Digital Public System of Urban Art: Navigating Human-Computer Interaction in Artistic Design for Innovative Urban Expressions

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Abstract—The convergence of digital technology and urban art has given rise to novel urban art digitalization systems. This paper investigates the relationship between Human-Computer Interaction (HCI) and creative design, particularly in the age of 3D printing, Virtual Reality (VR), and digital art. We highlight the transformative potential of these technologies using examples that include interactive public installations and VR art exhibitions, thereby providing empirical evidence to ground our discussion of the evolving paradigms of technology and public art mutual constitution. We also contribute prescriptive guidance for bringing digital art into cities. We hope to offer a full guide to understanding how digital innovation could catalyze the growth and evolution of the wealth of cultural assets that characterize cities.

Keywords—*Urban art; digitalization; human-computer interaction; creative expression; public art; technological innovation*

I. INTRODUCTION

Public art is a key tool of urban planning. It allows the creation of a sense of place or identity, as well as promotes human traffic. Public art can be anything from historical sculptures to temporary installations such as festival ornaments [1, 2]. It can be abstract or depict the culture, history, and character of a city [3]. It can be a memorial, commemoration, or even a landmark [4]. Public art revitalizes the environment through creative place making, creating concrete, economic, and social changes [5]. It has been used to enhance the public perception, identity, and physical form of cities worldwide [6].

As policy ideas circulate, they often undergo extensive mutations, posing difficulties in understanding the true 'nature' of the policy. For example, public art policies have permeated various aspects of society, leading to controversies and misunderstandings within this artistic discipline [7]. To comprehensively assess the development of any policy idea, including public art policy, it is valuable to explore how the official objectives behind the policy transform across different local contexts. Guided by this premise, we inquire: How do municipalities adapt and integrate discourse about public art within their policy documents and reports? And what underlying logic distinguishes one city from another in this regard?

Human-Computer Interaction (HCI) is an interdisciplinary research field that examines how computer technologies are designed and used, particularly for smooth and effective human-machine interaction [10]. In artistic design, HCI is important for determining how the interface is used for artists and users to

interact with digital media [8]. The dynamic interaction between HCI and the creative production process presents several options since HCI impacts accessibility, intuitiveness, and overall user experience. The significance of HCI in innovative design lies in its capacity to facilitate the integration of human creativity with technical functionality [9]. Artists employ digital tools and interfaces to materialize their creative concepts, and HCI serves as the medium for effortless and intuitive communication and self-expression [10].

HCI can be employed to generate immersive and compelling creative experiences. Adopting tools such as Virtual Reality (VR), Augmented Reality (AR), and gesture-based interfaces creates new outlets for creativity [11]. These technologies empower people to interact with art in novel ways, dismantling conventional obstacles between the viewer and the art work. The function of HCI in promoting interactive creative experiences is changing the position of the passive viewer to that of an active participant, resulting in a more dynamic and captivating connection between the artist's vision and the audience's perception.

In the age of fast technological progress in computers, the widespread impact of digitization has infiltrated every aspect of human existence. The widespread incorporation of this integration has not only emerged as a significant pattern but also as a powerful influence, substantially changing how individuals interact with different facets of their everyday lives [12, 13]. The introduction of digital technology in art has been widely understood to be a major transformation [14]. This transformation is central to new practice and fosters the evolution of the creation and presentation of art concerning the potential of digital media, both in terms of tools and methods. As technology and art come together, notable works that embrace and explore the potential of digital mediums have already been given. These innovative efforts combine conventional artistic aspects with state-of-the-art technical breakthroughs and drive human imagination into uncharted territories, cultivating a dynamic connection between technology and creative representation.

This study aims to increase understanding of how HCI impacts artistic design in urban contexts and the technology's ability to shape urban artscapes in transformative ways. This study aims to provide important insights into the complex relationship between technology and art in urban areas by analyzing the changing landscape of public art policy, the role of HCI in enabling creative encounters, and the impact of

digitalization on artistic expression. We provide an in-depth analysis and examination of the opportunities and limitations of using digital technology in public art.

The paper proceeds as follows: in Section II, we first provide an overview of the digital technology integration on urban public art. Then, in Section III, we focus on interaction and artistic design within the urban environment. In Section IV, open issues and future research directions are presented. We discuss the possible ways for the follow-up research to be carried out in the future. Section V concludes the research work by summarizing the main research findings.

