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Artificial Intelligence-based Restoration: The Case of Petra

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Abstract AI adoption in the construction sector has some hurdles besides its numerous benefits to the restoration of historical sites. This research paper investigates the possibilities of using AI solutions from construction and other sectors in restoring the 'Siq'. It first explains the concept of AI before illustrating its impact on the construction industry. It then describes Petra and the problems leading to its deterioration before explaining the values necessitating Petra's restoration. Further, the study focuses on the recent conservation at the 'Siq', possible changes in heritage restoration processes resulting from AI, and a discussion and conclusion on the use of AI in restoring historical sites. The study results show that technological breakthroughs can be used entirely to manage projects like the "Siq Stability" initiative. The study concludes that AI-based restoration processes increase the possibilities of adopting faster and cheaper approaches to rehabilitating Petra. The study contributes to architecture by reviewing the literature on heritage management, the "Siq Stability" initiative at Petra, and AI to investigate how digitalization in the construction sector disrupts traditional heritage protection processes. The concept of AI is new in architecture, necessitating the study's illustration of how heritage project managers at the 'Siq' can harness AI's benefits for seamless and faster restoration of the monument. The study explores the 'Siq', its deterioration problems, and values to show the need to take advantage of AI-based opportunities to foster enhanced heritage conservation approaches.

Keywords Artificial Intelligence, Restoration, Petra, 'Siq', Digitalization

1. Introduction

The digitalization in the construction sector is here to disrupt traditional heritage protection processes. Marc Lahmann, who is a PwC partner based in Switzerland, is one of the prominent analysts of the transformations that will result in using AI to manage such projects. In the article titled, "AI will transform project management. Are you ready?" Lahmann explains the expected AI-based changes in project management approaches [17]. He states that "The future of project management will be heavily influenced by technological breakthroughs, and there is no doubt that AI will change the course of how project management tasks are delivered and controlled in the future" [17]. The statement expresses the conviction that digitalization will disrupt the restoration of important World Heritage Sites like Petra, the Rose-red City in Jordan, by automating simple restoration tasks and predicting actions, analytics, and advice. AI-based restoration processes increase the possibilities of adopting faster and cheaper approaches from construction and other sectors in rehabilitating 'Siq'.

Petra is Jordan's most famous World Heritage Site. **Fig. 1** shows 'Siq' natural gorge measuring 12km serving Petra World Heritage Site as the main entrance [27]. In 1985, the United Nations Educational, Scientific, and Cultural Organization (UNESCO) registered Petra in the World Heritage List. While studying the concentrations of heavy metals in soil and dust from Petra, Eid Musa Eid and Omar Ali Al-Khashman revealed that Petra has numerous

ruins and monuments with unique distribution, durability, and architecture [5]. Petra contains over 2000 monuments like the 'Siq,' a natural gorge that has been under rehabilitation in recent years (UNESCO). Therefore, the site has various values that raise the need for its conservation.

The cultural and geological features of the 'Siq' endanger the site by exposing it to geological and natural hazards. As a result, the site's restoration becomes one of UNESCO's central technical support components to the national authorities conserving and managing Jordan's extraordinary heritage [27]. The need for rehabilitation arises from various factors, including diffusion of metals such as copper, zinc, lead, and iron due to wind direction [5]. Hence, UNESCO implemented the "Siq Stability" initiative to manage and mitigate such natural hazards.

Longhui Liao, Evelyn Ai Lin Teo, and Ruidong Chang studied the adoption of AI in the construction industry. The purpose of their study was the identification of critical factors inhibiting the AI adoption in Singapore's construction sector. The study reveals that AI adoption in the construction sector has some hurdles besides its numerous benefits to the restoration of historical sites [18]. The replacement of human workers is a crucial concern of using AI-based processes in rehabilitating Petra. The problem is logical as AI creates learning and self-direction programs and equipment that can perform activities traditionally performed by humans.

2. Objectives

Consequently, this research paper aims to investigate the possibilities of using AI solutions from construction and other sectors in restoring the 'Siq'. It proceeds by explaining the concept of AI before illustrating its impact on the construction industry. It then describes Petra and the problems leading to its deterioration before explaining the values necessitating Petra's restoration. Further, the study focuses on the recent conservation at the 'Siq', possible changes in heritage restoration processes resulting from AI, and a discussion and conclusion on the possibilities of using AI to restore historical sites.

