**SOUND, SHADOW AND LIGHT: generating the experience of a natural environment**
***Paper***

***Topic: Audio Visual installation***

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***Abstract***
Sound, Shadow and Light is a generative program that seeks to replicate the visual and aural experience of a natural environment in a designed space that responds to the inhabitants of that space. In a natural environment there are opposing senses of intimacy and expanse, bounded only by the horizon. While each natural environment may have different or unique elements in it, Sound, Shadow and Light explores the hypothesis that just a few of these elements may create a sense, or experience, of being in a natural environment. It will do this by defining and then distilling the prototypical elements of an environment to form an essence, a small set of events that may be influenced by the inhabitant to create a mental and emotional experience of being in a natural environment.

Sound, Shadow and Light bases its approach on the assumption that the natural environment is mostly static with predictable sounds, and that this causes the inhabitant to ignore most of the events in the environment. For this reason, it focuses on replicating the moving elements of an environment. By creating subtle and unexpected changes and introducing occasional unexpected events it is designed to create an experience of a natural environment with reduced overt interruption to the actual environment. The process for doing this is based on the concept of the garden as a place of simultaneous rest and subtle activity, in which expected events may occur at unexpected times; rhythmically repeated events occur separated by long periods, thus forming a sense of long structure; and occasional unexpected events that have no precedent.

An interactive program is used to generate natural and synthetic images and sound; it takes pre-existing images and sounds, arranges them in groups for playback, subverts these groupings, and introduce synthetic versions of the sounds and images.

This process is being developed to create virtual outdoor environments for people unable to venture into natural environments, as a demonstrator of responsive virtual environments, and as a platform for art-oriented projects.

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***Key words:*** Installation art, generative art, axiomatic realiy,
***Main References:***
[1] Susan Taylor-Leduc, "*The Pleasures of Surprise: The Picturesque Garden in France*", The Senses and Society, USA, 2015
[2] Yossi Shushan, Juval Portugali, Efrat Blumenfeld-Lieberthal, "*Using virtual reality environments to unveil the imageability of the city in homogenous and heterogeneous environments*", Computers, Environment and Urban Systems, USA, 2016

# SOUND, SHADOW AND LIGHT: generating the experience of a natural environment

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## Introduction

Experiencing a natural environment is said to be beneficial in many ways, anecdotally it is ‘good for the soul’, ‘calming’ has ‘health benefits’ and so on [1]. While Sound, Shadow and Light may be used in a variety of settings, the pilot demographic will be specific to aged care residential facilities, with a view to broader applications in rehabilitation, hospital and community healthcare settings. Currently there is no testing being done other than ‘in the lab’, but when a robust system has been developed it will be tested in situ. This demographic was chosen as it will pose the most challenges, that when solved will create a system that may potentially be used in any Gallery, Library, Archive, Museum (GLAM) or performance environment.

Sound, Shadow and Light is a complete AV system that provides a Virtual Reality /Immersive/Enhanced Environment (here 'VR' is used to represent all such systems). It is intended to be scalable from smaller, private rooms to the communal areas commonly encountered in residential aged care, rehabilitation and community aged care environments. This is considered a useful parameter within which to develop and implement the trial program. The program will be accessible and low risk to participants across a broad spectrum of cognitive, sensory and physical impairment. It is intended to minimize disruption to other residents and the provision of care requirements within the aged care setting.

### Assumptions

Defining a natural environment is difficult, and it can be idiosyncratic to purpose and function; here we are considering this space to be an exterior urban environment, such as the tree-lined avenue that may be walked through by an urban inhabitant shown in Figure 1, below. It would normally be recognised as having, visual, sonic and tactile qualities. These include: a range of focal lengths, where distances range between 1 to 60 meters; a range of similar colours, with distinct differences in contrast; expected sounds at irregular intervals; and fluctuations in temperature and air pressure.

