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Affective Computing in Generative Art Installations: The case of EmoLand

M.Sc. THESIS

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Affective Computing in Generative Art Installations: The case of EmoLand

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FOREWORD

I would like to extend my heartfelt gratitude to all those who have contributed to the realization of this research endeavor. This journey has been marked by the kindness, guidance, and support of numerous individuals, each of whom has played a pivotal role in shaping the trajectory of this study.

Furthermore, I wish to acknowledge the profound impact of Maurice Merleau-Ponty's words, "The real world is not this world of light and colour; it is not the fleshy spectacle which passes before my eyes. It consists, rather, of the waves and particles which science tells us lie behind these sensory illusions." These words underscore the essence of this research, reminding us of the profound depths underlying our sensory perceptions.

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ABBREVIATIONS

AC **:** Affective Computing
AI **:** Artificial Intelligence
ART **:** Attention Restoration Theory
AU **:** action units
CNN **:** Convolutional Neural Network
FACS **:** Facial Action Coding System
FER **:** Facial Expression Recognition
HCI **:** Human-Computer Interaction
IOT **:** Internet of Things
RNN **:** Recurrent Neural Networks
SVM **:** Support Vector Mach

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AFFECTIVE COMPUTING IN GENERATIVE ART INSTALLATIONS: THE CASE OF EMOLAND

SUMMARY

This thesis explores the relationship between human emotion and Artificial Intelligence (AI) in affective and interactive environments. The goal is to reduce individuals' distractions in public places, an area largely neglected by current AI and IoT technologies. Emotions play a significant role in people's behavior and decision-making, and attention. On the other hand, the built environment has a profound impact on emotions, and well-being. Therefore, this research investigates how affective and interactive installations can influence users' attention and mitigate distractions in public spaces.

This study stands at the intersection of several critical domains, drawing upon theories of generative art, affective computing, calm technology, and ambient media to forge a comprehensive framework for the design of installations within public spaces. While extensive research has explored the realm of interactivity, the intricate relationship between generative art installations, affective computing, and architectural elements has remained ambiguous. In this context, the research not only sheds light on these connections but also elucidates how technological advancements and computational capabilities can infuse deeper connections and fresh dimensions of interactivity, serving as a means to counteract the pervasive distractions that have proliferated in the age of ubiquitous screen technology. This study thus emerges as a pivotal contribution in the ongoing quest to harness technology and design for the purpose of restoring attention, fostering meaningful connections, and redefining the human experience within public environments.

The research methodology involves the development of a computational system that incorporates generative techniques applied through installations in public spaces. Facial expressions are used as a parameter to detect emotions through a Convolutional Neural Network (CNN) model trained for Facial Emotion Recognition (FER). An interactive visual art interface called Emo-Land is designed and developed using AI-models and projection mapping. The complexity of patterns in the installation adapts based on the user's emotional state.

By discussing the principles of Calm Technology and their application to the Emo-Land installation, the study tries to create an installation that let the users to restore their attention. This research aligns with the third wave of Human-Computer Interaction (HCI), emphasizing human values, meaning-making, and socially situated and embodied action.

The evaluation of the Emo-Land’s usability garnered an overall positive response, with users perceiving it as easy to use and expressing contentment with their interaction experience. The assessment encompassed dimensions of easey to use, efficiency, and satisfaction. Notably, users found the installation's design user-friendly and engaging, though some improvements are required to enhance its efficiency further. In terms of users' experiences, the majority of questions received favorable feedback, underscoring a positive ambiance and enhancing the spatial experience. Users' emotions were influenced by the installation. Biophilic patterns, while contributing to

attention restoration, posed challenges in fully grasping their meanings. Nevertheless, participants positively regarded the participatory interaction aspect of the installation, highlighting its potential for enhancing user experiences.

The findings of this study contribute to the understanding of how affective and interactive installations influence users' attention in public places and reduce distractions. By incorporating principles of Calm Technology and utilizing biophilic patterns, the research offers new perspectives on designing generative installations that foster an ambient commons in public places.

AFFECTIVE COMPUTING IN GENERATIVE ART INSTALLATIONS: THE CASE OF EMOLAND

ÖZET

Bu tez, duygusal ve etkileşimli ortamlarda insan duygusu ile Yapay Zeka (YZ) arasındaki ilişkiyi araştırmaktadır. Özellikle duygusal teknolojilerin YZ ile entegrasyonunu, generatif sanat enstalasyonları içinde Sakin Teknoloji ile birleştirmeyi hedeflemektedir. Ayrıca, mevcut YZ ve Nesnelerin İnterneti (NI) teknolojileri tarafından büyük ölçüde ihmal edilen halka açık yerlerdeki bireylerin dikkat dağıtıcı etkilerini azaltmayı amaçlamaktadır. Duygular, insanların davranışları ve karar verme süreçlerinde önemli bir rol oynamakta olup, inşa edilmiş çevre duygular ve iyilik üzerinde derin bir etkiye sahiptir. Bu nedenle, bu araştırma duygusal ve etkileşimli enstalasyonların kullanıcıların dikkatini nasıl etkileyebileceğini ve halka açık mekanlardaki dikkat dağıtıcıları nasıl azaltabileceğini araştırmaktadır.

Araştırma, halka açık mekanlarda enstalasyonlar tasarlamak için generatif sanat, duygusal hesaplama, sakin teknoloji ve ortam medyası teorilerinden yararlanarak bir çerçeve geliştirmektedir. Araştırma, kentsel mekanlarda dikkate hak ve ortam ortakları kavramını araştıran ortak kavramı keşfetmektedir. Sakin Teknoloji ve Duygusal Hesaplama kavramlarını birleştirerek, bu çalışma, ortam ortaklarının kavramlaştırılması ve eleştirel bir değerlendirme yapma amacıyla yerleşik medya yaklaşımlarını benimsemeyi hedeflemektedir.

Araştırma metodolojisi, halka açık mekanlarda uygulanan generatif teknikleri içeren bir hesaplama sisteminin geliştirilmesini içermektedir. Yüz ifadeleri, Yüz Duygu Tanıma (YDT) için eğitilmiş bir Konvolüsyonel Sinir Ağı (KSN) modeli aracılığıyla duyguları tespit etmek için bir parametre olarak kullanılmaktadır. Yapay Zeka modelleri ve projeksiyon haritalama kullanılarak geliştirilen etkileşimli bir görsel sanat arayüzü olan Emo-Land tasarlanmıştır. Enstalasyondaki desenlerin karmaşıklığı, kullanıcının duygusal durumuna bağlı olarak adapte olmaktadır.

Tez, Sakin Teknoloji prensiplerini ve bunların Emo-Land enstalasyonuna uygulamalarını tartışmaktadır. Ayrıda, biyofilik desenlerin kullanımını araştırmaktadır. Bu desenler, biyofili hipotezi ve Dikkat Restorasyon Kuramı ile ilişkilidir ve sakinleştirici ve dikkat yenileyici bir ortam yaratmak için kullanılmaktadır. Bu araştırma, insan değerlerini, anlam oluşturmayı ve sosyal bağlamda yer alan ve bedensel eylemi vurgulayan üçüncü dalga İnsan-Bilgisayar Etkileşimi (İBE) ile uyumlu bir yaklaşıma sahiptir.

Önerilen sistem kullanılabilirliğinin değerlendirmesi, genel olarak olumlu bir yanıt aldı; kullanıcılar bunu kullanmanın kolay olduğunu fark etti ve etkileşim deneyimleriyle memnuniyetlerini dile getirdiler. Değerlendirme, öğrenme kolaylığı, verimlilik ve memnuniyet boyutlarını içeriyordu. Özellikle, kullanıcılar tasarımın kullanıcı dostu ve etkileyici olduğunu buldular, ancak verimliliğini daha da artırmak için bazı iyileştirmelere ihtiyaç duyulduğu görüldü. Kullanıcı deneyimleri açısından, çoğu soru olumlu geri bildirim aldı ve olumlu bir ambiyans ve mekânsal adaptasyon vurgulandı. Kullanıcıların duyguları kurulumdan etkilendi, ancak katılımcılar görselleştirmenin eksiksiz bir rehberlik olmaksızın duygusal düzenlemeyi zorlaştırdığına işaret ettiler. Biyofilik desenler dikkati geri kazanmaya katkıda bulunsa da, tam anlamıyla anlamlarını kavramakta zorlandılar. Yine de, katılımcılar kurulumun katılımcı etkileşimi yönünü olumlu bir şekilde değerlendirdi ve bu durum, kullanıcı deneyimlerini artırma potansiyelini vurguladı.

Bu çalışmanın bulguları, duygusal ve etkileşimli enstalasyonların halka açık mekanlarda kullanıcıların dikkatini nasıl etkilediğini ve dikkat dağıtıcıları nasıl azalttığını anlama konusuna katkı sağlamaktadır. Sakin Teknoloji prensiplerini dahil etmek ve biyofilik desenleri kullanmak suretiyle, araştırma halka açık mekanlarda ortam ortaklarını teşvik eden generatif enstalasyonların tasarımı konusunda yeni perspektifler sunmaktadır.

1. INTRODUCTION

The use of digital technologies, Artificial Intelligence (AI) and the Internet of Things (IoT), has enabled greater control over the environment and customization of living spaces. According to Carpo (2017) the digital turn in architecture has brought significant changes in the design process, enabling architects to create more responsive and adaptable buildings. This thesis aims to address the gap in the understanding of the relationship between human emotion and AI in affective and interactive environments, which has been largely neglected by state-of-the-art technologies of AI and IoT, as highlighted by Greene et al. (2022). Specifically, this thesis investigates how affective technologies can be integrated with Calm technology within situated media installations to reduce individuals' distractions in public places. Most people's behavior and decision-making are affected by emotional fluctuations, such as stress at work, academic exams, and challenging relationships. While emotions such as fear, anxiety, and depression are happening to everyone, it is never advisable to remain in the same emotional state for a long time without realizing it. Generally, people rely on themselves to regulate their emotions through different approaches; however, in extreme cases, most people find it challenging to maintain a rational and calm mindset due to their overwhelming emotional state (Mengqi et al., 2020). Since Humans spend most of their lives at public places, and the built environment has a significant impact on their emotions and wellbeing (Cooper et al., 2011; Evans et al.2003; Fischer, 2011), researchers in the domain of architecture are trying to explore different ways to support the process of emotion regulation. It has been observed that emotions affect cognition and have a direct impact on attention, motivation, perception, and decision-making (Brosch et al. 2013).

This research aims to gain insights into Calm Technology by examining generative ambient installations at public spaces. The study seeks to expand on the notion of the ambient commons introduced by Malcolm McCullough (2013), which focuses on the right to attention and preserving the presence in urban spaces. By drawing on theories of generative art, affective computing (AC), calm technology, and situated ambient media to develop a framework for designing an instalation in public spaces. The outcomes of this research present new opportunities for fostering an ambient commons in urban environments by developing approaches to conceiving and evaluating situated media.

Throughout these researches AC field is coming to the forefront regarding the technological developments in AI and its methodological approach to represent/model the human emotions. How the matter of emotion can be modeled in relation to architecture and what kind of ingredients exist and emerge through the computation of these models have been the prior questions in this study regarding the spatial adaptation in interactive design. Spatial adaptation as a means of mental reconstruction of the space also can point out a responsive physical change in the environment (Gallagher et al., 2014).

Space as the primary element of this adaptation involves tangible and intangible matters regarding its design elements. While tangible matters can be form, shape, color, material, the intangible ones can be sound, movement, smell, etc. Among these matters the form comes to foreground with its multiple definitions based on a set of simple or complex constraint relations. These relations can be constructed on an idea, force of fields (Thompson, 1942), appearance of things, object configuration (Alexander, 1964), or active determining principle of a thing from multiple points of views (Arnheim, 1977). Form complexity is one of the factors that can elicit different emotional responses from occupants, such as curiosity, interest, pleasure, boredom, confusion, frustration, or stress (Bower et al., 2019). However, how these matters

engage with spatial adaptations in relation to interactive design still remains ambiguous. Hence, the study tries to answer the following research question:

> What is the impact of affective and interactive installations on the users in public places? Does it can reduce individuals' distractions in public places?

1.1 Method of Thesis

In order to conduct this study, it was necessary to comprehend how generative techniques applied in public spaces through situated media and could be developed as a social amenity. Figure 1.1 explains the domain of the research. The intersection between calm technology and affective computing was explored as a theoretical approach to first establish the idea of attention and calm as a guiding principle, and secondly to experiment with a designed pattern that can be put into operation in real-world settings. This approach aligns with the humanist discourse of third wave Human-Computer Interaction (HCI), which explains its relevance and contribution to fostering ambient commons.

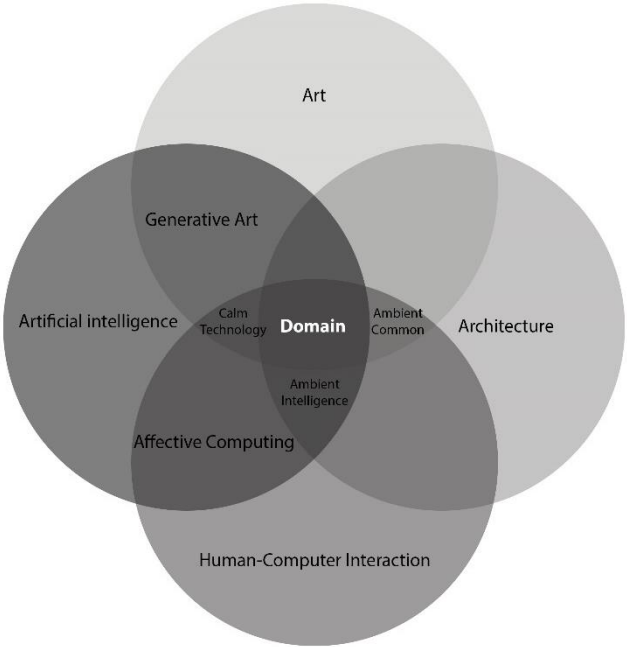


Figure 1.1 Domain of the study.

Departing from these, this study attempts to elaborate potentials of form and complexity matters based on the emotional state of the observer through a real-time responsive computational system. Facial expressions as the most common form of body language have been chosen as the main parameter to detect emotions through

camera. To this end, a Convolutional Neural Network (CNN) model for Facial Expression Recognition (FER) is trained via deep-learning methods. An interactive visual art interface called Emo-Land is generated with the trained AI-model through projection mapping. Then a pattern of wave as well as biophilic patterns is used as a visualization material regarding its efficiency with computer power and cost. Figure 1.2 explains the applied structure for deveoping the thesis steps. The pattern transforms based on the emotional state of the user. The generated interactive visual projection mapping can be used as a means of emotional and behavioral awareness.

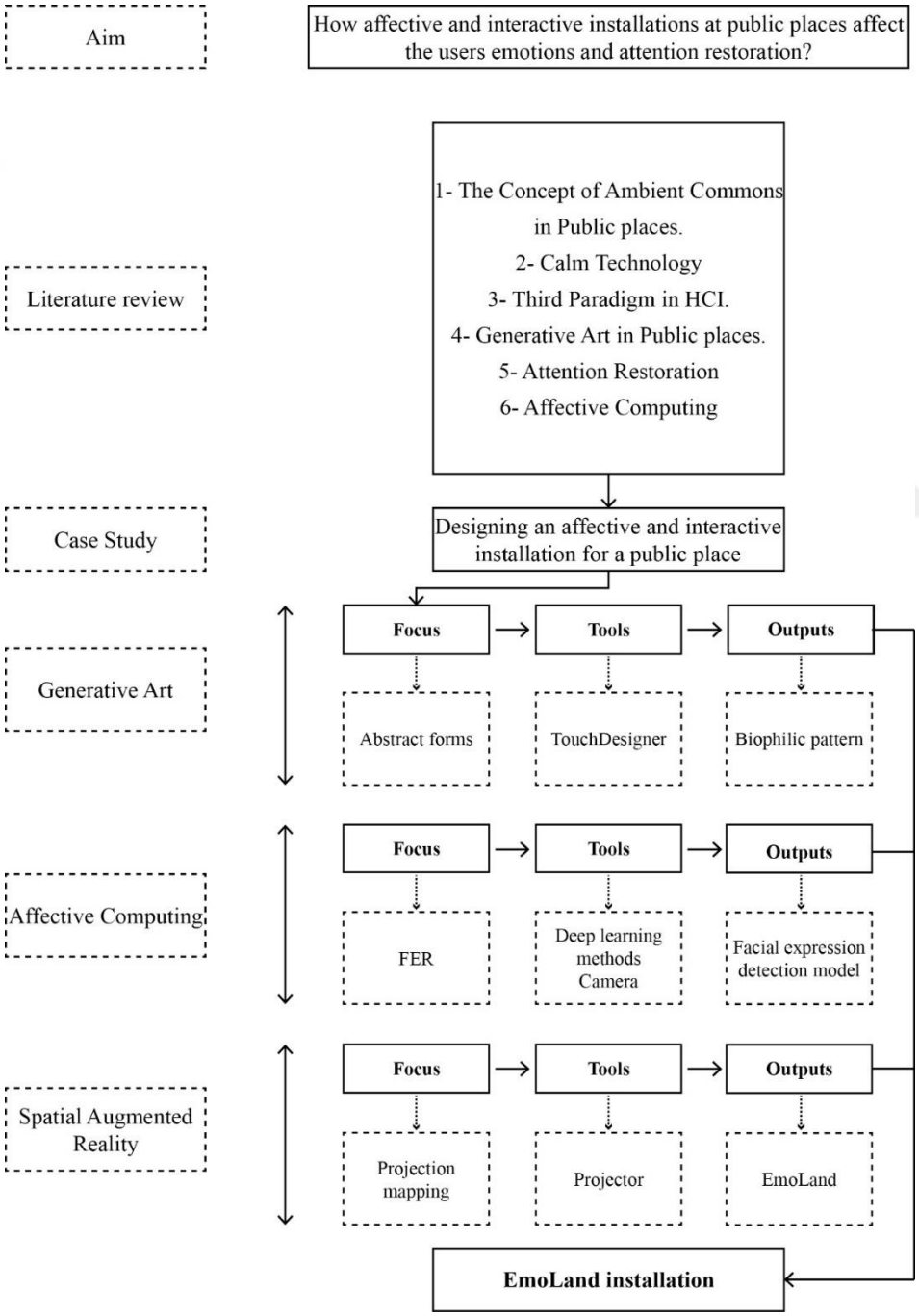


Figure 1.2 The applied structure for deveoping the thesis steps.

