek et al.,	2015	Science Direct

32	**Technological innovation**	Technological innovation, firm performance, and institutional context: a meta-analysis.	Singhal et al.,	2020	IEEE
33		Digital innovation: Creating competitive advantages	Berawi et al.,	2020	
34		Facing Disruptive Innovation: Strategic and Managerial Challenges	Tammam et al.,	2019	IGI Global
35		Technological Innovation and Competitive Advantage: Empirical Evidence from Large Telecommunication Firms.	Wanaswa et al.,	2021	Ideas
36		Technological innovation	Coccia,	2021	
37		The importance of technological innovation.	Ashford and Hall,	2018	Taylor and Francis
38		Healthcare sustainability through technological innovations. In Advances in Environment Engineering and Management	Mehrotra and Joshi,	2021	Springer
39		Technological Innovations in Management Education.	Kalia et al.,	2015	IGI Global
40		The adverse effects of technological innovation under WTO subsidy rules.	Kennedy,	2020	Cambridge
41		Technological Innovations in Care and Implications for Human Resource Development.	Oldridge,	2020	Springer
42		The impact of technological innovations on the competitiveness of the telematic companies	Dadelytė and Mačiulytė-Šniukienė,	2020	Science – Future of Lithuania
43		Advantages and Challenges of Digital Technology.	Stepnov,	2021	Springer
44		Desafios da Inovação Tecnológica para a Sustentabilidade Intergeracional	Boff,	2019	-

2.1 Cloud Robotics

Cloud robotics can be defined as the combination of cloud computing and robotics. When combined, the cloud technology provides robots with enhanced computational capabilities with the help of wireless networking, communication technologies, internet resources and large-scale storage. The field of robotics has had significant growth since its introduction and is used in many real-life scenarios like automated manufacturing, extra-terrestrial operations, unmanned search and rescue, disaster robotics, self-driving vehicles, socially assistive robots, and healthcare and medical robots. The robots used in many of these applications are single robots that are limited by their on-board hardware and computational constraints. To address this problem, the field of networked robotics emerged almost two decades ago, which connected a team of robots through a wired or wireless communication network. Networked robots address the problem associated with standalone robot systems by sharing the perceived data with each other and solving a task in a cooperative and/or coordinated manner. However, networked robots also encounter some of the same problems associated with single robot systems. The main problems associated with networked robots occur due to resource constraints, information and learning constraints, and communication constraints. The hardware constraints of each individual robot limits its computing and storage capacity resulting in a collective limitation of the networked robots. It is technically difficult to change or upgrade the resource configurations once a robot has been designed, built and deployed.

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Networked robots are also constrained by information, as they have access to only the information accumulated by robots possessing a limited variety of sensors and connected through a network. To address the discussed challenges, researchers have recently proposed the cloud-enabled robotics technology which utilizes the elastic on-demand resources offered by a ubiquitous cloud infrastructure. Cloud robotics originated as a recent technology integrating the advantages of cloud computing into robotics (Saha and Dasgupta, 2018; Chinchali et al., 2021; Toris et al., 2015; Du et al., 2017).

2.1.1 Cloud Architecture

The architecture of cloud robotics is mainly composed of two parts: the cloud platform and its related equipment and the bottom facility. The bottom facilities usually include all types of mobile robots, unmanned aerial vehicles, machinery and other equipment. Accordingly, the cloud platform is composed of a large number of high-performance servers, proxy servers, massive spatial databases and other components. Multi-robot cooperative works, such as SLAM and navigation networks, are typical applications of cloud robots. The term "networked robotics" refers to the communication mode of cloud robotics and multi-robot systems are composed as cooperative computing networks using wireless communication technologies (Wan et al., 2016).