II. BACKGROUNDS

A. Transformation of Urban Public Art Through Technology

When urban public art combines big data and Internet of Things (IoT) technology, it transforms significantly, resulting in dynamic and interactive experiences [15, 16]. This metamorphosis redefines how art, the environment, and the public interact. This confluence fosters a new era of intelligent and data-driven urban art installations [17]. Table I lists dynamic urban art installations made possible through Big Data and IoT. IoT devices deployed in public locations facilitate the creation of urban art pieces that may dynamically react to up-to-the-minute environmental data. For example, sculptures or lightworks can modify their colors or patterns according to weather conditions, noise levels, or air quality changes. This sensory connection intensifies audience involvement, creating a more immersive and dynamic experience.

Big data analytics can be employed to understand crowd behavior and preferences, shaping the design and placement of public art installations. By analyzing patterns in foot traffic, social media interactions, or demographic data, urban planners and artists can optimize the impact of art installations, ensuring they resonate with the local community [18]. Table II presents the characteristics of digital media art in urban environments. Utilizing big data, urban public art can adapt to its surroundings. For instance, sculptures could change their form or light installations their intensity based on the flow of people or specific events. This adaptability ensures that public art remains relevant and engaging in the ever-changing urban landscape.

TABLE I. EXAMPLES OF DYNAMIC URBAN ART INSTALLATIONS ENABLED BY BIG DATA AND IOT

Technology	Application	Examples of effects
IoT devices	Real-time environmental response	Sculptures or light installations changing colors or patterns based on weather conditions, noise levels, or air quality.
Big data analytics	Crowd behavior understanding	Optimization of art installations based on foot traffic, social media interactions, or demographic data.
Big data + IoT	Adaptive public art	Sculptures changing form or light installations adjusting intensity based on the flow of people or specific events.
Art technology	Interactive AR art experiences	Exploration of additional layers of information or interactive elements superimposed on physical art works.
Big data visualizations	Transformative artistic expressions	Visualizing real-time data streams (traffic patterns, energy consumption, air quality) into compelling installations.

TABLE II. CHARACTERISTICS OF DIGITAL MEDIA ART IN URBAN ENVIRONMENTS

Characteristics	Description
Essence	Reliance on digital technologies (software, algorithms, coding, interactive elements) as fundamental components of the creative process.
Exhibition	Departs from traditional gallery displays, often necessitating electronic screens, projectors, immersive installations, VR, and AR platforms.
Transmission	Relies on digital platforms and the internet for dissemination, allowing global reach and instant sharing through online platforms, social media, and digital galleries.
Interactivity and immersiveness	Creates immersive, dynamic, and interactive experiences for the audience, transcending traditional mediums like canvas or sculpture.

B. Integration with AR and Interactive Technologies

Integrating big data and IoT with AR technology allows for the creation of interactive AR art experiences [19]. Through mobile applications or AR glasses, users can explore additional layers of information or interactive elements superimposed on physical art works, creating a multisensory encounter. Table III summarizes key aspects of interaction design in urban public art. Big data visualizations can be transformed into artistic expressions, providing a unique perspective on urban dynamics [20]. Real-time data streams, such as traffic patterns, energy consumption, or air quality, can be translated into visually compelling installations that serve as art and raise awareness about urban challenges [21]. The experience of interaction in art is shown in Table IV. Interactive public art fueled by big data and IoT can encourage community engagement. For instance, a sculpture might react to social media hashtags or user-generated content, fostering a sense of shared ownership and participation in the artistic experience. The intersection of digital cities and public art is shown in Table V.

TABLE III. KEY ASPECTS OF INTERACTION DESIGN IN URBAN PUBLIC ART

Aspects	Description
User-centered design	Transition from functional-centric development to user-centered paradigm, focusing on creating products and experiences that prioritize usability and enhance user experience.
Human-computer interaction	Emphasis on dynamic and reciprocal communication processes between individuals and devices, systems, and websites.
Aesthetic appeal and functionality	Development of interfaces that are functional, intuitive, aesthetically pleasing, and capable of fostering seamless interactions between users and technology.

