Adaptive Interactive Environments: Harnessing Audience Interaction for Immersive Multisensory Spaces

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Abstract. This paper represents the first stage of the practice-led research project outlined below. It is concerned outlining the objectives, methodological approach and contextualizing the need for the study. The project aims to develop an affordable, flexible, and adaptable system to enable audience control of audio, visual, and lighting elements within site-based art installations / performances and immersive experiences. Leveraging low-cost computers, sensors, bespoke and open-source software, the project seeks to create an ecosystem of 'tools' underpinned by a wireless communication framework that can be used for a wide range of interactive audio-visual installations in various spaces. The study also aims to rationalize existing systems for the delivery of previous works, aiming to reduce inefficiencies in planning and designing new site-based installations. Importantly, this project focuses on creating the system for delivering installations rather than the design of the installations themselves. It employs the systems development life cycle (SDLC) methodology to address key research questions concerning audience interaction with media elements in immersive installations and the system's flexibility across various sites and content forms. The study explores the psychological impacts of live audience interaction, multisensory stimulation and the perception of space and environment as integral components of the immersive experience. It also outlines considerations for logistical changes to the system based on the artists practice-led research and requirements inherent in the move to a more site-adaptive approach

Keywords: Advertising Strategy, Social Movement, Hashtag, Millennial.

1 Introduction

This practice-led research project aims to develop an affordable, flexible, and adaptable system to enable audience control of audio, visual and lighting elements within site-based art installations/performances and immersive experiences. Building on past projects created by the authors as part of Friend or Foe, Sloan et al., [1], this research looks to explore ways of moving audience engagement with their works from a passive sight-specific experience, to an active and social site-adaptive experience. In leveraging low-cost computers, sensors, bespoke and open-source software, the aim is to create an ecosystem of ‘tools’, underpinned by a wireless communication framework that can be

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used for a wide range of interactive audio-visual installations within various spaces. The system will draw from both local and remote online data sources, enabling simultaneous events to connect between multiple locations.

The study also looks to rationalize the existing systems used for delivery of these works to reduce inefficiencies when planning and designing new installations and performance events. An ad-hoc and experimental approach to development has led to many elements of the performance and delivery systems being re-designed for each piece. In mapping previous works and consciously designing for the integration of new elements on a holistic level, it aims to define to current capabilities of the system, making it easier to plan and visualize new works.

Importantly, this project is concerned with creating the system for delivery of installations rather than installations themselves. Drawing from theoretical concepts of flow, atmosphere and cross-modality, the study explores the psychological impacts of live audience interaction, multisensory stimulation and the perception of space and environment as integral components of the immersive experience, aiming to achieve full immersion through focused participant engagement. This paper itself represents the first stage of this process. It is concerned with defining the approach to this study, outlining the objectives, methodological approach and contextualizing the need for the study. This research looks to answer two, key research questions:

1. Can we develop a wireless, transportable, adaptive system of tools that enables audience interaction with media elements such as audio, visual and lighting within an immersive installation?
2. Can this system be flexible enough to function across various sites and for various forms of immersive content?

2 Methodology

The system being developed builds on previous work created by Friend or Foe. Specifically, a range of installations and performances that have been developed over a number of years through practice, experimentation, collaboration and intuition, rather than a formalized, academic, process. From a technical viewpoint the works combine a wide range of audio / visual inputs and outputs, software and hardware that are linked together by communication protocols, the coordinated activity of performers and, in some cases, audience members. Unpicking the various functional elements of these works is an essential starting point in beginning to formalize an understanding of the technical approaches taken to date; identifying commonalities, desired features, issues, opportunities and planning for the effective integration of new components. Defining the various technical setups used in these works as ‘systems’ offers a theoretical framework on which to begin this analysis.