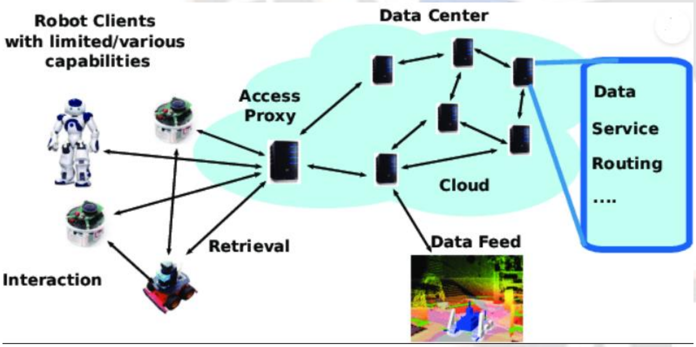

Figure 1. Wang et al., (2012) General Cloud Architecture

In the system, the robots perform functions like sensing the environment, processing information and actuating some work. When the information processing of the robots involves some complex and computing-intensive tasks, they may seek help from the computing powerful cloud. It is preferred that the computing tasks from the robots to be handled at the cloud side as ''Cloud Execution'', rather than being processed on the local robots as ''Standalone Execution''. When a robot needs to process the data it collects by sensing the environment, for example, it first sends a service request to the computing service platform at the cloud side. If the platform accepts the request, the robot uploads the data to the cloud for computation demand, otherwise, the processing work has to be performed locally. When the cloud computing service platform receives an information processing service request sent from the robot, the system needs to analyze the current load of computing resources at the cloud and then decide whether to accept the request or not, and if the request is accepted, the number of resources to be allocated to the service request should also be determined at the same time (Liu et al., 2018).

The major advantages of cooperative computing networks are the following: 1) a collaborative computing network can gather computing and storage resources, and can dynamically allocate these resources according to specific work requirements; and 2) because of the exchange of information, decisions can be made cooperatively between machines. The nodes' computing and storage capabilities' deficiency in networked robotic systems may lead to large delays, while in cloud robotic systems the nodes can collaborate with spare nodes by transferring computing or storage tasks. Nodes which are not directly connected to the cloud resource can connect to the cloud through other nodes that have already established links to the cloud. The application of this mechanism greatly expands the manageable complexities of tasks accomplished through multi-robot cooperative work and enhances the efficiency of specific work tasks. (Wan et al., 2016).

In summary, the main features of the cloud robotics architecture are as follows. 1) In the cloud infrastructure, where computing tasks are dynamic and resources are elastic and available on-demand. 2) The cloud robotics' "brain" is in the cloud. The results of processing can be obtained through networking technologies, while tasks are processed individually. 3) Computing work can be delegated to the cloud, which leads to a smaller robot load and greatly extended battery life (Wan et al., 2016).

Cloud robotics is a rapidly developing technology made possible by the current ubiquitous internet connectivity and the growing number of powerful cloud computing services available. Benefits include access to big data sets, open-source algorithms, code and programmes, massively powerful parallel or grid computing and the sharing of information between robots. The technology has been applied successfully to humanoid, industrial, mobile and other classes of robots, often through direct collaborations between robot manufacturers and major IT companies. Several new companies have been established in very recent years to exploit the capabilities of cloud robotic technologies (Bogue, 2017).

2.1.2 Challenges

However, there still exist several open challenges and problems in cloud robotics systems, which should be addressed for improving the performance of cloud-based robotic systems. In this section, we identify some of the open issues and challenges in this area.

A. Resource Allocation and Scheduling

Uploading computational tasks with high complexity to the cloud is one of the most notable characteristics of cloud robotics. Considering different working equipment, interface settings, and network environments, for a given computational task, the choice of uploading, self-processing or assigning the task to the nearest node has an important impact on overall performance (Wan et al., 2016; Wang et al., 2016).

B. Data Interaction Between Robot and Cloud Platform

Devices and sensors from different manufacturers may output data with different structures. In fact, even different models of a product from the same manufacturer may result in considerable differences in the output data's structure. The diversity of data structures presents high requirement on the compatibility of the cloud input interface. To solve this problem, current mainstream cloud platforms often provide multiple interfaces for various types of data formats. However, due to the limited number of interfaces, the data to be uploaded must be properly preprocessed, and the robustness and real-time performance of the data exchange is greatly affected by data formats requiring translation from one form to another (Wan et al., 2016).

C. Cloud Security

The introduction of cloud technology has greatly expanded the complexity of multi-robot operations. At the same time, it also introduced new technical challenges: the privacy and security issues brought by the cloud technology. These hidden dangers also affect data generated by computing devices and sensors used in cloud robotics. Commercial science and technology solutions have suffered from serious data leakage incidents, especially during the upload of photos and video to the cloud. In scientific research and industrial practice, key data stored in the cloud may be far from the hacker to steal, leading to the loss of key data (Wan et al., 2016).