TABLE IV. INTERACTION IN ART (A JOURNEY OF EXPERIENCE)

Perspective	Description
Artistic perspective	Interaction intertwined with human experiences, encompassing perception, interpretation, intention, feeling, imagination, arousal, and thinking.
Dynamic and evolving encounters	Interaction as a dynamic process that unfolds over time, inviting individuals to engage with the art work and fostering a deep connection between observer and creation.
Artistic experience	Transformation of passive observation into an active and immersive encounter, making the artistic experience a dynamic and evolving tapestry of human connection.

TABLE V. THE INTERSECTION OF DIGITAL CITY PUBLIC ART

Intersection points	Description
Economic and cultural roles	Digital city public art as a manifestation of the dual ambition of cities - showcasing economic prowess and fostering a vibrant and innovative cultural environment.
Transformative shift in identity	Integration of digital technology reshaping how cities express their identity and engage with inhabitants, providing a platform for synthesizing technology and culture.
Democratization of art ecosystem	Digital city public art reaching global audiences through online platforms, social media, and digital galleries, fostering a more democratized and accessible art ecosystem.

C. Digital Media Art

Digital media art stands at the crossroads of technology and art, representing a fusion that gives rise to a form of expression characterized by richness in form and depth of connotation [22]. While firmly situated within the realm of art, digital media art distinguishes itself through profound disparities in its essence, exhibition, and modes of transmission compared to traditional artistic practices. At its core, digital media art is characterized by its reliance on digital technologies as fundamental components of the creative process. Artists in this genre leverage software, algorithms, coding, and interactive elements, transcending traditional mediums like canvas or sculpture. The essence of digital media art lies in its ability to harness the capabilities of technology to create immersive, dynamic, and often interactive experiences for the audience [23].

The exhibition of digital media art departs significantly from traditional art galleries or museums. Instead of static displays, digital media art often necessitates electronic screens, projectors, or immersive installations. VR and AR platforms have also become integral exhibition spaces, allowing viewers to engage with the art work in novel and interactive ways, transcending physical space constraints. The transmission of digital media art is inherently different from traditional art forms, owing to its reliance on digital platforms and the internet. Digital media art can be instantly disseminated globally, reaching audiences across geographical boundaries. Online platforms, social media, and digital galleries have become primary channels for artists to share their work, fostering a more democratized and accessible art ecosystem.

Digital media art represents a paradigm shift in artistic creation and consumption. It challenges traditional notions of creative expression, introducing a dynamic interplay between the artist, technology, and the audience. As technology continues to evolve, so will the boundaries of digital media art, offering new possibilities for creative exploration and reshaping the landscape of artistic innovation.

D. Interaction Design

Interactive design represents a specialized product to enhance and facilitate people's daily activities [24]. The term ''interaction'' within this context encompasses the dynamic and reciprocal communication processes between individuals and the various devices, systems, and websites that form an integral part of their environment. This discipline is particularly crucial in application development, where the trajectory is gradually transitioning from functional-centric development to a more user-centered paradigm. In interactive design, emphasis is shifting towards creating products and experiences that prioritize usability and enhance the overall user experience. This user-centric approach acknowledges the significance of aligning design decisions with the end-users' needs, preferences, and behaviors. As a result, designers increasingly focus on developing interfaces that are functional, intuitive, aesthetically pleasing, and capable of fostering seamless interactions between users and technology.

The evolution of interactive design has been fueled by advancements in technology and a growing awareness of the importance of human-computer interaction. Designers are now leveraging innovative techniques to create products that respond to user input, adapt to individual preferences, and provide a more engaging and personalized experience. This shift reflects a broader acknowledgment of the intrinsic link between design and user satisfaction, recognizing that well-crafted interactive experiences significantly contribute to the success and adoption of a product.

From an artistic perspective, interaction is intricately intertwined with a rich tapestry of human experiences, encompassing perception, interpretation, intention, feeling, imagination, arousal, and thinking. These terms denote behavioral aspects and encapsulate the realm of emotions. In this artistic context, interaction extends beyond a mere transactional engagement; it becomes a profound and multifaceted journey through time and space. It is a dynamic process that unfolds over time, inviting individuals to engage with the art work and fostering a deep connection between the observer and the creation. This participatory element invites the audience to immerse themselves in the artistic narrative, transcending the boundaries of passive observation.