Systems analysis is a process that is used in multiple fields to study a “procedure or business to identify its goal and purposes and create systems and procedures that will efficiently achieve them" [2]. In the field of information systems, this process is used specifically to analyse existing systems that combine “technology, people, and data”

[3]. Applied in conjunction with system design, this step-by-step approach provides a framework to "analyse, develop and maintain information systems" [4]. Tilley [3] defines the component parts of these systems as "hardware, software, data, processes and people" and whilst the end goals of a multimedia, arts-based installation might seem far removed from the needs of organizational and business information systems, from a functional viewpoint, we can see how the components of the system reflect each other.

This study uses the systems development life cycle (SDLC) methodology as a theoretical and practical framework to structure its approach to answering the key research questions. SDLC is a common methodology within the field of system analysis and design that utilises several phases to "mark the progress of the systems analysis and design effort" [4]. Whilst the precise life-cycle model and number of phases vary between organisations and authors the broad categories can be summarised as planning, analysis, design, implementation and maintenance [4]. The purpose of these stages and how they will be applied in this study are outlined below.

2.1 Planning

"The purpose of this phase is to perform a preliminary investigation to evaluate an IT-related business opportunity or problem." [3]. This phase of SDLC is concerned with identifying the need for the system or adaptation, scoping the problem or opportunity and defining the approach to addressing it [4].

Application in study – This paper outlines the theoretical and logistical need for the adaptation to the existing installation system, alongside defining the scope of the project and the methodological approach to addressing it.

2.2 Analysis

"The purpose of the systems analysis phase is to build a logical model of the new system." [3]. During this phase of the SDLC existing systems that might be enhanced or replaced are thoroughly analysed. The requirements are then studied and structured in a way to identify interrelationships and eliminate redundancies. "The output of the analysis phase is a description of (but no a detailed design for) the alternative solution recommended by the analysis team." [4].

Application in study – All previous systems used will be analysed through the construction of flow diagrams and descriptors. The elements of these systems will be categorised into sections (e.g., hardware, software, inputs, outputs, communication protocols etc.) to define the range utilized across the body of work. Commonalities, outliers, and redundancies will be identified from these results and structural requirements for the addition of interactive elements will be defined.

2.3 Design

"The purpose of the systems design phase is to create a physical model that will satisfy all documented requirements for the system." [3]. Typically, there are two steps to this phase of the SDLC:

a. Logical Design - A logical model of the new system is designed. These designs are theoretical and as such independent of "any specific hardware or software platform" [4].
b. Physical Design – Dependent on the system, the approach to this stage can take many forms, "from creating a working model of the system to be implemented to writing detailed specifications describing all the different parts of the system and how they should be built." [4]. Essentially, however, this stage is concerned with determining many of the physical details (e.g. hardware, software, programming languages etc.) required to build the system.

Application in study – A flow diagram and description mapping out the structure of the new system will be created. Specific hardware (or hardware types), communication protocols and possible software integrations will be defined here.

2.4 Implementation

"During the systems implementation phase, the new system is constructed." [3]. During this phase of the SDLC the physical system specifications are used to create the system. Through rounds of development and testing each element of the system is checked and refined along with the system itself.

Application in study – This is the practice-led section of the study. Interactive devices will be constructed and approaches to integrating them within the wider system will be tested. Experimentation with sensor types, software libraries, media and function control will be used to refine approaches and explore creative possibilities.

2.5 Maintenance

"During the systems support and security phase, the IT staff maintains, enhances, and protects the system." [3]. This phase of the SDLC is where ongoing changes and improvements of the system are made in response to usage. Whether this is due to problems with function, evolution of needs or additions and improvements, it is concerned with keeping the system running and useful. "In a sense, maintenance is not a separate phase but a repetition of the other life-cycle phases required to study and implement the needed changes." [4].

Application in study – Initially, analysis of the completed systems functionality, and creative experimentation completed with it, will form the basis for reviewing its effectiveness and suggesting improvements/additions. As the system is used for subsequent installations and events, this process will be expanded, testing its application in different contexts; amending and improving the system in response.

