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Potentials of Employing Digital Technologies to Enhance Multi-Sensory Experiences in Open Public Spaces in Bahrain

* ¹ Dina Abdullah, ² Najla Allani

¹ & ² Department of Engineering, Faculty of Architecture, University of Bahrain, Bahrain

¹ E-mail: diabdulla@uob.edu.bh, ² E-mail: nallani@uob.edu.bh

¹ ORCID: <https://orcid.org/0009-0004-6128-8586>, ² ORCID: <https://orcid.org/0000-0002-1970-4388>

Abstract

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The emergence of digital technologies such as Artificial Intelligence (AI), Augmented Reality (AR), Virtual Reality (VR), and the Internet of Things (IoT) offers potential to improve multisensory experiences in open public spaces, moving beyond visual dominance to support richer social interaction and greater user comfort. While applied globally, this approach remains underexplored in Bahrain. The research employed a qualitative approach, examining related literature and international and regional case studies to explore how these tools could be used in the context of Bahrain. It proposes potential applications of these tools within three key areas: Environmental control, User engagement, and Cultural preservation. Moreover, it identifies critical implementation challenges, including climate adaptation and digital accessibility. The research provides a structured framework for integrating digital technologies to create meaningful, context-sensitive experiences in Bahrain's public realms, offering practical insights for policymakers and designers in similar regional contexts.

Keywords: Open Public Spaces; Multi-sensory Experiences; User engagement; Digital Technologies.

1. Introduction

Open public spaces are more than leftover spaces between buildings; they are dynamic environments that shape our cities' social and cultural identities by fostering connections with nature and establishing social and cultural bonds between the built environment and users. Traditionally, urban design has relied on the visual sense as its primary focus, overlooking the role of other senses in perceiving the surrounding environment. Despite that, there has been a growing interest in recent years in creating designs that cater to all the senses by immersing users in rich, multi-sensory experiences (Ranne, 2019).

Research has shown that people experience spaces on a deeper level when all their senses are involved, allowing them to perceive, think, and draw meaning from their everyday encounters, which in turn enhances both their physical and mental well-being. Therefore, a balanced integration of all senses (sight, sound, touch, smell, and taste) allows for a more holistic and thoughtful approach to design (Tabassum, 2024). Multimodal environments often create meaningful and memorable experiences, encouraging social interaction, which builds community cohesion and promotes a sense of belonging to the place (Hanna & Parvaresh, 2024).

Digital tools such as Artificial Intelligence (AI), Virtual Reality (VR), Augmented Reality (AR), and the Internet of Things (IoT) have created more possibilities to be explored in urban design and established unique ways to enhance user interaction, comfort and engagement as opposed to traditional design methods (Kim et al., 2020; Ajina & Al-Saaidy, 2025). According to Kim et al. (2020), these technologies can transform public spaces into more interactive and engaging settings that allow people to have a unique perception of the space, due to their real-time responsiveness, interactive features, and the possibility to personalize experiences.

Despite the widespread use of digital tools to enhance the multi-sensorial experiences in public spaces globally, this area remains underexplored in the Gulf region, especially in Bahrain. This paper aims to address this gap by examining the use of digital tools in open public spaces worldwide and proposing ways to adopt some of these tools and methods in the Bahraini context, given its unique climate and cultural identity.

The primary questions guiding this research are: How can digital technologies enhance multi-sensory experiences in public spaces? What are the opportunities and challenges of implementing them in Bahrain?

The paper investigates previous research done in the areas of creating multi-sensory experiences, urban design, and the design of open public spaces. Additionally, it examines six international and regional case studies of digital applications in public spaces, highlighting the opportunities and challenges of implementing them in Bahrain.

2. Literature Review

Considering all senses while designing enables a more comprehensive and holistic perception of spaces; people tend to experience spaces more intimately when all their senses are involved and enticed (Lefebvre, 1991). Bruce et al. (2015) argue that using all visual, auditory, tactile, olfactory, and gustatory inputs when engaging with an urban space enhances users' perception of it and improves their overall health and well-being.

2.1 Designing for all senses

An intentional design of public spaces can affect the way people feel after being in that space, helping them establish a meaningful connection with it. Therefore, understanding the effect of these senses on the overall human experience is essential (Amen et al., 2023; Aziz Amen & Ali, 2025). For example, the visual aspect of designing urban spaces often focuses on natural elements, such as trees, water, and greenery, which not only add an aesthetic dimension to the design but have also been proven to reduce stress and improve cognitive health (Tabassum, 2024; Hartig et al., 2014).