D. Service Quality Guarantee Methods and Effects' Analysis

Network latency is what researches cannot ignore. In fact, the real-time demand, to great extent, affects the overall performance. The introduction of a service quality assurance system and effects' analysis for a given bandwidth can ensure adequate network flow to great extent. The core of service quality systems and effect analysis is to balance the limited network resource and the real-time demand. In order to meet the needs of users with different service quality demands, the network is expected to provide different levels of quality according to the requirements of users: real time requirements require high priority data processing, while tasks with less than real-time requirements are granted lower priority (Wan et al., 2016).

2.1.3 Benefits of Cloud Robotics

Completely decoupling the closed-loop control of the robot from the robot's embedded system and placing it into an edge cloud execution environment while sustaining the necessary KPIs is feasible. Moving the control logic into the cloud benefits from ease of maintenance of the control software and improved resiliency to software and hardware failures. Furthermore, it enables the physical platform and control intelligence to evolve separately from each other (Balogh et al., 2021). Cloud robotics allows mobile robots the benefit of offloading compute to centralized servers if they are uncertain locally or want to run more accurate, compute-intensive models (Chinchali et a., 2021).

Many benefits of cloud computing are now well-established. Backed by the virtually unbounded resources of the cloud, battery-powered mobile robotics can also benefit from cloud computing, meeting the demands of even the most computationally and resource-intensive tasks. Cloud robotics benefits include efficient resource utilization, improved task performance, and dynamic adaptation to changing environments, enhancing the capabilities of battery-powered mobile robots through cloud computing. (Akbar et al., 2020).

Imagine a world in which robots are a part of everyday life, performing elegant and safe motions to accomplish complex tasks. To achieve this vision, robots will need access to extensive computational resources. Cloud-based computers have the potential to provide the needed computing power, while lowering robot cost, space, and energy requirements. Academia and industry are already exploring the cloud as a purveyor of data in a wide variety of applications, and have shown the benefit of the cloud for accelerating offline- and pre-computations. it is possible to extend a robot's useful service life and battery-based operation time, improve its efficiency and profitability, and reduce its initial costs, by using the cloud in complex online and interactive computations (Ichnowski et al., 2020).

2.1.4 Application of Cloud Robotics

Industrial cloud robotics (ICR)

Industrial cloud robotics (ICR) integrates cloud computing with industrial robots (IRs). The capabilities of industrial robots can be encapsulated as cloud services and used for ubiquitous manufacturing. Currently, the digital models for process simulation, path simulation, etc. are encapsulated as cloud services. The digital models in the cloud may not reflect the real state of the physical robotic manufacturing systems due to inaccurate or delayed condition update and therefore result in inaccurate simulation and robotic control. Digital twin can be used to realize fine sensing control of the physical manufacturing systems by a combination of high-fidelity digital model and sensory data (Xu et al., 2021). In the context of Industry 4.0, industrial robotics such as automated guided vehicles have drawn increased attention due to their automation capabilities and low cost. With the support of cognitive technologies for industrial Internet of Things (IoT), production processes can be significantly optimized and more intelligent manufacturing can be implemented for smart factories (Wan et al., 2017).

Automated Guided Vehicles (AGVs)

Factory logistics is a crucial aspect for the production flow in industrial plants: since the transportation of raw materials and final products is a very frequent operation in a warehouse, any bottleneck and inefficiency strongly affect the overall energy consumption, impacting on the factory productivity and competitiveness on the market. In the last decades the goods production flow in industrial environments has reached high levels of automation in all manufacturing processes, allowing to improve the safety for workers, increase the efficiency of the production and reduce costs. However, factory logistics is still marginally integrated in automated manufacturing processes and it involves manual operations performed by human workers and manually driven forklifts: this arouses inefficiencies together with high risky working conditions for workers and problems in product traceability. To cope with the lack of efficiency and flexibility in factory logistics, warehousing in modern industries can rely on Automated Guided Vehicles (AGVs), and integrated systems for the complete handling of logistic operations. AGV systems are employed for managing the automatic transportation of raw materials and final products among different locations of an industrial site and they are typically employed to pick up a pallet of goods from the end of an automated production line, and bring it to the warehouse, or from the warehouse to the shipment (Cardarelli et al., 2017).