3 Result

As this paper is concerned with outlining the approach to the project as a whole, the results only reflect work completed in the initial stage (Planning) of the SDLC methodology outlined above. This section contextualizes the 'need' for the adaptation and the 'discussion' section analyses the findings in relation to this context.

3.1 Planning – Defining The Need

Created, largely, in non-conventional exhibition/performance spaces, Friend or Foe's site-specific works explore themes based on the location and consist of abstracted, textural experiences that conjure a sense of 'something' rather than utilizing explicit narratives. The works typically (though not exclusively) consist of live musical performances accompanied by visual elements such as projections and/or lighting. The visual elements are controlled by bespoke software (developed specifically for each piece) that has the capability to respond to the live audio (via FFT interpretation of live audio feed and MIDI etc.) and be manipulated by performers. Essentially, a range of 'live visual instruments' are played alongside the aural elements of the works, generating a live, immersive, audio-visual experience.

Drawing on the physical, historical and contextual properties of wherever the performance takes place, the works look to elicit emotional, visceral responses that are connected to place. These aims influence the spatial configuration of speakers and noise emitting objects, the mapping of projections and lights, the positioning or movement of audience and/or performers within the environment. In their most recent work (Turn To The Sea) Sloan [5], the merging of data from audience interaction and online meteorological and ecological data was seen as a transition from site-specific to site-adaptive artwork; creating a constantly fluctuating experience, encouraging extended audience engagement and repeated visits to an ever-changing exhibit.

Where traditional understanding of 'site-based' artwork and performances may contest that to "move the site-specific work is to re-place it, to make it something else." [6] Contemporary practitioners and audiences have grown accustomed to the idea of them being 'serialised' at multiple different locations [7]. Specifically, in relation to dance performances, Kloetzel [7] discusses the idea that work created with this purpose in mind is 'site-adaptive' in that it veers "away from the classic model of 'site-specific' performance, where an artist creates a work for a singular site with that site's history, physicality, community, and/or design as the primary inspiration for the work". The primary concern for people developing such work is mobility rather than specificity and "adaptation is the technique to prepare for such mobility." [7].

Taken in this context it is possible to define how we envisage 'site-adaptive' work in relation to this project. Where previous installations and performances had been built as singular experiences, with singular content for singular sites, the inherent flexibility of online data sources and audience interaction utilized in Turn To The Sea demonstrate the beginnings of an approach that is more adaptive. In transplanting this artwork to another site, the ability to incorporate different data sources and content, whilst also offering a different audience control, allows the work to adapt to the new location. Site-

adaptive in relation to this project, then, means creating artwork with a thematic or conceptual framework that can adapt to, and be integrated within, multiple sites.

The development of interactive additions and a rationalization of the current system is driven by this desire to expand on the possibilities for audience engagement and facilitate the move to more site-adaptive artwork. Flexible and adaptive artworks, require a flexible and adaptive method of delivery. Defining the context for this 'need' has both theoretical and logistical consideration:

1. Theoretical: Interactivity in the context of a site-based immersive experience.
2. Logistical: Movement from site-specific to site-adaptive artwork.

4 Discussion

As previously highlighted, one of the primary motivations of the proposed system adaptation is to shift the focus from creating 'site-specific' to 'site-adaptive' works. While both terms describe installation artworks designed to respond to a particular location, they have distinct differences with reference to their approach and relationship to the site. Encouraging artists to "embrace strategies of site creation that aim for serialization rather than specificity", Kloetzel [7] suggests a more flexible, site-adaptive approach provides greater opportunities for a site-based works be presented at multiple locations. Adopting what is, arguably, a more sustainable, accessible, and cost-effective method for continuing further development and reaching wider audiences requires, first, defining the differences between these site-based artworks. The distinctions outlined in the table below, represent those considered important to this project. These were constructed as a means of focusing on those strategies that are important for serialization:

Table 1. Site-Specific and Site Adaptive Installation Artwork.