Furthermore, a questionnaire with 41 questions employed that allowed participants to express their opinions. Following the completion of the questionnaire by all participants, the collected data were analyzed using the SPSS software packages. Regarding the assessment of the proposed installation, the findings of the questionnaire survey indicate an overall positive feedback on system usability and user experience.

The literature review in this study comprehensively delves into several key concepts critical to the design of interactive installations in public spaces. These concepts include Calm Technology, preserving attention, utilizing fixed architectural elements, establishing emotional bonds with users, creating embodied and multisensory experiences, understanding the dynamics of place, enabling mindful dwelling, ensuring ease of recognition, regulating distractions, fostering shared space experiences, enhancing aesthetic encounters, and employing affective computing. Through an extensive review of relevant scholarly work, the study synthesizes the outcomes and findings related to these concepts. The culmination of this literature review is synthesized in the form of a comprehensive diagram that visually represents the interplay of these concepts and their implications for designing interactive installations (Figure 1.3). These outcomes from the literature review serve as the foundational design principles that will guide the development of the Emo-land installation, ensuring that it effectively engages users, preserves their attention, and contributes positively to their experiences within public spaces.

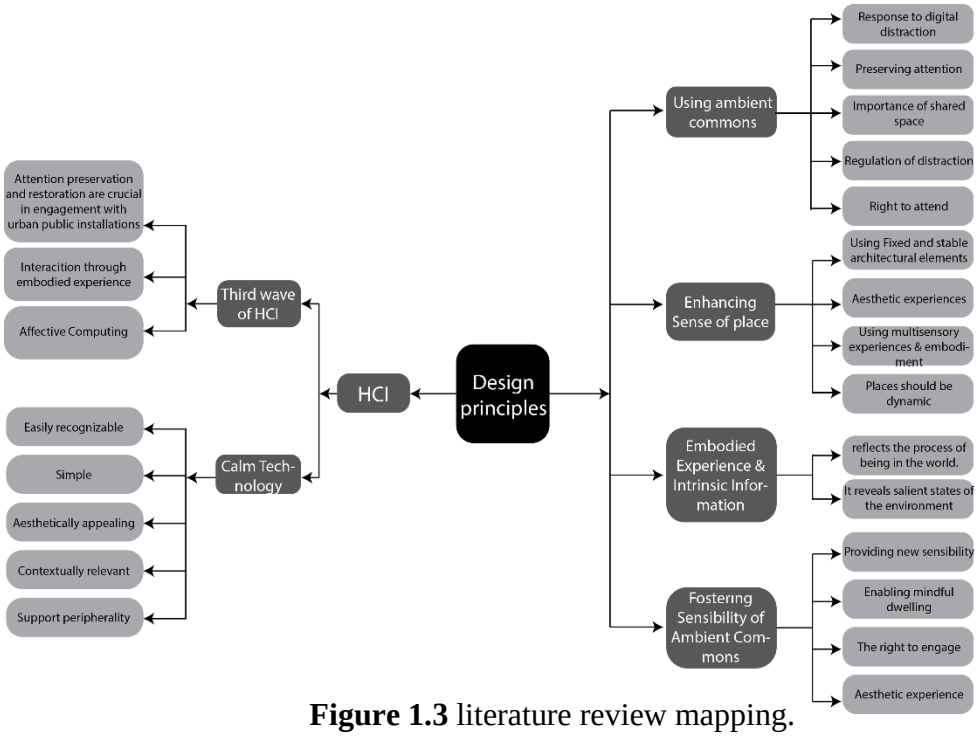


Figure 1.3 literature review mapping.

1.2 Significance of the Study

During the early 1990s, Mark Weiser and John Seely-Brown at Xerox's Palo Alto Research Centre (Xerox PARC) recognized the importance of the periphery of attention concerning the emergence of ubiquitous computing (or ubicomp) and how people would cope with constant mediated information feeds in the 21st century. The researchers anticipated the rise of distraction due to alerts, data feeds, and screen-based technologies, as well as the draining effects they would have on attention. Weiser and Seely Brown proposed "Calm Technology" as a set of principles to humanize ubiquitous computing by alleviating the draining and stressful effects of constant distraction (Weiser & Brown, 1996, 1997).

The proliferation of smart devices is predicted to reach an average of five to ten devices per human by 2035 (Case, 2015). This represents a conservative estimate of fifty billion online devices. To counteract the overwhelming amount of distraction that has resulted from ubiquitous screen technology, Amber Case has synthesized empirical research and extended the principles of calm technology originally proposed by Weiser and Seely Brown in the 1990s. Case has distilled eight principles of Calm Technology that enable designers to incorporate signals in the periphery of attention while empowering users to incorporate the environment into their attentional frame without becoming drained. By prioritizing the periphery, the design features of ubiquitous computing treat attention humanely, and allow for a shift in the function of the public installations from a technology of attention-seeking to a technology of attention restoration.

This research utilizes the principles of calm technology for assessing the Emo-land installation which interacts with the user through facial expression as well as biophilic patterns. Biophilic patterns are procedures that have been developed in fields such as environmental psychology, architecture, and have been increasingly used in green building. The patterns are linked directly to Stephen Kellert’s biophilia hypothesis, which argues for the health benefits of access to natural environments (Kellert, Heerwagen, & Mador, 2011). The influential contributions of Rachael and Stephen Kaplan to the field of biophilia through Attention Restoration Theory (ART) assert that exposure to nature and patterns in nature can restore directed attention (Kaplan,

1993, 1995; Kaplan & Kaplan, 1989). The refinement of biophilic effects into a series of patterns has been utilized to develop outcomes in this research.

The utilization of biophilic patterns in situated media as Calm Technology can be viewed in the context of third wave HCI. According to Harrison et al., the first paradigm of HCI is seen in the human-machine command-and-control situation in the cockpit, where the machine's operation and settings are directly linked to the pilot's intentions and actions. The second wave of HCI, influenced by cognitive science and activity theory, sees the user as a social unit targeted by an interface that mirrors human modes of learning and communication. This thinking has expanded to influence collaboration, domestic and social life through task-oriented efficiency and seamlessness of communication and interaction, including play. Filimowicz and Tzankova describe the third paradigm or "third wave" of HCI as emphasizing human values, meaning making, situated knowledge, and experiences. It involves design research that considers the full context of socially situated and embodied action, incorporating humanistic and social science considerations. By opening HCI research to the messy context of social situations, there is an opportunity to take a new perspective on how we might use situated media technologies. This different approach to the treatment of human attention creates entirely new ways of thinking about the interface. While we need not discard the first and second HCI paradigms, the third wave of HCI presents a different viewpoint.

2. LITERATURE REVIEW

2.1 Exploring the Ambient Commons

2.1.1 The concept of ambient commons in public places

The increasing prevalence of digital installations in public spaces contributes to a culture of distraction and erosion of place, forming part of a media ecology (McCullough, 2013). In response, McCullough proposes an "ambient commons" that acknowledges the distractive influence of information overlays in public space as a

shared concern, affecting the attentional, cultural, and civic life of all urban dwellers. The ambient commons addresses the challenges to attention posed by the combined effects of increasing global urbanity, ubiquitous computing, and pervasive media. McCullough suggests that the ambient commons could preserve attention and regulate distraction across various layers of digital, social, cultural, regulatory, and shared urban space, although he admits that establishing a commons of attention is a difficult task due to its ephemeral nature and reliance on consensus. By proposing the protection of attending in public space, McCullough aims to safeguard a sense of local identity from the distractive excesses of digital media that are placeless, timeless, and erasable (McCullough, 2013, p. 105).

McCullough (2013) argues that the ambient commons cannot be understood in the traditional sense of a tangible pooled resource, such as a lake for fishing or a field for grazing, but rather draws on a sense of tangible embodied and shared space that historian Ivan Illich referred to as "that part of the environment which lay beyond their own thresholds and outside of their own properties, to which, however, they had recognised claims of usage" (Illich, 1983, p. 2, as cited in McCullough, 2013, p. 286). Illich explained that these practices of the commons were part of shared ways of seeing the environment and that "the customary law which humanised the environment by establishing the commons was usually unwritten" (Illich, 1983, as cited in McCullough, 2013, p. 287). These customs of civil behaviour and sharing still inform the ideas of a commons and are encoded in the law to protect freedom of assembly and freedom of speech, which are fundamental to democratic civic life. McCullough also cites Stephen Carter, a legal scholar and novelist, who characterizes civility as the inherent obligation of a citizen to hold to "the sum of the many sacrifices we are called [upon] to make for the sake of living together" (Carter, 1998, as cited in McCullough, 2013, p. 263). In today's world, the resource that we must share, respect, and protect for the sake of an ambient commons is human awareness itself.

According to McCullough (2013), our pre-attentive sensitivity to the environment involves embodiment. In paraphrasing psychologist William James, McCullough asserts that "You are what you attend to", suggesting that attention, embodiment, and environment shape our awareness of being in the world. For this reason, McCullough is concerned about the potential consequences of distracting screens, which could

erode a sense of the local, civic life, and engagement in built space. It is the protection of a "right to attend" (McCullough, 2013, p. 263) that serves as the foundation for the ambient commons.

Just as citizens have the right to be heard and not silenced by more powerful individuals or groups, they also have the right to attend, and just as crucially, to choose not to attend. This implies a right to ownership of attention. McCullough argues that it is the duty of society to prevent the theft of this right. By respecting the mental lives of others, particularly in the context of civic life, the right to reflect is upheld (p. 262).

When a culture of distraction takes hold, it not only erodes our sense of the local, but also our sense of citizenship and engagement in civic life. Neglecting the local and the specific further contributes to a loss of our connection to the living environment as a whole (McCullough, 2013, p. 287).

2.1.2 Impact of digital technologies on attention

The issue of distraction from media is still a concern, but it is now more complex due to the various forms of technology, interfaces, feeds, channels, and social contexts. According to Ophir et al. (2009), who conducted a range of attentional tests, individuals who use multiple online screens are more susceptible to developing chronic distractibility. They conclude that "heavy media multitaskers" are more likely to be interfered by irrelevant stimuli in the environment and irrelevant representations in memory (Ophir et al., 2009). However, Wiradhany and Nieuwenstein (2017) have questioned some of these claims through subsequent replication of these tests, and there is still a debate on how to understand distractibility.

Baroness Susan Greenfield's book, Mind change: How digital technologies are leaving their mark on our brains (2015), received criticism from researchers for making vague claims that lacked scientific support. Some of these claims, such as the assertion that spending time in virtual worlds causes cognitive damage leading to "autistic-like traits," have been extensively debated (Bell, Bishop, & Przybylski, 2015; Greenfield, 2015). Greenfield, was accused of selectively using scientific research to provide cultural commentary on the effects of digital technology (Robbins, 2014). Bell, Bishop and Przybylski, in their critique of Greenfield, call for a more measured discussion of

the effects of digital technology while acknowledging that screen time reduces children's academic learning and outdoor physical activities, leading to sedentary behaviors that increase the risk of obesity and diabetes (2015). Although there is considerable research on the short- and long-term effects of screen use and screen exposure on distractibility, this dissertation will only touch on other critical perspectives on the effects of media on attention.

2.1.3 Embodied experience in creating a sense of place in urban installations

McCullough (2013) highlights the significance of fixed and stable architectural features in creating a sense of local identity and place. He suggests that fixity enables attention over time, creating shared knowledge and a sense of belonging. In contrast, he argues that large digital installations may erode this sense of place, potentially causing longer-term views of the world to suffer or disappear. Despite this, McCullough believes architects have a responsibility to explore the opportunities presented by urban installations, questioning how they might serve collective memory, become a usable public infrastructure, or take on aspects of the commons. The reflexive process of orienting to surfaces, objects, and people in space is important for creating significance and identifying with places. This investment of meaning occurs through embodied and aesthetic experiences, ritual, signs, language, stories, and laws, all of which can now be mediated through installations in urban space. Cresswell (2014) suggests that the concept of place has resurged in the era of global media, with art practice continuing to question the relationship between place and belonging. Drawing on Agnew's (1987) work, Cresswell summarizes place as being constituted by locale (place as a setting for social interaction), location (place in geographical space), and sense of place (attachment between people and place).

According to the geographer Yi-Fi Tuan, any place where we choose to stay or keep our belongings can develop a significant attachment. Tuan believed that the act of pausing in movement can transform a location into a place, emphasizing the importance of aesthetic in experiencing locations (Tuan, 1977, as cited in Cresswell, 2014). Tuan's work highlights the significance of multisensory experiences in developing aesthetic discernments. The process of moving and seeing is co-attuned and embodied, allowing us to perceive and conceptualize the world (Tuan, 1990, p.

235). Anthropologist Tim Ingold states that the process of embodiment is the development of the organism in its environment (Ingold, 2000, p. 170).

2.1.4 Intrinsic information and embodied in urban installations

McCullough (2013) defines "intrinsic information" as the direct phenomena we experience, which links embodiment, attention, and interface to the environment. According to him, urban installations can reveal intrinsic information, which is inherent to the material, structure, or composition of something, reflects the process of being in the world, and has continuity with the environmental information that dominates the cosmologies and mythologies of traditional societies. This information reveals salient states of the environment without requiring much attention and does not need language, symbolism, or code. For instance, a sunrise indicates the start of the day, without requiring any instructions (McCullough, 2013).

According to McCullough, intrinsic information refers to the direct phenomena we experience and is the link between embodiment, attention, and interface with the environment. He states that an encounter between urban dwellers and urban installations that uses intrinsic information reveals aspects of the environment that are inherent to the material, structure, or constitution of something, innately reflecting the process of being in the world and has continuity with traditional societies' cosmologies and mythologies. McCullough borrows from environmental psychologist JJ Gibson’s concept of affordance in explaining that intrinsic means “within the essential nature of something.” McCullough also believes that intrinsic information extends to embodied encounter with signals suffused in the environment outside semantic codification. McCullough suggests that architecture can play a cognitive role in channeling the flux of ambient information into high resolution, low pace affordances that can contribute to creating calm and restorative places. He cites erosion textures, animal tracks, or tree stumps' rings as examples of nonsemantic information that reveals intrinsic information. According to McCullough, the dawn need not be a social construction, and intrinsic information makes little demand on our attention yet pre-cognitively reveals salient states of the environment (McCullough, 2013).

McCullough (2013) argues that public installations have the potential to contribute to the restoration of attention in urban environments. He emphasizes that designing for a

calm environment is different from designing for attention restoration. He proposes that real-time generative media can be used to reflect the natural pace and continuity of the passage of time and contribute to orientation with the environment and restorative ambient settings. McCullough notes that large digital installations can transmit intrinsic information as part of the presence of a place. In this way, urban installations should consider the attentional impact of encounters with situated media or large installations. McCullough connects fixed urban structures, embodiment, intrinsic (environmental) information, arguing that embodied information combines mediated with intrinsic information. McCullough contends that persistent structures and recurring patterns provide the frameworks by which to assimilate new or changing phenomena.

McCullough is concerned that pervasive media can cause people to forget or ignore intrinsic information, which might be mistaken for synthetic environments. This raises concerns for urban dwellers who may not have had experiences with outdoor play or exploration. McCullough turns to philosopher Albert Borgmann's concept of commensuration, which involves reconciling the fluidity of information technology with the stability of important practices and things such as nature, cities, work, and art. Borgmann's perspective is relevant to the question of how artist/designers can create vivid synthetic environments while maintaining a reference point to these important aspects of our lives (McCullough, 2013).

2.1.5 Fostering sensibility of an ambient commons

McCullough argues that being mindful of the ambient qualities of a space was once considered irrelevant or luxurious but has now become crucial in the current era of changing planetary circumstances. This personal attention to immediate surroundings could initiate a cultural shift. Sensibility and behavior are influenced by the setting itself and can be observed in sacred architecture, gardens, and landscape architecture, among other cultural aspects. These settings are optimized for common enjoyment of a specific attention restoration. According to McCullough, reflective awareness that shapes spatial configurations of everyday practices can be valued for engaging intrinsic information, as a community of practice, or as a way of calming. Therefore, urban environments should be adapted to enable multiple levels of mindful dwelling.

The superficial flux of media undermines the sensibility of dwelling without persistent context (McCullough, 2013).

McCullough envisions a city landscape where installations and media displays are integrated into the local character of a place instead of being mere gateways to other spaces (McCullough, 2013). By embodying information persistently in a physical common, a new kind of urban space can be created (McCullough, 2013). He argues that this treatment of information overlays can provide a new way of living in urban spaces and calls for a new kind of sensibility to be developed (McCullough, 2013, p. 280). The ambient commons, as a concept, offers a direction toward how we can envision, inhabit, and create environments where information overlays neither distract nor overwhelm, but instead enable people to develop a renewed sensibility to their surroundings (McCullough, 2013). This new way of living in urban spaces can help people engage with intrinsic information, practice mindful dwelling, and foster a sense of community (McCullough, 2013, p. 82).