Moreover, the auditory aspect of design plays a significant role in controlling people's moods and states of mind. Joyous and relaxing sounds of nature, for instance, have a calming effect on people compared to industrial and traffic noises, which can negatively impact the user's comfort levels (Pijanowski et al., 2011). In addition, employing certain textures and materials in design can enhance the overall impression of the space. Choosing materials that complement the concept and design intention can provide a sense of unity among all design elements, making them easier for the eye to recognize (Classen, 1997; Tabassum, 2024).

Furthermore, the olfactory sense adds another dimension to the richness of the experience. Although often overlooked by designers, pleasant scents of flowers, trees, and food can improve the overall feel of the space and create a memorable impression for the user (Henshaw, 2014). Finally, gustatory elements, such as food markets and dining areas, contribute to building an immersive sensorial experience, which creates opportunities for social interaction and cultural exchange (Lupton, 1996).

Designers are encouraged to move beyond unisensory approaches and cultivate multisensory experiences within spaces. This triggers cross-connected neural activity in the minds of users, offering a more intense, significant, and meaningful cognitive impact (Oviatt, 2017). Moreover, by engaging all senses, designers can more effectively evoke a particular sensation or a specific emotional response from the users of these spaces (Ranne, 2019). Cognitive engagement through creative and innovative experiences serves as a crucial way of enhancing the multisensory experiences in open spaces. For example, interactive public art and installations challenge users' minds and encourage physical interaction, thereby improving their mental and physical health (Erel, 2022).

2.2 Enhancing Multi-sensory Experiences Through Digital Tools

With the rise of digital technologies in the past few decades, public spaces have benefited from various applications to create efficient designs (Mehan & Mostafavi, 2024). Research on digital applications, such as Artificial Intelligence (AI), Augmented Reality (AR), Virtual Reality (VR), the Internet of Things (IoT), and others, has proven that these technologies could be employed to improve the multi-sensory experiences within the space, due to their ability to gather instant data, provide quick analysis, and offer immediate outputs (Ajina & Al-Saaidy, 2025). This section discusses the most common digital tools and their role in contributing to the design of open public spaces.

2.2.1 Artificial Intelligence (AI)

In urban spaces, Artificial Intelligence (AI) could be used for gathering and analyzing information about foot traffic and users' movement patterns within spaces, allowing for a real-time adjustment to lighting, sound, and thermal systems. All of which contribute to creating an enjoyable and comfortable experience for the users (Hanna & Parvaresh, 2024; Szpilko et al., 2023).

2.2.2 Augmented Reality (AR), Virtual Reality (VR), and Extended Reality (XR)

In their paper *'Emerging technologies in urban design pedagogy: augmented reality applications'*, Mehan and Mostafavi (2024) explored the potential of using technologies such as Augmented Reality (AR) and Extended Reality (XR) in urban design and spatial planning. They highlight how these digital tools facilitate visualizing and interacting with urban environments, ultimately creating a rich interactive user experience, improving design proposals, and creating human-centric urban design solutions.

According to Mehan and Mostafavi (2024), AR and XR technologies offer a unique blend of technology and physical form, where designers can add a digital layer to an existing physical structure, making it easier to visualize and comprehend spatial relationships. These tools not only serve to engage the user in an immersive experience but also aid in solving significant urban challenges.

Additionally, AR has been widely used in the Arts, especially in public art installations. Applications such as Artive and Adobe Aero could be used by artists, allowing them to easily explore and expand their artistic abilities beyond traditional means of expression, enhancing their creativity in multi-media storytelling (Young & Marshall, 2023).

Moreover, Virtual Reality (VR) transports users to a completely different world, offering a creative and novel way to engage them in a unique journey. VR systems are usually comprised of tracking sensors, a head-mounted display (HMD), and high-performance computers. All of which work together to create this immersive experience. While HMDs receive visual and auditory inputs, sensors track head and hand movements, allowing the system to control users' interactions

within the environment (Riva et al., 2012). These technologies often detach users from the real-world and engage them in a completely made-up, virtual environment (Xiang, 2024).

