Imperative Role of Digital Twin in the Management of Hospitality Services

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***Abstract*—Digital twin implementation enables more effective terms of evaluation and planning, and also effective utilization of resources with a flood of knowledge to improve the real-time services. The hospitality industry settings utilize digital twin technologies to introduce new ideas with sensor, actuators, AR/VR improve production, and improve customer services. Currently, the hospitality industry is focused to create a fast, virtual world space where customers can get a real world of hospitality. The technologically digital twin of a vast inn office can be implemented to create both discrete and continuous event recreations in order to precisely conceptualize the events that occur in distinct frameworks. Based on the above facts, the adoption of the digital twin in the hospitality industry has gained significant attention. With this motivation, the study aims to investigate the significance and application of the digital twins in the hospitality industry for establishing innovative and digital infrastructure. In addition to this, the study discusses different elements that are significant for the digital twin. Finally, the article summarizes and recommends vital recommendation in the adoption of digital twin in hospitality industry.**

***Keywords*—Hospitality industry; digital twin; sensor and actuator; IoT; augment and virtual reality**

I. INTRODUCTION

The Sustainable Development Goals act as a road map for building a better and more sustainable future for all while also addressing urgent, serious global issues [1]. This article will examine some of the challenges that the hotel industry may encounter to assist it to contribute to the Sustainable Development Goals (SDGs) [2]. It will also provide some deeper, more thorough viewpoints on industrial sustainability. One of the primary hospitality-related SDGs of the 2030 Agenda of the United Nations is "sustainable tourism"[3]. Three SDGs specifically mention the hospitality industry: life below water (SDG 12), sustainable consumption and production (SDG 12), and sustainable economic growth (SDG 8) [4]. For many years, hospitality industry facing challenges in the consumer perception of the way to facilitate the services to improve the quality and reliability [5]. The hotel industry's assertiveness is influencing numerous substantial and small collaborators to leverage technologies to alleviate limitations [6]. The hospitality industry is undergoing a digital transformation that will result in a far more personalized, customer-focused experience. Digital twin technologies are an indication of this development because they offer guests more flexibility over even the most modest components of their stays [7].

With the use of digital twins, restaurants, hotels and other hospitality businesses can get an advantage over rival businesses [8]. The majority of hotels employ connected devices nowadays to streamline customer requests and identify their unique characteristics in order to provide customized services. Examples of this include Marriot and other stakeholders' design of smart hotels and the use of concierge digital twins by various groups [9]. When used correctly, digital twin arrangements are capable of accurately recreating various resources, cycles, and frameworks in a virtual environment. This effectively makes the digital twin an option for huge accommodations were monitoring multiple cycles within a framework while executing innovative concepts is a frequent occurrence [10]. This diagram illustrates how the hospitality sector uses digital twins to portray digital pictures of all management.

This paper makes up a commitment to the top-of-the-line digital twins for putting together and coordinating operational frameworks for the hospitality industry. The primary goal of this study is to draw attention to the divergence between the theoretical and imaginary network of digital twins for assembly and storage and their practical application in considerations of theatrical illustration. The main contributions of the study are presented in the following:

- The most recent advancements in reenactment techniques that might establish the foundation for digital twins with advanced levels of information reconciliation, mechanization, and smart skills.
- This study uses a similar approach to analyze fictitious and specialized preparation for building highly devoted and powerful digital twins for the hospitality industry.
- Although digital twin technologies have shown significant advantages, their implementation still faces difficulties.

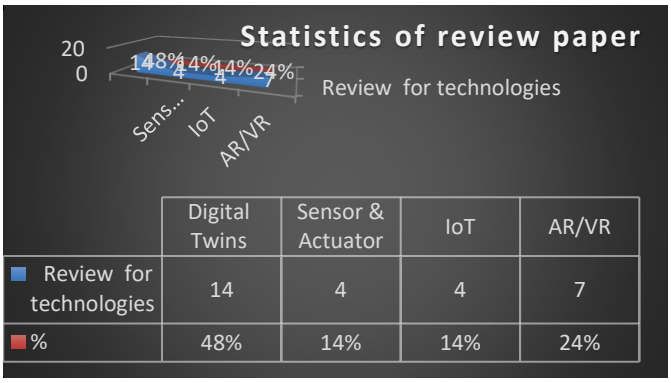
- In this paper, we are representing the future benefits of digital twins in this sector because new research opportunities have been made possible by the introduction of digital twin technology.

