Impact on human perception and expression, using augmented reality technology as a medium for computational art

RESEARCH PLAN - SAMUEL BILBOW

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This research proposal develops multi-sensory AR technology as a novel method to address the current visual bias in AR development, through the question: What impact do multi-sensory AR experiences have on human perception and expression in participatory installation art? I outline contemporary literature that discusses the possibility for multi-sensory AR, as well as examples of installations that utilise non-visual modes of perceptual mediation. I will use an iterative design process to create my own multi-sensory AR instruments, which will be used in an installation. Through individual and group studies of the instrument and installation respectively, I aim to answer the question through a combination of rigorous survey-based quantitative data analysis, as well as a grounded theory approach to qualitatively analyse interview feedback. The findings would culminate in a thesis paper exploring the impact of augmented reality technology on user perception and expression, and the creation of a software tool that could be used as a research platform and framework for creating multi-sensory AR experiences that are immersive for both artist and audience.

1. STATEMENT OF SCOPE, AIMS AND BASIC APPROACH

This practice-led research develops multi-sensory augmented reality as a novel medium for creative perception and expression within the context of computational art. There has been a recent surge in development for and of augmented reality technologies due to its implementation into consumer technologies such as mobile computing devices (Höllerer and Feiner, 2004). Mobile development has primarily been concerned with visual displays of information, through infra-red camera technology and software kits that allow access to scene depth-information (ARKit, 2020), (ARCore, 2020). A number of papers have been published (Chevalier and Kiefer 2018) that call for a more multi-modal form of augmented reality experience, one that stimulates the auditory and/or somatic sense, not just the visual, which has seen almost unrivalled popularity as the primary mode of display of information in examples of AR usage. The aim of my research is to support installation artists and computational scientists in creating more interesting experiences, by better understanding the impact of their medium on users perception and expression as well as conversely better understanding human perception and expression through installation art and computational science. Through this, I hope to create a novel software tool that will be used as a research platform and framework to support artists to in creating more immersive experiences using multi-sensory augmented reality.

1.1 RESEARCH QUESTIONS

(1) What impact do multi-sensory AR experiences have on human perception and expression in the context of installation art and computational science?
(1A) How can augmented reality and its materiality be understood as a medium for computational artists?
(1B) How can multi-sensory augmented reality in collective experiences be exploited to create new aesthetic experiences for both artists and audiences?

2. RESEARCH CONTEXT

This research project is a multi-disciplinary research project that will aim to bring together work from computer science, the arts and humanities, and the sciences. I will focus on the following topics: human computer interaction, multi-sensory interfacing, computational art, cultural theories of space production, multi-sensory integration, and the extended mind - especially embodiment in interactive art. In this plan I will focus on just a few of these.

2.1 AUGMENTED REALITY

Thus far, augmented reality technology and its use cases have been primarily skewed in favour of visual displays of information (Chevalier and Kiefer, 2017). A survey in the late 1990s, which is relatively early considering the first functional uses of AR were conceived in the early 1990s (Rosenberg, 1993), highlights this, and draws attention to the possibility of other sensory modes for augmentation (Azuma, 1997). Azuma defines AR as a system that “supplements reality rather than completely replacing it”, unlike virtual reality, which aims to take the user outside of their own physical reality into a synthetic and ‘remote’ environment. Azuma lists three criteria for an augmented reality system: to be a combination of real and virtual environments, to be interactive in real time, and to be registered in 3-D. The paper features prevailing medical, manufacturing, visualisation, and entertainment applications for the technology of the time, and identifies two methods of display: optical see-through and video see-through. For context, a recent example of an optical see-through device would be the Hololens head-mounted-display by Microsoft. Mobile computing technology takes advantage of infrared camera technology to enable video see-through in most portable AR use cases today.

2.1.1 AUGMENTED REALITY IN THE ARTS

More recent research urges for a more multi-sensory version of augmented reality within the arts, where more than just the visual sense is augmented (Kiefer and Chevalier, 2018). In this paper, AR is defined as real-time computationally mediated perception that follows Azuma’s criteria for an AR system, and can be considered, within creative practice, as a medium for creative “new nuanced and fine-grained emergent aesthetic experiences”. Several artworks that offer “varying sensory modalities” are examined, including the ‘Augmented Hand Series’ which demonstrates that even the perception of ones own corporeity can be altered when using augmented-reality technology. As outlined, although concerned with mainly visual AR, conversations about the implications of artists upon the advancement of AR has arisen. Artist Helen Papagiannis details the crucial role that artists have in developing the medium:

> “Understanding the capacities of the technology and its constraints to exploit the technology to artistic use by envisioning novel applications and approaches, and developing new aesthetics and conventions beyond previous traditional forms.” (Papagiannis, 2017)

Bloom: Open Space, a 3-D sound art installation version of the popular generative music app Bloom, created by Brian Eno and Peter Chilvers and hosted by Microsoft earlier this year shows the power of AR in augmenting human perception and expression within the context of computational art. The space in which participants of the installation occupy is brought to life through the Hololens HMD, which displays a 3D visualisation of the generative world of bloom, where hand gestures create new nodes which emit sound and interact with each other using Unity3D’s audio spatialisation engine (Ray, 2018).

> “There’s all sorts of experiences we’ve never thought of before. We’re only beginning to scratch the surface of

> possibilities for music and technology." - Brian Eno

> "It's a way to turn a piece of music into an environment, which is a very different way of understanding it. It taps into the brain in a way that's different than if you put headphones on." - Peter Chilvers

In a recent formative audience study on using audio augmented reality as a mode of collective musical expression within the context of a sound art installations, researchers found that auditory perceptual mediation can generate a deep sense of immersion within an environment - with some participants of the study describing a sense of shock once they removed themselves from the mediated environment. As well as this, it was found that AR can induce playful approaches to the exploration of participants' environment (Chevalier and Kiefer, 2018).

2.2 MULTI-SENSORY HCI

The Tate Sensorium (Vi et al., 2017) is an example of a multi-sensory art installation. One of the pieces on display used mid-air haptic devices to enhance a piece of visual art. The results of the attached study found that congruent multi-sensory experiences (having some relation between the haptic sensation and the visual appearance of the piece) lead to audiences finding the artwork more emotionally engaging. What happens when artists purposefully design incongruent sensory experiences?

2.3 SPATIALITY

Binaurally spatialised audio cues have been shown to be able help with attention redirection, demonstrating that augmenting the auditory sense can provide heightened perception and immersion (Barde et al., 2016). In this study, an experiment was performed where participants had to locate and target visual stimuli with the aid of an optical see-through HMD. The test was run without an audio cue, then with a static audio cue, and finally with a dynamically spatialised audio cue. Participants located the visual stimuli faster when presented with an spatialised audio cue, which was presented to them through bone-conducing headphones, which didn't mask sounds of the environment that the participant was situated in, but instead augmented the users auditory sense.

Furthermore, within the field of acousmatic composition, there has been recent interest in the importance of three-dimensional spatialisation of sounds as a key compositional element - as important as melody, rhythm or sonic texture over time (spectromorphology) (Smalley, 1997). Smalley writes that spatiality in acousmatic music can be considered as an

> "Aesthetically created environment which structures trans-modal perceptual contingencies through source-bondings and spectromorphological relations" (Smalley, 2007)

Here, Smalley makes a similar argument to that of Lefebvre's in that space is a production of cultural artefacts, in this case, one that makes sense of modal percepts i.e. auditory, visual, and proprioceptive stimuli. Lefebvre argues:

> "Space has no "reality" without the energy that is deployed within it: energy modifies space or generates a new space". (Lefebvre, 1991)

Smalley argues that space achieves this through *source-bonding:* the subjective attribution of a non-existent sound-sources to a musical events, and *spectromorphological relations:* the interconnection/action of sonic textures in a musical event.

He goes on to classify three space-forms that embody performed space: *gestural space* is the "intimate space of individual performer and instrument", *ensemble space* is the "personal and social space among performers", it holds individual gesture spaces. The final space-form of performed space is *arena space, "*the whole public space inhabited by performers and listeners".

2.3.1 SHARED PERCEPTUAL SPACE

In their artistic research project 'Orchestrating Space by Icosahedral Loudspeaker" (OSIL), which used a 20-sided loudspeaker and ambisonic beam-forming techniques to produce space using 'plastic' sound objects, researcher and artist Gerriet Sharma, and engineers Mathhais Frank and Franz Zotter, use the term "shared perceptual space" to denote the "intersubjective space where the perception of composers, scientists, and audience intersect". (Sharma et al., 2015)

Their listening tests, based on compositions created using a bottom-up methodology (*miniatures*, *etudes*, *pieces*), found that it is possible to create shared perceptual spaces in their acousmatic compositions (Wednt et al., 2017), and have created a listening-based approach to verbal description of spatial sound phenomena and shared perceptual spaces.