Therefore, Virtual Reality (VR) could be incorporated into the design of public spaces by allowing users to be engaged in intense multi-sensory experiences. It can also create broader possibilities for stakeholders to visualize possible ideas for urban developments and solutions to current urban issues, through their ability to build a virtual world and allow people to be a part of it (Pham et al., 2025).

2.2.3 The Internet of Things (IoT)

The Internet of Things (IoT) is a network of physical objects such as devices, vehicles, and appliances that are equipped with sensors. These devices, which are often referred to as smart objects, use embedded sensors to collect and share real-time data (Al-Fuqaha et al., 2015; Doulaveras, 2025).

There are multiple purposes for using smart devices, and they often work within a more complex network of other devices and systems. Some of the major benefits of IoT could be utilized to enhance the multi-sensory experiences and improve the conditions of public spaces by monitoring environmental qualities and offering immediate responses (What Is IoT, 2023). Their ability to gather instant data on how these spaces perform in terms of temperature, lighting, humidity, air quality, and foot traffic is essential in proposing immediate possible solutions and ways to make users' experiences more comfortable (Hanna & Parvaresh, 2024).

2.3 Digital Placemaking

Placemaking as a concept builds on the urban theories of Jacobs (1961), Whyte (1980), and Gehl (2017) of humanizing public spaces by keeping users at the center of the design. In its essence, placemaking emphasizes human-scale approaches to design that foster social cohesion, build a sense of place identity, and establish a connection between people and their built environment (Urbanowicz & Nyka, 2016).

In recent years, placemaking started to intersect with the use of digital technologies and expanded into the field of digital placemaking. This development allowed for the utilization of digital tools and technologies in reshaping traditional placemaking into a more immersive and interactive experience of the urban environment. Technologies such as augmented reality, embedded sensors, and artificial intelligence encourage human collaboration and participation in urban spaces, shifting the role of users from passive observers to active contributors to the spatial experience (Fredericks et al., 2016).

In addition, as these technologies are being utilized to produce a creative and communicative urban setting, open public spaces are transforming into adaptive interfaces, able to sense, interact, and engage with the changing circumstances of the built environment (Ouda et al., 2022). Lastly, while some of these tools create more comfortable experiences, they are crucial in enabling communication among stakeholders, allowing for broader possibilities for improving user experience of public spaces (Kim et al., 2020; Toland et al., 2020).

2.4 Research gap and aim

Despite the widespread use of digital technologies in the design and management of public spaces worldwide, research in this area remains limited in the Gulf region, particularly in Bahrain. To enhance the multi-sensory experiences within public spaces in Bahrain, this paper investigates the digital tools that could be implemented to achieve that and proposes ways to apply these technologies in Bahrain. Ultimately, it serves as a roadmap for decision-makers to facilitate the incorporation of digital tools into future design and development of open public spaces in Bahrain.

3. Materials and Methods

The research employs a qualitative approach, drawing on a review of the literature. The literature is obtained through systematic research through scientific papers and open-access online sources to gather knowledge about global and local applications of digital technologies in public spaces and enhance the multi-sensory experiences of the users in these spaces. The paper examines international and regional case studies of projects that employ digital tools such as AI, AR, VR, and the IoT in their public art installations, influencing people's interactions within those spaces.

The case studies were chosen based on a set of criteria. First, to showcase the diverse applications of digital tools across various types of projects. Second, to suggest innovative methods to engage the users and enhance their multi-sensory experiences, serving as a source of inspiration for public spaces in Bahrain. Finally, the case studies are chosen to span multiple geographical regions, international and local, providing more potential for implementing these technologies in countries similar to Bahrain in terms of climate, culture, and social values.

Six case studies were selected from different parts around the world, employing different digital tools and targeting various uses and applications. Upon analyzing the case studies, a comparison is made to identify the technologies used in these projects and propose possible ways to implement them in open public spaces in Bahrain. The analysis also highlights the significant challenges to be faced if these technologies were to be used locally.

3.1 Impulse by CS Design and Lateral Office, Canada

Impulse, designed by CS Design and Lateral Office, is a public art installation in Montreal, Canada. The installation consists of a series of seesaws equipped with built-in LED lights and speakers, as illustrated in Figure 1. This art installation is designed to create a welcoming, fun, and engaging experience for users of all ages. The attractive light used in the design invites users to try the seesaws. Consequently, sound emanates from the speakers interactively and unpredictably, transforming the open plaza into a creative playground where the interplay of light and sound allows kids and adults to enjoy their time (Sinthia & Sarker, 2024; Nowara et al., 2025).