McCullough suggests that a new sensibility is needed to perceive the environment in a broader sense that includes information overlays in public spaces. These information overlays can provide environmental affordances for both calm and attention restoration without demanding too much attention. He argues that situated media can support an awareness of the built environment's implications in the global environment, which must evolve with metropolitan culture. McCullough sees a connection between sensibility, attentional balance, and citizenship, as an ambient commons can foster shared cultural and ethical dimensions. He suggests that design practices can improve environmental experience by forming digital information into appropriate textures and resolutions, thus letting the world speak for itself. McCullough envisions a new kind of sensibility that involves cultivated attentional preferences, refined receptivity, and attentional resources. He argues that the design and governance of shared built space can benefit from information ethics, making spaces more usable and allowing intrinsic information to have its chance (McCullough, 2013).

McCullough believes that a positive environmental experience promotes healthy engagement in the community and is key to improving every aspect of an individual's experience. Improved environmental experience can help in effortless attention, which

is beneficial for better practices of attention, mood, productivity, and relationships. In this regard, McCullough supports engagement with the environment as it also benefits the commons, and engaged experience can make better citizens. Therefore, it is essential to configure urban media overlays that respect the rights of attention as a shared human flourishing matter. As part of this shared experience, McCullough contends that citizens have the right to engage one another and the built world unmediated, uninstructed, unscripted, and undocumented (McCullough, 2013).

In this research, it is observed that the concept of the ambient commons can be applied in creative practice through what Böhme refers to as "aesthetic work." According to Böhme, aesthetic work involves producing atmospheres for their emotional and aesthetic presence, and the aesthetics of ambience are intrinsic to the social mood of the built environment. McCullogh views Böhme's approach to atmospheres as a humanist one that forms part of an ambient commons and recasts aesthetics into a general theory of embodied perception. Böhme's perspective on architecture and design emphasizes the importance of "tuning the space" to affect our bodily presence, which I find relevant to this practice of generative art, where algorithms are fine-tuned to achieve aesthetic signals. Böhme's theory of atmosphere highlights the practice of creating an affective aesthetic presence, which involves perception in the full sense of the term, as the experience of the presence of users, objects, and environments (Böhme, 1993, p. 116). McCullogh, sees Böhme's approach to atmospheres as a key constituent of an ambient commons, as it recasts aesthetics into a general theory of embodied perception (McCullogh, 2013, p. 170). According to Böhme, the theme of aesthetics encompasses the full range of aesthetic work, including the production of atmospheres, and autonomous art is a special form of this work with the social function of mediating encounters and responses to atmospheres in specific situations such as museums and exhibitions (Böhme, 1993, p. 116).

2.2 Calm Technology and the Evolution of HCI in Public Spaces

2.2.1 Attention and calm in public spaces

The preservation and restoration of attention have become crucial in the engagement with urban public installations, where attention is a central concern. The ambient commons emphasizes the need for artists, designers, and architects to create ambient

aesthetic settings that promote attention and respect for attention in shared spaces. William James stated that "my experience is what I agree to attend to," indicating the critical role of attention in being in the world (James, 2007). Attention Network Theory (ANT) provides a contemporary model of attention, showing that attention is a networked "organ system" within the brain that coordinates different states (Fan et al., 2002; Posner, 2011). Attention is affected by both endogenous and exogenous orientation, with Margaret Bradley highlighting the importance of emotions and attention being equally implicated in orientation (Bradley, 2009). The treatment of the periphery becomes an essential aesthetic consideration in spaces that support attention and calm, as the link between the attention restoration and emotion implies the importance of aesthetic signals in the environment (Bradley, 2009).

2.2.2 Calm technology principles in public spaces

The concept of Calm Technology has been utilized to create various types of ambient displays and installations. According to Calm Technology literature, ambient installations that are designed to inform while remaining in the periphery are considered a subset of Calm Technology that emphasizes aesthetic values. Room settings and environments have been fitted with ambient displays using video displays, such as "Information Art" (Holmquist & Skog, 2003), "amplified artworks" (Redström, Skog, & Hallnäs, 2000), which employed modernist geometric abstraction aesthetics, or "electronic paintings" (Stasko, Miller, Pousman, Plaue, & Ullah, 2004) to encode information channels such as clocks, alerts, notifications, thermostats, or "personally relevant information". Ambient installations are described by Pousman and Stasko (2006) as creating subtle overall changes to raise awareness of large systems, such as network traffic (Ishii et al., 1998; Wisneski et al., 1998). Several methods for assessing ambient installations have been developed by McCrickard et al. (2001), Mankoff et al. (2003), Pousman and Stasko (2006), and Levin (2008), all of which emphasize easily recognizable and familiar graphics, simplicity, appealing aesthetic design, relevance of information to the context, and requiring "minimal attention" (Matthews, Dey, Mankoff, Carter, & Rattenbury, 2004) or support for "peripherality" over time (Mankoff et al., 2003, McCrickard et al., 2001).

The criteria noted in the literature on ambient installations can be synthesised through Case's principles of Calm Technology, which emphasize empowering the user to reach their goal with the least amount of attention possible, not just technical minimalism.

Early research in HCI, particularly through theories of embodiment, shows the influence of attention, the environment and computing on computer interfaces. Embodiment is built into Calm Technology, with the idea of the periphery influenced by environmental psychology and philosophy of embodiment respectively through “affordance” and “tacit knowledge.” “Tacit knowledge” ties back to HCI through anthropologist Lucy Suchman’s development of activity theory, where concepts of embodied knowledge are informed by a complex of social and instrumental situations (Dourish, 2004; Gibson, 2014; Norman, 2013; Polanyi, 1966; Suchman, 1987).

The design of calm situated technologies draws attention to the elements of embodiment, such as the periphery, affordance, and context. While interface design has traditionally focused on directed attention, more consideration should be given to pre-attentive processing. McCullough notes that interaction designers have concentrated on how users apply technology for a particular purpose in the foreground of attention and less on the significance of context or tacit knowledge (2013). Ambient installations and interfaces have been studied in workspaces and interior environments and are primarily variations on gentle alerts. The present research applies the principles of Calm Technology outside of the work environment and uses them in public spaces. The influence of installations on qualities of attention in shared spaces is reinforced by the background of embodiment in HCI. Public installations and the physical environment intersect in public spaces, and advertisers use them to stimulate, and attract; However, they could also be used for other affordances. This research investigates how ambiance can support an ambient sensibility that empowers our periphery and supports calm and attention. The focus is on embodied experience in a local context, which represents a turn in HCI research characterized as a "third paradigm" (Harrison et al., 2007). The "Ambient Room" created at the Massachusetts Institute of Technology (MIT) Media Lab in the late 1990s, which experimented with peripheral ambient engagement, is an example of the development and research of ambient displays and interfaces (Ishii et al., 1998).

2.2.3 Third paradigm in HCI

Harrison et al. (2007) propose a "third paradigm HCI" that addresses certain kinds of human-computer interaction that were previously considered irrelevant by the HCI research community. The term "third paradigm HCI" from McCullough's book Digital

Ground (2004) and draw theoretical issues raised by Dourish in "Where the Action Is" (2004). They argue that the first, second, and third waves of HCI are each characterized by underlying metaphors that establish different epistemological frames for knowledge acquisition.

The second wave, influenced by the cognitive revolution, sees the human mind as computer-like and values generalizability in applications, promoting research methods that measure the effectiveness of communication. However, this approach excludes local conditions and social contexts as "messy" and "marginal phenomena." In response, Harrison et al. propose a third paradigm that places embodied experience in context at the center of HCI problems, treating interaction as a form of meaning making rather than information processing, subject to multiple interpretations by designers, analysts, users, and other stakeholders (Harrison et al., 2007).

According to Harrison, three different metaphors are central to each of the three waves of HCI research, which respectively focus on human-machine interaction, mind-as-computer for optimized communication, and meaningful embodied experience in context. These metaphors create different epistemological frames, which enable recognition of certain types of knowledge and use of appropriate methods. As Harrison et al. (2007) note, each metaphor establishes centers and margins, which inform choices about suitable methods for designing interaction, and for validating knowledge claims about interaction.

In the first two waves of HCI, efficiency, rationality becomes the primary mode of developing HCI researches. Consequently, Harrison et al. (2007) notes that phenomena that are difficult to assimilate to information processing, such as people's feelings about interaction, the role of a particular interaction in larger systems of use, and elusive aspects of everyday life such as "what is fun?" are often left at the margin.

As ubicomp gains prominence, the effects of computer interfaces on personal life and the influence of context on these interfaces have become more apparent. Since ubicomp involves a diverse range of local contexts and subjective responses, it is challenging to apply the rational methods of the first two waves of HCI research. Harrison et al. argue that design, and the arts offer alternative research approaches to ubicomp, as these methods acknowledge that use context is essentially unspecifiable.

In the public context, ethnographic methods have been employed to investigate how participants encounter the indeterminate and shared setting of an ambient installation. The EmoLand installation, which is not based on formalized tasks or communication procedures, does not fit within the first or second paradigms of HCI research. Harrison et al. contend that “standard evaluation techniques are ‘task-focused’ in the sense of asking users to pay attention to and evaluate the interface, precisely what the system is devised to avoid,” making it difficult to apply usability studies to ambient interfaces (Harrison et al., 2007).

According to Harrison et al., the third paradigm in HCI research acknowledges the influence of cognitive psychology on the effects of emotions on cognition, as demonstrated in research by Bradley in psychophysiology. This influence is seen in the work of researchers such as Rosalind Picard and Donald Norman, who apply interdisciplinary methods in their research on affective computing. The third paradigm also emphasizes a phenomenological approach to understanding situated embodied experience, which recognizes the importance of physical and social context in shaping individuals' understanding of themselves and their interactions with the world. By incorporating emotional and subjective factors through interpretive methods such as thick description, the third paradigm permits knowledge that cannot be adequately addressed through the rational, efficiency-focused methods of the first two waves of HCI (Harrison et al., 2007).

To comprehend the encounter within a context of an ambient installation, an interpretive approach has been used in this research, which provides a comprehensive account of participants' experiences. As per McCullough’s proposal for the third paradigm in HCI, the emphasis on embodied and situated experience prioritizes the importance of place and place-making in the use of computer interfaces. The change in focus is consistent with the interpretive exploration into the various ways that an ambient installation in public can be utilized. This shift reveals that "elegance" is no longer the only aesthetic requirement; "appropriate" or "appropriable" are equally central aesthetic requirements (Harrison et al.). The notion that an ambient installation can be adapted in unpredictable ways aligns with the call for a third paradigm in HCI that considers meaning making in local context and the researcher's interpersonal interaction. According to Harrison et al., "a preference for multiple interpretations that

give a rich sense of the site of interaction over a single, objective description of it" is one of the characteristics of the third paradigm.

The third paradigm in HCI focuses on situated embodied encounter with the aim of supporting situated action in the world. This approach calls for consideration of the rich, complex, and messy situations that surround the interaction and how to complement formalized, computational representations and actions with them.

The aim of this study is to investigate the interaction with an ambient installation in public spaces while considering the principles of Calm Technology. By utilizing the concepts of the third paradigm in HCI, it was found that the impact of Calm Technology on public settings could potentially facilitate the use of ambient signals in the periphery for the purpose of increasing attention and allowing people to spend more time in public spaces.

2.2.4 Affective computing

Hebert A. Simon's contributions in 1967 are considered early works in the field of Affective Computing, although the field itself gained prominence when Rosalind W. Picard popularized it in 1997. Simon's theory proposed that organisms, including intelligent systems, have the ability to alternate between deliberate and reactionary processing to achieve their goals. In the context of human-machine interaction, this suggests that emotionally intelligent machines should be capable of detecting and responding to user frustration caused by usability issues, thereby facilitating the accomplishment of the user's objectives. Picard described this effect as challenging to quantify or predict, but emphasized the importance of improving its management to prevent users from being metaphorically "caught in a thunderstorm without an umbrella" (Picard, 2003, p. 111). Affective Computing is situated at the intersection of social, biological, and computational sciences, and a comprehensive understanding of its computational aspects requires an exploration of the historical and contemporary understanding of affect.

Facial expressions are commonly used in visual emotion recognition to identify human emotions, and the relevant data is easily accessible (Wang, Phillips, Dong, & Zhang, 2018). Regardless of cultural background or lineage, facial expressions consistently convey and interpret emotions (Pérez-Espinosa, Zatarain-Cabada, & Barrón-Estrada, 2022). The universal nature of core emotions across individuals suggests the potential

for machine-based emotion recognition through pattern analysis (Pérez-Espinosa et al., 2022). Automated facial expression recognition typically involves three stages: registration, representation, and recognition (Sariyanidi, Gunes, & Cavallaro, 2014). Registration focuses on identifying facial images, while representation, also known as feature extraction, utilizes techniques like local binary patterns to extract appearance-based features (Ahonen, Hadid, & Pietikainen, 2006). Moreover, advanced deep learning methods such as convolutional neural networks (CNN) have recently been employed for emotion recognition from facial expressions (Sariyanidi et al., 2014).

Body gestures offer another approach to visual emotion recognition, involving the detection of movement in the head, hands, and other body parts to convey feelings and thoughts (Santhoshkumar & Geetha, 2019). Similar to facial expressions, many gestures are innate and universal across cultures, inherited from ancestors (De Stefani & De Marco, 2019; Tracy & Matsumoto, 2008). Consequently, emotion recognition through body gestures is applicable to diverse populations. The process of body gesture emotion recognition typically comprises four stages: human detection, pose estimation, feature extraction, and emotion recognition (Noroozi et al., 2021). The input can either be a configuration of distinct body parts or a skeletal representation of the human body (Wang et al., 2015). In earlier studies, machine learning algorithms like decision trees, k-nearest neighbors, and support vector machines (SVM) were used for recognizing emotions conveyed in body gestures. However, recent years have seen the emergence of deep learning algorithms such as recurrent neural networks (RNN) and convolutional neural networks (CNN) in this field (Noroozi et al., 2021; Santhoshkumar & Geetha, 2019; Wang et al., 2015).

It is noteworthy to highlight several influential works in the field of Visual Affective Computing, specifically in the area of facial expression analysis, which has garnered significant attention over the past two decades. Facial Expression Recognition (FER) has been a crucial topic in biometrics even before the emergence of the term "Affective Computing" (Samal & Iyengar, 1992; Yacoob & Davis, 1996; Essa & Pentland, 1997; Yin et al., 2000; Sim et al., 2002; Chang et al., 2006; Zeng et al., 2009; Gross et al., 2010; Lucey et al., 2010).

Damasio (2000) proposed that emotions arise from brain activity involving chemical and neural responses that give rise to behavioral and psychological patterns. Ekman (1993) investigated the relationships between emotions and physiological signals, uncovering psychophysiological differences across emotions. Studies on emotion-

specific physiology, as well as autonomic and central nervous system activations, have facilitated the correlation of emotion-based physiological signals with neurological patterns, enabling the extraction of emotional data from biological signals (Panksepp, 1992). Damasio (2000) developed computer simulations to enable systems, such as robotic devices, to emulate emotions, feelings, and consciousness. In this study, the FER method is utilized for emotion detection due to its precise numerical variations and high accuracy compared to other methods such as heart rhythm, skin conductance, or body temperature (Wegrzyn et al., 2017). FER is considered the most common form of body language, representing human emotions such as anger, fear, sadness, disgust, stress, happiness, and neutrality. FER is made possible through deep learning models that attempt to detect landmarks on the human face to infer facial emotions and emotional states.

2.3 Interplay of Dwelling, Dynamics, and Attention Restoration in Public Places

2.3.1 Dwelling, place, and aesthetics

According to Norberg-Schulz, understanding and knowing a place involves the connection between the concepts of dwelling and place. He asserts that dwelling is not only related to shelter, but also implies that the spaces where life happens are places, which have a unique character (1980). This character of a place is synonymous with the genius loci or the spirit of the place. Norberg-Schulz believes that we can discover this character of a place through concrete experiences of everyday life, by paying attention to the objects, spaces, and atmospheres of our life-world, and by reflecting on the phenomenology of our daily environment (1980). The sense of place accumulates and changes with the seasons, the course of the day, and the weather, which mainly determines different conditions of light (Norberg-Schulz, 1980).

Yi-Fu Tuan, a geographer, approaches the concept of “topophilia” with an emotional dimension, describing it as “the affective bond between people and place or setting” (Tuan, 1990). Furthermore, Tuan perceives “attachment to place as a function of time” (Tuan, 1977). He argues that experiences over time contribute to a sense of place, which he defines as “a unique blend of sights, sounds, and smells, a unique harmony of natural and artificial rhythms such as times of sunrise and sunset, of work and play. The feel of a place is registered in one’s muscles and bones” (Tuan, 1977). Similarly,

philosopher Edward Casey emphasizes the importance of time in dwelling by stating that it gives a place its “peculiar perduringness, allowing us to return to it again and again as the same” (Casey, 1997).

Most people find a silent and featureless space oppressive. Aesthetically pleasing order in homes and workplaces usually involves salient features that are arranged to create positive visions and ways of thinking. The process of place making involves creating aesthetic situations that develop personal attunement to sensibility and ambiance. There is pleasure in returning to a beautifully ordered place. Place making through aesthetic means is also a form of social communication. As philosopher Immanuel Kant stated, in judgments of taste, "we are seeking agreement from everyone" (Meredith & Walker, 2008). Aesthetics are used not only to order the world in delightful and contemplative ways but also to appeal to shared experiences with others.