Site-Specific Installation Artwork	Site-Adaptive Installation Artwork
Fixed Relationships: • Concept has a deep connection to the site in which it is to be exhibited, in response to specific characteristics, history, or context of that location. • Moving location compromises the intended meaning or impact.	**Adaptability:** • Designed with flexibility and adaptability in mind, to be adjusted or reconfigured to fit different environments, sites, and locations.

Integration with Surroundings: • Defining / blurring the boundaries between the artwork and the surrounding environment. • Enhancement of space, transforming the viewer's experience of the site.	**Interaction with Environment:** • Modular components and reusable materials enable rearrangement and adjustments to be made according to the specific features of a given space. • Interactive elements provide dynamic feedback response to changes in environmental / location / time-based data.
Material and Form: • The significance of materials incorporated, how they resonate with the site and relate to the artwork and form a bond within its surroundings. • Form and structure of the artwork dictated by the physical and conceptual attributes of the chosen site.	**Conceptual Focus:** • Emphasizing conceptual or thematic elements of the artwork rather than a fixed relationship to a particular site. • Maintaining a consistency in the fundamental concepts or ideas of the artwork across different locations, while allowing for variations in exhibition according to the possibilities / limitations of each site.

As evident from the table above, there are both conceptual and logistical considerations with the move from a site-specific to a site-adaptive approach. Whilst the design of thematic and material elements can be identified as concerns relevant to specific artworks, the modes of engagement and immersion (defined by site/s or interactivity) alongside the flexibility of physical components are issues that require consideration from a more holistic viewpoint. As such, the need for this system change was outlined in these terms. Separating the concerns of individual artworks from concerns of the system adaptation as a whole, we arrived at the two contextual elements which will be discussed below.

4.1 Theoretical: Interactivity in the context of a site-based immersive experience.

To provide context for the theoretical aspect of this system adaptation, immersive experience is considered through an analysis of the following component parts: Interactivity, Cross-modality, Atmosphere.

Interactivity

Csikszentmihalyi's concept of flow, 'the ideal form of immersion' in Cotter et al. [8], refers to a participants' intensely focused engagement, fully immersed in an activity, often losing track of time and self-awareness. 'When playing, children pay attention

because they want to, because they find the information interesting and important in its own right' [9].

The evolution of immersive art is characterized by the interplay between 'technical interaction, environmental interaction, and interpersonal interaction' [10]. Immersive art continuously evolves as artists explore a multi-sensory approach. Progressive creative adaptation of affordable, customizable and reusable technology enables artists to incorporate live audience interaction and feedback as a main structural component of their work. The incorporation of interactive elements addresses this need for the spectator to be handed an element of control in the situation, while simultaneously providing immediate sensory feedback, enabling the spectator to acknowledge the result of their own and/or others' actions, encouraging spontaneous exploration. The spectator now takes on the role of participant / contributor to delve deeper, beyond the initial curiosity which may have attracted them to the work initially, to demonstrate and expose features of interest or information, while attracting the interest and further participation of others.

Initial attraction and attention may be garnered through curiosity, but unless intrinsically rewarding, the audience is likely to lose focus. Csikszentmihalyi [9] argues convincingly that this motivation is dependent on the information or activity being personally important or interesting; inherent psychological needs beyond food and security driving an individuals' need to learn, to find out more and to figure things out. 'It is important to consider what makes an experience rewarding in and of itself, so as to understand what may motivate a person to look and think about an exhibit for 'no good reason'- that is, in the absence of external rewards.' Csikszentmihalyi & Csikszentmihalyi, 1992. This assertion that the immersive arts experience relies upon personally motivated exertion for ultimately 'no good reason' or externally meaningful reward draws a clear, albeit negatively expressed, parallel to game play. Whether the immersive work is defined or intended as an artwork or a game, both are likely to involve a user-interface of sorts, 'driven by some form of pleasure or curiosity' [11]. In her analysis of the players' immersion in the game, Collins [12] argues that 'the act of play [itself] leads to the immersive experience,' rather than the player being 'immersed in the game.'