Figure 1. Impulse installation (Lee, 2023).

3.2 Waterford Walls project in Ireland, 2021

An interesting application of Augmented Reality (AR) in Art is its use as a tool for storytelling. A collaboration in Waterford, Ireland, as part of the Waterford Walls project in 2021, involved international artists painting large-scale murals around the city (Young & Marshall, 2023). The project aimed to bring these murals to life by incorporating augmented reality artwork to layer on top of the existing murals. Subsequently, the visitors were directed to download an application on their phones to enable them to view the AR Artwork, adding an exciting dimension to the original 2D artwork. Figure 2 shows the initial artwork and an image of the Augmented Reality layer added on top (Young & Marshall, 2023; De Luca et al., 2022).



Figure 2. Waterford Walls project (Young & Marshall, 2023).

3.3 Birr Vintage Week AR project in Ireland, 2021

In 2021, a collaboration took place as part of Birr Vintage Week and Art Festival in Ireland (Birr 20:20 Vision CLG, 2020). This project used abandoned architecture as its main canvas for a series of AR artworks, designed to be site-specific and to tell a story about the site with an added digital layer on the walls of the abandoned buildings (Young & Marshall, 2023). This is an example of how digital tools can help activate neglected urban spaces and bring life back to them by attracting visitors and tourists. Figure 3 illustrates one of those buildings before and after the added augmented artwork.



Figure 3. Birr Vintage Week AR project (Young & Marshall, 2023).

3.4 Translation Stream in Abu Dhabi, 2023

Translation Stream is a public art installation designed by Atelier Lozano-Hemmer in 2023 in Abu Dhabi, as a part of Manar Abu Dhabi exhibition. The artwork presents a beautiful and creative way of bridging the gap between culture and technology. The installation presents a stream of words from poems by contemporary Emirati poets in a slow, steady stream of letters projected across a trail, lighting the way as people pass by and walk along it, as shown in Figure 4. This interactive installation employs digital sensors to create an instant interaction between people walking and the movement of the letters. When people move, sensors detect their movement, and the letters follow suit (Manar Abu Dhabi, 2023).



Figure 4. Translation Stream, Abu Dhabi (Lozano-Hemmer, 2023).

3.5 Future You in the United Kingdom, 2019

Future You is an AI-powered public art installation designed by Universal Everything in 2019 as part of the AI: More Than Human show in the United Kingdom. This artwork engages people's senses by mimicking the movements of visitors' bodies in the exhibition, as shown in Figures 5 and 6. It aims to create a synthetic image of people by mirroring their reflections and adapting to their body movements. The forms start simple and get more complex and creative as the movement increases. This artwork processes data through body-tracking sensors and specialized software that detects and interprets body movement, creating synthetic viewer versions. The artwork offers 47,000 variations of options and possibilities that only come to life when a person interacts with it (Li, 2020; Bowen et al., 2020).



Figure 5. Future You installation (Universal Everything, 2019).



Figure 6. Future You installation (*Universal Everything*, 2019).

3.6 The Sound of Millstone, Riyadh, 2024

The sound of Millstone is an Artwork by Artist Najla AL Qubaisi that was designed as part of the Noor Riyadh Art festival in 2024 in Riyadh. This interactive art installation serves as a cultural and historical testimony of the songs rural women from the Najd region in Saudi Arabia used to sing while grinding at the millstone. With the intention of portraying the process of producing flour in the past, the artwork employs projection mapping to form a circle resembling the shape of the millstone. At the same time, Artificial Intelligence is utilized to generate dynamic shapes and movements that move across the surface of the millstone in a harmonious interaction with the folk songs and the sound of grinding grains, as shown in Figure 7 (*Riyadh Art*, 2024).

The user is invited to travel in time to the past to witness the production of flour, as the women used to turn the millstone to crush the grains into flour, while listening to the songs they used to sing during the process. This is an example of how digital tools are used to reflect and preserve the culture (*Riyadh Art*, 2024).