In art, interaction is synonymous with experience, a visceral encounter that goes beyond the visual or auditory to evoke a spectrum of emotions and thoughts. It prompts the audience to become spectators and active participants as they navigate the realms of perception and interpretation. This engagement with the art work becomes a journey of shared experiences, where the artist and the audience merge in a dance of creation and interpretation. Thus, interaction in art is an invitation to traverse the nuanced landscapes of emotions, to perceive and interpret the artist's intentions, to feel the resonance of the creation, and to engage in a cognitive and emotional dialogue. It transforms the passive act of observation into an active and immersive encounter, making the artistic experience a dynamic and evolving tapestry of human connection and expression.

In the realm of digital game design, the concept of interaction as experience takes on a distinctive significance. In exploring game design principles and practices, Richard Luce III asserts that players harbor an inherent expectation to actively participate and engage with the game rather than being passive observers. This paradigm shift underscores the crucial role of interaction in shaping the player's experience within the gaming environment. In digital games, interaction is not merely a mechanical process but a conduit through which players immerse themselves in the virtual worlds crafted by game designers. Players seek to do more than witness the unfolding narrative; they yearn to be active agents, influencing events,

making decisions, and experiencing the consequences of their choices. The act of playing, therefore, becomes synonymous with the experience itself.

E. Digital City Public Art

Digital city public art stands at the confluence of digital technology and urban artistic expression, serving as a focal point in the exploration undertaken in this paper. The evolution of human society into the modern era has positioned the city as an economic hub and an aspirational cultural center. As cities strive to solidify their roles as economic powerhouses, there is a parallel pursuit for cultural prominence. Digital city public art manifests this dual ambition, intertwining technology and artistic innovation to redefine the urban landscape. This genre of public art goes beyond traditional forms, incorporating digital elements, interactive installations, and innovative mediums that reflect the dynamism and diversity of contemporary urban life.

Integrating digital technology into city public art represents a transformative shift in how cities express their identity and engage with their inhabitants. It provides a platform for synthesizing technology and culture, allowing cities to showcase their economic prowess and commitment to fostering a vibrant and innovative cultural environment. As urban spaces evolve, digital city public art becomes a testament to the intersectionality of technology and artistic vision. It speaks to the multifaceted nature of modern cities, where economic development and cultural leadership converge. This paper explores this dynamic interplay, seeking to unravel the implications, trends, and potential future trajectories of digital city public art. By examining the fusion of technology and artistic expression within urban environments, this research contributes to a deeper understanding of the contemporary landscape's evolving relationship between cities, technology, and culture.

TABLE VI.   DIVERSE FORMS OF DIGITAL PUBLIC ART

Artistic forms	Description
Film and television art	Large-scale displays and projections transforming urban spaces into dynamic canvases, narrating stories or conveying messages through cinematic visuals.
Installation art	Interactive installations employing sensors and responsive technologies, inviting public participation and creating immersive and experiential environments.
Graphic image art	Integration of intricate graphic design and digital imaging in public art, utilizing LED screens, digital billboards, and augmented reality applications.
Music art	Introduction of sound installations and interactive musical compositions, becoming integral parts of urban spaces, enriching the shared experience.

The convergence of digital public art is evident through various facets, primarily manifesting in diverse forms of artistic expression. This intersection encompasses a broad spectrum of creative mediums, showcasing the dynamic fusion of technology and art within the public sphere. Notably, digital public art embraces a range of artistic forms, including film and television, installation, graphic image, music, and beyond.

Digital public art integrates film and television elements, leveraging visual storytelling techniques to engage and captivate audiences. Large-scale digital displays and projections transform urban spaces into dynamic canvases, narrating stories or conveying messages through cinematic visuals. Table VI shows diverse forms of digital public art. The digital realm enhances the possibilities of installation art within the public domain. Interactive installations, often employing sensors and responsive technologies, invite public participation, creating immersive and experiential environments that blur the boundaries between art and audience.

Digital technology allows for integrating intricate graphic design and digital imaging in public art. LED screens, digital billboards, and AR applications contribute to creating visually stunning and impactful visual image art that can dynamically adapt to various contexts. The auditory dimension of digital public art introduces music as a significant element. Sound installations and interactive musical compositions become integral parts of urban spaces, enriching the shared experience and providing a multisensory encounter with artistic expression.