3. Materials and Methods

3.1. Artificial Intelligence

Artificial Intelligence is a phrase that brings science fiction movies like Terminator to people's minds. The idea of AI originated from John McCarthy, the computer scientist who coined "artificial intelligence" in the 1950s to refer to the automation that protects Crete from invasion (McCarthy, 63). Jackie Marsh indicates that the masses came to know about AI in 1998 following the introduction of an electronic toy known as Furby that mimics personality development and language learning [21]. Marsh is a University of Sheffield's School of Education scholar who studied how the internet of things is changing games that people play. The study concludes that Furby influenced people's personalities depending on how one played with, and the duration spent playing with it [21]. Since then, other significant AI milestones keep emerging and have a massive impact on people's lives.

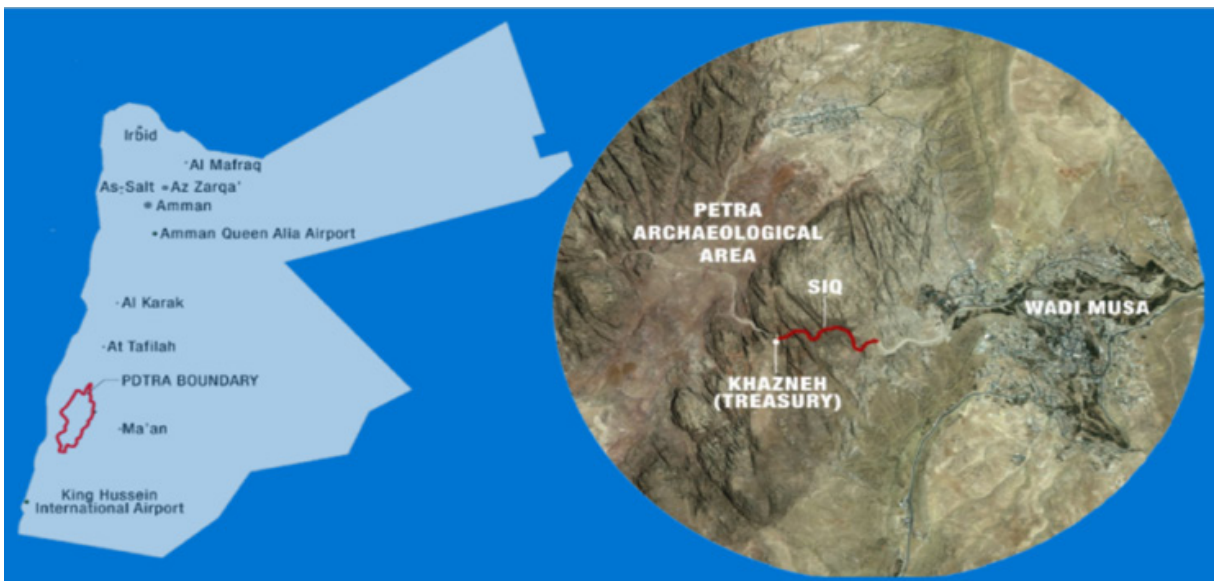

Figure 1. Map showing 'Siq' natural gorge measuring 12km serving Petra World Heritage Site as the main entrance (UNESCO, 2019).

Cynthia Breazeal, an associate professor at the Massachusetts Institution of Technology, created Kismet, the first significant AI milestone in 2000. The subsequent birth of self-driving cars in 2009 emerged as another critical milestone, thanks to efforts that Google puts in place to make the world a better place. Then, IBM contributed to making AI a reality by developing Watson, which managed to beat the highest-earning contestant, Brad Rutter, in Jeopardy! [10]. Also, Watson beat Ken Jennings despite his longest winning streak in Jeopardy! Subsequently, Google DeepMind developed AlphaGo between an application that managed to beat Fan Hui among other players who were Go champions.

Recent developments in AI keep emerging as the world embraces more digital technology in carrying out various tasks and procedures [12]. Creating a self-driving technology car firm called Waymo is one such milestone in 2016 after Google opted to take another significant step in producing self-driving cars. Stephen Hawking warned in 2017 about the impending possibilities of AI becoming the worst achievement in the history of globalization [26]. Finally, in 2018, Tesla's CEO Elon Musk highlighted the opportunities of using artificial intelligence to develop an "immortal dictator," as Google's Sundar Pichai cited that humans are working AI, which is one of the essential things in the world [26]. Therefore, people are currently interacting with AI in several ways.