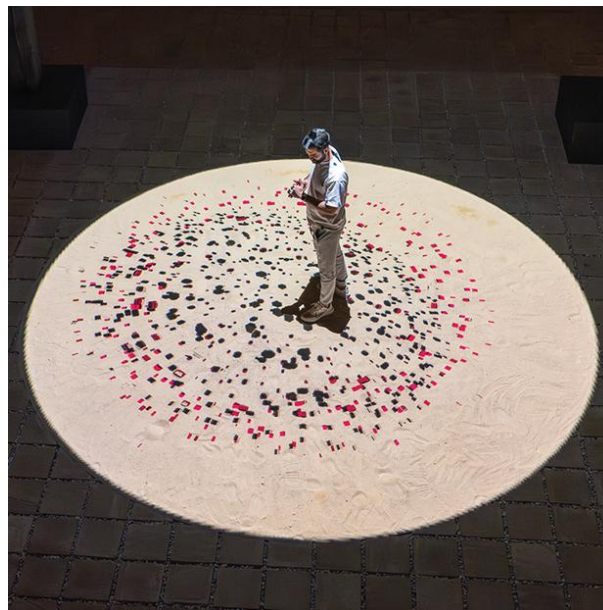


Figure 7. The sound of Millstone Artwork (*Riyadh Art*, 2024).

4. Results

The case studies investigated serve as a basis for understanding how digital technologies in Art can enhance the multi-sensory experiences in public spaces, and the extent of their effect on the depth of the human experience. A cross-comparison between the six projects covered the following areas: technologies employed, targeted sensory modalities, level of engagement between the users and the artwork, type of user interaction, and the impact of the installations on users. All of which are shown in Table 1 below.

It is evident from the analysis that although the case studies cover a wide range of technologies, most of them primarily focus on the visual sense, which limits the depth of the human interaction to only the visual aspect and restricts the potential of these technologies to create a fully immersive experience within the built environment. Despite that, some case studies were more successful than others in curating specific experiences and triggering certain emotions in users.

The case studies were also analyzed based on the users' engagement levels, by dividing them into three main levels: passive, reactive, and immersive. Passive interaction mainly targets the visual sense and requires minimal physical interaction with the artwork, such as 'Waterford Walls' and 'Birr Vintage' projects; reactive is where the project is more responsive to body movement, which is evident in projects like 'Impulse' and 'Translation Stream', where physical exchange activates the artwork, and immersive is where the artwork aims to curate a deep experience of emotional

connection through senses, such as ‘Future You’ and ‘The Sound of Millstones’ which use body movement and sound to immerse the user into deep emotional states and trigger cognitive responses.

Table 1: Comparison between all six case studies based on the technologies used in them, their purpose, the sensory modality targeted, user interaction, and insights into applying them in Bahrain.

Case studies	Technology Used	Sensory Modalities targeted	Level of Engagement	User interaction	Impact
Impulse by CS Design and Lateral Office, Canada	IoT (sensors, LED lighting, speakers)	Auditory, Visual, and Tactile	Reactive	Physical movement to activate light and sound	Creates an atmosphere of playfulness and physical interaction with the surroundings
Waterford Walls project in 2021, Ireland	AR (Augmented Reality through a mobile app)	Visual	Passive	Mobile-based viewing with minimal body movement.	Enhances visual storytelling by adding a technology layer to existing cultural sites
Birr Vintage Week project in 2021, Ireland	AR (Augmented Reality)	Visual	Passive	Mobile-based viewing with minimal body movement.	Revitalizes abandoned places by adding a digital layer to enhance visual engagement
Translation Stream, Abu Dhabi	IoT (Movement sensors, projected text)	Visual and Tactile	Reactive	Body movement is essential for the installation to come to life.	Brings poetry closer to people by creating a dynamic interaction between body movement and art
Future You by Universal Everything, United Kingdom	AI (Artificial Intelligence) body-tracking sensor	Visual	Immersive	People stand before the screen and move their bodies. Movement is essential	Triggers spontaneous cognitive responses by mirroring body movement and unlocking imagination
The Sound of Millstone, Riyadh	Projection mapping AI (Artificial Intelligence)	Auditory, Visual	Immersive	People interact by walking on the projected Millstone while listening to folk songs.	Creates a deep emotional connection between people and culture through immersive storytelling

4.1 Multi-Sensory Experiences and User Engagement

The analysis revealed that using technologies such as AI, AR, VR, and IoT contributed to enhancing the multi-sensory experiences of the users of the space by engaging multiple senses and modalities. However, the potential for creating multi-modal experiences remains limited, as much of the artwork primarily focuses on the visual sense. That said, creating deeply meaningful and immersive experiences doesn't solely depend on the number of senses involved, but also on how they are employed in the design to carefully meet the project's aim.