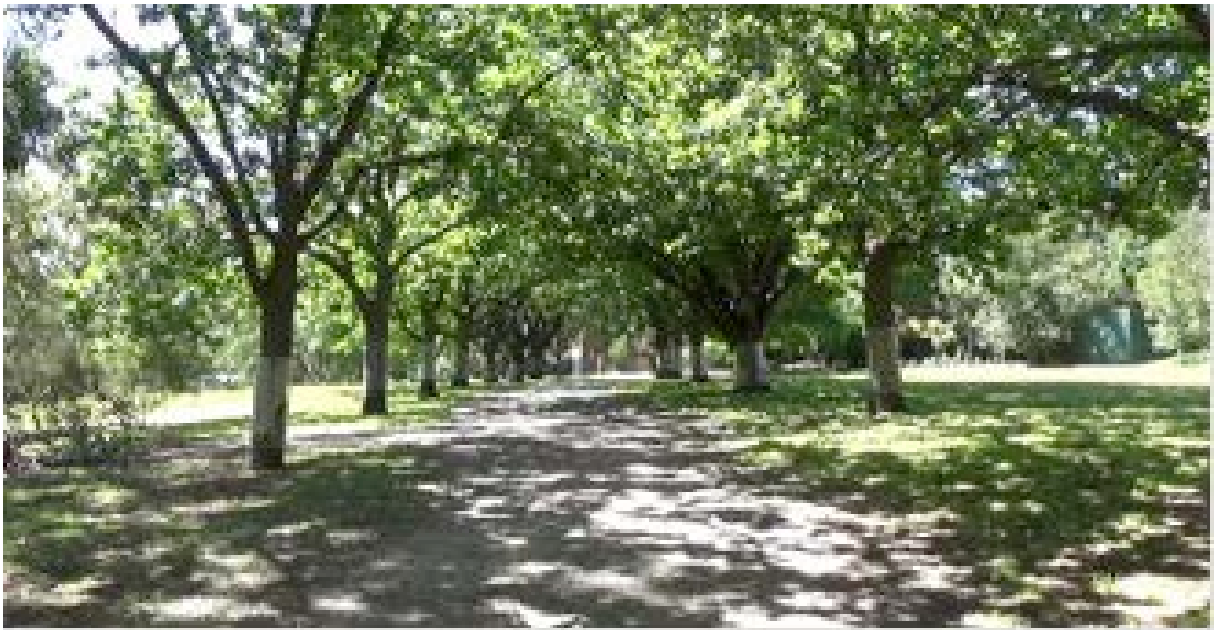

Figure 1 An outdoor environment within a city

This is a very simplified, meta-version of a natural environment, but it serves as a starting point for the development of the Sound, Shadow and Light system.

## Current examples of designed therapeutic environments in care facilities

Here we will look at two examples of therapeutic environments created for aged care facilities. These are examples of VR environments designed for aged care facilities, but the systems use are potentially translatable to other indoor environments.

**Reminiscence Rooms**

Reminiscence rooms provide an environment where aged care residents are reminded of past times relevant to the residents, with the intention that this will be beneficial for the resident and the carer. This approach has been in action through the example of a Rempod [2]. A commercial and portable version of the concept is seen in Figure 1.There are a variety of responses regarding the benefits of this approach as therapy and in generally ameliorating aged care [3-9].


Figure 2 Rempod example

**Snoezelen rooms**

The Snoezelen multi-sensory room concept was originally developed in the Netherlands by therapists Jan Hulsegge and Ad Verheul at the DeHartenburg Institute in the 1970s for therapeutic application in cases of intellectual disabilities, such as autism. A multi-faceted Snoezelen Center at Whittington Hall in North Derbyshire, England, was the first to adopt such an environment in 1987 and became a pioneer in multi-sensory therapy research. A Snoezelen room integrates a wide array of equipment that consists of auditory, visual, scent, and tactile stimulation that aims to stimulate a patient's senses through controlled stimuli, such as fiber optic tactile tubes, in a calm, comforting environment. There is increasing literature on multisensory therapy and as the uptake of Snoezelen has expanded rapidly over a decade in residential care, hospital and school settings [10-12].

Figure 3 Snoezelen example [13]

Figure 4 Immersive environment example [14]

**Testing outcomes in aged care**

Kjellgre and Burkhall [15] compared responses to a the woods in Karlstad Nature Park with a slideshow of 97 photographs in a quiet, dimly lit room. Outcomes for both Snoezelen and Reminiscence environments “appear to have some short-term beneficial effect on mood and behaviour, with considerable variation between individual subjects [or] any significant differences between the interventions in terms of impact on subjects’ behavior” [16].

Modern Australian aged care facilities will cater towards dementia specialisation in staff training and secure areas for these residents. Interior design of dementia specialist environments frequently comprises murals or visual 'dummies' of community/outdoor environments in the interior spaces, replicating a sense of natural interaction, freedom of movement and familiarity. These facilities often include secure outdoor garden areas that are safe for wandering residents to access- however, it can be difficult to supervise and

monitor at-risk residents over an expansive facility with limited staff. The VR augmented environment has the potential to increase observation and safety of residents whilst offering an analogous experience. The 'natural environment' can arguably be extended beyond a reading of the outdoors only. A natural environment may also include reminiscence of previous activities of daily life, prior to the person's entry into aged care. A detailed, upscale exemplar of this concept is the Hogeweyk Village in the Netherlands. This gated community has been designed as a totally immersive, familiar environment specifically catering to the care needs of dementia- affected residents [17]

**VR and Health Outcomes**

The use of VR in healthcare contexts has been wide-ranging in potential applications across a number of outcomes, for example, enabling physical activity and engagement in older individuals and for rehabilitation in clinical studies [18-23]. In some studies, VR is seen to offer a safe environment within which to carry on different interventions in various health settings, e.g. ranging from the rehabilitation of discharged patients in their home to the support of oncological patients in a hospital ward [20, 24, 25].