Several facts prove that AI is a significant part of various things people interact with or do in the current world. Google Maps is an outstanding example of the use of AI to facilitate navigation. Facebook Messenger also has over 30,000 chatbots powered by AI that millions use in making purchases [13]. Spam filters in emails are another aspect that shows that AI helps people get rid of possibly infected mails besides powering suggested responses for text email and messaging apps. Therefore, many people are using AI even though some are aware of it while others do not know it.

3.2. AI in the Construction Industry

As Jose Blanco et al. shows, the construction professionals embrace more generalized and collaborative approaches and tools like Integrated Project Delivery, Open BIM, etc. [9]. Equally, the democratization of technological development from other sectors results in new measures and tools in construction sites and offices. Lately, there has been an increased use of AI because of efforts that people put in place to remove barriers blocking its generalized access. Like other sectors, construction is adopting all the AI advancements due to the significant influence of technology in other industries [9]. For instance, drones are some of the AI technologies that have been widely used in different industries like photography, and security is one of the technologies within the construction industry. Architects nowadays rely on drones' virtual reality capabilities to envision incomplete projects or select the best setting as predicted by AI.

The implementation of AI solutions in the construction sector remains behind despite the sophistication of its customers. The severe under-digitization emerges in various construction stages, including preconstruction and rehabilitation phases. However, Juszczyk revealed that the adoption of technological solutions powered by AI algorithms keeps growing [15]. The evolving technologies enable construction professionals to overcome numerous significant challenges such as safety concerns and schedule and cost overruns that majorly affects the construction industry. Hence, people expect a modest proliferation of AI in the construction industry soon. Indeed, even though managers are highly interested in AI solutions because it increases return on investment, their implementation remains a challenge to many construction companies [15]. The challenges in adopting AI include a lack of capabilities like tools, personnel, and processes for implementing the solutions.

Admittedly, a change is coming because stakeholders like service providers, contractors, owners, and operators taking part in various construction stages have started conceiving the possibilities of using AI to enhance architectural approaches [15]. Adjacent sectors like manufacturing, pharmaceutical, and transportation are indeed exhausting traditional barriers between them as they try to operate more like an ecosystem. An example is the use of industry-specific algorithms, solutions, and tools across industries that enable market entrants to compete with traditional capital projects.

AI methods have increased the ability to work across various industries, which further lowers the market barriers. Such advances are significant in determining future ecosystems even though the construction players can only realize their role [15]. Hence, construction companies will need to adopt faster strategies of catching up with AI techniques and tools to rekindle their hope of competing with new entrants in the market. Such an effort will compel construction firms to direct more resources in the building of the necessary capabilities.

4. Results

4.1. AI in the Construction Industry at Present

The current cases regarding the use of AI in the construction industry are still relatively nascent. However, a few startups adopt AI-focused practices, enabling them to gain considerable attention and traction [16]. Below are some of the current AI capabilities in the construction sector.

- Project schedule optimization: AI facilitates the consideration of numerous project delivery alternatives besides continuously enhancing construction projects' overall planning.

- Recognizing and sorting images: the existing AI enables construction players to evaluate video data from construction sites for identifying unsafe behavior of workers and aggregate the information to inform education and training priorities in the future.
- Enhancing analytics platforms: the current AI technologies help in the collection and analysis of data relayed by sensors that foster an understanding of patterns and signals for prioritizing preventive maintenance, cutting costs, preventing unplanned downtime, and deploying real-time solutions.

4.2. AI in other Sectors

The use of AI in other sectors is relatively higher than in the construction sector. The following are some of the critical sectors using AI.