For example, The Sound of Millstones is a very moving artwork, as it builds on history and cultural backgrounds to trigger a feeling of nostalgia, by utilizing sound and light to emphasize this emotion. Moreover, Future You is a project that mainly targets the visual sense, but it leaves people wondering and questioning different possibilities of interpretations suggested by the artwork, expanding their imagination. Furthermore, artworks like Impulse and Translation Stream primarily relied on the visual and tactile senses, utilizing people's movement, such as walking and playing, to activate specific parts of the artwork that would not otherwise be activated. Lastly, AR artworks depended on the concept of layering by adding a layer of digital art on top of an existing structure to emphasize digital storytelling. Nevertheless, minimal movement and sensory engagement are required for this artwork, which could also limit the level of emotional and cultural immersion.

These projects serve as a basis for understanding how technologies could be integrated to create a deeper multi-sensorial experience through public art. By recognizing the possibilities and potentials of these tools, it will be possible to communicate deep emotions and messages and engage users in brain-stimulating experiences. In addition, all artworks reflect the profound role of the user in becoming a part of the story. Users' participation was a significant catalyst in delivering the meaning behind the work. This was evident in the way these installations were incomplete until people were encouraged to walk, dance, and see-saw, to comprehend the message. However, the level of interaction varies depending on multiple factors, such as the number of senses targeted, the depth of the concept behind the artwork, and the level of engagement between the artwork and the users.

4.2 Applicability in Bahrain

The Bahraini government has been diligently working in the past few decades to activate public spaces in Bahrain through projects that engage the users, often targeting historic areas like Muharraq and Manama, which reflect deep history and cultural richness. Projects, such as “Muharraq Nights”, which takes place in the historic city of Muharraq, as well as “From the Post” and “” in Manama, which are planned by the Bahrain Authority of Culture and Antiquities (BACA) make use of the nice weather during the cooler months of the year to bring people together to celebrate the country’s rich history (Ahmed, 2025). In addition, the “Hawa Al-Manama” event, organized by the Bahrain Tourism and Exhibitions Authority (BTEA), aims to bring people closer to their roots through a series of cultural, educational, and artistic events that take place in the heart of the capital city of Manama (Ahmed, 2025).

The case studies demonstrate a potential for utilizing digital technologies in public spaces in Bahrain, in ways that align with the government’s vision toward engaging the public and making art and culture more accessible to everyone. For example, AR murals could be used in these historic areas to revitalize them and create a sense of curiosity to explore the past. Moreover, employing AI tools to respond to people’s movement through light and sound transformations could be an interesting way to tell stories of the past while creating a fun and interactive experience with the artwork. Finally, Artworks that trigger body movement serve as an exciting way to enhance the multi-sensory experience in the space, improving people’s mental and physical health.

5. Discussion

Upon reviewing research papers on the use of digital technologies in public spaces and their ability to enhance the multi-sensorial experiences of users globally, and analyzing specific case studies of relatable projects, this section proposes some of these possible applications. It suggests ways to utilize these digital technologies to create an engaging experience for the user, optimize atmospheric conditions within the space, and propose solutions to urban design issues.

5.1 Global applications of digital technologies in urban design

5.1.1 Enhancing the Quality of Public Spaces and Creating Social Justice

Using technologies like Augmented Reality (AR) and Extended Reality (XR) can improve the quality of transitional spaces in cities, such as the spaces between public and private areas, by enabling researchers to visualize efficient ways to develop and utilize these spaces. Utilizing AR and XR could help create an immersive experience that visualizes the complex spatial structure and sociopolitical aspects of specific areas, offering a clear understanding of the possibilities of enhancing the space (Horvath et al., 2015; Mehan & Mostafavi, 2024).

According to Mehan and Mostafavi’s (2024) research, a possible application of AR and XR in public spaces is to visualize green solutions for the infrastructure, to alleviate the heat island effect, where participants provide feedback on the design of public green spaces, which was applied in cities like Houston. Moreover, AR can be utilized to explore strategies for mitigating the impact of natural disasters, such as flooding, by envisioning proposed tactics and implementing solutions to alleviate their consequences, as illustrated in Figure 8.