The study organized as follows: The background of the hospitality sector and digital twin covered in Section II, along with an overview of the technology in Section III, sensor and actuator presentations in Section IV, the Internet of Things in Section V, AR and VR in Section VI, and digital twin in the hospitality sector in Section VII.

A. Methodology

This section includes the methods used to complete the review on the digital twin in the hospitality industry. All the sections contain the analysis, data collection, criteria, and the searched strategy over the digitalization with digital twins. The concern of the review is to connect the digital twins and related technologies with the hospitality industry for future automation. The research question is: How digital twin technology can automate the hospitality industry? Based on this research question, we have collected research and review papers. The research paper was collected from various databases such as Scopus and web of science. The following parameters have been followed for the inclusion and exclusion of articles for analysis and they are: abstract of the paper but the full text of the study is not examined in the review. Algorithms and methodologies were used in the review but results are not used in this review. Research articles without peer review are not taken into consideration for review. There is no review of book chapters, patent applications, or communications for this review.

In this review, we are representing the statistics of the reviewed paper for different technologies. Fig. 1 represents the percentage of technology used in this literature survey: 48% digital twin's technology, 24 % & AR/VR, 14 % sensor & actuator, and 14 & IoT technology review for this review paper.



	Digital Twins	Sensor & Actuator	IoT	AR/VR
Review for technologies	14	4	4	7
%	48%	14%	14%	24%

Fig. 1. Overview of the review paper of technologies.

II. Background of the Hospitality Industry and Digital Twin

Technologies used in the hospitality industry 4.0 present fresh possibilities for advancing sustainable growth [11]. Innovation has increased over the past few years in the hospitality business; self-registrations, contactless assistance, web-based seeking, and payment through applications have become the new norm [12]. While many businesses specifically target socioeconomics, the hospitality industry is more distinctive. Even inside the same place, Industry 4.0 offers diverse experiences to distinct groups [13]. Technologies used in the hospitality industry 4.0 present fresh possibilities for advancing sustainable growth. It can assist hospitality firms in streamlining operations; better marketing themselves, and meeting visitor needs [14] [15]. Organizations need to have fallback plans in place so they may be prepared for any challenges the world of innovation may throw at them [16]. If the innovation framework isn't set up at all or goes down, it can stop the entire presentation structure.

Customers give businesses online reviews via comments, ratings, and photos on internet platforms, which are growing in popularity daily. In order to improve its standing, the neighborhood company has been working hard to establish points of strength for interaction with customers [17]. Organizations can be destroyed or glorified by audits and comments; therefore, the business must take advantage of certain opportunities and manage its reputation. The hospitality industry is noted for having a high employee turnover rate, with about 33% of workers quitting after only six months on the job and about 45% remaining for an average of two years [18]. The industry is expected to continue to grow, which means that businesses must ensure that their representatives have strong personal qualities, professional skills, and knowledge in order to remain competitive [19]. Associations must be informed of the most recent trends for attracting and retaining employees because representative assumptions are constantly changing and evolving. This is becoming a constant challenge within the hospitality industry. Technology-based comparison is shown in Table I which shows the need for technology in the hospitality industry to improve the feature, quality, and services.

Online registration and looking voluntarily become more important to the business with visitors not coming to the front work area to receive a key due to new pleasant separation measures and a concentration on neatness [20]. As more people use their smartphones to request room management, computerized advancements made possible by mobile applications will become the norm for many businesses. The implementation of these innovations will require a significant initial investment but will ultimately result in efficiency and cheaper prices [21]. Rapid invention development has simultaneously created a variety of previously distinct arrangements that are now coming together.