- The transport sector is the first industry that uses AI to provide better means of optimizing traffic and optimize routes. Reinforcement learning is an AI projected to be present in the future allow algorithms to use trial and error in learning [1]. Hence, technology provides a more effective means of optimizing transport routes.
- AI is also used in the pharmaceutical sector to predict constructability issues [20]. The industry leads other sectors in adopting AI due to considerable budgets in adopting intelligent solutions.
- AI also optimizes the retail sector's supply chain to facilitate the management of inventories and materials [7]. The technology has reduced manufacturing downtime, like reduced variability, costs, and logistical burden, among other sector achievements.
- In the healthcare sector, AI is leading to enhanced image recognition capabilities [20]. As a result, medical practitioners find a more straightforward means of detecting factors leading to various conditions.
- The robotics industry trains robot arms to learn simulations that aid their movement. 3-D printing and modularization are also on the rise.

4.3. PETRA

a). The World Heritage Site

In Jordan, Petra is a region that many consider being the world's most intellectually intriguing and historically significant regions. The kingdom boasts over 10,000 recognized archeological sites, with Petra being the most famous World Heritage Site [4]. Many people consider Petra to be among the most impressive archeological sites in a Nabatean city comprising of Limestone Mountains and colored sandstone. Petra is derived from a Greek word meaning the stone. The Bible refers to it as "Sela", a Hebrew word meaning the rock. The Red Rose City is another famous name of the city that resulted from its sandstone's wonderful colors [4]. The archeological site attracts huge numbers of tourists who visit Jordan every year. However, erosion and weathering problems resulting from human and natural causes remain a significant problem.

Climate

Jordan is predominated by a Mediterranean climate that leads to the cold and wet climate during the winter with hot and dry summers. During spring and autumn are often short periods where the region experiences quick transitions [2]. Petra is also a steppe-like, semi-arid area that supports small plants' growth during spring and winter. The site is generally characterized by cold and dry winters and hot and dry summers.

Economy

Besides its historical value, Petra has significant economic value for Jordanians and Nabateans. Petra was considered as the capital of the Nabateans Kingdom and its trade center [2]. For instance, Petra is strategically positioned on the trade routes used during ancient times, thereby facilitating communications between the Mediterranean and Hejaz ports. Petra is located in a naturally defensible region that offers a safer and more comfortable means of conducting trade. Trade enabled the city to achieve a great civilization owing to its resultant economic profits [2]. Indeed, the trade between Nabateans and the Roman Empire, among other nations, improved the region's economic situation by enabling them to get the money for constructing the eighth wonder of the world.

b). The problem at Petra

The weathering process is the knowledge aspect that endangers most of the monuments in the region. El-Gohary reveals that weathering has led to the erosion of over 80 percent of the site’s sandstone façades [11]. UNESCO also inscribes Petra in its list of the most endangered historical sites in the world.

The weathering process in the ancient city results from human activities, lack of maintenance, and natural processes, as summarized below.

i Water erosion

The hydrological systems the Nabatean put in place indicate their awareness of the impending problems resulting from water erosion. **Fig. 2** shows flash floods which lead to water erosion at Petra during rainy seasons [29]. Hence, they took measures to protect these monuments from rainwater impacts by constructing ceramic pipes and their faces and bedrocks according to Petra’s topographic relief and the position of The Theatre and Al Khazneh (the Treasury) at the end of ‘Siq’. Besides, Nabateans also used multilayered motor in

covering horizontal surfaces to protect them from running water. Lately, the water erosion experienced at the site results from the Nabateans' water systems [11]. Water clogged in the Nabatean channels and earthquakes creates cracks and joints, thereby exposing Petra to attack by water from outside and from within.

Figure 2. Flash floods in Petra (The Treasury, Petra – Jordan… Flash Flood, n.d.)

ii Earthquakes

UNESCO Report indicates that Petra is in a tectonically active area. El-Gohary reveals that the three main faults in the region include the Wadi Arab Fault, the Abu Ullayqa Fault, and the Al Matahan Fault

The region has been experiencing a series of earthquakes whenever seismic slip occurs between the faults.

iii Wind erosion

Petra monuments also weather due to wind erosion. Wind destroys the World Heritage Site because of wind-blown sand and enhances salt crystallization, among other agents of weathering [11]. The wind-blown sand mainly gets into contact with the lower parts of the ruins and monuments, thereby restricting this weathering agent's effects to the lower parts.

iv Salt crystallization

Weathering in Petra also results from salt crystallization. Previous researches indicated that calcium sulfate and sodium chloride are some of the leading chemical components of samples drilled from the site [11]. The study results showed that wind speed significantly contributes to salt crystallization, especially when it sweeps across the area at a fluctuating rate.