2.2 Digital transformation and automation

2.2.1 Need for Digital Transformation

Maintaining the status quo is no longer acceptable in the process industries due to building pressure from a number of areas, such as:

• More stringent health, safety and environmental regulations are forcing facilities to digitize so they can maintain their operating licenses.

• Changing industry demographics are creating leadership, succession and competency challenges — along with different worker needs.

• Proliferation of data and data-driven organizations is compressing time frames for decision-making and introducing new digital competitors.

• Technological innovation and digitization are causing disruption and forcing consideration of new operating models.

• Rise of shareholder involvement is driving demand for financial stewardship and asset optimization (Rogers, 2017) .

These and other factors are driving the need for digital transformation — the process of digitizing and acting upon data. When implemented correctly, this can transform a company by reducing safety incidents, eliminating unplanned outages and enabling nimble response to market demands. These benefits can be realized by a rigorous adherence to operating plans implemented by a motivated and informed workforce. An example is using big data analytics to improve condition monitoring of critical plant assets such as compressors, heat exchangers and pumps. In the past, the data required for monitoring the condition of these types of assets was gathered by technicians using pen and paper. Once gathered, this data was manually entered into a condition monitoring and asset management software platform, where it was manually analyzed by experts to reveal areas of improvement. But there is a better way through digital transformation. Figure 1 depicts current best practices using wireless monitoring to automatically gather data at much more frequent intervals than practical with manual readings and data entry. This cuts costs dramatically compared to

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ISSN: 2321-8169 Volume: 11 Issue: 9
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manual methods, while improving safety by limiting the need for personnel to spend time in the field (Rogers, 2017).

2.2.2 Digital Transformation Using Technology

Cloud computing

Cloud computing is a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and\ services) that can be rapidly provisioned and released with minimal management effort or

service provider interaction. This cloud model promotes availability and is composed of five

essential characteristics (On-demand self-service, Broad network access, Resource pooling, Rapid elasticity, Measured Service); three service models (Cloud Software as a Service (SaaS), Cloud Platform as a Service (PaaS), Cloud Infrastructure as a Service (IaaS)); and, four deployment models (Private cloud, Community cloud, Public cloud, Hybrid cloud). Key enabling technologies include: (a) fast wide-area networks, (b) powerful, inexpensive server computers, and (c) high-performance virtualization for commodity hardware (Schwertner, 2017).

The Internet of things

Internet of Things (IoT) technologies are transforming the focus of business processes from physical products to data-driven services. IoT applications are sometimes called cyber-physical systems (CPSs). While each term has different contexts of use, we use them interchangeably here. From an "end product" point of view, both concepts feature physical goods with powerful embedded microelectronic systems that have their own identity, can sense environmental parameters, determine their position, process data, make their own decisions, and communicate and cooperate with the environment directly or via an "Internet of Services (Pflaum and Gölzer, 2018). Internet of Things (IoT) applications have radically changed our lives, bringing immense value to the activities of both individuals and companies. Nowadays, billions of everyday objects are equipped with advanced sensors, wireless networks, and innovative computing capabilities. This profusion has given rise to wearables, smart home applications, advanced health care systems, "smart cities" and industrial automation. After years of uncertainty, IoT seems poised to cross over into mainstream business use: The number of businesses adopting IoT technologies is on the rise, with the worldwide number of IoT-connected devices projected to reach 43 billion by 2023. IoT reflects this mounting trend toward physical devices that possess the computing and communication capabilities to collectively gather information on a real-time basis (Sestino et al., 2020).

Big Data and Data Analysis

The digitalization process and its outcomes in the 21st century accelerate transformation and the creation of sustainable societies. Our decisions, actions and even existence in the digital world generate data, which offer tremendous opportunities for revising current business methods and practices, thus there is a critical need for novel theories embracing big data analytics ecosystems. Big data, business analytics, and "smart" environments have attracted great attention over the past few years in driving organizational decision making, as organizations are working on how on how to give purpose to the data, and get value-driven answers that will increase their performance, influencing different members in the society (e.g., individuals, businesses, governments). Big data may be one the most significant technological disruptions in business and academic ecosystems in recent years. As the label itself indicates, big data refers to large volumes of data generated and made available online and in digital media ecosystems. Big data are generated from different type of sources, such as the multiple transactions performed daily, posts made on social media, or from the increasing number of sensors installed in numerous objects (e.g., mobile phones, home appliances, cars, etc.). Big data analytics is a tool that goes beyond pattern analysis, allows the prediction of events, and supports artificial intelligence that is able to automatize processes, transform companies and create new types of business as it can do now, as well as to create value for the development of sustainable and prosperous societies (Pappas et al., 2018).