As we adopt multi-sensory augmented reality for the perception and expression of computational arts, understanding how *this* medium constructs and produces its own space as well as how it morphs into existing spaces is of importance if we are to create immersive *mediated* environments that are shared by audiences.

3. METHODOLOGY

The methods I will use to address my research questions and create my software tool involve two studies centred around the iterative design of an AR **instrument**, a participatory **installation** where each participants' perception and action-potential is computationally mediated in real-time through these instruments, and the development of **experiences** called Snippets, Scenes and Spaces. It is the instrument that will allow the user to interact and immerse themselves with the installation. This design process would not only be informed by the user studies, but also around my own ongoing critical writing on the design, development of snippets, scenes and spaces, and testing of the instrument and installation.

3.1 ITERATIVE DESIGN

The table below explains the differences between the three types of experiences, which

Experience type	**Snippet**	**Scene**	**Space**
Experience description	Small-scale clip-like experience	Medium-scale experientially congruent snippets	Large-scale shared space produced through experientially congruent/ incongruent scenes
Experience example	Feeling a texture	Knowing the context of a texture	Being inside a texture
Experience size	Space between two hands	Space in and around a body	Space that a person walking for 10s could create
Modalities engaged	2	3	4-5
Technology	Hand or head based tracking paired with a body-fixed modal display	Body tracking paired with multiple body-fixed modal displays	Head and room tracking with body-fixed multi-modal displays and room displays (speakers, screens, scent diffusers)
Interaction type	Reactive	Interactive	Immersive

will most likely be developed in Unity3D and Arduino (or similar microcontroller).

Snippets will be small textural experiences focused around reacting with/manipulating a sound object in the users immediate environment.

Scenes build on this, with potentially multiple snippets providing a coherent medium-sized experience space where the sound objects are not only reactive, but are interactive to the users environment.

Spaces are created with multiple scenes, both congruent but also allowing incongruent, alienated experiences to occur, such as the re-wiring of participant senses with others and inter-modal translation.

Snippets and Scenes will be tested with the AR instrument in individual user studies, whereas Spaces will be trialled in an installation, with multiple AR instruments being used by a variety of users and an audience group study. This bottom-up methodology of creating experiences borrows from the compositional methodology found in the OSIL project (Sharma et al., 2015), and the classification of performed spaces (Smalley, 2007).

An example of one of the instruments I will design is that of a glove with flex and accelerometer sensors. In an example scene, the user would be able to create sounds in 3D space through gesture and hear them through bone conduction headphones (thus not obstructing normal hearing). I would examine the use of the instrument by individuals in a study, and feedback would inform new iterations of both the instrument and snippet/scene, aiming to create more a more immersive artistic/perceptual experience. Other snippets/scenes would use different output modalities, i.e. feedback via smell and sound, smell and touch etc. I would use contemporary theories such as ‘extended mind’ (Clark, 1998) as well as the data analysis methods detailed below to better understand the materiality of augmented reality as a medium for computational artists to create these experiences, addressing question **1A**.

The installation would take place after the design process of the AR instrument and experiences had finished and would be a shared participant experience involving the augmentation of four to five senses. Participants would be able to hear, see, touch, smell, and potentially taste sounds that they and other participants have created with the instrument, allowing them to create, layer and remove sounds in real-time, resulting in varied and stochastic shared sound environments. The space itself will also offer augmented experiences through technologies that wouldn’t be affixed to the users body - loudspeaker interactions, UltraHaptic feedback and sonification displays for example. The installation would be concerned with understanding the possibility for creating new aesthetic experiences with the medium, through the potential rewiring and alienating of senses between participants and subsequent reactions, hence addressing question **1B**. Critically understanding these new experiences could also involve grounding them in the contemporary discussions of embodiment in interactive art (Stern, 2013)

A crucial aspect of these studies validly addressing my research questions, and informing my multi-sensory AR tool and framework, will be the diversity of the participants. As it concerns experiences that are subjective and personal, this will require me to find commonality across these experiences, which I plan to do through a grounded theory approach, and the shared perceptual space framework.