III. THE CONCEPT OF INTERACTION IN URBAN PUBLIC ART DESIGN

Urban public facilities encompass the public services and service facilities offering public service products. Functionally, these facilities fall into four categories: (1) health safety service facilities, including public toilets and street lamps; (2) leisure service facilities, such as seating areas and newspaper kiosks; (3) information communication facilities, like road signs and bus stations; (4) art service facilities, encompassing flowerbeds and landscapes. As an integral component of the city, urban public facilities mirror urban development and culture and establish connections with the urban environment, creating a 'human–environment' system with the public. With the introduction of digital media technology, public facilities, and citizens collaboratively form an interactive experience system characterized by the interplay of user behavior, environment, and technology.

Integrating Maslow's hierarchy of needs with elements of interaction design and the classification of urban public facilities offers a comprehensive framework for understanding and categorizing these facilities. Following this approach, public facilities can be organized into four distinct categories, with the first being "information query," representing an early-class facility.

1) Information query (physiological needs): In alignment with Maslow's hierarchy, addressing physiological needs is fundamental. Public facilities designed for information queries cater to the basic need for access to essential information. This category includes early-class facilities that provide information kiosks, directional signage, or digital screens offering details about the surrounding environment, public services, transportation, and emergency information. Satisfying this need ensures individuals have access to crucial information for their safety, well-being, and navigation within urban spaces.

2) Functional facilities (safety needs): The second category encompasses operational facilities that address safety needs. These may include emergency services, police stations, fire stations, and medical facilities. The design of these facilities incorporates interactive elements to streamline communication

during emergencies and ensure swift responses. Interactive maps, emergency contact points, and easily accessible information contribute to meeting safety needs within urban environments.

3) Social interaction spaces (social needs): The third category corresponds to social interaction spaces that fulfill social needs. Urban parks, communal spaces, and recreational facilities fall into this classification. Interaction design principles are applied to create inviting, user-friendly spaces that encourage community engagement, socialization, and a sense of belonging. These spaces may incorporate interactive installations, event boards, and communal gathering areas to foster connections among residents.

4) Cultural and artistic spaces (esteem and self-actualization needs): The fourth category focuses on cultural and creative spaces, aligning with esteem and self-actualization needs. Museums, art galleries, theaters, and public art installations contribute to the cultural enrichment of urban environments. Interaction design elements, such as AR exhibits, interactive art installations, and multimedia presentations, elevate the user experience and contribute to the fulfillment of higher-level psychological needs.

In recent years, the profound influence of science and technology on various facets of our daily lives has become increasingly apparent. Operators in the urban public service system should actively require technical support to be strengthened. For example, the maintenance of front desk interface hardware and the regular update of background data are important guarantees for normal operation and the flow efficiency of urban public facilities. Additionally, the construction of common space requires operators and decision-makers to be cautious. If the isolation site is constructed before the technology is ready, some future technologies may make the isolation site less likely to be used and the construction meaningless. The isolation site cannot be used much with the change in user demand or technology upgrading. Therefore, the knowledge of relevant technology and its use in the public infrastructure is also necessary for the construction units and decision-makers to make the right choice.

In urban congestion, administrative departments are faced with the challenge of selecting public facilities that prioritize both convenience and benefits for the citizens. This decision-making process requires meticulously evaluating available technologies and infrastructure solutions to alleviate congestion

and enhance urban mobility. The study conducted by Chapman, et al. [25] serves as a valuable reference, offering insights into the careful selection and implementation of public facilities based on Maslow's theory of needs. The public facilities classification map based on Maslow's theory, as illustrated in Fig. 1, visually represents how these facilities align with various levels of human needs. This classification map guides operators and decision-makers, emphasizing the importance of addressing fundamental needs such as information query, safety, social interaction, and cultural enrichment when planning and implementing public facilities.

In urban public art, the image serves as the paramount sensory carrier, transcending considerations of size and complexity. The visual impact of public art is often its most potent communicative element, capable of evoking emotions, conveying narratives, and shaping the aesthetic character of the urban environment. Cameras are necessary instruments to record and provide this vital visual data. They are the eyes through which urban public art is viewed, recorded, and distributed. They serve as a way to capture the transient and interactive quality of art in the urban context. Whether monumental sculptures, vibrant murals, or interactive installations, cameras enable the preservation and dissemination of these artistic endeavors to a wider audience. Certainly, the part played by cameras in urban public art is more than visual recording. They are a venue for narrative, which has the potential to mediate the part artists, enthusiasts, and communities may play in urban art. Camera-mediated urban public art can involve more than just raising visual awareness to the public. These images can be increased in many forms, from social media, online galleries, and digital archives to worldwide displays.