TABLE I. OVERVIEW OF THE DIGITAL TWIN APPLICATION SCOPE AND FINDINGS

Ref.	Objective	Digital Twins (Sensor/Actuator/IoT)	Key Findings	Advantages	Future Scope
[7]	Hospitality Industry "Accommodation and services"	NA	Hospitality industry, Tourism, Services, Hospitality units, Tourists	Accommodation and service management are easy to improve for the customer	Technologies are required for customer satisfaction and service improvement
[8]	Identifying determinants of success in the development of new high-contact services: Insights from the hospitality industry	General Technologies such as mail and simple data collection methods are used only.	Service operations, Design and development, Hospitality services, Employee involvement	Services improvement, Market improvement, Process improvement and Hospitality improvement	Technologies are required to digitalize the hospitality industry for better customer satisfaction
[9]	Analyzing service quality in the hospitality industry	The general method used to make the hospitality industry reliable	Hospitality industry, Measurement, Service quality	Reliability, Responsiveness, Assurance, Empathy, Tangibles and Combined scale	Technologies are required to digitalize the hospitality industry for better customer satisfaction
[10]	Why do employees stay? a qualitative exploration of employee tenure	Quantitative and qualitative analysis of data without technology	Retention, Interviews, Turnover, Employee and Restaurant	Employee stability in hotels and restaurants, Hospitality Improvement	Technologies are required to digitalize the hospitality industry for a better customer Retention rate
[12]	Technology in Hospitality Industry	IoT, AR, Energy management, Beacon, and Automation	Interoperability, Data management, security, and Privacy	Modern Service platform for customer	Need to be overcome to institute a lasting, future proof solution for the hospitality industry.
[14]	The Digital Future of the Tourism & Hospitality Industry	AI, AR, VR and Blockchain	Customer Service, Customer Travelling, Technology used	Effectiveness, Improvement in Customer Services	Need to use the latest technologies to develop a sustainable and effective system for the hospitality industry
[40]	Research progress on virtual reality (VR) and augmented reality (AR) in tourism and hospitality	AI, AR	Augmented reality; Hospitality; Review; Technology; Tourism; Virtual reality	Virtually concept makes the easy to use for the customer in the hospitality industry	Need to use the latest technologies to develop a sustainable and effective system for the hospitality industry

This can create a challenging environment, especially for larger accommodation networks, which usually deal with a unique set of technological challenges [22]. However, integrating technologies and data across entire corporate ecosystems may be necessary to fully realize their potential [23]. Companies today use digital twin capabilities in several different ways. They are increasingly important mechanisms for modernizing entire manufacturing value chains and developing new goods in the hotel and aviation industries [24]. Operators in the hotel business collect and analyze massive amounts of in-hole data, which they then use to construct digital models that control drilling operations in real-time. With the use of digital twins, hotels, resorts, and other hospitality businesses can get an advantage over rival businesses, and then it is shown in Fig. 2. There are different elements, in which the digital twin can be beneficial in the hospitality industry such as interior direction; online concierge; personalized marketing; operation effectiveness.

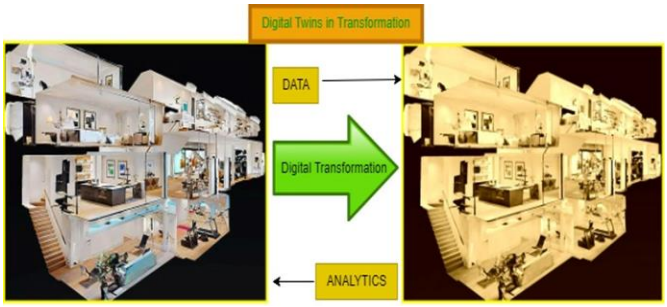


Fig. 2. Overview of the Digital Twins in the hospitality industry.