"The human, confronted with the artwork (or game), takes an action that the work responds to. Typically, a sequence of actions and responses develop and continue until a goal is reached or the human is satisfied or bored." [11].

Atmosphere

The efforts to manipulate the spectators' experiential perception through the use of uncertain, challenging or unconventional stimuli and interaction with and within the environment, what Csikszentmihalyi & Hermanson [9] label 'situational interest', is another common objective of the processes involved in the creation of an immersive atmosphere. By attempting to eradicate the familiar; the artist aims to elicit an emotional response untethered by exterior influence, to place the observer in an unfamiliar space, to evoke an emotional response. Böhme [13] defines atmospheres as 'tuned spaces', multi-sensory environments designed to be experienced from within, rather than what

he describes as the ‘old scenography’: spectacles designed to be viewed from a distance. 'Can one really make atmospheres?’ asks Böhme [14]. After all, an artist only has the tools of manipulation of material conditions to construct the intangible, ‘the making of atmospheres is confined to setting the conditions in which the atmosphere appears.’

Edensor & Sumartojo [15] define atmosphere as ‘a quality of environmental immersion’, continuously developing, emerging from ‘a host of constituents… ‘affects, sensations, materialities, emotions and meanings are all enrolled within the force-field of an atmosphere’. The notion of a created atmosphere being a ‘force-field’ of some sort, shielding the observer from exterior influences, is an elusive ideal, which is arguably the goal for which the creator of an immersive work strives. 'Lights, colours, rituals, installations and sound can both make familiar places strange and strengthen affective belonging… kindling a sense of wonder… so that we attend more intently to the previously overlooked or undervalued’ [15].

Edensor & Sumartojo [15] stress that the location and setting is of crucial importance to the successful creation of an ‘affectively, emotionally and sensually profound’ atmosphere, giving consideration to the architectural qualities of the space, the amount of control available to the designer to manipulate and regulate sensory factors such as light, temperature and sound within the space, access and maneuverability for the spectators within the space, and any social, cultural, historical or other connected associations an audience may have with a location.

The open availability of real-time data streams from both local and external sources significantly broadens the scope of interaction beyond the audience or performer, exposing to artist’s new opportunities to engage, influence and inform audiences by creating artworks which explore innovative approaches to perceiving and interpreting information. The atmosphere becomes an element to both harness as a controller and to be controlled in itself - the idea Birringer [16] refers to as ‘so-called “intelligent environments” - spaces that detect/sense or capture behaviours and movements, “open scores” so to speak occurring within them and that respond to data generated within”.

Cross-Modality

O’Callaghan [17] identifies the impact of one sense upon the perception of another as ‘Cross-modal perceptual illusions’ and suggests that this phenomenon can profoundly improve overall accuracy and reliability of sensory analysis. ‘Theorising about the individual modalities all on their own fails to appreciate… what goes on in one sense depends upon and affects what goes on with the others’ [17].

It follows that, beyond those component events specifically designed to occur within the work, atmosphere organically feeds both from and into the actions and reactions of an audience, events in themselves, whether triggered by the work or not; their moods, their modes of communication, their response to each other through voice, gesture and movement.’[Designers] can never be sure whether a crowd or group will charge the atmosphere with unwanted or unexpected tones or play the roles envisaged [15].

Edensor [18] suggests that by limiting the senses, the atmosphere designer can afford an element of control over external influence or distraction, while heightening the perceived sensitivity of the other senses. 'The ways in which light transforms space are

complex and multiple. We see both with and in light... 'Light conditions the ways in which we perceive – guiding what we are able to see, inflecting visible colours and informing our sense of the shape of space.' [18].