v Thermal shock

Thermal shock at Petra results from massive daily and seasonal temperature variations. The wide variation leads to more expansion of some materials than others [11]. A subsequent significant contraction during cold hours of the day can then lead to cracks, which lead to weathering.

vi Biological weathering

The grass is a critical cause of biological weathering at Petra due to its overgrowth at the heritage site. The most affected area is the Corinthian Tomb, which is among the facades with overgrowth because of water availability [11]. Damage may also result from other biological causes, including insect colonization.

vii Human activities

The monument also deteriorates due to human activities. El-Gohary cites tourism as the primary destructive factor [11]. **Fig. 3** shows a 15,000 seating capacity amphitheater eroded by modern tourists as they scramble across the seats [19]. The study concludes that traffic pollution leads to the disappearance of masonry marks.

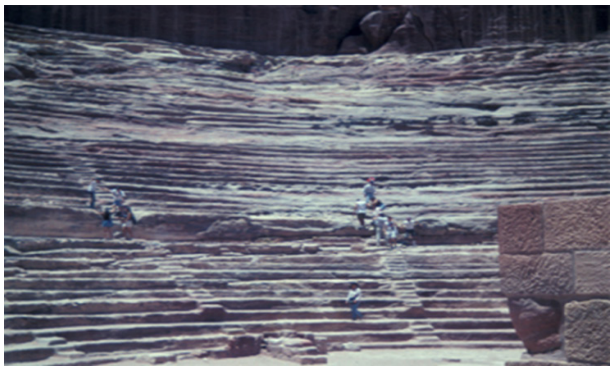

Figure 3. 15,000 seating capacity amphitheater eroded by modern tourists as they scramble across the seats (Lubick, 2004).

c). VALUES NECESSITATING THE RESTORATION OF PETRA

Petra is associated with several values besides its outstanding value and significance. The following are some of the types of values that necessitate conservation.

i Economic value

The site has a significant economic value gained from the monetary benefit resulting from sales of tickets. The Jordanian Treasury, Petra WHS, and PDTRA benefit from such money [3]. The site also enables people to earn a living by creating employment opportunities in various industries stemming from its economic value.

ii Social values

Petra is of social value for multiple local communities living near the site. The people's past connections to the site, and being that many of them work at the site, make it socially valuable [3]. The shared identity attaches them to the site where they ascribe to the same communal values.

iii Natural values

The site’s landscape setting and cultural landscape significantly depend on biodiversity [3]. The area contains

rich endemic species, forest cover, among others.

iv Education value

Petra's educational value is very high due to its position in Jordanian and international geography and history. The site relates to numerous fields and levels of study [3]. Specifically, Petra is a source of multiple educational opportunities for people training in architecture, natural science, conservation, and hydrology.

v Intangible values

Intangible values also make Petra a recognizable heritage site. The values include the traditions and cultures of people attached to it [3]. Examples of intangible values include tent-making craftsmanship: food, animal husbandry, and handicraft.

vi Research value

Petra has significant research value for historians, architects, and archeologists who research its trade links, history, buildings, and settlement patterns. The unique rock formations and water systems significantly facilitate further studies in hydrology [3]. Environmental research can also be conducted on Petra's natural habitat.

vii Spiritual values

Petra has numerous past and present places and buildings of spiritual significance and worship. Further, spirituality is engraved by the many tombs representing Petra's iconic imagery today [3]. An example is Tomb 825.

viii Artistic value

Petra has artistic values because of the artistic expression in architectural composition and media [3]. The developments include elaborate hydrological monuments and simple vernacular settlements using the Neolithic period's best available materials.

ix Landscape values

The site's setting caused by its surrounding geological formulations is also an integral aspect of the monument that makes it unique worldwide [3]. Therefore, the site has a geological value forming a discrete cultural landscape.

x Historical value

The Nabatean civilization and its preceding and succeeding civilization make Petra one of the most recognized cultural and historic sites. The numerous trade links and important settlement further emboldens its historical value [3]. Thus, the site remains a crucial region where Explorers and archeologists excavate.