2.2.3 Challenges in Digital transformation

Digital transformation presents several challenges that organizations must navigate to achieve successful implementation. One significant hurdle is the resistance to change among employees, which can stem from a lack of digital skills or fear of job displacement, leading to decreased morale and productivity during the transition phase (Sidenko, 2021). Additionally, organizations often face difficulties in aligning their digital strategies with existing business processes, resulting in fragmented efforts and wasted resources (Abdallah et al., 2021). Moreover, the rapid pace of technological advancement can overwhelm companies, making it challenging to keep up with the latest tools and trends, which can hinder effective decision-making

(SOBOLIEVA and HOLIONKO, 2021). Security concerns also pose a critical challenge, as increased digitalization can expose organizations to greater risks of cyberattacks (Alhubaishy and Aljuhani, 2021). Finally, insufficient leadership support and unclear vision can stall digital initiatives, as employees may lack the motivation and direction needed to embrace new technologies (Vogelsang et al., 2021). Addressing these challenges requires a comprehensive approach that includes training, strategic alignment, and strong leadership commitment.

2.2.4 Digital transformation and automation

As described by Kehoe et al.,(2015) cloud technology can also benefit the process of automation. The technological evolution in the last decades has led us to the forefront of the digitization of services at every stratum of the processes and businesses. As the technology is advancing, an era of automation is witnessed in each field. Intelligent Process Automation (IPA) is amalgamation of Robotic Process Automation (RPA) with Artificial Intelligence with a view to create end-to-end processes which can think, learn, and adapt on their own (Kholiya et al., 2021).

2.2.5 Challenges in Automation

As autonomous and semiautonomous systems are developed for automotive, aviation, cyber, robotics and other applications, the ability of human operators to effectively oversee and interact with them when needed poses a significant challenge. An automation conundrum exists in which as more autonomy is added to a system, and its reliability and robustness increase, the lower the situation awareness of human operators and the less likely that they will be able to take over manual control when needed. The human–autonomy systems oversight model integrates several decades of relevant autonomy research on operator situation awareness, out-of-the-loop performance problems, monitoring, and trust, which are all major challenges underlying the automation conundrum (Endsley, 2017).

2.2.6 Need for Automation

The need for automation is increasingly recognized across various sectors due to its potential to enhance efficiency, reduce human error, and optimize resource allocation. Researchrs emphasizes that automation can significantly streamline processes, leading to improved productivity and cost savings in industries that traditionally rely on manual labor. It was further highlighted that automation not only accelerates production rates but also allows for the reallocation of human resources to more strategic tasks, thereby fostering innovation. Moreover, the role of automation in improving safety and compliance, particularly in high-risk environments, where human error can have severe consequences. It was noted that automation can also facilitate data collection and analysis, providing organizations with valuable insights for decision-making. However while automation offers numerous benefits, it may also lead to workforce displacement, necessitating a balanced approach to implementation. Overall, the integration of automation is essential for modernizing operations and maintaining competitive advantage (Ball et al., 2021; Harris et al., 2018; Desai, and Parimala, 2017; Quintana and Plätzer, 2015).

2.3 Technological innovation

A technological innovation system is defined as a set of elements, including technologies, actors, networks and institutions, which actively contribute to the development of a particular technology field (e.g. a specific technical knowledge field or a product and its applications). The TIS perspective emphasizes systemic interdependencies between these elements, which give rise to various forms of synergies, such as collective assets on which the different actors can draw but which they could not produce if they worked in isolation.4

The existence of system-level assets (or resources) implies that system boundaries have to be carefully chosen. The boundary separates the TIS (i.e. the realm where systemic interdependencies in a specific technological field play out) and its “context” (all other structures and relevant factors outside of the TIS) (Bergek et al., 2015).