A. Interior Direction

The immediate benefit of employing digital twin technology in the hospitality sector is probably indoor navigation. Virtual representations of resorts, which are typically accessed through a mobile app, allow visitors to navigate to different on-site amenities like the pool or bar with turn-by-turn directions. Visitors can visually visit a hotel room or even the entire resort thanks to indoor navigation. Even when booking a suite, guests can specify a certain view or location. These amenities are a great way for prospective customers to choose whether they want to stay at a specific hotel.

B. Online Concierge

The level of customization and virtual concierge service that digital twins can provide are challenging to match. With a digital twin, visitors can remotely control anything from lighting and temperature to choosing a room from digital floor plans, having a drink delivered just to their location within the resort, and even submitting maintenance issues.

C. Personalized Marketing

Both guests and management benefit from this technology's targeted marketing advantages. Based on consumer behavior, management might promote certain room or service improvements to customers, encouraging guest spending. In turn, offerings that are pertinent, timely, and customized make guests happier.

D. Operation Effectiveness

The operational advantages that digital twins offer significantly enhance the guest experience. In order to save expenses (by optimizing staffing, lighting, and temperature during specific hours), comprehend how facilities are actually used, and meet operational performance goals, management might leverage data from consumer behavior. Finding possibilities to boost revenue, raise customer satisfaction, and maximize employee efficiency all depend on this data. Digital twins are advantageous to property managers as well as visitors. Through way finding, 3D visual experiences, virtual concierge services, and other means, they provide visitors with tailored experiences. They also give management analytical insight into how to improve staff productivity, increase operational efficiency, and deliver individualized guest marketing.

III. Overview of Digital Twin Technology

A digital twin is a representation of a physical product, procedure, or service in the digital world. A digital twin is a digital representation of a real-world object, such as a jet engine, wind farm, or even larger objects like a building or even an entire city [25]. The digital twin technology can be used to duplicate processes in order to gather data and forecast their performance, in addition to physical assets [26]. In essence, a digital twin is computer software that simulates how a process or product would work using data from the real world. To improve the output, these systems can use artificial intelligence, software analytics, and the internet of things [27]. Additionally, before any physical deployment is started, digital twin environments establish an environment that is conducive to testing new business operations, regulations, and assets to determine their performance levels [28].

The simple state to understand the digital twin is shown in Fig. 3. A virtual model can help identify surrenders and predict when an item's life will expire. Digital Twins can speed up creation, shorten the time it takes to market new products, and help reduce support expenses [29]. IoT, sensor, and actuator technologies are employed to convert physical systems into virtual concepts for novel setups and phenomena. This facilitates forecasting, adjusting, and decision-making on the real-time monitoring of performance and ease of future work [30].

Digital twin starts the work with sensor, actuator and IoT together to collect the information and to create the information to further digital work environment. There are two components of the digital twin to the work first is hardware component and other is software component [31]. Hardware components consist of IoT, sensor and actuator that assist the information for the whole process in the digital twins. In the software component the research engine, which turns naive observations into crucial business knowledge, is a key component of digital twinning. It is frequently governed by AI models [32]. In digital twin there are digital threat may be creating the complication in the data collection from the physical components of the system shown in Fig. 4. You can connect actual structures and their virtual representations into a closed circle known as a computerized string if all the necessary components are nearby.

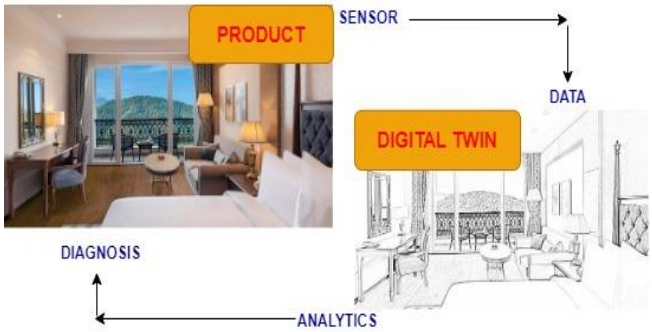


Fig. 3. Simple state and representation of digital twin concept.