A comprehensive digital interactive urban public system, enriched with input and output components, is anchored in a core mechanism of communication and processing. This pivotal interaction involves the transmission of digital signals from sensors to the CPU or microcontroller of a computer, and subsequent operations are executed according to predefined rules. The formulation of these rules is intricately tied to the artistic vision and desired effects. The communication aspect of this system initiates with inputs from various sensors strategically integrated into the urban environment. These sensors act as the sensory receptors, capturing data and transforming it into digital signals. These signals serve as the system's language for the surrounding context, whether user interactions, environmental changes, or other dynamic factors.
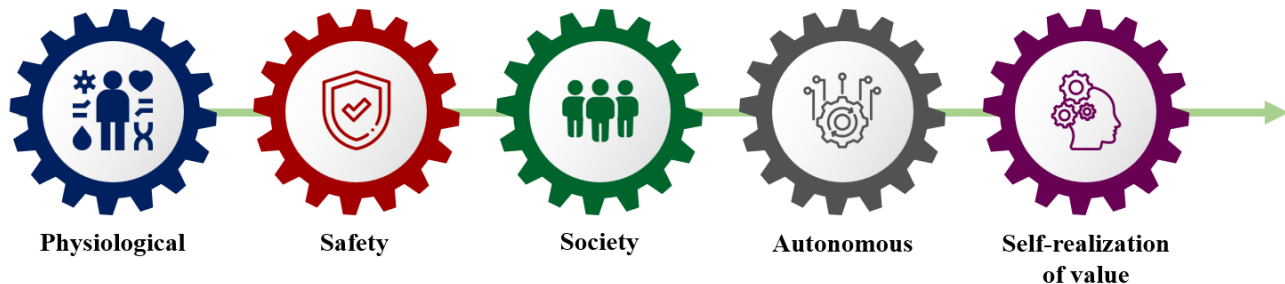

Fig. 1. Public facilities classification map.

The CPU or microcontroller, as the system's brain, receives and processes these signals; then, based on predefined rules, the CPU or microcontroller initiates a series of actions. These rules are defined to capture what Moholy-Nagy intended. It is in this last phase that the programming and the rest of the power-driven system of the light space modulator reside, and where complexity is introduced. Complicated algorithms and mechanical linkages mediate between the artist's initial inspiration and the series of actions that a machine can carry out. Rule-setting is a delicate balance of artistic inspiration and engineering pragmatics. Artists work closely with programmers and engineers to articulate the formal conditions under which the input signal "tells" the system to perform a subsequent action. This part proves the digital interactive urban public system, in a way, carries out the artist's conception, besides, it is synchronized with the digital interactive urban public system in technology. The power-driven systems are a series of devices that contribute to the digital interactive urban public system directly with motor, actuator, or related machines, to be more specific, these devices unfold, close, lift, or otherwise engender the response of the system. These power-driven systems are normally concealed so that the viewer's cannot see or touch them, and the system's energy or output can be delivered without revealing the technology.

Urban space reaches far beyond its geographical boundaries and is instead a living, breathing encapsulation of the lives that occupy it daily. Urban space is an ever-changing scene resulting from a series of activities, interactions, and common experiences. It must be both functional and beautiful, making our lives better and enriched due to living in the city. Urban public spaces must be planned meticulously to serve well-defined functional roles for the community. These functional roles address basic needs such as accessibility, utility, responsiveness, and safety. For example, usable functions may include seating, walkways, well-placed amenities, and infrastructure that allows ease of movement and stimulates numerous activities. These spaces should be designed with an understanding of the community's diverse needs, ensuring that they are inclusive, user-friendly, and responsive to residents' daily routines.