2.3.2 Dynamics of place and ambience

The study under consideration investigates dwelling, emplacement, and place making in a dynamic context of transient public spaces. According to geographer Doreen Massey, place is a constantly changing set of trajectories that involve power relations, and she suggests the need to theorize space and place as a product of social relations that are likely to be conflicting and unequal. Edward Casey argues that the fundamental dynamism of a place is encountered through the body, which acts as a "field of localization." Amidst this dynamism, places accumulate experiences, histories, languages, and thoughts. Returning to a familiar place brings back memories, expectations, old and new things, and the familiar and the unfamiliar (1997).

According to anthropologist Tim Ingold, places are formed through the accumulation of traces left behind by organisms, resulting in a meshwork of fluid space (Ingold, 2008). Public places are viewed as dynamic, heterogeneous, and constantly evolving, emphasizing the importance of preserving individual attention so that each person can develop their own sense of place. Cultural theorist Nikos Papastergiadis and colleagues suggest that large screens in public spaces have potential as "ambient installations" that can be used for civic and relational purposes (2016). They propose a second generation typology for digital installations, which emphasizes design that contributes to the locale, a reduction in advertising, and diversity in programming (Papastergiadis

et al., 2016). While this research project incorporates the first two aspects of promoting the locale and a lack of advertising, it differs significantly in the third aspect, particularly in terms of aesthetic and communicative approaches. These divergent perspectives of the "ambient installations" aim to humanize public screens by making them a local, relational, and dynamic part of place in order to foster a commons.

The correlation between the dynamism of place and the characteristics of ambience is evident. Leo Spitzer, a literary critic, defines "ambience" as the elusive sensory impressions surrounding us, yet at the periphery of our perception. The term "amphí," meaning "on both sides, around," originates from ancient Greek and has given rise to words such as amphitheatre, providing a view from all sides. The Latin "ambire," meaning "to go around," also derives from this word. The Italian use of "aria ambiente" in 1656 by Galileo denotes the surrounding air. Newton referred to the "ambient medium" in his 1687 Principia, defined as the ether through which astral bodies influence each other from a distance. The French translation of Newton's work in the eighteenth century produced the term "milieu ambient," which connects the concept of determining influence to the notion of milieu (which translates to "middle place"). Similarly, native words were adopted in various languages to refer to the same concept of an aggregate of influences or conditions that form or govern the existence, development, life, or behaviour of an individual or an entity (Spitzer, 1942).

2.3.3 Restorative environments

Biophilic patterns are supported by the "Attention Restoration Theory" (ART), which was proposed by landscape architect Rachael Kaplan and psychologist Stephen Kaplan in 1989. According to ART, natural environments can help to restore mental fatigue caused by "directed attention" (R. Kaplan & Kaplan, 1989; S. Kaplan, 1995), which can be mentally draining over time, even when focusing on a target stimulus that is not present, such as watching for kangaroos while driving at dusk or waiting for intermittent signals on social media. The effect of attention restoration in ART is said to be derived holistically from four components of restorative environments, namely being away, extent, fascination, and compatibility, as described by Stephen Kaplan in 1995. Being away refers to changing mental settings, which can be achieved conceptually or environmentally, such as by looking out a window while working. Extent is the degree to which the environment is perceived as integrated into a

continuous whole, while fascination can be derived from comprehensible, contained, yet unpredictable activities (hard fascination) or undetermined phenomena emerging in perception (soft fascination). Compatibility refers to the alignment of environment, needs, and intentions, where there is no sense of straining to orient or being on guard, and where there is a fit between one's emotional and mental state and desired activities.

The first component of restorative environments is "being away," which can be accessed by changing one's mental settings and can be both conceptual and environmental. For example, simply looking out a window while working can provide a sense of being away. The second component, "extent," is the degree to which the environment is perceived as an interconnected whole, as Kaplan explains it, "rich and coherent enough to constitute a whole other world." The third component is "fascination," which can be experienced along a hard-soft dimension. "Hard fascination" arises from comprehensible yet unpredictable activities such as watching sports or reading a crime procedural, while "soft fascination" is derived from ambiguous phenomena that emerge in perception, such as walking in a natural setting. The fourth and final component is "compatibility," which refers to the alignment of environment, needs, and intentions, without any sense of straining to orient oneself or being on guard, and a fit with one's emotional and mental state and desired activities (S. Kaplan, 1995).

Stephen Kaplan proposes that attention restoration can be achieved by utilizing an alternative mode of attending that temporarily renders the use of directed attention unnecessary. This alternative mode is facilitated by a network of mutually supporting elements that are holistically aligned in a safe, cognitively rich setting where individuals can identify with it for their own sense-making purposes. This setting has a special advantage in terms of providing an opportunity for reflection, which can further enhance the benefits of recovering from directed attention fatigue. These "restorative experiences" are best met in "restorative environments." Research by Shanahan et al. (2016) affirms Kaplan's claims that exposure to nature supports recovery from the fatigue of directed attention along with other health benefits. Naturalistic change in the periphery was also shown to support attention restoration in line with the elements described by Kaplan (1995) (Kaplan & Kaplan, 1989; Kaplan, 1995; Shanahan et al., 2016).

2.4 Generative Art and Installations at public places

2.4.1 Generative art and ambience

The aesthetic potential of generative ambient installations through an analysis of the cultural and aesthetic elements established by 20th-century ambient music. Various ways in which ambient music contributes to aesthetic encounters have been identified, such as creating an atmospheric background, introducing new modes of attention, and incorporating unpredictability and surprise. Additionally, high-fidelity reproduction enables ambient media and can be applied to a diverse range of aesthetic experiences and contexts. The visual aspects of generative media are also examined, adding to the conversation surrounding embodied experience within a context and the experience of the setting.

The current research project applied digital computer-driven generative processes to explore the aesthetic features of ambient installations. Generative art involves using rule-based systems to create aesthetic objects, which can be characterized as autonomous, legitimized by the artist's authorship of the rules, and subject to the artist's intention and critical choice of technology. While computers are not strictly necessary for generative art, contemporary practice increasingly relies on algorithmic digital automation. Therefore, this study uses "generative art" to refer to both a field of practice and a type of artifact that involves computers (Galanter, 2003; Verostko, 1998; McCormack et al., 2014; Boden & Edmonds, 2009; Fry, 2010).

Computers, by nature, involve automation, but in this context, the term refers to the strategic use of algorithms by artists to shift low-level decision-making tasks to computer code in the creative process. The emergence of computer-generated art in the early 1960s challenged traditional notions of creativity, decision-making, and artistic craftsmanship. Contemporary generative artists have varied opinions on the nature of creativity in relation to the use of algorithms. An algorithm is a set of rules or processes used for calculations or problem-solving operations, which can operate in conjunction with other algorithms in complex systems. For example, artist Harold Cohen developed the AARON computer program between 1973 and 2016 as a proceduralisation of his own creative decision-making. However, he maintained that AARON itself did not possess any creative ability. The unexpected and diverse outputs

of algorithmic generation can create the impression of creative agency and even reproductive power arising from the machine, which is a manifestation of the human tendency to anthropomorphize machines (Cohen, 2016; Fry, 2010; Galanter, 2003; McCormack et al., 2014; Verostko, 1998).

Artists are attracted to the precise control, visual intricacy, and limitless variation of form that can be achieved through the use of stochastic, combinatorial, self-organizing, emergent, and evolutionary processes generated by recursive functions, iterative systems, non-linear indeterminacy, and data-driven processes. While generative methods go beyond the capabilities of even the most skillful human hand, pioneering generative artist Vera Molnár believed that algorithmic instruments "...can help to realize what is most subjective, unattainable, and profound in a human being" (Popper, 1996).

2.4.2 Immersive installations and generative artworks in public places

According to computer scientists and artists Jon McCormack and Alan Dorin, generative media can evoke a sense of the "computational sublime," which arises from the infinite possibilities and emergent behavior of generative systems. They reference the generative artwork (Figure 2.1) IMA Traveller (1996) by Dutch artists Erwin Driessens and Maria Verstappen, which uses cellular automata to create a space that is algorithmically infinite and evokes both pleasure and fear. Additionally, psychologist Alice Chirico et al. found that virtual spaces can elicit experiences of awe, which can have positive or negative connotations depending on interpretation, but most research focuses on the positive experiences of perceptual vastness (2016).

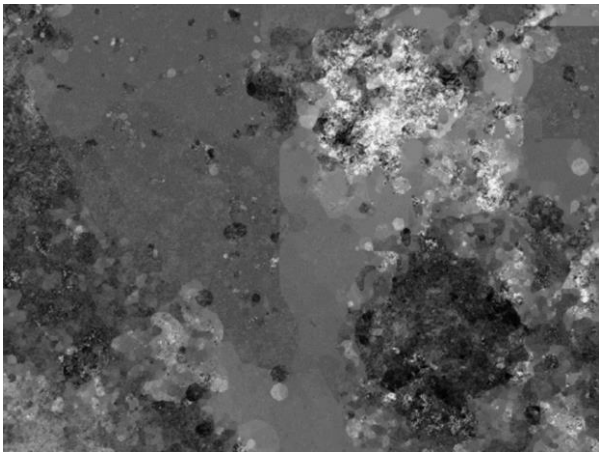


Figure 2.1: IMA Traveller (1996) by Erwin Driessens and Maria Verstappen.

2.4.3 Installations and generative artworks in public space

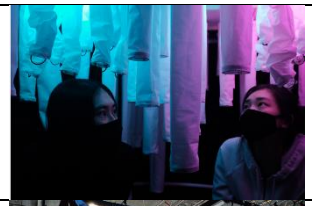
Christa Sommerer and Laurent Mignonneau are internationally recognized for their work in immersive installations that use plant forms and garden-like virtual environments for nearly 30 years. Their work (Figure 2.2) started with Interactive Plant Growing (1992) and later created Eau de Jardin (Sommerer & Mignonneau, 1994) inspired by Claude Monet's vision for the water lily rooms, where real-time animated plants created an immersive field of botanical patterns echoing the impressionist approach to embodied encounter

Figure 2.2: Interactive Plant Growing (1992) and later created Eau de Jardin.

Matt Pyke founded Universal Everything in the UK in 2004, and Toshiyuki Inoko founded teamLab in Tokyo in 2001, each established around a core of generative practice. Both have built portfolios known for immersive installations in both cultural and commercial contexts. teamLab established teamLabBorderless, a permanent public Tokyo venue for real-time generative immersive spaces inviting visitors to "Wander, explore, discover in one borderless world" (teamLab, 2020) (Figure 2.3). While teamLab's approach emphasizes immersion and spectacle, it also provides a model that could be applied with ambient gentleness for a variety of attentional contexts, as in the project work presented here.

Below (Figure 2.1) are some of the selected interactive installation projects that contain the concept of embodiment such as AC

Table 2.1 : Selected works, names of the presented interactive installations, installation type, and background for the concept of embodiment.

Ref	Year	Installation name	Image of the installation	Installation Type									Embodiment type				
				Music	Tangible	Enactive	Performance	Dance	Playful	Emotional	Mindfulness	Psychophysiology	Affective Computing	Biofeedback	Bodily Movement	Tangible Interfaces	Embodied Interaction
R1	2021	Wisteria-A								●			●	●			●
R2	2020	Reflectego		●					●	●					●	●	
R3	2020	Textrinium							●	●					●	●	
R4	2019	reSpire			●					●	●	●					

’continued’

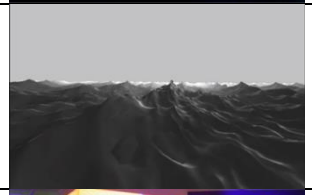
Ref	Year	Installation name	Image of the installation	Installation Type									Embodiment type							
				Music	Tangible	Enactive	Performance	Dance	Playful	Emotional	Mindfulness	Psychophysiology	Affective	Computing	Biofeedback	Bodily	Movement	Tangible	Interfaces	Embodied	Interaction
R5	2019	Touch of Smell					●	●	●	●										●	
R6	2017	Pulse Breath Water				●						●								●	
R7	2013	Caracolomobile								●			●								
R8	2012	Sonic Cradle		●						●						●					

Figure 2.3: Wander, explore, discover in one borderless world art museum, Tokyo.

The demand for didactic and sensational images on public screens is usually driven by commercial interests. However, a new trend in advertising-free public screens is emerging, where screens are being used purely for aesthetic purposes as permanent design features both indoors and outdoors. The UrbanScreen in Surrey, British Colombia (Figure 2.4) is an example of this trend, where it is considered “Canada’s largest, non-commercial screen dedicated to presenting digital artwork by regionally and internationally significant artists” (Surrey, 2020).

Figure 2.4: The UrbanScreen in Surrey, British Colombia.

Refik Anadol, a generative artist, created Interconnected (Anadol, 2018; Boraks, 2018), a generative artwork displayed on a 43-meter digital screen at Charlotte Douglas International Airport (Figure 2.5). The artwork utilizes data being transmitted across the airport's internal networks. These examples demonstrate the expanding cultural expectations of what architectural-scale screen technologies can provide in public spaces.

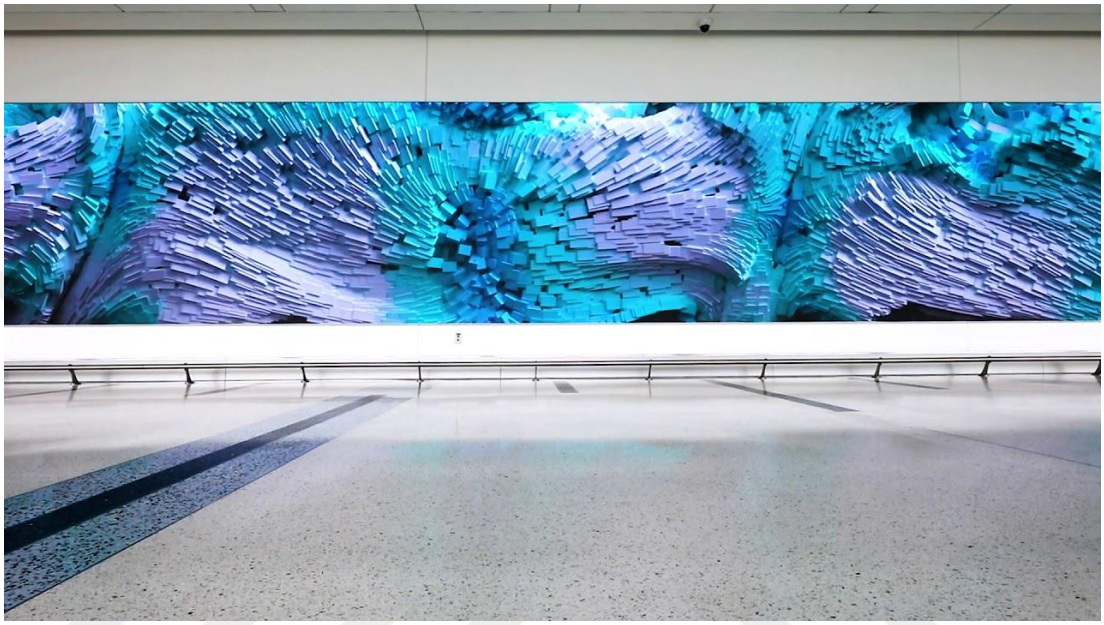


Figure 2.5: generative ambient public screen at Charlotte Douglas International Airport.

2.5 Conclusion

In conclusion, the literature review has provided valuable insights into the intersection of generative art, affective computing, calm technology, and ambient media in the context of designing installations for public spaces. It is evident that the rapid proliferation of smart devices and screen-based technologies has led to a pervasive issue of distraction, prompting the development of calm technology principles to humanize these technologies and restore users' attention. The incorporation of biophilic patterns, inspired by nature and validated by Attention Restoration Theory (ART), presents a promising approach to mitigating distraction and enhancing user experiences in public spaces. Additionally, McCullough's concept of the "ambient commons" and the "right to attend" highlight the growing significance of attention management in contemporary urban environments, emphasizing the need for

communal efforts to create aesthetic, attention-sensitive public spaces that facilitate meaningful interactions and experiences.

Moreover, the literature has highlighted the importance of the third wave of Human-Computer Interaction (HCI), which prioritizes human values, situated knowledge, and the messy context of social situations in design research. This paradigm shift offers a new perspective on the treatment of human attention, emphasizing the need to create technology that aligns with the user's needs and cognitive well-being. From this review, it is evident that the relationship between generative art installations, affective computing, and architectural elements in public spaces remains a relatively uncharted territory. This research presents an opportunity to explore how advances in technology and computing can offer deeper connections and new layers of interactivity to enhance user experiences in public spaces. The synthesis of these concepts and principles provides a strong foundation for the subsequent installation design, aiming to assess the impact of affective and interactive installations on users' attention restoration and emotional experiences. This research holds promise not only in advancing our understanding of the role of technology in shaping public spaces but also in contributing to the development of more human-centric and attention-sensitive interactive installations in architectural design.

3. CASE STUDY; EMOLAND INSTALLATION

3.1 Practice-led Methodology

Practice-led research in the arts refers to an extensive approach that aims to create new shareable knowledge within and/or about a particular creative field. Gray, drawing from Schön, defines practice-led research as research that is initiated through practice and where the research strategy is executed through practice. On the other hand, Rust et al. define practice-led research as an inquiry in which the professional and/or practices of art, design or architecture play an instrumental role. Candy acknowledges that a researcher may engage with both practice-based and practice-led approaches, but one will be dominant, with practice-based research dealing with instrumental

knowledge and creative outputs and practice-led research dealing with theories and concepts. Candy and Edmonds make a distinction between practice-based and practice-led research, where practice-based research is grounded on a creative artifact, while practice-led research leads to new understandings about practice (Gray, 1996; Rust et al., 2007; Candy and Edmonds, 2018).