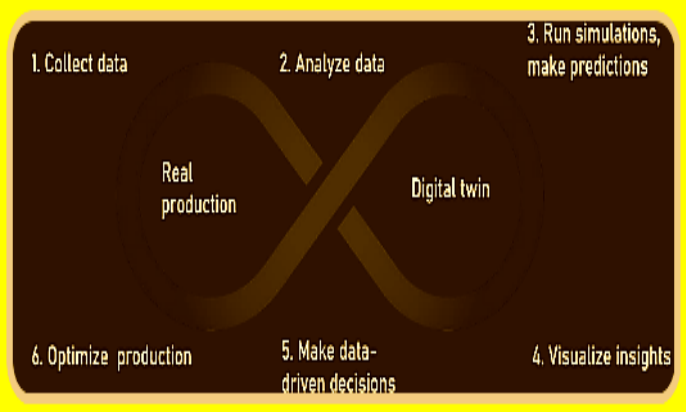


Fig. 4. Digital threat in the software and hardware component of the digital twin.

Within the Digital threat, it involves some of the operations processes such as [33]: A physical object's environment at large is both sources of data that are transferred to the central repository. Data is produced for feeding to the digital threat after analysis. The digital twin uses new data to assess what would happen if the environment changes, discover bottlenecks, and mimic the object's operation in real-time. AI algorithms can be used at this stage to make product design adjustments, identify harmful tendencies, and avert expensive downtimes. The dashboard displays and visualizes analytics insights. Stakeholders make decisions based on actionable data. Accordingly, the physical object's parameters, procedures, or maintenance plans are modified [34].

Tandem Twining Experts can evaluate the strength, adaptability, energy efficiency, and other characteristics of the various components that make up an item credit to the necessary degree of twinning [35]. To analyze how the part in question will behave under static or heated pressure and in other real-world circumstances, they can use reenactment programming.

Resource or item twinning the full item's replication reveals how various components work together under various conditions and how greater execution and dependability might be achieved. Instead of creating new models, advanced twinning can be used to develop new specialized arrangements [36]. This shortens the progression period and accounts for quicker emphasis.

Twining of the creation and cycle Advanced twinning applies to processes in addition to physical resources [37]. You create complete virtual models of the creation procedures for this scenario. This method helps to provide preferable answers to important questions like: How long will it take to produce a specific item? What will the price be? What should each machine accomplish? Which processes are automatable? Is there any way that a certain thing can be developed? Additionally, it is easier to avoid expensive free time when you can visualize the entire organizing process.

Device twinning Complex item and cycle interconnections and dependencies are made perceivable by a digital twin of the framework [38]. The twinned framework, which can be thought of as an arrangement of frames, can be practically as large as a multistory building, electrical lattice, or even an entire city. However, the risk involved in building such a reproduction typically does not equal the expected return. Because of this, framework twinning is typically not as flexible as other digital twin types.

IV. Sensor and Actuator in Digital Twin

Data from the physical system is collected by the digital twin and converted into digital data via the sensor and actuator [39]. The sensor and actuator are depicted in Fig. 5 and collaborate with IoT and digital twins. A sensor is a device that converts actual events or qualities into electrical signals [40]. This piece of technology converts the contribution that the weather makes and uses it to support the structure. As an illustration, a thermometer converts the temperature from a real sensor into electrical signals for the system. An actuator is a device that converts electrical signals into real-world events or characteristics.

Fig. 5. General representation of sensor and actuator.

Every sensor, including electromagnetic, capacitor, resistive, and others, has a different operating principle [41]. They often perceive the climate's contrasting quality and translate it into an electrical sign of corresponding size. A latent sensor doesn't require an additional power source to function, but a detached sensor does. A working piezoelectric sensor transforms strain into an electrical signal [42]. A potentiometer is an example of a detachable sensor since its resistance varies with location but needs additional power to convert it into an electrical signal.