In addition to pragmatic aspects, the design of urban public spaces must also account for their aesthetic purpose. The aesthetic dimension is vital in defining the city's character and its inhabitants' emotional comfort. Well-designed greenery, public art, and architectural installations set the scene for pleasant surroundings, which offer a source of pride and connection for the residents. The focus on aesthetics is critical because it enriches the physical environment through spaces and places, turning them into living, breathing urban scenes that enhance the spirit of community and identity. The complete unification of the practical and the beautiful in the urban environment is a fundamental condition for producing environments sensitive to the manifold and changing needs of the inhabitants. The balance between use and beauty prevents public spaces from being no more than neutral spaces; it makes them selective environments, which contribute positively to the quality of life, the cultural wealth of the city, and the creation of a sense of community among its inhabitants.
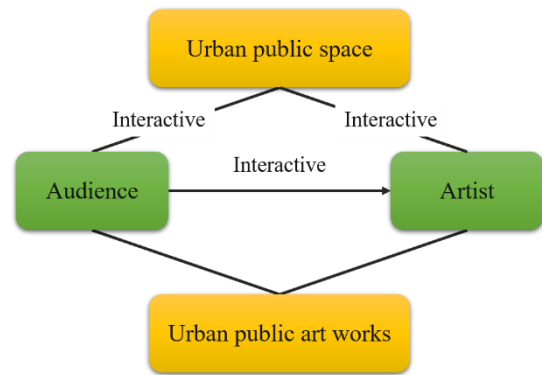

Fig. 2. The interconnected dynamics of public art, urban space, and urban art themes.

Inhabitants of urban spaces are always acclimatized into their city context through cultural and geographical osmosis. This commences from how individuals absorb, comprehend, log, and calculate information to and from. The information is never static, and hence, there is a sense of dialogue of mind with the city. At the same time, the audience encountered by the artists was an audience with a high artistic culture and personal public awareness of the group, which became a significant force in the formation of public space in the whole city. People's responses to urban spaces are complex, involving acquiring, identifying, storing, and processing various information. These adaptive processes are intricately connected to the cultural and geographical characteristics of the urban environment. The city's history, traditions, and geographic features influence how citizens navigate and engage with their surroundings, shaping a distinctive urban identity.

There is a synergy between a community of artists and a community of people with high artistic literacy and civic awareness in forming the urban public space. The former creates the context and the digital field of culture, and the latter expands it and connects various forms of artistic expression with and among themselves. Urban artists, among others, define the cultural profile of a city and provide an opportunity for urban residents to learn their local identity through it and be proud of it. In turn, audiences with a heightened cultural awareness actively engage with and interpret these art works, further enriching the city's cultural tapestry. The relationship among urban space, public art works, and urban art themes is depicted in Fig. 2. This diagram highlights the interdependent relationships among these components. Urban space forms the crucible in which public art works are displayed and perceived. The themes of these art works, influenced by the cultural and geographical context, contribute to the city's narrative, shaping its visual and cultural landscape.

IV. OPEN ISSUES AND FUTURE RESEARCH DIRECTIONS

Within the urban public art domain, promising opportunities and difficulties lie ahead, leading to thrilling prospects and unresolved matters. As we contemplate the progression of this ever-changing discipline, several crucial themes and factors come to light:

1) Integration of emerging technologies: Rapid technological change, including AR, VR, and AI, is likely to dramatically alter the scope and purpose of urban public art. This could include developing a more sophisticated intersection between these technologies to create immersive and interactive public experiences that confuse the boundaries between the physical and digital worlds.

2) Sustainability and environmental consciousness: There is a trend towards sustainability and ecological consciousness in urban planning and design, so future urban public art projects may become more eco-oriented. These public art installations can even be a canvas for discussing ecological issues, using them as a stage for environmental education and sustainable lifestyle. It can be not only art as a culture but art as a practice, using eco-friendly materials and practices.

3) Inclusivity and accessibility: In the future, practical efforts are essential for urban public art to become more inclusive. Future urban public art should prioritize accessibility to encourage involvement from diverse groups. This means not only considering people with disabilities but also implementing universal design in public art work. Moreover, urban public art practices should involve and utilize the creative capacity of the socially underprivileged for the benefit of mutual learning within communities.

4) Community collaboration and co-creation: Art projects created collaboratively by local community artists will likely become even more common. The community-based model of public art work guarantees culture will be respected, and community members will take pride in its existence. Community members will work with artists and urban planners on projects, producing superior works of art that relate more to the landscape.

5) Dynamic and evolving art installations: In the near future, urban public art could be designed from dynamic, ever-changing, and infinitely variable installations that may respond in real-time to data, such as the current weather, user footfall, or social media activity. These responsive installations could change and react to their environment, enhancing the experience for the public.

6) Addressing social issues and cultural narratives: Urban public art can become the most efficient medium for handling social issues and cultural history. More projects can revolve around the concept of social justice and diversity as they can produce a cultural narrative that resonates with people.