Technological innovation, a complex and multidimensional construct, refers to innovations

associated with an organization’s operations, such as the introduction of new/improved products or processes. Scholars and practitioners recognize the importance of technological innovation in a firm’s ability to obtain a sustainable competitive advantage. technological

innovation has a significant and positive impact on a firm’s performance. Further, we find

empirical support for the moderating influence of cross-cultural and institutional differences on the relationship. We observed a better performance outcome for innovation occurring in nations with a lower propensity to avoid uncertainty and collectivistic attitudes. In contrast, performance suffers when technological innovation occurs in nations that have stronger patent protection (Singhal et al., 2020).

The diffusion of innovations during the fourth industrial revolution reshaped economic systems and caused structural changes in different economic sectors. These innovations have become the basis of the new digital infrastructure of society. Digital technology is used to manage integrated product whole-life cycles and enhance efficient, reliable, and sustainable business operations. Intelligent production processes and supply chains can be used to optimize entire end-to-end workflows and create business competitive advantages. Artificial intelligence, internet of things, machine learning, blockchain, big data and other digital technologies have been used to create business agility and resilience and further transform societal behavior. Digitalization creates new ways for companies to create business added value. Modernizing business enterprises by combining digital technologies, physical resources, and the creativity of individuals, is an essential step in innovative business transformation that may constitute a competitive advantage. Companies need to transform their business processes and enhance the satisfaction of their customers by using digital technologies that connect people, systems, and products or render their services more effective and efficient. Digital technologies create new ways for companies to integrate customers' requirements into product development or service delivery across entire process chains. Digital technologies are becoming increasingly important due to strong market competition. Many studies have shown that there is a strong correlation between business growth and the use of digital technologies to create innovative business models. Technological innovations create new products, processes, and services that generate more added value for companies (Berawi et al., 2020).

Among the trajectories of technological change, this work focuses on disruption, which, by creating new-markets and impacting on the low-end is re-shaping the boundaries of several industries and altering the nature of business while exposing organizations to new competitive logics and threats, affecting strategic and innovation management. Thus, this scenario projects the need of new business processes, the definition of new business models, a different innovative thinking and novel managerial challenges. The change driven by disruptions is also transforming the way organizations learn, communicate, and work in a significant way, modifying consolidated ways of organizing as adaptive responses; managers are thus challenged to plan, strategize and think differently and need to work on individual and organizational capabilities to be able to cope with innovative business models, innovative thinking, tracking technological evolution and focusing on consumer demands. Additionally, disruption can yield a different impact depending on the type of market in which it happens and based on the peculiarities of that type of market. Indeed, for a disruption to occur the presence of a technological core is extremely important, since the innovation will develop in quality to gradually compete with higher-quality products (Tammam et al., 2019).

2.3.1 Advantages of Technological Innovation

Findings reveal a significant and positive influence of technological innovation on competitive advantage. Technological innovation explained the variations in competitive advantage. It is deduced from the findings that more technologically innovative telecommunication firms are likely to produce better products and services and consequently able to acquire more customers earning competitive advantage compared to less innovative telecommunication firms. The study presented notable implications on the policy framework, the strategic management practice, and theory implications in the telecommunication industry and beyond. At policy level, the Government would benefit from the study by ensuring that policy makers and regulatory authorities in the sector formulate policies that would promote technological innovation for enhancing competitive advantage. Managerial practitioners may consider institutionalizing innovation by creating the requisite direction and controls that enable the emergence of innovation and value creation for sustainable competitive advantage. The study findings' implications further extended, supported, and added value on the theory adopted by the study (Wanaswa et al., 2021).

Technological innovation plays an important role in society for satisfying needs, achieving goals, and solving problems of adopters directed supporting corporate, industrial, economic,and social change for competitive advantage ofrms and nations, and improving overall human progress (Coccia, 2021).