V. IoT in Digital Twin

Especially, the explosion in IoT sensors is crucial to the possibility of digital twins. Additionally, as IoT devices develop, advanced twin scenarios can involve less complex and modest products, providing additional benefits to businesses [43]. Digital twins can be used to predict different outcomes in light of varying knowledge. Computerized twins may usually enhance an IoT setup for maximum efficiency with additional programming and information analysis [44]. They can also help designers determine where things should go or how they should function before they are ever dispatched.

IoT is a technological revolution that represents the future of computing and communications, and its success is dependent on rapid technological advancement in a variety of sectors, from wireless sensors to nanotechnology [45]. It can essentially turn those items or appliances into ‘smart' things that can transmit and receive data as well as communicate with one another. This can help with data collecting, automation, and allowing various devices to be managed or monitored from a single location, such as a phone or table. Its customization makes people feel special and since the primary aim of the hospitality industry revolves around providing the ultimate guest experience, this is what IoT should be embraced as shown in Fig. 6 [46]. While the concept of the IoT has been around for a long time, recent breakthroughs in a variety of technologies have made it a reality.

More liable technology: IoT innovation is turning out to be progressively open to additional producers on account of the accessibility of minimal expense, and high-dependability sensors.

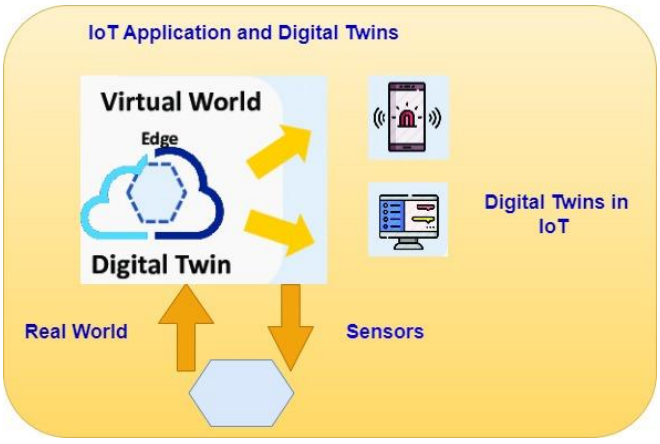


Fig. 6. General representation of IoT and its significance.

Connectivity: A variety of internet network protocols have made it simple to connect sensors to the cloud and other "things" for data transfer.

Platform for Cloud computing: As cloud platforms become more widely available, organizations and individuals can gain access to the infrastructure they need to scale up without having to manage it all.

Analytics and Machine learning: Organizations can obtain experiences quicker and all the more essentially on account of improvements in AI and examination, as well as admittance to different and huge volumes of information put away on the cloud. The development of these connected innovations keeps on pushing the outskirts of IoT, and IoT information takes care of these advances also.

Conventional AI: Natural language processing (NLP) has been brought to IoT gadgets (like computerized individual aides Alexa, Cortana, and Siri) because of advances in brain organizations, making them engaging, reasonable, and practical for home use.

VI. AR AND VR IN DIGITAL TWIN

AR/VR has recently become a big idea in the hospitality industry since it allows hotels and other associated businesses to improve the actual environment they are offering or to enhance the experience of exploring the surrounding area [47]. AR is the perfect fusion of the real world and the electronic one to create a fake environment. Applications that use AR technology are developed for mobile devices or workspaces to integrate cutting-edge components into the current world [48]. A computer-produced reproduction of an alternate reality or environment is known as VR shown in Fig. 7. It is used in computer games and 3D movies [49].

AR shows the client relevant content by using computer vision, planning, and depth following. With the use of this functionality, cameras may collect, transmit, and interpret data to display cutting-edge material that is appropriate for the client being viewed [50] [51]. A VR headset screen must be placed in front of the client's eyes to remove any participation with our current reality in this way [52]. The built-in reality is vivid in augmented reality because you can also use visual, audible, and haptic excitement. AR and VR are used in hospitality management applications for various purposes [53].

Fig. 7. Virtual reality in hospitality industry.