3.2 Design Process

The Emo-Land project consists of six phases: (1) Training the AI model for FER by the use of CNN algorithm (2) Mapping the real time data with the trained AI model (3) Designing the emotion-based interaction projection mapping, (4) Designing the surface for augmentation, (5) User experience, and (6) Analyzing user feedback. The general process of the methodology used is depicted in (Figure 3.1).

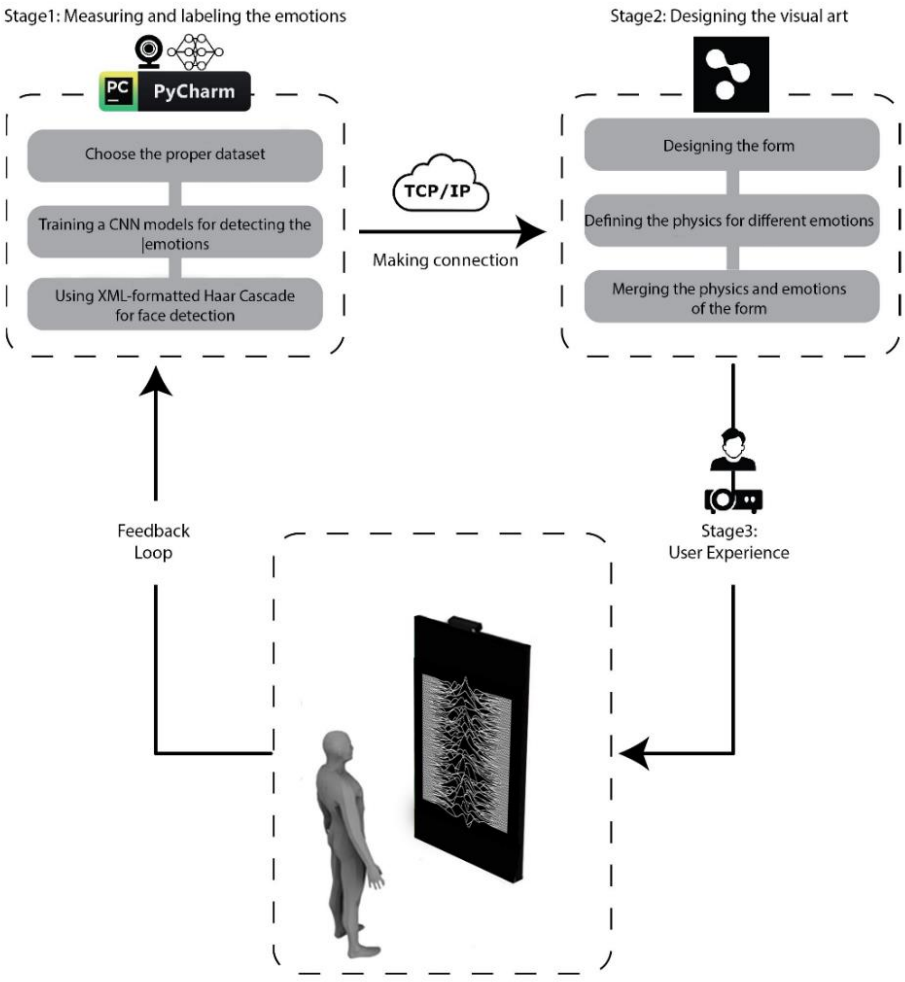


Figure 3.1: Design process diagram.

PyCharm is used to develop the project as an integrated development environment for the Python programming language and Derivative TouchDesigner as a real-time rendering, and visual programming platform. The two systems are able to connect via the use of TCP/IP sockets that are sent over the network.

3.2.1 Training the AI model

The development of machine learning models for image classification and recognition has seen significant advancements in recent years. One of the most popular approaches for building such models is through the use of deep learning techniques. The Python programming language has become a widely adopted tool for building these models due to its simplicity and flexibility. In particular, the deep learning library Keras, built on top of the TensorFlow framework, has been instrumental in the development of multi-layer artificial neural network models that can be interconnected in a modular way. This abstraction of complexity allows for the efficient creation of complex models that can be trained on large datasets.

The success of deep learning in image classification and recognition has been demonstrated by its ability to surpass human-level performance on certain tasks. As such, it has become an important area of research for the development of intelligent systems that can be trained to recognize and classify images with high accuracy. The use of Python and Keras in deep learning models has also contributed to the development of new and innovative applications in areas such as affective computing, robotics, and autonomous vehicles. The continued growth and advancement of deep learning techniques, along with the accessibility of Python and Keras, make them important tools for the development of intelligent systems and the advancement of artificial intelligence as a field.

Facial expression recognition is a crucial part of many human-computer interaction systems. In our system, this process involves two steps. Firstly, the video captured by the webcam is processed using a traditional computer vision technique for face tracking included in the OpenCV library. This step is essential because it helps identify regions of interest in the video frames where faces are located. The method utilizes the Viola-Jones algorithm, which is known for its robustness and accuracy in detecting faces in real-time applications. The algorithm uses a cascade of Haar-like features, which are simple rectangular patterns that capture specific image characteristics such

as edges and lines. These features are evaluated on sub-windows in the video frames, and those that match the pattern are used to identify potential face locations. Figure 3.2 describes the used architecture for training the AI model.

In the second step of the facial expression recognition process, the faces detected in the first step are analyzed to recognize the different facial expressions. This is achieved using deep learning-based models trained on large datasets of facial expressions. The models can classify the facial expressions into different categories such as happy, sad, angry, surprised, and natural. The accuracy of the recognition process depends on the quality of the input video and the performance of the deep learning models. In summary, the facial expression recognition process in this system involves a combination of traditional computer vision techniques and deep learning-based models to provide accurate and real-time recognition of different facial expressions.

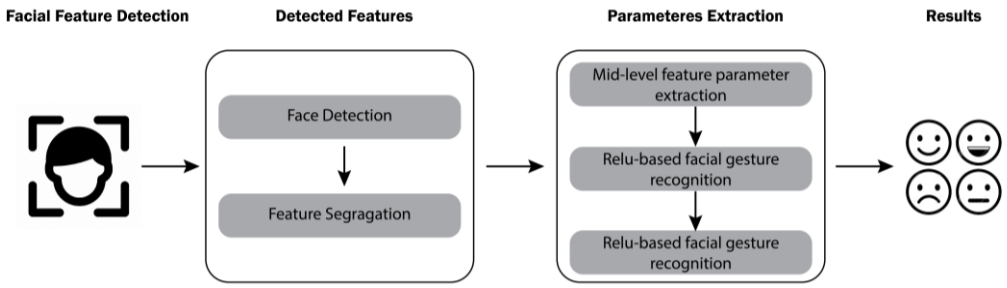


Figure 3.2: FER architecture diagram.

This FER system involves two distinct stages. The initial step detects faces in the video input using a traditional computer vision technique, which involves the Viola-Jones algorithm present in the OpenCV library. The algorithm uses Haar Cascade files in XML format for frontal face detection. In the second stage, a Deep Learning model employed based on a CNN model that is constructed using Keras and TensorFlow frameworks. The CNN model used five layers and has previously been demonstrated to be effective in the Kaggle facial expression recognition challenge held in 2013. The model is trained on the FER 2013 dataset, which contains 28,000 training and 3,000 test images of faces saved as 48 by 48-pixel grayscale images.

In this stage, the sub-windows with detected faces from the previous step are resized to 48 × 48 pixels to match the image data format expected by the CNN model. Python code is used to build the facial expression detection model in Keras, along with other Deep Learning models and weight parameters utilized in the project. The code used for building the models is brief and straightforward to understand after familiarizing

oneself with Keras syntax. The materials used in the project, including the code for building the models, are available for public use.

3.2.2 Mapping the real-time data with the trained AI model

In this phase of the project, a method was developed to represent the user's emotional states by modifying a projection mapping installation. The installation underwent a transformation and was reconfigured to align with the user's current facial expression. This was achieved by reading the latest emotional prediction made by a PC running TouchDesigner every seconds through communication with the server using the TCP/IP method. The PyCharm and TouchDesigner programs were able to communicate with each other to facilitate this process.

The state space approach and machine learning techniques were used to detect changes in the user's emotional states through communication with the server. The relationship between the user's emotions and the alterations in the installation's speed and form were then mapped out. The projection mapping installation was designed to reflect the user's emotional state by creating visual effects that match the user's current facial expression. This allowed the user to observe the relationship between their emotions and the resulting changes in the installation. The system's ability to communicate and update in real-time enabled the installation to be interactive and dynamic, providing the user with a unique and immersive experience.

The communication between the PyCharm and TouchDesigner programs was essential in ensuring that the installation could update and reconfigure in real-time, allowing it to reflect the user's current emotional state. By using the state space approach and machine learning techniques, changes in the user's emotional states were detected, and the installation's speed and form were adjusted accordingly. This allowed the user to have a more immersive and engaging experience, as the installation provided a dynamic representation of their emotions.

3.2.3 Designing the emotion-based interaction projection mapping

Most people's behavior and decision-making are affected by emotional fluctuations, such as stress at work, academic exams, and challenging relationships. While emotions such as fear, anxiety, and depression are happening to everyone, it is never advisable

to remain in the same emotional state for a long time without realizing it. This form and its interactivity wants to convey the concept that maybe the user cannot control some aspects of the life such as work pressure, academic exams, and relationships' challenges, but she can control the inner peace, productivitty, and possitive attitude which are the most important aspects of life (Figure 3.3). So the study selected the form concept of Joy Division based on its ability to establish an emotional connection

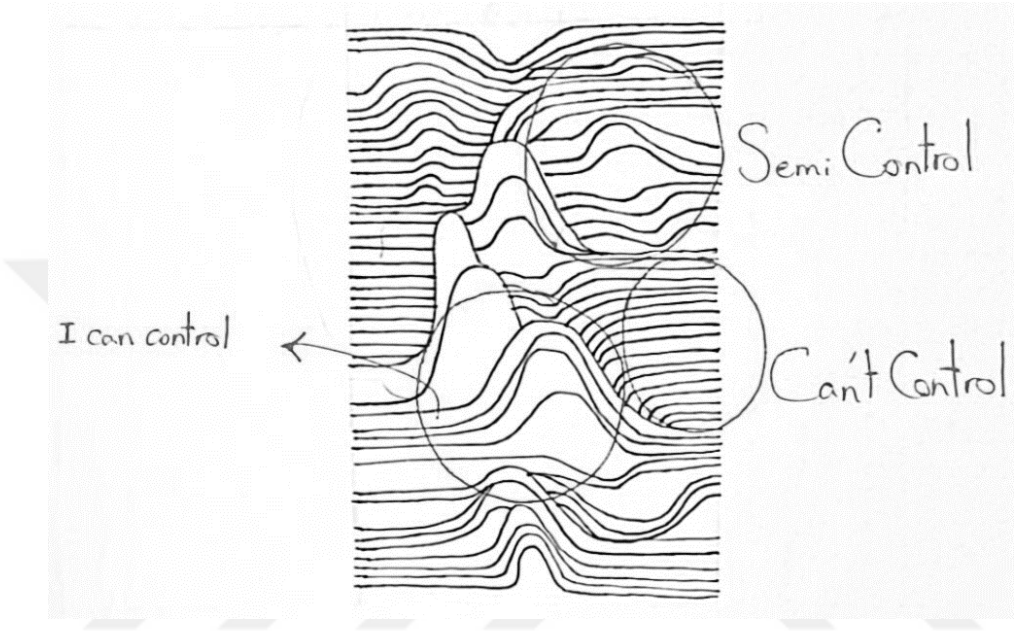


Figure 3.3: Form's concept.

with users. Previous scholars like Flanagan (2009) and Gosling (2019) have emphasized the emotional impact of abstract forms, which can evoke a sense of mystery and fascination, fostering a deeper connection with the artwork. Additionally, the Joy Division form concept offers computational efficiency, requiring minimal computing power to render its distinctive lines and waves. This advantageous trait enables even low-cost PCs to handle the necessary computations for creating an interactive installation. Hence, the Joy Division form concept was considered suitable for this study's objectives, as it combines emotional engagement with computational efficiency.

The study utilizes Derivative TouchDesigner as a real-time rendering and visual programming platform, which provides robust tools for creating interactive installations, media performances, and real-time visual effects. To investigate the impact of visual stimuli on human emotions, the study draws insights from Tan's (2016) research, which demonstrates how different shape-change behaviors can

influence users' emotional states. By integrating TouchDesigner's visual programming capabilities with Tan's findings, this project explores the relationship between real-time visual stimuli and human behavior. It is well-documented that humans generally prefer forms that are moderately complex but not excessively intricate. Studies, such as those by Berlyne (1971), have indicated that moderate levels of complexity in visual art can evoke positive emotions like curiosity and interest. In light of this, the speed and density of lines in the Joy Division experience could be mapped to the user's emotional state in a manner that reflects the level of complexity in the visual design (Figure 3.4). For instance, during positive emotions like happiness and surprise, the lines may become denser and move faster, while during negative emotions like sadness and anger, the lines could become less dense and slower.

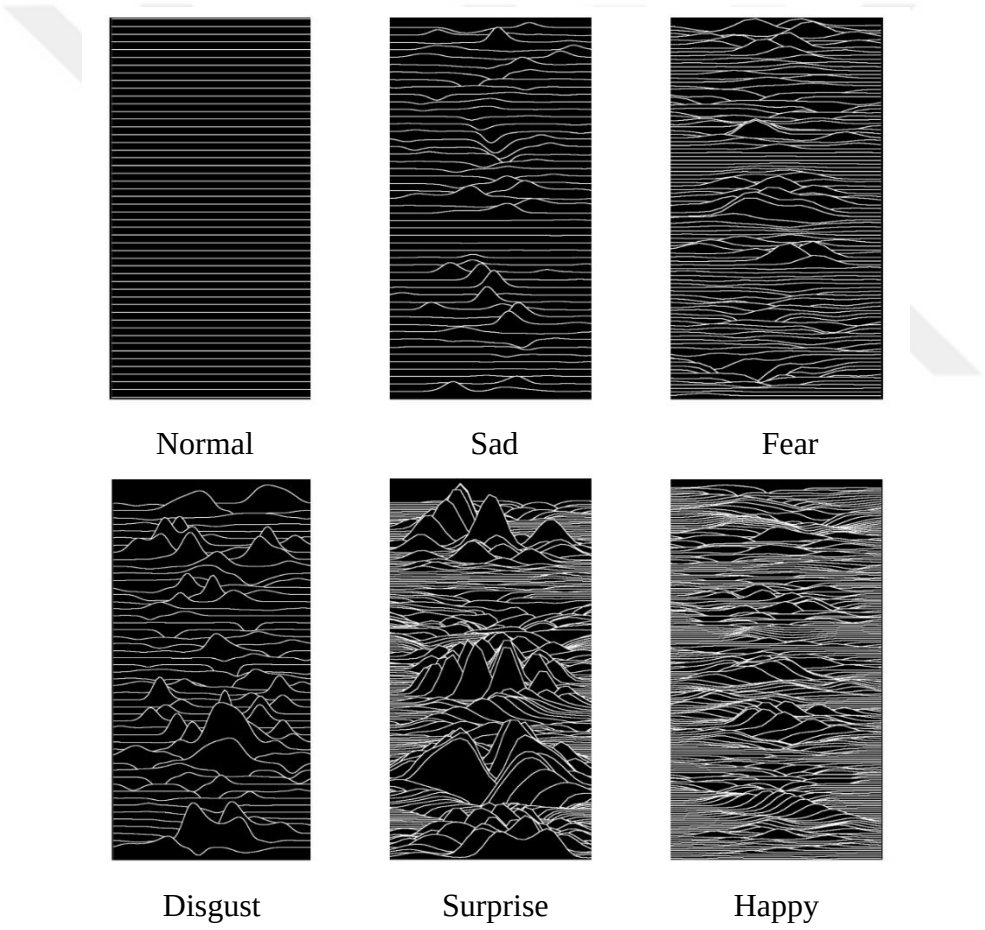


Figure 3.4: Form's reconfiguration based on different facial expressions.

Wave textured surfaces offer a unique canvas for projection mapping, enabling architects to create visually captivating and immersive experiences. The integration of wave textures with projection mapping provides advantages in terms of enhancing the realism of architectural spaces. One key aspect of wave textured surfaces is their ability

to seamlessly integrate digital content. The organic undulations and natural movement represented by wave textures lend themselves to the projection of lifelike images and animations. By mapping the projected content onto the contours of the waves, architects can create a sense of realism and immersion that is difficult to achieve with traditional flat surfaces. Furthermore, the interplay of light and shadow on wave textured surfaces adds another layer of depth and dimensionality.

In addition to realism enhancement, projection mapping on wave textured surfaces offers aesthetic advancements. The inherent depth and dimensionality of wave textures create a visually captivating environment. Projection mapping takes advantage of these features by projecting that follow the curves and contours of the waves. This creates a sense of depth and visual interest. Moreover, the dynamic nature of projection mapping allows for the transformation of wave textured surfaces into living canvases. The interplay between the waves and projected content can simulate natural phenomena or create the illusion of rippling water, adding a mesmerizing and aesthetically pleasing element to architectural designs.