PETRA RESTORATION: CONSERVING THE 'SIQ'

Numerous restoration programs have been taking place at the Petra, and the "Siq Stability" initiative is one example. Italy collaborated with UNESCO to restore 'Siq' between 2011 and 2018. The 'Siq' is a natural gorge measuring 1.2 km [27]. **Fig 4** shows a hazardous region at a spectacular tourists' entrance along the slopes of 'Siq' [28]. It serves as the primary entrance to the site by snaking through numerous sandstone cliffs. The 'Siq' has unique cultural and geological elements that expose it to geological and ecological hazards. Accordingly, the Government of Italy has supported UNESCO with the management, mitigation, and assessment of natural risks at 'Siq'.

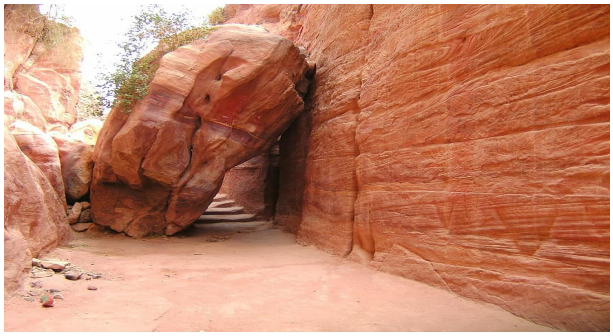

Figure 4. A hazardous region at a spectacular tourists entrance along the slopes of 'Siq' (Petra, Jordan, rock, pierre, throat, nature, danger, fall, n.d.)

Phase 1

The first stage of the restoration program involved assessing the site to determine whether the landslide could occur during the restoration [27]. Programmers were also trained to equip staff with the required skills for supplying and installing the tools and equipment at the 'Siq' besides getting conservation skills for running the program. As a result, reliable and accurate techniques were used in installing a unified monitoring system. The project personnel then used advanced techniques to comprehensively document the site before establishing a new GIS platform for management, analysis, and data storage.

Phase 2 and 3

The phases involved operationalization of landslide mitigation by implementing urgent and priority interventions. The stage involved the execution of the restoration work to conserve the 'Siq'. In this phase, the local staff gain hands-on experience as they restore the monument, an element that created facilitated a comprehensive restoration by creating a strong base for accompanying traditional knowledge with scientific and modern conservation skills. The interventions targeted the most dangerous the upper plateau and the slopes of the "Siq" [27]. Then, awareness-raising and capacity development activities followed to secure Petra's future operations.

5. Discussion

AI can lead to efficient and cost-effective processes used during the three restoration phases in the 'Siq Stability' initiative. First, AI can facilitate the exploration of better restoration efficiencies by UNESCO Amman Office, Italian Agency for Development Cooperation, and other partners in the restoration program [27]. AI has led to the development of programs and software that simplify environmental analysis and facilitate building calculations. Nowadays, architects restoring cultural heritage sites can make good use of information at their fingertips and pull data like material ratings, weather, and temperature, among other aspects whose compilation required more time [8]. As a result, the solutions may reduce the time needed to, for example, evaluate landslide risks at the site.

Likewise, smart technologies enable architects to design sustainable restoration processes. For example, smart stormwater and intelligent lighting solutions provide the possibility of working such management systems into blueprints. These milestones could have been inexistent almost a decade ago (in 2011) during the process's initial stages [16]. The pervasive growth of technology, which now allows even smaller practitioners to work on larger restoration projects, may be considered. Involving smaller practitioners increases the possibilities of developing cost-effective and efficient proposals by tapping into various resources, including the internet.

AI can provide faster means of getting from one point to the other during the restoration at the 'Siq'. Shortcuts may be among the harmful elements when planning to restore various historical sites. Nevertheless, Building Information Management (BIM) is available to significantly reduce the time architects spent while planning and designing conservation works [22]. McArthur further explains that Computer-Aided Design (CAD) helps create two- and three-dimension restoration models. BIM provides possibilities of gaining more from the existing technology by incorporating costs, product information, and time for architects to understand their restoration projects' entire scope. Additionally, BIM and other design software applications can help create a clear picture of heritage sites, including their renovation plans. Hence, the appropriate leveraging of AI can allow the design of longer-lasting restoration projects by taking data and identifying inefficiencies or trends without spending significant time during data analysis.