Technological innovation plays a crucial role in driving economic growth, enhancing productivity, and addressing societal challenges. Innovation is essential for sustainable development, as it enables industries to adapt to changing environmental regulations and consumer demands. Technological innovation is crucial for firms' competitiveness, societal progress, and GDP growth. It drives product development, process efficiency, and differentiation strategies, necessitating strategic management for success (Ashford and Hall, 2018). Technological advancements can

International Journal on Recent and Innovation Trends in Computing and Communication
ISSN: 2321-8169 Volume: 11 Issue: 9
***Article Received:** 25 July 2023 **Revised:** 12 September 2023 **Accepted:** 30 September 2023*

significantly improve operational efficiencies and foster competitive advantages in various sectors. Technological innovations in healthcare enable early disease diagnosis, management, and prevention, reducing morbidity and mortality rates, leading to better healthcare sustainability and improved quality of life (Mehrotra and Joshi, 2021). Kalia et al. discuss the transformative impact of digital technologies on traditional business models, suggesting that organizations must embrace innovation to remain relevant in a rapidly evolving market (Kalia et al., 2015). Furthermore, Innovation not only contributes to economic performance but also plays a vital role in social progress by improving quality of life and addressing global issues such as climate change (Singhal et al., 2020).

2.3.1 Challenges of Technological Innovation

Technological innovation, while often heralded for its benefits, also presents several disadvantages that warrant consideration. One significant drawback is the potential for job displacement, as automation and advanced technologies can render certain roles obsolete, leading to increased unemployment and economic inequality (Kennedy, 2020). Additionally, the rapid pace of innovation can create a digital divide, where those lacking access to technology or the skills to use it are left behind, exacerbating social disparities. Disadvantages of technological innovations in care include costliness, potential failures, increased time consumption, altered roles, and responsibilities, as well as impacting working relationships and care provision efficiency (Oldridge, 2020). Moreover, the environmental impact of new technologies cannot be overlooked; many innovations contribute to resource depletion and pollution, raising concerns about sustainability. Excessive investment in technological innovation may not always yield positive returns, posing a risk for telematics companies. Balancing costs and benefits is crucial for sustained competitiveness (Dadelytė and Mačiulytė-Šniukienė, 2020). Furthermore, the reliance on technology can lead to vulnerabilities, such as cybersecurity threats and data privacy issues, which pose risks to individuals and organizations alike. The challenges of digital technologies include threats to business model efficiency, influenced by internal and external factors. Digital strategies may fail due to financial discrepancies compared to industrial companies (Stepnov, 2021). Lastly, the pressure to continuously innovate can foster a culture of stress and burnout among employees, undermining workplace well-being (Boff, 2019). Collectively, these factors highlight the complex challenges associated with technological advancement.

3. Methodology

For this study, the Systematic Literature review methodology was adopted. The main reason for choosing this methodology is that it plays an important role as a foundation for all types of academic enquiries (Xiao and Watson, 2017). They can serve as a basis for knowledge development, and have the capacity to engender new ideas and directions for a particular field. Systematic literature reviews is essential for gathering existing knowledge and examining the state of a field in academic research (Linnenluecke et al., 2019). This benefit of the systematic literature review closely aligns with the aim of this study which is to provide a comprehensive overview of the topics to make researchers quickly understand the current state of knowledge in a field without needing to consult multiple sources. This synthesis provides a foundation for new research, helping scholars identify gaps, trends, and key findings that can guide future studies. For this study, research articles from the year 2015 to 2021 were selected and analysed to provide a brief overview of the following topics: cloud robotics, digital transformation and automation and technological innovation. The process of extraction and the inclusion and exclusion criterion are depicted in the below image. Google Scholar was used to search for the articles to be utilized in this study.

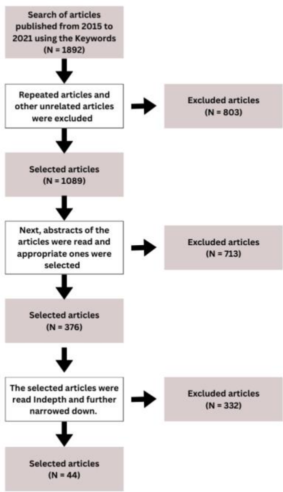

Figure 2: Systematic Literature Review Process

The first step was to search Google scholar using the keywords such as “cloud robotics”, “digital transformation”, “automation”, “technological innovation”, “challenges”, “advantages”, “applications”, “benefits”, “disadvantages”, “drawbacks”, “uses”, etc. These keywords were used in different combinations to gather the articles and research articles from the year 2015 to 2021 were selected.

The next step was excluding the repeated articles and other irrelevant articles. For the remaining articles, the abstracts were read and appropriate ones were selected. Finally, the selected articles were read in-depth and appropriate ones were selected which is about 44 final articles.