VII. DIGITAL TWIN IN HOSPITALITY INDUSTRY

A Digital twin is a representation of anything virtually [54]. This concept is evolving into an element of the dynamic process for increasing efficiency. In order to handle an item's nearly continuous state, operating condition, or position, digital twins use information from sensors that have been installed on the actual item [55]. This concept glorifies the replication processes of computer assisted design and computer assisted engineering. Any component of a physical object or process can be replicated using digital twins. The digital twin can reflect a new product's engineering drawings and measurements as well as all the subcomponents and associated lineage in the larger supply chain from the design table to the end user [56]. They might also appear in "as maintained" form, which would be a physical representation of the machinery on the factory floor.

The simulation depicts how the machinery works, engineers maintain it, or even how the consumer interacts with the products this machinery produces. Although digital twins can take many different forms, they all use and record data that simulates the real world. You can experiment with much iteration in the digital hotel sector to develop the scenarios that are most applicable to your company. New era industry 4.0 is the new revolution in hospitality industry to develop the simulation system on large scale to serve the society [57]. The hospitality industry has a wide range of uses for digital twins, which makes them a highly sought-after tool for investigating different market potential in this specialized area.

Real-time animation of the hospitality working process is also possible with the 3D plant model, which may be utilized to pinpoint the difficulties faced by this industry [58]. The primary factors that relate to the client for quality and service purposes are as illustrated in Fig. 8. Digital twin enables a virtual process to evaluate each step of the hospitality industry and provide an explanation of why a hotel and its services should be used [59]. The virtual facility gives a brief summary of all the features and amenities offered by the hotel as well as how the service provider addresses all the criteria in Fig. 7.. Over the coming years, it is anticipated that digital twin [60] applications will spread widely and no longer be restricted to activities or procedures exclusive [61] to the hotel business [62]. All types of hotel operations that want to stay competitive in their respective industries will use the technology. We can observe some instances of hospitality businesses that have already seized this chance. KFC Spain has joined MAPAL Data [63] Labs as the first business unit in the world to collaborate on a ground-breaking Digital Twin [64] project that uses cutting-edge digital [65] simulation to maximize labor and operational efficiencies [66]. It seems clear that digital twin technology will endure. The instrument has endless potential and offers numerous commercial advantages. Furthermore, although this technology [67] is currently viewed as a "nice-to-have," it will soon be necessary for companies that want to remain competitive and appealing to customers [68].

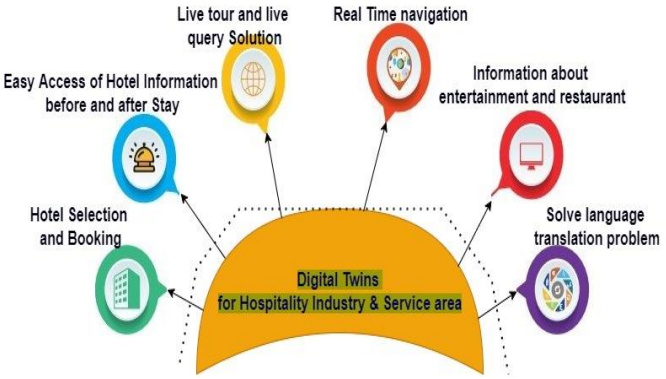


Fig. 8. Digital Twins for hospitality industry and simulation points.

VIII. Conclusion

Digital twins play a crucial part in the technological advancement that has the potential to build a new foundation for the future. The merging of the physical and digital worlds makes it possible to make wise judgments at every stage of operations and hospitality, which can promote a data-driven smart hospitality environment. The use of the digital twin in the hospitality sector has drawn a lot of interest as a result of the facts mentioned above. In context of this purpose, the study's goal is to examine the value and potential applications of digital twins in the hospitality sector for the creation of cutting-edge digital infrastructure. The study also highlights many components that are important for the digital twin. The study concludes by summarizing and offering critical advice for the implementation of digital twins in the hospitality sector.