User perception studies indicate that projection mapping on wave textured surfaces generates a higher level of engagement and emotional connection compared to traditional flat surfaces. The realistic representation of biophilic elements through projection mapping enhances the overall user experience, making architectural spaces more memorable and impactful. Space as the primary element of this adaptation involves tangible and intangible matters regarding its design elements. While tangible matters can be form, shape, color, material, the intangible ones can be sound, movement, smell, etc. Among these matters the form comes to foreground with its multiple definitions based on a set of simple or complex constraint relations. These relations can be constructed on an idea, force of fields (Thompson, 1942), appearance

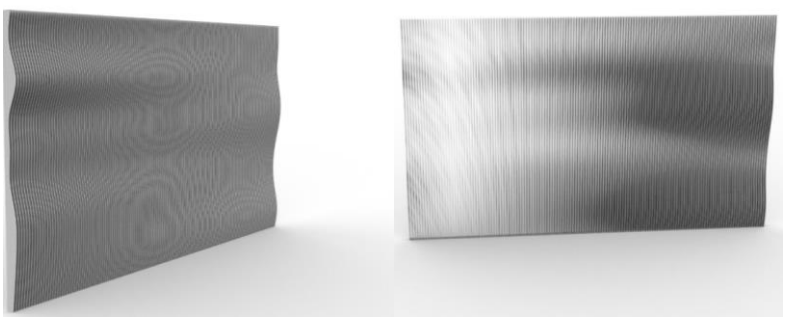


Figure 3.5: The designed wavy Form for EmoLand installation.

of things, object configuration (Alexander, 1964), or active determining principle of a thing from multiple points of views (Arnheim, 1977). Form complexity is one of the factors that can elicit different emotional responses from occupants, such as curiosity, interest, pleasure, boredom, confusion, frustration, or stress (Bower et al., 2019). research has shown that spaces with curvilinear forms are perceived as more pleasant and can evoke positive emotions compared to spaces with sharp, angular forms (Vartanian et al., 2013). In this regard a wavy and curvilinear form designed with Rhino and Grasshopper softwares (Figure 3.5).

3.3 Case Study Analysis: "EMO LAND—An Interactive Installation"

Emo-Land is an interactive installation capable of creating an emotional bond by actively responding to the physiological conditions of the user through a reconfiguration of its qualities.

The installation of EmoLand took place in a semi-public corridor at Istanbul Technical University, strategically positioned in front of professors' rooms, with a constant flow of students and professors walking past the installation throughout the day. The corridor served as a bustling gathering point for professors engaging in small talks before and after their classes. As professors and students traversed the corridor to attend their classes, they had the opportunity to interact with the installation, providing them with a momentary respite and an avenue to rest their minds. The location proved to be ideal for fostering interactions with the installation, allowing individuals to pause for a minute, engage with the ambient signals, and experience the calming effects it offered. The constant foot traffic and social interactions in the area created a dynamic and vibrant backdrop for EmoLand, turning the corridor into a unique space for enriching experiences and cultivating a sense of calm amidst the academic environment.

The design tries to create an emotional landscape of the user through the interaction of real time data and projection. Emo-Land can communicate with seven emotions of the user, which are anger, disgust, fear, happiness, sadness, surprise, and neutral. Emo-Land's creation mechanism is presented in this study, as a living structure that became a representation of the user's facial expressions. The project results include(Figure 3.6):

1. Analyzing, interpreting, and detecting facial emotion data, including a deep learning algorithm that continuously predicts the user's emotional state.
2. An installation that responds to the emotions of the user by the real-time transformation of form, speed of transformation, order, and complexity; enhances the ability to bond a relationship between machine and user.

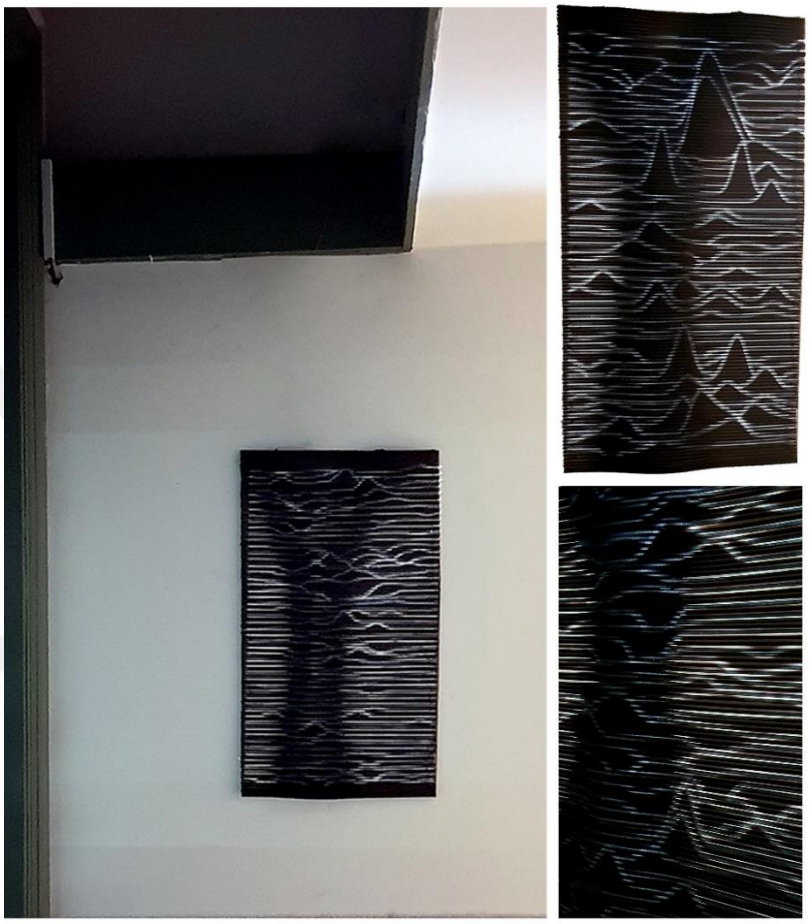


Figure 3.6: Images of the EmoLand installation.

3.3.1 User experience

In this study, two strategies were employed to assess the effectiveness of the proposed system in terms of system usability and user behavior, experience, or affect. The initial strategy involved utilizing the observational method (Latko et al., 1997). Figure 3.7 demonstrate different responses of the installation to user’s facial expressions. The second approach consisted of conducting questionnaire surveys. These methodologies are introduced in this section, and the outcomes obtained from evaluating the collected data using these approaches are elaborated in the subsequent section.

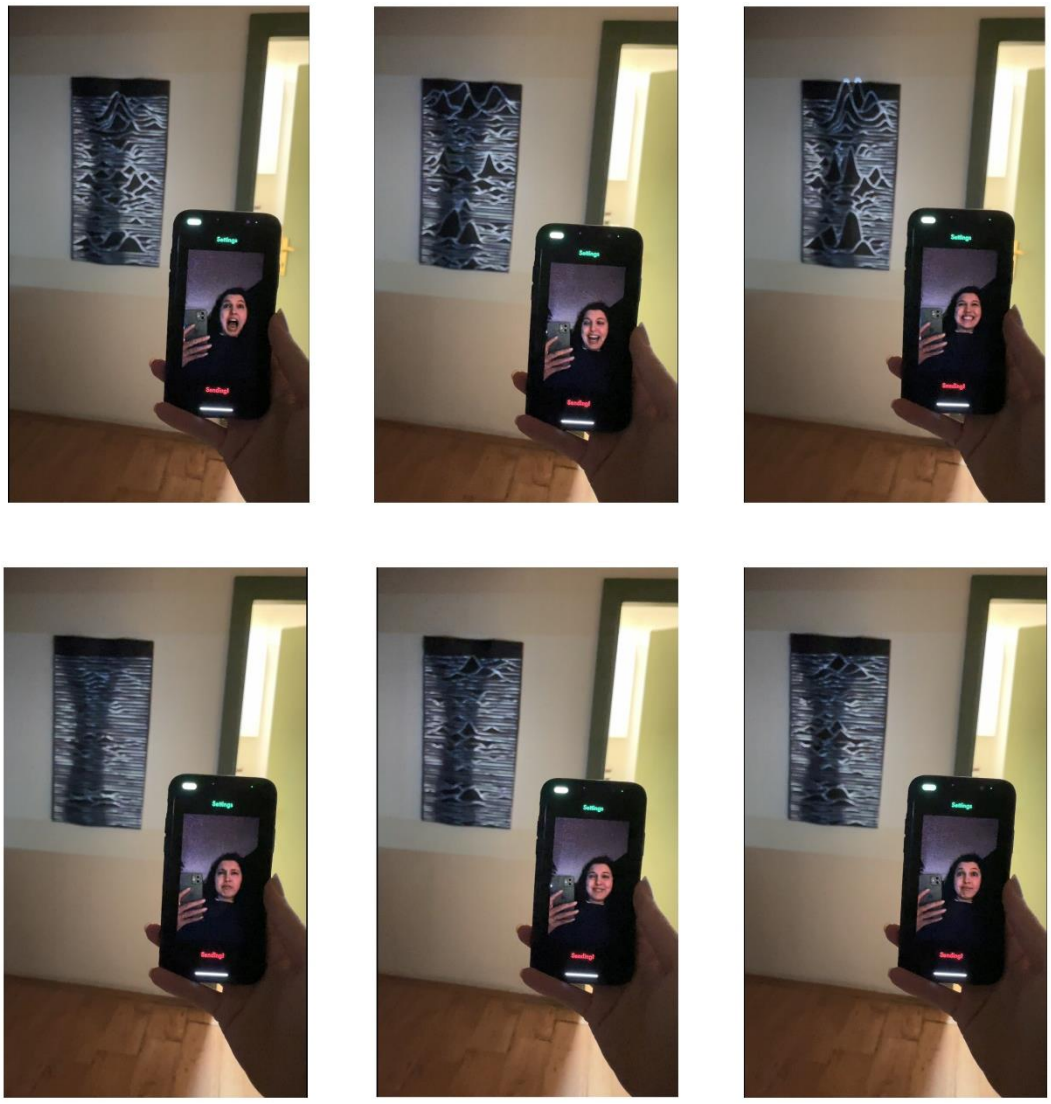


Figure 3.7: real-time response of the EmoLand to different facial expressions of the user.

3.3.2 Questionnaire design

Questionnaires are widely utilized as effective tools for collecting desirable data in various surveys (Agresti, 2013). To ensure the effectiveness of the data gathered, it is crucial for questionnaires to provide simple and concise descriptions of the items being evaluated without excessively guiding the participants. In this study, the questionnaire items were specifically designed to assess two indicators: system usability and the user's experience regarding their interactions with the installation(Figure 3.8). Several considerations were taken into account during the questionnaire design process.

Nielsen (1993) proposed four indicators for evaluating system usability, including installation setting, setting attraction, ubicomp tools and interaction in analyzing usability. Norman et al (2007) suggested six items that a system with good usability should encompass: visibility, feedback, limitation, correspondence, consistency, and prediction. Yeh (2010) identified three indicators to evaluate the usability of an interactive design: effectiveness, ease, and enjoyability. These studies share similar conceptual frameworks, which served as the basis for designing the questions in this study. Table 3.1 presents the specific questions used to assess the usability of the proposed system.

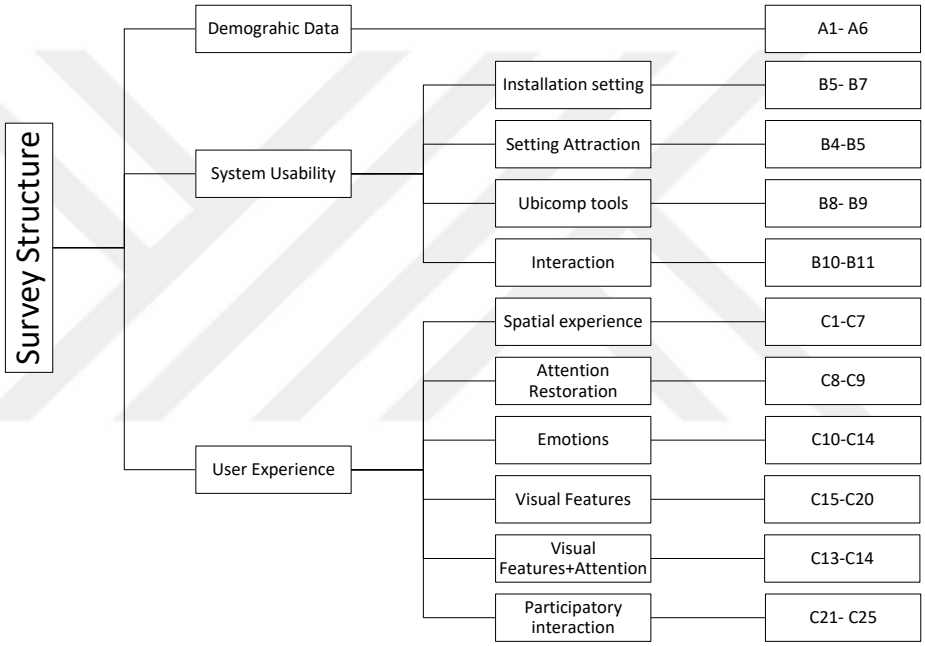


Figure 3.8: List of items for observations of the two indicators of system usability and user's behavior.

The questionnaire employed in this study serves as a comprehensive tool designed to evaluate the impact of a wide array of design principles elucidated within the literature review. The formal understanding towards formal perception of design principles has also been changing with the developments in technology. These encompass Calm Technology, with a primary focus on preserving attention, the strategic use of fixed architectural elements to forge emotional bonds, the cultivation of embodied and multisensory experiences within the ever-evolving dynamics of the place, and the promotion of mindful dwelling through easily recognizable elements for distraction regulation. Moreover, the questionnaire delves into the creation of shared space

experiences, aiming to encapsulate aesthetic and affective computing-driven encounters. By probing these multifaceted design facets, the questionnaire's overarching objective is to unveil the degree to which these principles influence participants' holistic perceptions of the installations, their emotional engagement, and the effectiveness of attention restoration within public spaces (Figure 3.9). By harvesting insights from participant feedback and responses, this research endeavors to provide a deeper understanding of the efficacy of these principles in shaping user

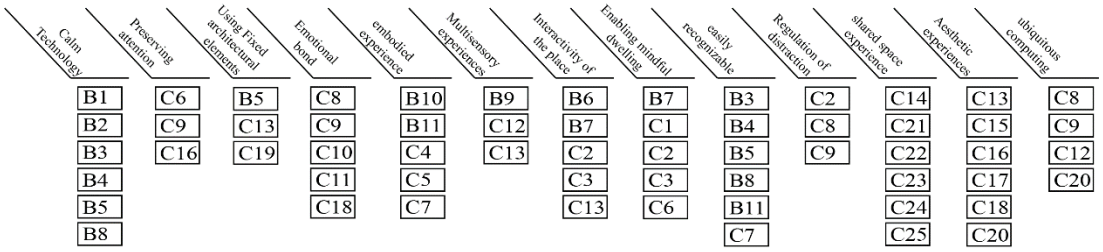


Figure 3.9: List of items for observations according to the design principles.

experiences within the realm of architectural design and interactive installations.

When users engage with the proposed installation, the primary form of human-machine interaction involves interactions that can elicit real-time emotional changes in the user, along with visual feedback from the system presented in various multimedia formats such as animations, images, and sound. This study draws inspiration from Schmitt's (1999) strategic experience modules, which encompass five types of experiences related to the user's emotions. These include sensory experience, affective experience, creative cognitive experience, social-identity experience, and behavior and lifestyle. These concepts were considered relevant for exploring user emotions during the interaction process and their perceptions of system usage. To assess system usability and user experience, a questionnaire was developed, comprising 41 questions based on the identified types of experiences Schmitt's (1999) strategic experience modules (Table 3.1).

Table 3.1: List of questions of the questionnaire for evaluating system usability and users' experiences.

Indicator	Lebel	Question
Demographic info	A1	How old are you?
	A2	Please choose your gender
	A3	Have you ever interacted with any interactive installations except this one?
	A4	How were you feeling today before interaction

Indicator		Lebel	Question
		A5	How are you feeling now? (After interaction)
System Usability	Installation setting	B1	I think it is easy to interact with this kind of setting in public places.
	Installation setting	B2	I cannot concentrate on interacting within this setting.
	Installation setting	B3	I quickly learned how to interact within this setting.
	Installation setting	B4	I cannot utilize this installation./Bu kurulumu kullanamıyorum.
	Setting Attraction	B5	The installation setting attracts my attention.
	Setting Attraction	B6	The installation was placed at an attractive place.
	Setting Attraction	B7	The installation made the space more attractive.
	Ubicomp tools	B8	This installation effectively integrates several tools and functions such as mobile phone usage and facial expression recognition.
	Ubicomp tools	B9	I would like to interact more with places through my cell phone, smart watch and any other daily device I use.
	Interaction	B10	Interaction with this installation is interesting for me.
	Interaction	B11	I can interact with the installation smoothly.
User's experience	Spatial experience	C1	This installation affected my feelings to this space.
	Spatial experience	C2	This installation affected the ambience of the space.
	Spatial experience	C3	Which part of the installation effected your feelings to the space?
	Spatial experience	C4	Which part of this experience is more interesting for you?
	Spatial experience	C5	When would you like to use this installation at public places?
	Spatial experience	C6	This installation helped me to feel being away of this place.
	Spatial experience	C7	I easily adapted to the space.
	Attention restoration	C8	Facial expressions helped me to restore my attention.
	Attention restoration	C9	Facial expressions helped me to feel away of this place.
	Emotions	C10	Interaction with facial expressions helps me to control my emotions better.
	Emotions	C11	Using this installation can affect my mood.
	Emotions	C12	I am more willing to interact with affective installations after using this installation.