Furthermore, the efficiency of incorporating AI in such projects results from its ability to walk stakeholders through the restored site before commencing the restoration project. Drones and such technologies can bolster some of the approaches adopted during the three 'Siq' restoration phases. Besides, augmented reality is like virtual reality that thrives in the video gaming industry since the technology can also be used by architects and designers [14]. According to Ibáñez, María-Blanca, and Delgado-Kloos, AI improves the possibilities of stimulating everything, including feedback, sounds, and aesthetics, before immediately implementing them into the design before spending money on materials and construction. Therefore, the solutions can now allow stakeholders in restoration projects to have the first-hand experience of the proposed restoration initiatives at 'Siq' in the future.

Restoration process need a constant update, and AI can be useful in this respect by updating restoration works that are still in progress at the 'Siq' to preserve its values. The construction sector is a significant industry in the world's economy because it employs about 7% of the labor force people, even though its technological advancement remains low. However, there is an excellent possibility of integrating AI into restoration, which can reduce up to 20% of the costs [16]. Construction practitioners can use computers to analyze job sites and identify potential risks like landslides to decrease possible delays and safety hazards.

Similarly, AI improves the possibilities of making the 'Siq' more secure in the future. Video security has been in use on campuses, apartments, offices, and businesses to monitor individuals' movement despite the possibility of missing a significant volume of collected footage when nobody is charged with the responsibilities of going through the recordings [16]. On the other hand, integrating smart security into historical sites under rehabilitation improves the possibilities of scanning and detecting suspicious operations automatically before sending alerts to people in charge of the project [6]. Smart locking systems are another AI solution that can help restrict access to various parts of the heritage sites to users who do not have a keycard, thereby reducing losses that increase restoration costs.

AI takes care of energy-related expenses through its maintenance optimization capabilities of fostering various platforms for managing energy. The technology can help in the restoration by determining usage patterns for creating ideal energy conservation conditions. For example, the time has come when technologies like nest thermostats can be included in the heritage sites to regulate their temperatures and alert tourists if the temperature rises or dips to a hazardous degree [25]. The historical sites can also be fitted with AI devices for taking in and analyzing data from sensors to monitor malfunctions by providing easier means of the efficiency and performance of restored areas.

Finally, informed large-scale interaction design can be achieved through AI. Video feeds help worldwide collect data on usage patterns and behavior of various individuals [25]. For instance, AI already helps in optimizing flow in multiple places like airports and museums. Architects can advance to the next level by adopting restoration procedures based on how people feel while in public spaces like 'Siq' and their surroundings. This will enable

them to use the available technology to the maximum.

6. Conclusion

Technological breakthroughs can be used fully in the management of projects like the "Siq Stability" initiative. Undoubtedly, AI will revolutionize the delivery and control of restoration projects in the future. AI will indeed be used in carrying out simple and complex tasks. AI can foster automation of various management processes during such restoration projects and enable architects to streamline and automate multiple standardized tasks by integrating workflow and automating processes. The technologies directly integrate updates of various project budgets into the report for forecasting the budgets without involving manual interventions.

AI provides means of adopting a more robust plan for restoration projects using programmed logics in auto-scheduling. As a result, this will facilitate automatic tracking of the status of various tasks performed at the site and alert project managers to intervene in exceptional scenarios. Therefore, it is evident that the digitalization of restoration processes increases the possibilities of adopting faster and cheaper approaches to rehabilitating Petra. The existing AI in the construction industry cannot facilitate the whole management of rehabilitation programs like the “Siq Stability” initiative. Other sectors are ahead because they have adopted AI solutions to a considerable extent. The only AI options in the construction sector include millions of project delivery alternatives for continuous project planning enhancement by project schedule optimization personnel. Hence, architects can consider using AI technologies from other sectors in various restoration processes at Petra.

Route optimization technology in the transport sector can help optimize the planning of ‘Siq' rehabilitation projects. Its capabilities of assessing endless combinations based on similar initiatives to optimize the best path can enable conservation workers to save resources used to waste in the past. AI solutions for predicting pharmaceutical outcomes can help in the investigation of constructability issues. Consequently, UNESCO and partnering agencies can use it in projecting structural stability of the gorges, constructability, and risks before providing insights to decision-makers who may then save vast amounts of money. Therefore, AI solutions offer cheaper and efficient restoration approaches to conserving World Heritage Sites.

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