IX. Future Work and Recommendations

The research also examines technologies that benefit from and enable digital twinning. In-depth predictions are also included in the research for a variety of market areas and use cases, such as hotel service and simulations, production analytics, and others. A virtual object representation of a physical object that is mapped to actual objects in the real world, such as machinery, robots, or essentially any linked business asset, is what is known as a "digital twin". IoT systems and software that are used to build a digital representation of the physical asset allow this mapping in the digital realm. A physical asset's digital twin can offer information about its status, including its physical state and disposition. The proposed digital architecture of the Hospitality Industry with digital twins is shown in Fig. 9.

On the other hand, tele-operation allows a digital object to be utilized to manipulate and control a real-world asset. This technology serves the hospitality industry in many ways such as:

- Future predictions from the digital twin solution: Planners can adjust for the following event iteration, improve operations, boost efficiency, and resolve any difficulties before they occur in a real-world setting by using digital twins, which frequently behave as a living, breathing model of the venue.
- Determine market obstacles and chances for digital twinning: By precisely recording their physical qualities, reproducing their actions, and altering their scale, a digital twin technology should be able to mimic both basic things and complex object relationships.
- Recognize the function of virtual twinning in product development, quality, and guest services: The ability to control quality and services is made possible by the vitality in digital twins, which will aid the hospitality business in the future. It makes the work faster to control and give the ability to handle the future challenges.
- Virtual simulations aid in understanding future plans and facilitate smooth decision-making with the least amount of money and effort: The hospitality industry can improve operational decision-making by utilizing the digital twin idea. Virtual reality has the functionality to help people make decisions more quickly in order to correct flaws.

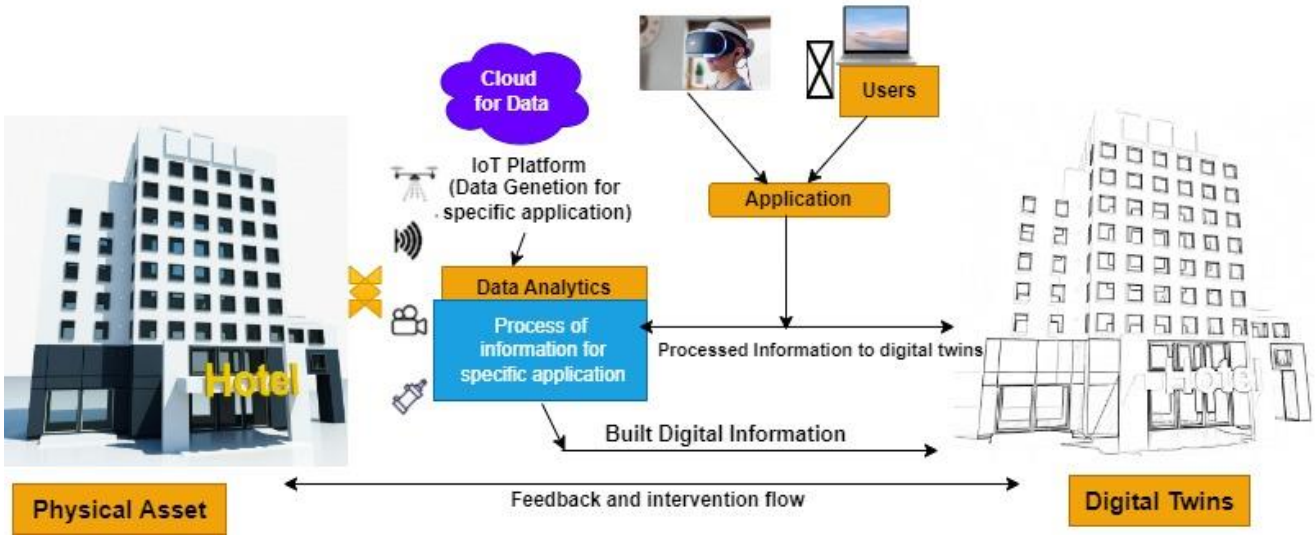


Fig. 9. Proposed architecture of the digital twin and hospitality industry.

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