7) Data-driven art installations: As cities grow increasingly interlinked by the Internet of Things (IoT) and big data, the future public art could connect to data flows to respond to them. By using up-to-the-minute data on environmental conditions, urban activities, and city patterns, urban art might develop a synesthetic dimension that is utterly responsive to data streams, not merely drawing from them.

8) AR walking tours: The integration of AR in urban public art could lead to the development of AR walking tours. Residents and visitors with AR-enabled devices could explore the city and interact with virtual layers of art superimposed on the physical environment, offering a unique and personalized experience.

9) Digital placemaking and smart cities: Urban public art can play a pivotal role in the concept of digital placemaking within the framework of smart cities. Art installations may create more innovative, sustainable, and livable urban environments by incorporating technology that enhances safety, mobility, and connectivity.

10) Cultural exchange and global collaborations: Advancements in communication technologies can facilitate cross-cultural collaborations in urban public art. Artists worldwide may engage in virtual collaborations, sharing cultural narratives and perspectives. This global exchange can result in a rich tapestry of diverse artistic expressions within city spaces.

11) Ethical considerations in public art: As public art becomes increasingly integrated with technology, ethical considerations around privacy, data security, and surveillance must be carefully addressed. Striking a balance between innovative artistic expression and respecting individuals' rights to privacy will be crucial to future urban public art endeavors.

12) Interactive and participatory installations: The future of urban public art may witness an increased focus on installations that actively engage and involve the public. Interactive and participatory art projects could encourage individuals to contribute to art creation, fostering a sense of ownership and community connection.

13) Temporary and pop-up installations: Temporary or pop-up public art installations may gain prominence. These installations, designed for short-term display, allow experimental and innovative expressions. They can activate underutilized spaces and contribute to the dynamic character of the urban environment.

14) Art as urban infrastructure: Public art could be integrated as a fundamental component of urban infrastructure, contributing to aesthetics and serving functional purposes. For instance, public sculptures designed to serve as seating, lighting installations, or sustainable green spaces that also function as artistic expressions.

V. CONCLUSION

The synergy of digital technologies and urban art leads to the digitalization of urban art, which reshapes the interaction between art and technology media. This paper discussed the connection between HCI and artistic creation, emphasizing the transformative power of new technologies, such as 3D printing, VR, and digital art. These technologies empower artists to transcend the limitations of urban environments, which have historically shaped and influenced human civilization, and express their creative vision in every aspect of the city. Cities serve as a platform for fulfilling several requirements of this system, encompassing the sustenance of human civilization, the preservation of a diverse culture, and the satisfaction of residents' wants.

The study has several unique contributions. In terms of theory, it provides an in-depth investigation into the

transformation of public art with digital technologies in the urban context. It establishes a new research paradigm of smart art and proposes the innovative application of IoT, AR, big data, and other technologies to explore the dynamic and interactive installation of public art that can be adapted to environmental and social information. As for methodology, the study develops an innovative solution to insert digital technologies into urban art projects and focuses on the realization of performance-based digital arts in public spaces. In culture, public art has influenced urban identity and regional cultures. This study further underscores the art function that concerns both social expression and cultural heritage.

The convergence of IoT and big data enables public art to react dynamically to environmental fluctuations and social engagements, resulting in captivating and interactive viewer encounters. Furthermore, using digital art technologies can enhance the inclusivity and accessibility of public art, enabling it to reach a broader audience and actively involve diverse populations. Incorporating cutting-edge, environmentally-friendly materials and sustainable methods in digital public art can raise environmental consciousness and cultivate a stronger bond with nature in urban areas.

Although this study offers useful insights, it also acknowledges various limitations. The conclusions are derived from unique case studies and may not have general applicability; future studies should investigate a wider range of metropolitan environments and cultural situations. Furthermore, there is a need for more research to explore the lasting impacts of digital art interventions on urban populations and public places. Continual study is necessary to investigate the novel applications and consequences of digital technologies on urban public art.

Subsequent investigations should prioritize examining emerging technologies, such as AI and blockchain, in the realm of public art. Longitudinal studies are essential for evaluating the enduring effects of digital public art on community involvement and urban progress. In the context of the increasing presence of digital technology in society, much more research is needed in incorporating sustainability elements in digital public art in terms of both techniques and materials. Future studies may open a door for the development and potential to further improve the urban public art domain while ensuring the importance and effectiveness of digital public art in the wave of digital technology.

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