3.2 METHODS OF DATA COLLECTION

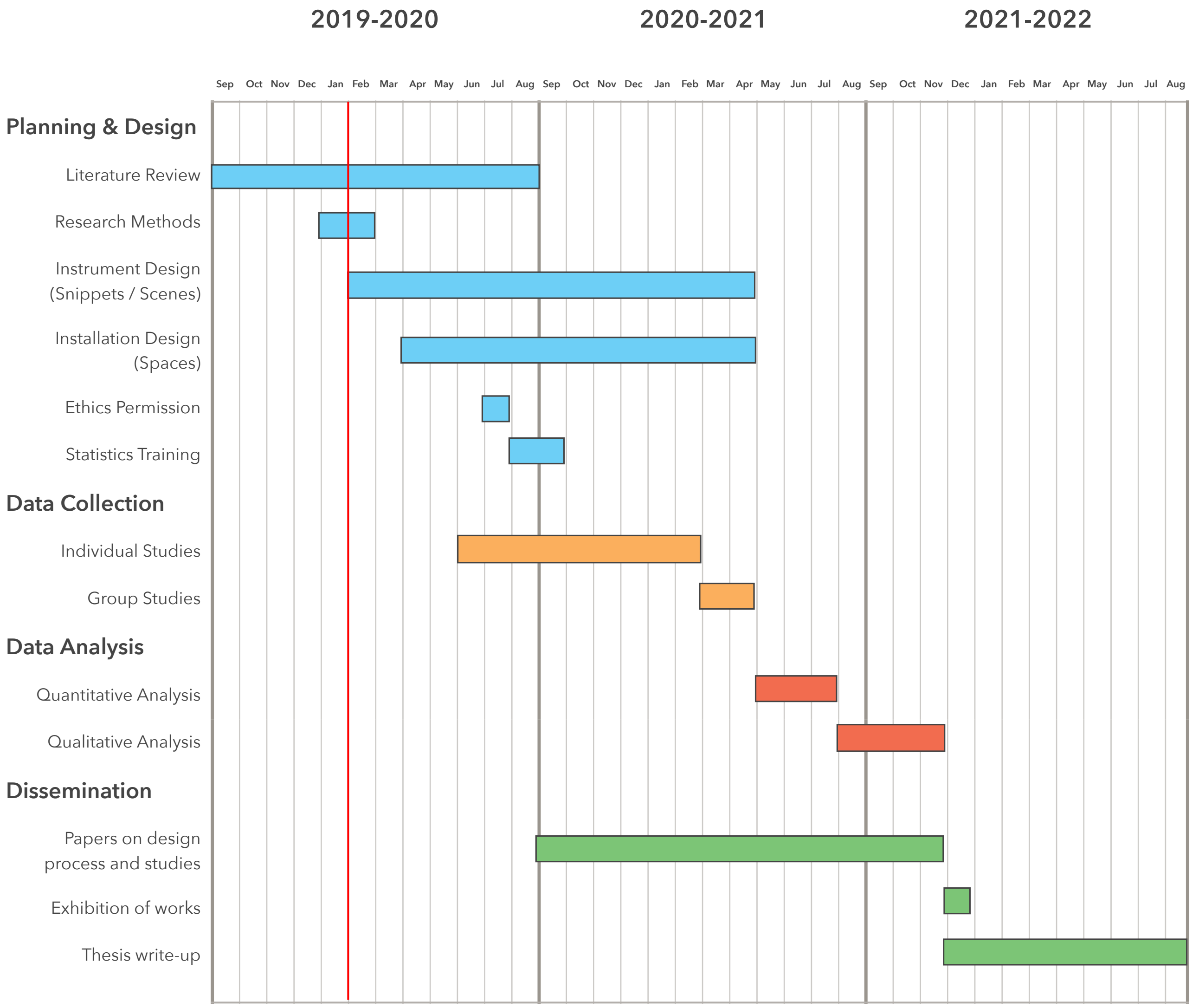
1. Survey for quantitative analysis
   - About participant perception, behaviour, expression, to answer questions on participants' immersion, adapted from (Tcha-Tokey et al., 2016).
2. Interview, the responses from which would be transcribed then codified using grounded theory methodology and split up into categories for qualitative analysis
   - Questions on shared interactions with other participants (installation)
   - Questions on the effect on participants own artistic expression (instrument)
3. Numerical data logs from instrument sensors and 3D engine world data
   - Exploratory statistical analysis for summarising behavioural characteristics in participants
4. Video recording of participants engaging with the installation.

The outcome of these analyses would culminate in the creation of a framework that would allow further understanding of these experiences' effects on these perception and expression in audiences of computational art.

3.3 ETHICS

All data collected would be anonymised and the video recording would not be made public. Due to the nature of the studies informing the creation of a tool for creating shared experiences, the participant sample would be a diverse group. I acknowledge the ethical risk of potentially altering participants perception through sensory mediation and this would therefore be carefully considered when complying with the University of Sussex ethical guidelines and ethics approval process.

4. A SCHEDULE OF PRACTICAL OUTCOMES



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