Indicator		Lebel	Question
	Emotions	C13	This installation provides a pleasant and comfortable atmosphere.
	Emotions	C14	This installation makes me feel welcomed, safe and relaxed.
	Visual Features	C15	The feedback of the visual complexity attracts my attention.
	Visual Features	C16	The pattern of the used visual attracts my attention.
	Visual Features	C17	The transformation of the pattern attracts my attention.
	Visual Features	C18	Complexity of the lines makes me feel...
	Visual Features	C19	I liked the projection mapping on the wavy surface.
	Visual Features	C20	I liked the transformation of the landscape of lines with my facial expressions.
User's experience	Participatory interaction	C21	This installation attracts me to participate in the interaction.
	Participatory interaction	C22	Participatory interaction in this installation made me feel good.
	Participatory interaction	C23	The installation lets me to interact with sorrounded people?
	Participatory interaction	C24	I synchronized with the emotions of the cell phone user who interacted with the installation
	Participatory interaction	C25	Which part of the installation effects social interaction? (You can choose multiple choices)

Understanding the intricate relationship between space, affection, technology, and architecture is of paramount importance, as highlighted by the need for a comprehensive questionnaire. In the evolving landscape of architectural design and HCI, these factors converge to shape the way individuals experience and interact with their built environments. Space, as the physical backdrop, provides the canvas upon which technology and architecture work together to evoke emotional and affective responses from occupants.

By delving into this multifaceted relationship, the questionnaire aims to uncover critical insights into how the design of spaces, integration of technology, and architectural elements collectively impact individuals' emotions, behaviors, and overall experiences within these environments. As we navigate an era where interactive and responsive built environments become increasingly prevalent, the need to gauge occupants' reactions, moods, and participation levels becomes even more

pressing. Ultimately, this understanding will guide architects, designers, and technologists in creating spaces that not only serve functional purposes but also foster positive emotions, well-being, and a sense of belonging among their users, ushering in a new era of human-centric design.

Furthermore, the questionnaire employed the Likert 5-point scale (Allen & Seaman, 2007) to assign scores ranging from 5 to 1 to each question, indicating the degree of agreement or disagreement with the statements. The scale allowed participants to express their opinions, ranging from "strongly agree" to "strongly disagree." Following the completion of the questionnaire by all participants, the collected data were analyzed using the SPSS software packages. Through this analysis, clusters of related questions were identified, and their grouping was presented in Table 3.1. Each cluster represented a specific question dimension or scale associated with the indicators of installation usability and user experience, as outlined in Table 3.1.

3.3.3 Analysis of data collected in the experiment

The process of gathering feedback to the installation through the experiment's activities is visualized in Figure 3.10.

The survey process was conducted in the following sequence:

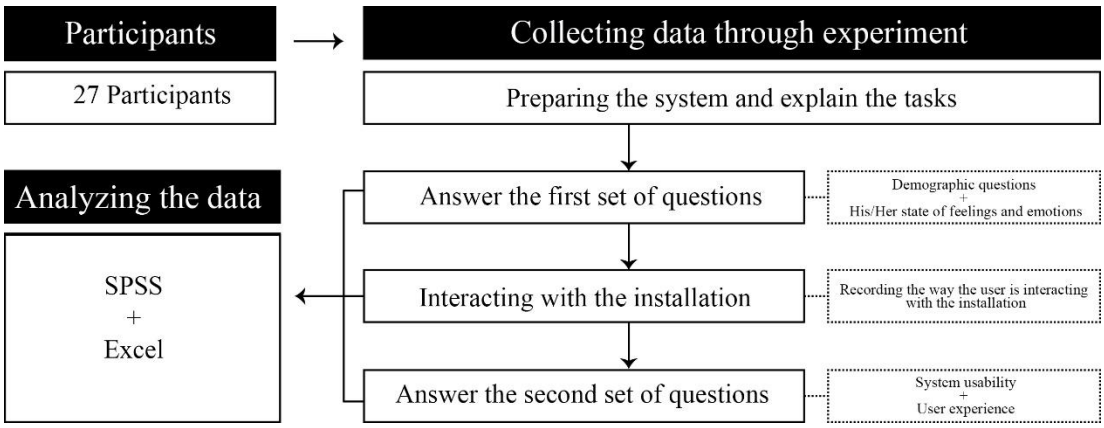


Figure 3.10: Procedure of the conducted survey.

(1) The system was introduced to the participants, providing an explanation of the experiment's objectives and the interactive process.

(2) The participants' demographic information and emotional state were recorded.

(3) The participants were guided and assisted in engaging with the installation and interacting with it.

(4) The participants were asked to complete the second part of the questionnaire.

The users' opinions, gathered through the questionnaire and the recorded data, were analyzed.

A total of 27 participants, spanning different age groups, participated in the experiment and interacted with the installation. All 27 participants completed the questionnaire survey, resulting in 27 valid questionnaires. Finally, when participants were filling out the questionnaire, I ensured to maintain a distance, allowing them to freely complete it without any external pressure. Figure 3.11 displays images capturing the environment and activities of the experiment.

Figure 3.11: Experiment setting and participants activities.

3.4 Results of Questionnaire Surveys

A total of 27 responses were obtained from the questionnaire survey conducted during the experiment. The questionnaire consisted of inquiries regarding the participants'

demographic information and their evaluations of system usability and user experience, which served as the two indicators of interest. The specific questions corresponding to these indicators can be found in figure 3.12. The feedback data, collected using a Likert 5-point scale, was subjected to detailed analysis from various perspectives. The statistical analysis results of the two indicators are presented in Tables 3.2 and 3.3. The subsequent sections will provide a comprehensive description of the analytical approach employed.

Table 3.2: Score percentages of the collected data of the two indicators of system usability and user's experience.

Question	Strongly Agree(5 Scores) (A)	Agree (4 Scores) (B)	No Opinion (3 Scores) (C)	Disagree (2 Scores) (D)	Strongly Disagree (1 Scores) (E)	Percentage of Agreements (F = A+B)
B3	85.18	11.10	3.70	0	0	96.28%
B5	74.07	7.40	14.81	0	3.70	81.47%
B6	33.33	7.40	14.81	11.10	14.80	40.73%
B7	74.07	14.80	11.10	0	0	74.21%
B8	70.37	11.10	7.40	11.10	0	81.47%
B9	66.66	22.22	11.10	0	0	88.88%
B10	70.37	22.22	7.4	0	0	92.59%
B11	74.07	14.80	3.7	7.4	0	88.87%
Average						**80.56**
C1	62.96	0	18.51	11.1	7.4	62.96%
C2	55.55	37.03	0	3.7	3.7	92.58%
C6	29.62	29.62	25.92	11.11	3.7	59.24%
C7	59.25	18.51	11.11	0	11.11	77.76%
C8	55.55	18.51	14.81	7.4	3.7	74.06%
C9	44.44	18.51	18.51	7.4	11.11	62.95%
C10	33.33	25.92	25.92	11.11	3.7	59.25%
C11	66.66	22.22	7.4	0	3.7	88.88%
C12	59.25	25.92	3.7	3	0	85.17%
C13	55.55	25.92	14.81	0	0	81.47%
C14	51.85	18.51	22.22	0	7.4	70.36%
C15	25.92	25.92	7.4	3.7	0	51.84%
C16	55.55	25.92	7.4	7.4	3.7	41%
C17	74.07	22.22	3.7	0	3.7	96.29%
C19	66.66	25.92	3.7	0	3.7	92.58%
C20	74.07	11.11	11.11	3.7	0	85.18%
C21	66.66	18.51	0	11.11	3.7	85.17%
C22	70.37	18.51	0	7.4	3.7	88.88%
C23	70.37	14.81	3.7	11.11	0	85.18%
C24	37.03	22.22	22.22	0	11.11	59.25%
Average						**74.07**

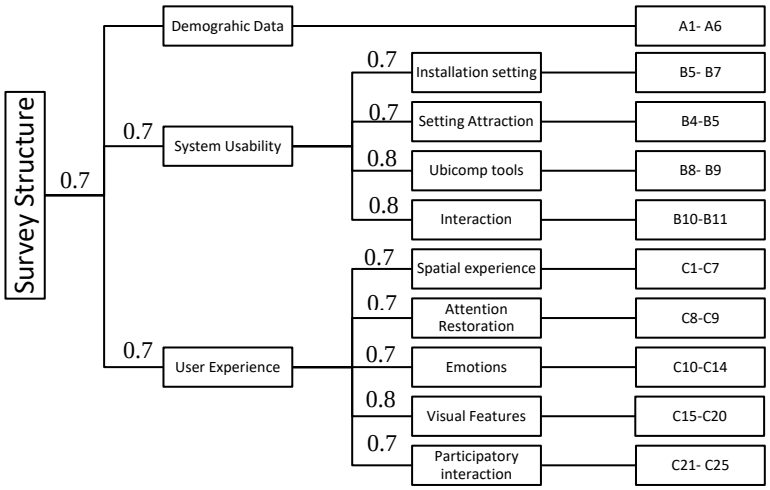


Figure 3.12: Mean of the collected data.

Table 3.3: Statistics of the collected data of the two indicators of installation's usability and user's experience.

Indicator	Label	Question	Min	Max	Mean	S.D.
System Usability	Installation setting	B1	0.2	1	0.81	0.22
		B2	0.55	1	0.81	0.28
		B3	0.43	1	0.91	0.14
		B4	0.54	1	0.95	0.11
	Setting Attraction	B5	0	1	0.85	0.24
		B6	0	1	0.59	0.34
		B7	0.45	1	0.86	0.17
	Ubicomp tools	B8	0.26	1	0.80	0.22
		B9	0.48	1	0.86	0.17
	Interaction	B10	0.58	1	0.87	0.14
		B11	0.36	1	0.86	0.19
	Average				**0.79**	
User Experience	Spatial experience	C1	0.15	1	0.72	0.29
		C2	0.19	1	0.77	0.24
		C6	0.14	1	0.66	0.24
		C7	0.17	1	0.83	0.22
	Attention restoration	C8	0.19	1	0.74	0.25
		C9	0	1	0.66	0.32
	Emotions	C10	0.03	1	0.67	0.25
		C11	0.13	1	0.82	0.22
		C12	0.20	1	0.80	0.23
		C13	0.40	1	0.80	0.21
		C14	0.07	1	0.77	0.27
	Visual Features	C15	0.23	1	0.82	0.20
		C16	0.08	1	0.75	0.25
		C17	0.58	1	0.88	0.14
		C19	0.14	1	0.86	0.20
		C20	0.27	1	0.87	0.20
	Participatory interaction	C21	0.19	1	0.82	0.26
		C22	0.12	1	0.81	0.25
		C23	0.24	1	0.79	0.21

	C24	0.12	1	0.68	0.26
	Average			**0.76**	

A noteworthy aspect to emphasize is the utilization of a reverse scoring technique for questions B1, B2, B3, and B4 due to their negatively worded nature. This approach aimed to maintain uniformity in the average scores. Hence, responses indicating "agree" and "strongly agree" for these questions were considered as "disagree" and "strongly disagree," respectively, and vice versa.

The analysis of the demographic data collected from the participants revealed that out of the total number of participants, 15 were female, while 12 were male. Additionally, among the participants, 17 individuals had no prior experience with interactive installations, 9 had some previous exposure, and only 1 person had extensive experience with +interactive installations.

Furthermore, before engaging with the installation, 12 participants reported feeling happy, 3 expressed sadness, and 11 felt a normal emotional state. However, following the interaction, there was a shift in emotional states, with 16 participants feeling happy, 10 experiencing surprise, and one individual remaining in a normal emotional state (Figure 3.13).

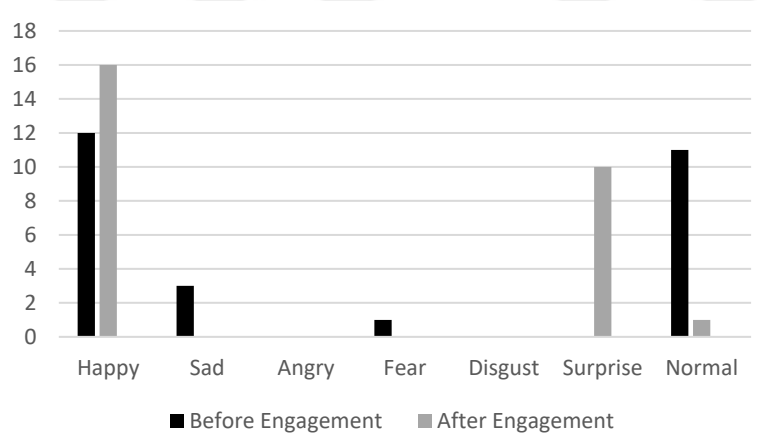


Figure 3.13 : Statistics of the collected data of the participants emotional state before and after the experiment.

Based on the responses to questions C3 and C4, it was observed that the behavioral response of the installation had an impact on the emotional state of 14 individuals in relation to the space (Figure 3.14). Out of the participants, 5 reported that controlling a specific area of the space had a greater effect on their feelings, while another 5 believed that the interactive biophilic pattern influenced their emotional response to

the space. Furthermore, the use of projection mapping was found to have an impact on the emotional state of 3 participants.

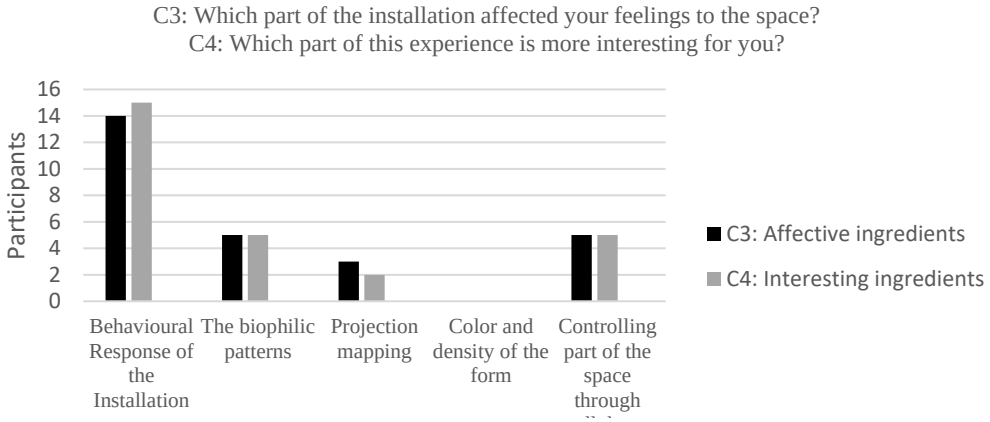


Figure 3.14 : Statistics of the ingredients that effected users' feelings to the space.

The survey results reveal compelling insights, with a significant 74.06% of participants reporting the ability to restore their attention during interactions, while an impressive 62.95% expressed the sensation of "being away" from their immediate surroundings. These findings underscore the central question that drove the research: whether affective and interactive installations have the potential to influence users' attention restoration in public spaces. The affirmative response from the majority of participants suggests a promising avenue for leveraging innovative design, technology, and architectural elements to enhance cognitive well-being and immersion within public spaces. This research paves the way for a deeper exploration of the transformative impact of interactive installations on the human experience in shared spaces, heralding a future where design can positively shape our attention, emotions, and sense of presence in the built environment.

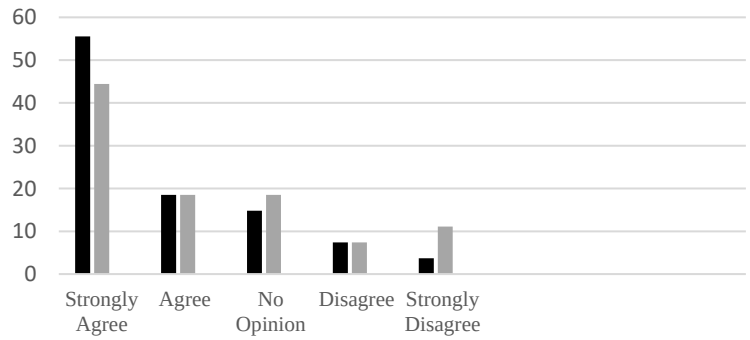


Figure 3.15 : Statistics of the ingredients that effected users' attention restoration and fee being away.

The analysis of the questionnaire data in this study involved the utilization of the SPSS and AMOS software packages. Additionally, Microsoft Excel was employed for result tabulation. Before conducting the analysis, a test was executed to evaluate the properties of the collected data and ensure their appropriateness for further analysis and interpretation. The characteristics of the data and the verification methods applied are described in the following section.

3.5 Assessment of the Collected Data

The notion of reliability concerns the consistency of a dataset when measured repeatedly (Scott, 1955). To assess the reliability of the questionnaire data in this research, Cronbach's α coefficient was employed. This coefficient was obtained through the exploratory factor analysis (EFA) as previously mentioned (Cronbach, 1951). Cronbach's α coefficient provides insight into the internal consistency of a scale or dataset, with higher values indicating increased reliability.

Cronbach's α coefficient is a valuable tool for assessing HCI projects in architectural design for several reasons. In architectural design projects related to HCI, the goal is often to create environments and interfaces that facilitate positive user experiences. To evaluate these experiences, researchers typically employ various metrics and questionnaires. Cronbach's α helps ensure the reliability and internal consistency of these measurement instruments. In the context of architectural design, this means that the metrics used to assess factors like usability, comfort, and user satisfaction consistently and accurately capture users' perceptions. A high Cronbach's α value indicates that the questionnaire items or metrics within the HCI project are measuring the same underlying constructs consistently, providing confidence in the reliability of the data collected. This is especially critical in architectural design projects where user feedback and experience data are fundamental to refining designs and optimizing the built environment to meet users' needs.