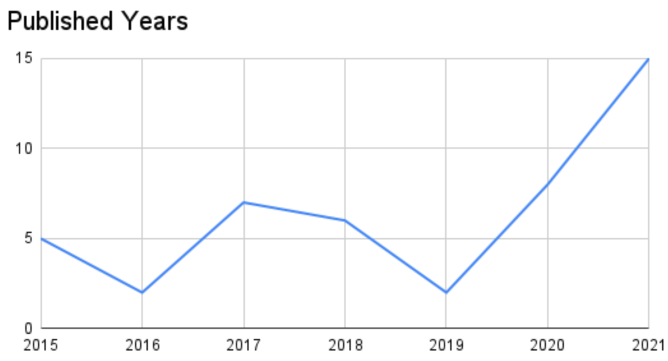

Figure 3: Number of published articles yearwise

Out of the 44 articles selected through the systematic review, the articles published in 2021 was highest in number with 15 articles. The below figure represents the number of articles in each of the three major topics of this study. The digital transformation and automation has the highest number of articles. The final figure represents the publications of the 44 articles collected.

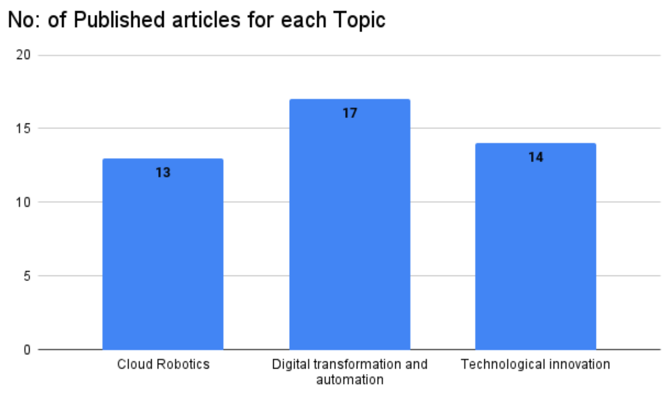

Figure 4: Number of published articles for each topic

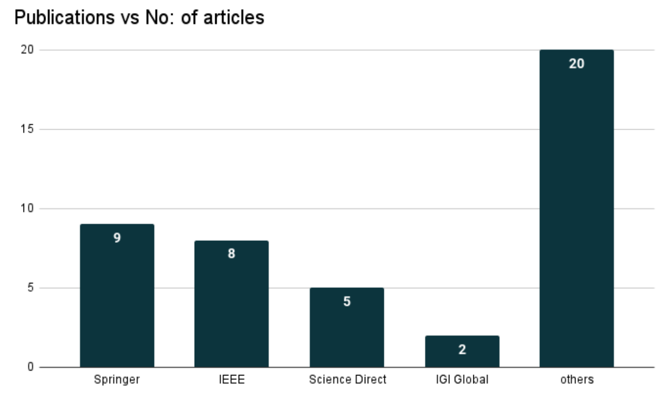

Figure 5: Number of articles for each publication

4. Results

A comprehensive overview of the topics has been provided in this study. The topics were briefly explained and the advantages, applications and challenges associated with their implementation were also provided. With this study, researchers can quickly understand the current state of knowledge in a field without needing to consult multiple sources. First in the Introduction part, a basic outline of cloud robotics, digital transformation and automation and technological innovation was given. Next, in the Review of Literature, the topics were explored more briefly and in-depth. First, cloud robotics was explained and the architecture of cloud robotics was provided with a brief overview. Next, the challenges, benefits and applications of cloud robotics were provided. The next section was digital transformation and automation. Here, the need for digital transformation and automation, its challenges, various technologies in digital transformation and the association between these topics were provided. Finally, technological innovation was briefly explained along with its advantages and challenges.

5. Conclusion

The study provided a comprehensive overview of cloud robotics, digital transformation and automation and technological innovation. First, the basic introduction about the topics were provided in the first part of the study which is the Introduction. In the next part, the advantages and challenges associated and its application were also provided in a detailed manner. As mentioned in the study, cloud robotics, digital transformation and automation and technological innovation are all connected with each other. It can be seen that cloud robotics is a technological innovation that can be used for digital transformation and for automation. Employing these strategies will result in enhanced performance and a reduction in time and cost. Though there are numerous advantages, there are still some challenges that need to be overcome in order to attain the complete advantages of these innovations.

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