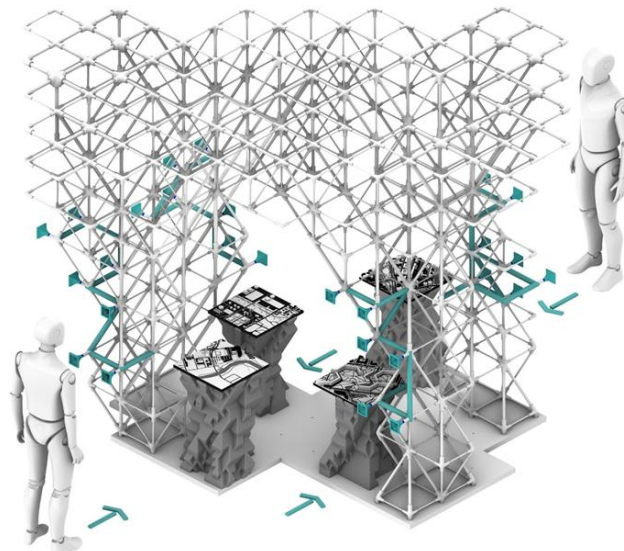


Figure 8. Interactive Phygital Trails show how integrating AR can collect user feedback (Mehan & Mostafavi, 2024).

In Amsterdam, people suggested ways to improve and transform some of their open public spaces using XR and VR technologies to enable them to picture spaces and suggest modifications. Moreover, an XR platform has been developed to offer stakeholders the opportunity to experiment with different scenarios for urban development of the area, resulting in the generation of a plan that harmoniously integrates modern development with the preservation of the historic regions (Mehan & Mostafavi, 2024).

In addition, digital tools, such as AR and XR, facilitate user participation in designing public spaces, improving user experience, and promoting social justice. Besides their potential in transforming urban design into a more accessible, interactive, and responsive process, it is possible to use these tools to shed light on the needs of the underprivileged

communities in some urban environments and ensure the voices of the marginalized people are being heard and their issues are being addressed (Mehan & Mostafavi, 2024).

5.1.2 Enhancing Multi-sensory Experiences

Using AR in art installations challenges the traditional ways of introducing public art to the public. It bridges the gap between both the digital and physical worlds by creating immersive, multi-layered, and multi-sensory experiences (Young & Marshall, 2023). AR applications in art offer the ability to engage users and allow them to interact with their surroundings in ways unexplored before, with an added digital layer, making them more engaged and present in the moment (Jin, 2016).

Additionally, AI systems could be integrated into interactive art installations by engaging and challenging users' perceptions, which contributes to creating an exciting and dynamic environment (Erel, 2022). Furthermore, these digital tools not only enhance the user experience but can also be utilized to convey messages, educate, and raise awareness about specific phenomena.

5.1.3 Improving Sensorial and Spatial Experiences

Using digital tools such as the Internet of Things (IoT) can help collect real-time data on temperature, humidity, lighting, sound, and movement patterns, which can improve the sensory experience in public spaces (Kim et al., 2020). Moreover, the data collected through sensors of smart devices could be adjusted instantly using AI systems to respond to people's needs, which creates a more comfortable user experience (Szpilko et al., 2023).

5.1.4 Creating Personalized and Inclusive Experiences

Collecting instant data and processing information quickly enables digital systems to create a personalized spatial experience that caters to users' needs and preferences. For example, they can suggest pathways and attractions to each visitor, specifically based on their interests and desires (Szpilko et al., 2023).

Furthermore, using AI makes public spaces more accessible and inclusive for users with special needs. This is due to AI's ability to add audio signals to help navigate spaces. Ultimately, making public spaces more accessible to people with disabilities and enhancing their sense of inclusion and belonging (Bhowmick & Hazarika, 2017).

5.2 Enhancing Multi-Sensorial Experiences in Bahrain

5.2.1 Optimizing Climatic Conditions

The use of digital tools in urban design has proven effective in contributing to the multi-sensory experiences of the users. For example, AI is used to optimize the use of some spaces due to its ability to gather instant data, analyze it, and provide timely responses. This makes it ideal for creating a more comfortable environment for users, where data on temperature, humidity, foot traffic, lighting, and sound is collected and adjusted in real-time to human needs and comfort levels (Xiao, 2023; Hanna & Parvaresh, 2024).