Furthermore, architectural design projects in HCI often involve multidisciplinary factors. Cronbach's α can help harmonize the various aspects of these complex projects by providing a quantifiable measure of the internal consistency of the evaluation tools. It allows to assess whether the measurements are reliable and aligned in their

objectives. In architectural design projects, where the built environment directly influences user behaviors and experiences, ensuring that the assessment tools are consistent and reliable is essential for making informed design decisions. As stated by Gilford (1954), the proximity of the Cronbach's α coefficient to its maximum value of 1.0 serves as an indication of the dataset's reliability. When the Cronbach's α coefficient approaches 1.0, it suggests higher reliability for the dataset.

$$\alpha \geq 0.70 \rightarrow \text{highly reliable;}$$
$$0.35 \leq \alpha < 0.70 \rightarrow \text{reliable;}$$
$$\alpha \leq 0.35 \rightarrow \text{unreliable,}$$

The Cronbach's α coefficient, referred to as α, presents the coefficient's value. Table 3.4 presents a comprehensive presentation of the Cronbach's α coefficient values for the nine question dimensions (scales) and the two indicators. As can be observed in the table, all the Cronbach's α coefficient values are between 0.35 and 0.70, with most values exceeding this range. These outcomes imply that the gathered questionnaire data for each question dimension and the indicators demonstrate an acceptable level of reliability.

Table 3.4: Cronbach's α coefficients of nine question dimensions.

Indicator	Question Dimensions	Cronbach's α Coefficient	Cronbach's α Coefficient of the Indicator
System Usability	Installation setting	0.778	0.814
	Setting Attraction	0.765	
	Ubicomp tools	0.839	
	Interaction	0.671	
User Experience	Spatial experience	0.745	0.831
	Attention restoration	0.724	
	Emotions	0.772	
	Visual Features	0.643	
	Participatory interaction	0.775	

3.6 Summary of questionnaire surveys

Based on the preceding discussions, it can be inferred that the questionnaire data obtained from the participants regarding the system usability and user's experience indicators possess both reliability and validity, enabling their utilization for subsequent analysis of the data content. These findings contribute to the following conclusions.

3.6.1 Evaluation of the system usability

Regarding the assessment of the proposed system's usability, the findings of the questionnaire survey indicate an overall positive feedback. This is evident from the average agreement percentage of 80.56% in the upper part of the last column of Table 3.2, suggesting that users generally perceive the system's usability as good. Among the 11 questions, questions B8, B9, B10, and B11, which pertain to the performance of ubicomp tools and interaction, received scores higher than the average, with over 90% of participants acknowledging the installation's strong performance,. Conversely, two questions, B6 and B7, related to the attractiveness of the setting, received lower scores. 40% of participants acknowledged the installation was placed at an attractive place, and 74% believed that the installation made the space more attractive. Based on the analysis of the system's usability, the following conclusions can be drawn:

(a) Users found the proposed system easy to use, indicating a favorable design of the installation.
(b) Users expressed feelings of happiness and interest during their interaction with the system, indicating satisfaction with the interaction experience.
(c) Users felt that the installation was not positioned in an appropriate location, suggesting the need for better placement of the system.

Regarding the evaluation of system usability, the three question dimensions of "ease to learn," "efficiency," and "satisfaction" were considered. The average scores for "ease to learn" and "satisfaction" were above four, and the proportions of agreement (combining "strongly agree" and "agree") exceeded 90%, as indicated in Tables 3.2. These findings suggest that the users can perform well while using the proposed system. However, in terms of "efficiency," the average score was 3.83, which is lower than four. The proportion of agreement was 72.84%, while the proportion of

disagreement was 9.27%. This indicates that improvements are required to enhance the efficiency of the proposed system in this aspect.

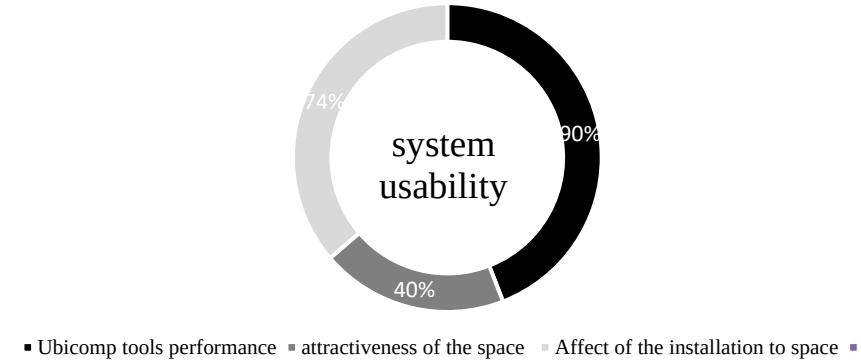


Figure 3.16 : Statistics of the ingredients that impacted system usability.

3.6.2 Evaluation of the users' experiences

Regarding the evaluation of the user's experience, a majority of the questions received positive feedback, as evident from the lower section of the last column in Table 3.2.

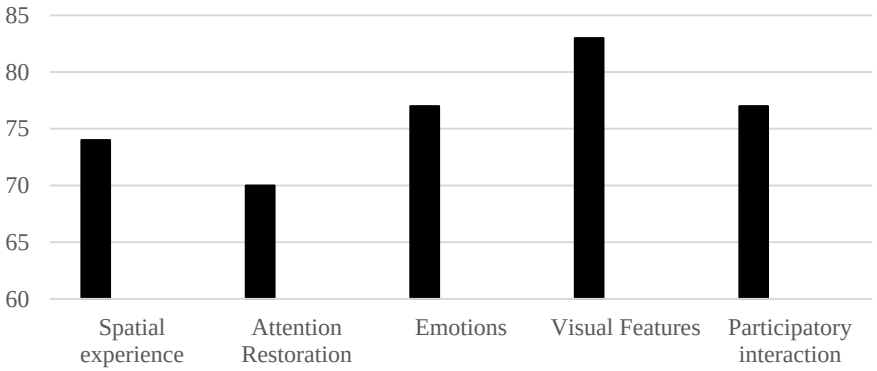


Figure 3.17 : Evaluation of the users' experience.

The average agreement percentage was found to be 74.07%, indicating an overall positive user experience. Among the 24 questions, four questions (C2, C17, and C19) obtained average scores of strongly agree and agree, as observed in the lower part of Table 3.2. The corresponding proportions of agreements were over 90%, suggesting that the users had positive experiences with the system's interaction. However, two questions, C10 and C24, received lower scores. Further detailed analysis of the users' experiences with the installation led to the following conclusions.

(a) The participants had a positive spatial experience, which enhanced the ambiance of the space. Through this system, they encountered spatial adaptation in a novel manner.

(b) Analyzing the users' emotions, it was observed that the installation influenced their moods; however, participants did not have control over their emotions or a comprehensive understanding of their emotional changes.
(c) The users faced difficulty in comprehending the method to regulate emotions during the experience with the system, as the installation focused on emotional visualization and feedback without providing direct instructions for emotional control.
(d) While biophilic patterns holds various meanings, the primary purpose of this system was attention restoration feedback. Therefore, the user found it challenging to fully grasp the meanings of it through this system.
(e) The users expressed a positive opinion regarding the participatory interaction aspect of the installation.

4. DISCUSSION & LIMITATIONS

This study introduces a generative ambient installation known as EmoLand, which incorporates principles of Calm Technology and utilizes biophilic patterns to enhance public spaces and promote a humane and restorative approach to attention. The installation was developed to create ambient signals through a continuous and abstract landscape scene that reflects real-time facial expressions of the user, offering an infinite variety of traversing possibilities. The installation was presented in a semi public setting at Istanbul Technical University to explore its impact and gather feedback from the participants. The findings of the study highlight how the ambient sensory field created by the generative ambient installation seamlessly integrated into the participants' attentional background, fostering a sense of pleasant habituation, relaxed immersion, and positive emotions. The ambient signals generated by the installation served as either a subtle presence in the periphery or a captivating visual field for contemplation. Overall, the ambient field facilitated a state of calm, promoted endogenous attention, and contributed to attention restoration.
The project followed an interdisciplinary cycle that encompassed distinct phases of experimentation, reflection, and analysis. This iterative process facilitated double loop learning, wherein knowledge generated through bottom-up approaches informed both

the practical implementation and theoretical frameworks of the project. The aim was to leverage principles of Calm Technology and theories of ambience and attention to create public spaces that prioritize the well-being of attention. The outcomes of the project offer concrete examples of real-world installations and serve as a critical foundation for artists and designers to contemplate alternative modes of engagement with public urban installations. These installations aim to support a sense of calm, restoration, and cultivate a shared understanding of an ambient commons.

The project utilized Affective computing methods to create EmoLand, a generative ambient installation in public spaces. Affective computing is of paramount importance in the built environment as it enables the integration of human emotions and responses into the design process. By leveraging technologies that can recognize, interpret, and respond to human emotions, built spaces can be transformed into more empathetic, adaptive, and supportive environments. EmoLand's use of facial expression recognition through Convolutional Neural Networks (CNN) exemplifies the potential of affective computing to enhance user experiences. By capturing real-time emotional states, the installation creates a dynamic and interactive space that promotes calmness, attention restoration, and positive emotions. The integration of affective computing methods in the built environment allows designers to cater to users' emotional needs, fostering a stronger connection between individuals and the spaces they inhabit. Moreover, understanding the impact of design elements on users' emotions can lead to the creation of more inclusive and psychologically beneficial spaces, ultimately contributing to improved well-being and satisfaction among occupants. As cities become increasingly complex and urban spaces evolve, Affective computing offers a valuable tool for architects and designers to address the intricate interplay between emotions and the built environment, resulting in more human-centric, responsive, and harmonious places for people to live, work, and interact.

AI serves as an invaluable toolkit in the realm of design, providing a wealth of opportunities to enhance creativity, streamline processes, and optimize outcomes. Within this toolkit, several fundamental design criteria come to the forefront. Firstly, AI facilitates efficiency through automation, significantly reducing the time and effort required for various design tasks. Whether it's generating complex algorithms for generative art installations or analyzing vast datasets for user behavior patterns, AI accelerates the design process, enabling designers to iterate, refine, and experiment more rapidly.

Secondly, AI empowers designers with the ability to harness data-driven insights. Through machine learning algorithms and data analytics, AI can process immense volumes of information to unveil trends, preferences, and user behaviors. This data-driven approach informs design decisions, ensuring that creations are not solely based on intuition but grounded in empirical evidence. By understanding user needs and preferences, designers can tailor their creations to provide more meaningful and impactful experiences.

The objectives in design when leveraging AI in this study are twofold: efficiency and user-centricity. AI-driven design strives to optimize workflows, , and enhance productivity. It aims to deliver results faster and with greater accuracy, thereby maximizing the efficiency of the design process. Simultaneously, user-centricity remains a paramount objective. AI helps designers create solutions that resonate with end-users, fostering emotional engagement and satisfaction. By considering the human experience and tailoring designs to meet their needs, AI-driven design aligns with the principles of user-centered design.

In assessing whether these design criteria and objectives are met, a rigorous evaluation process becomes essential. Designers must scrutinize the extent to which AI has expedited their workflows, improved accuracy, and enriched the overall creative process. Additionally, user feedback and usability testing play a pivotal role in determining whether AI-powered designs truly enhance the user experience and meet their expectations. The interplay between AI as a toolkit, design criteria, and design objectives is an intricate dance that, when orchestrated effectively, can result in innovative, efficient, and user-centric creations.

4.1 Research Outcomes

In this research, it has been observed that the concept of the "ambient commons" can be applied in creative and innovative ways to address the contemporary challenges posed by pervasive screen technologies and the resulting distractions in public spaces. McCullough's notion of the "right to attend" and the communal management of attention within shared environments offer a fresh perspective on how technology can be harnessed to foster meaningful interactions and experiences. By strategically integrating the principles of calm technology, biophilic patterns, and affective computing, this study aims to demonstrate that public spaces can indeed be

transformed into attention-sensitive and aesthetically engaging environments. It underscores the potential of technology to enhance rather than detract from our interactions with the built environment, thus contributing to the growing discourse on human-centric architectural design and the creation of spaces that genuinely cater to the needs and well-being of their occupants.

The findings suggest that the installation called EmoLand met the criteria of a calm application by providing informative content without causing distractions. The installation effectively conveyed real-time sensory information about the local environment, which could be received in the periphery of users' attention. The design of the installation, including its abstract landscape scene and window-like format, contributed to a fluent and easily orientable experience for users.

The physical setting of the installation also played a role in the overall spatial experience. The implementation of generative and ambient patterns in the space provided multisensory ambient cues, supporting users' attention in the periphery. This approach aligned with the principles of Calm Technology, creating a socially conducive setting that supported peripheral and endogenous attention. The outcomes of the research indicated several positive effects of the installation:

1. Aesthetically attractive and interactive design: The installation's design was visually appealing and interactive, which likely enhanced user engagement and enjoyment.
2. Support for the periphery of attention: By presenting information in the periphery of users' attention, the installation enabled users to effortlessly receive real-time sensory information without requiring their full focus.
3. Promotion of habituation: Users were able to habituate to the installation over time, suggesting that it became a familiar and integrated part of the environment.
4. Effective transmission of embodied information: The visual features of the installation successfully conveyed embodied information, allowing users to understand and interpret the content presented.
5. Utilization of generative art: Generative art was employed in an aesthetic manner, enlivening the periphery of users' attention while maintaining a calm and ambient threshold.

Overall, these findings demonstrate the potential of affective and interactive installations to reduce distractions for individuals in public places. By incorporating

principles of Calm Technology and leveraging the periphery of users' attention, such installations can create engaging and informative experiences without overwhelming users' focus.

The findings suggest that while EmoLand initially provided a novel way for participants to encounter an installation, they soon became habituated to it and perceived it as a holistic component of the overall installation. Participants engaged with the multisensory ambient installation both in an attended and unattended manner, selectively sampling and appropriating from it.

According to the analysis of the questionnaire responses, 74% of participants found the setting of EmoLand to be a pleasing social amenity that supported calm dwelling and attention restoration. However, it was less effective in helping participants feel a sense of being away from their current place. Despite this, most participants enjoyed the open-endedness of the ambient signals and utilized them for personal reflection, imaginative free play, storytelling, and place-making.

The analysis also highlighted the participants' sensitivity to the full range of biophilic patterns, which are patterns that evoke a connection with nature. The dynamic use of these patterns correlated with the stages of attention that lead to attention restoration, as proposed by S. Kaplan (1995). This suggests that the incorporation of biophilic patterns in the installation design contributed to participants' attention restoration and overall positive experience.

The findings suggest that the generative installation extend the conceptualization of Calm Technology by accommodating the indeterminate nature of the public context. Unlike calm applications typically designed for predetermined tasks in personal or workspaces, generative installations were found to be adaptable to human appetitive drives within an indeterminate environment.

This outcome expands the category of Calm Place, which signifies the possibilities of generative installation as a social amenity where a "right to attention" is assumed as a goal. By introducing affective and interactive generative installation as an aesthetic element in built spaces, the installation provides affordance for various experiences such as repose, mindful dwelling, solace, reassurance, and restoration. These findings highlight the potential of generative installations and the EmoLand installation to create an environment that supports calm and positive experiences for individuals in public places. By tuning the generative installations to human appetitive drives and incorporating them as an aesthetic element, the installation can enhance the overall

atmosphere and provide opportunities for repose, mindfulness, and attention restoration. However, it's important to note that further improvements may be needed to enhance the sense of being away from the current place for participants, as mentioned earlier. These enhancements could potentially strengthen the transformative and immersive qualities of the installation, creating a more immersive and captivating experience for users. Overall, the research outcomes indicate that the EmoLand installation have the potential to contribute to the development of Calm Technology and Calm Place concepts, providing individuals with a social amenity that supports attention, solace, and restoration in public spaces.

4.2 Limitations

This thesis conducted by a landscape architecture student, although comprehensive in its scope, could have benefited from the involvement of professionals from other disciplines such as psychology, neuroscience, and software development. Collaborating with experts from these fields would have provided a more precise and nuanced approach to the study, leading to a more robust analysis of the research topic. One limitation of the study was the lack of assessment with neuroscience devices to measure the effect of the installation on users' brain activity and biological signals. Incorporating such devices would have allowed for a deeper understanding of the cognitive and physiological responses elicited by the installation. However, due to time constraints and limitations in access to suitable equipment, this aspect could not be fully explored.

Another limitation relates to the size of the installation. The small scale of the installation may have restricted the level of immersion experienced by users. A larger installation size could have provided a more encompassing and immersive experience, potentially enhancing the overall impact on users and their engagement with the installation.

Furthermore, device limitations posed challenges to the study. The availability and functionality of technological devices used in the research could have influenced the range of data collected and the accuracy of measurements. Employing more advanced or specialized equipment could have provided enhanced functionality and a more comprehensive assessment of user experiences.

It is important to consider the generalizability of the findings, as they may be specific to the context of the installation and the participants involved. Different environments and individuals may yield different outcomes, and caution should be exercised when applying the results to other settings or populations.

Additionally, the study acknowledged the need for further improvements in creating a sense of being away from the current place for participants. Strengthening the transformative and immersive qualities of the installation could enhance the overall experience and increase the potential impact on users.

External factors, such as environmental conditions and individual differences, were not extensively explored in the study. Considering these factors in future research could provide a more comprehensive understanding of how external influences may affect users' experiences with the installation.

The sample size and diversity of participants in the study may have been limited, which could impact the generalizability of the findings. Including a larger and more diverse sample in future research would offer a broader perspective on the installation's impact on different individuals.

Lastly, the study relied on self-reported feedback from participants, which is subjective and may be influenced by individual biases or preferences. Integrating objective measures or complementary qualitative methods could provide a more comprehensive evaluation of the installation's effects.

These limitations should be taken into account when interpreting the findings of the study. They also highlight areas for further research and improvement in future investigations to address the identified constraints and enhance the validity and applicability of the study's outcomes.

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