The restriction of vision through the controlled synchronized use of light in dark spaces dramatically reduces the main sensory input most spectators rely on, offering the opportunity to focus attention, intensify the senses, distort spatial perception, and challenge experiential familiarity. In her exploration of alternative approaches to analyzing data in the absence of sight, astronomer Wanda Diaz Merced highlights the need for 'attention control', in which the immersion of the act itself becomes an essential component of the task at hand: 'Sensory modality is greatly enhanced when there is a matching cross-modal stimulus… Congruent sound aids attention control over visual ambiguity... and combined auditory–tactile information enhances attention control over competing visual stimuli' [19].

4.2 Logistical: Do It Again?

The context for the logistical aspect of the system adaptation is, inherently, more simplistic and defined by personal experience. In developing the interactive elements and resolving previous approaches into a coherent system we hope to address the following issues: Repetitive work, Adaptability, Improved workflow, Less Wires! and Handcrafted.

Repetitive Work

Whilst certain software 'modules' (e.g. video control, FFT analysis etc.) and aspects of system setup (e.g. linking of audio & visual computers, MIDI as control device etc.) can be re-used and adapted to different projects, the need to build many aspects of installations from the ground up for each site has been apparent with our current approach. Accompanying the time wasted by this approach, we often invest and develop multiple resources that are used once and never again.

Adaptability

The transition from site-specific to site-adaptive work requires flexibility in design. Building on the idea of not repeating work, there is a need to for the new elements added to be flexible in terms of location (where they can be placed), form and functionality. Alongside this, when rationalizing the new system, flexibility in terms of software and hardware integration is an important consideration.

Improved Workflow

Linking the two ideas outlined above a clearly defined system will allow us to plan and visualise installations more effectively. This will mean more time can be spend on the

creative process, rather than developing, testing and troubleshooting technical aspects of the production. Importantly, we are not imagining a setup with specific media and narrative elements that can be transported from site to site but, rather, a system that can be flexible in these various sites from a functional viewpoint.

Less Wires!

The nest of cabling and wires for these productions is immense and complicated. This is problematic for a number of reasons. From tracking down issues to limiting how a space can be used and health and safety considerations, the move to wireless communication wherever possible would add both flexibility and functionality to the system on a number of levels. Specifically, with regard to interactive elements for audiences, the ability to place (or move!) these without consideration for wiring would offer much more freedom, flexibility and opportunities for experimentation.

Handcrafted

Whilst many interactive systems and devices are available to buy, the idea of creating our own is essential to this process. Affordability is a factor, but more important is the idea of developing devices specific to our needs. Functionality of 'off the shelf' solutions can be harder to adapt, leading to concepts being constructed around this functionality. The flexibility offered by custom-developed devices delivers a greater range of control to the artists, allowing nuance of function and form. The idea of form is not only important from the viewpoint of functionality, however. Although technology is a central tool in these installations, much of the work created is concerned with creating a visceral and emotive sense of human presence. 'Handcrafted' devices allow material and conceptual considerations to be incorporated within the physical design of these objects, cementing that connection further.

5 Conclusion

In its entirety, this practice-led research project focusses on the development of a versatile, cost-effective system that empowers audiences to actively engage with audio, visual, and lighting elements in immersive site-based contexts. This paper addresses the technical and methodological aspects of the project development, while acknowledging the psychological impacts of interactivity, the creation of immersive atmospheres and the cross-modal sensory stimulation that are fundamental to the success of immersive art experiences. It also highlights the need for the system from a logistical viewpoint, outlining the artists key concerns for any solutions developed. By addressing these critical elements, this paper lays the groundwork for an ecosystem of interactive tools underpinned by wireless communication capabilities, capable of fostering engagement across various locations and events.

It defines SDLC as an appropriate methodological framework to utilize in approaching the study and developing the system. It identifies this paper as completing the first stage of the SDLC ('planning') and prescribes the means by which each of the other stages will be addressed:

- Analysis – Analysis of previous systems and definition of various elements
- Design – Logical and physical design of proposed system
- Implementation – Prototype construction and testing
- Maintenance – Testing, analysis and refinement of system.

The stages above, define the next steps for developing this project

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