This is especially important in Bahrain, given its unique climatic conditions. Having the tools to adjust the environment according to the users' needs broadens the possibilities for using those spaces at different times during the year. Moreover, it allows for the creation of adaptive and personalized experiences for users, based on their preferences and needs. This interactive role of AI increases the cognitive engagement of the users in public spaces, which is an essential aspect of their multi-sensory experience (Hanna & Parvaresh, 2024).

5.2.2 Engaging Users' Senses

Interactive art installations have gained popularity in recent years due to their ability to engage users' senses, provoke body movements, and encourage physical interaction. Which, in turn, fosters a more meaningful connection with the space, stimulates thinking, and influences people's emotions (Hartanti et al., 2024). In Bahrain, public spaces could benefit from digital tools such as AR and VR in reviving historic areas like Muharraq and Manama, building creative experiences for users of all ages, and fostering a profound sense of belonging to the space. According to Srijon and Priota (2025), these tools can be applied in various ways through digital screens, interactive street furniture, and artistic sculptures. All of which engage people's senses and shift their role from passive spectators to active participants in society.

5.2.3 Cultural Preservation through Digital Storytelling

In many of the previously examined case studies, such as "The Sound of Millstone", the artists utilized the potential of digital tools in establishing an emotional connection with the user through storytelling. In Bahrain, these tools could prove effective in preserving the historic stories and ancient crafts by reintroducing them to the users in a contemporary and engaging style. Therefore, incorporating technologies like AI, AR, and VR into the country's cultural projects offers a compelling way for younger generations to explore traditional practices while maintaining their emotional, mental, and physical engagement.

5.3 Challenges for applying digital technologies in Bahrain

With all the benefits that digital tools have to offer users of public spaces, it is worth noting some of the significant challenges that could hinder the process of applying these tools or maintaining their long-term benefits. First, the initial cost of some of these technologies could be high, which requires a well-studied plan and a strategy to finance them with minimal losses. Second, digital illiteracy could be a significant challenge that affects the accessibility of the artwork. The varying levels of digital knowledge within the population could make it more challenging to implement these technologies or to optimize their potential fully. Older people, users with special needs, and kids should all be able to safely and

efficiently enjoy interacting with the artwork to guarantee its long-term success (Hartanti et al., 2024). Third, since public spaces are accessible to everyone, keeping these installations safe from vandalism and public misuse is a challenge, as it requires constant security and surveillance (Srijon & Priota, 2025). Lastly, one of the most critical challenges in Bahrain is its harsh climatic conditions during the summer months, where temperatures can soar to extremely high levels, reaching up to 47°C, and the humidity levels can exceed 85%, which are expected to rise more due to global warming (Kadhem et al., 2025). All of which could hinder the integration of some of these technologies, as they are in direct contact with the weather conditions.

6. Conclusions and Recommendations

This paper investigates previous literature related to enhancing multi-sensory experiences in open public spaces using digital technologies. It also analyses six case studies from different parts of the world, as well as from the Gulf region. These case studies demonstrate practical ways of utilizing digital tools to engage the public through public art installations and encourage them to interact with the space using all their senses, ultimately creating memorable experiences for users and improving their physical and mental well-being.

Furthermore, the paper explores the potential for applying some of these technologies in urban public spaces in Bahrain. For example, they could be used for interactive art installations, solving urban issues, improving the spatial and sensorial experience in spaces, and adjusting atmospheric properties to create a more comfortable setting.

Although the paper lists those possibilities, it is also crucial to understand some of the challenges in applying these systems or technologies in Bahrain. Some of these factors include the initial and ongoing costs of integrating digital tools, ensuring their accessibility for all users, planning for their long-term maintenance, and mitigating harsh climatic conditions to preserve their condition.

This research serves as an exploration of the possibilities of enhancing users' multi-sensorial experiences in open public spaces using digital technologies. However, future research could delve deeper into studying specific locations in Bahrain and how these technologies can contribute to their enhancement, while addressing practical issues that arise from this experience. This could help in understanding the extent to which these tools can be beneficial as well as their weaknesses.

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