VR studies have also been associated in addressing the support and/or improvement of cognitive and emotional well-being in these scenarios, including loneliness and quality of life [26-29].

Simulation of natural environments has particular resonance in these studies [24, 30]. The linking of natural settings to the promotion of health and well-being and the use of VR to provide an understanding of the various mechanisms involved are increasing areas of research investigation [24-26, 30]. Where real nature experiences, for instance, have been found to reduce stress, improve attention and cognitive functions [31-34], there are potential correlations with simulated virtual environments of nature [24, 30, 35].

VR allows for the possibility of disassembling some of the stimuli or cues we receive from being in nature, such as birdsong or gardens, and for those, for instance, unable to readily experience natural settings, an improved understanding of various cues could allow us to provide access to simulations of the natural world [24, 30-32, 35]. Snoezelen room interventions have also been associated with comparable studies [36-38] Similar to a placebo effect there can be certain expectations that we hold about such an intervention [39], so by being aware of nature experiences these might be preparing our mind to react a certain way when we visit a park or garden [24, 26, 31, 33].

In VR, the concept of presence has garnered some attention in the literature[40-42]. As with sites in the physical natural world, VR and virtual environments provide spaces for ‘social interaction and identity exploration’ [41]. Presence may be seen in association with the emotional impact of specific cues in VR, but also may appear to depend on the comparability of a virtual environment to a real life situation. According to Diemer [42] the ‘depth’ of a VR experience in terms of presence and emotion is more strongly influenced by factors separate from the technological quality of a VR or virtual environment system.

Of particular relevance to this study is the use of VR interventions as ones that can be used to induce different emotions [24, 30-32, 35]. Layous and Lyubomirsky [43] investigate the importance of considering the baseline status of the participants’ well-being before implementing positive interventions. Within this context, VR has the capability to fall within a type of positive intervention that can allow the individual to capitalize on positive experiences, such as positive reminiscence and a positive sense of place [24, 26, 35, 41, 44, 45].

## Problems with current approaches to Virtual/Augmented Reality and Immersive environments.

The general cost of a projected or attached ’immersive environment’, is expensive. Figure 4 above shows a large wall space with an image of an outdoor scene, the cost of creating such an image is potentially quite large, depending on the kind of technology is used. Non-

projection, wearable options, such as those offered by Samsung, Microsoft, HTC, Google and so on may be less expensive per unit, but tis saving is reduced if more participants are intended. These systems also require significant expertise in creating and preparing content, and in operating; this adds to any expense.

Like most GLAM and performance venues, aged care facilities in Australia have dedicated lifestyle, health and well-being programs. This non-invasive VR program could offer a low cost adjunct to programs which often require consumable or high cost equipment, vehicles (such as for community outdoors access), specialised staffing or supervision to fit, oversee or direct. The hourly cost of providing these directives and supervision, such as that delivered by a Registered Nurse, can be upwards of $22 (AUD) to around $50 (AUD) in staffing time per resident per hour [46], similar staffing costs are anticipated in GLAM venues.

Some residents in aged care facilities may not tolerate current iterations of VR wearable technologies, particularly in the cases of comorbidities such as dementia or cognitive impairment, or physical limitations related to mobility/balance and macular degeneration. There may be limitations in these residents' abilities to report and feedback on their experience of the proposed program, and in many instances, interventions that place restriction on resident's liberties to interact with their 'natural' environment (such as wearing a headset that limits their view) may be viewed as a form of restraint, requiring specialist permissions to be sought first.

## Solutions to problems with current approaches to VR

It is intended that the cost for a usable system be minimal, costing under $500 (AUD) per unit; this cost will degrease over time and the options for extending and developing the system also increase as computer based technologies gain power and manufacturing costs reduce.

For aged care residents, manual interaction with interfaces may be challenging. Sound, Shadow and Light can be setup with minimal hands-on input required from their interactees, this provides a useful test for usability for non-technical audiences, but also this minimal set up more readily supports a range of sensory perceptions not necessarily dependent on hand coordination.

In structuring the Sound Shadow and Light experience, an integral aim is to facilitate access to aged care residents that may not be able to access the natural environment. Prohibiting factors in this access is likely due to impairments in mobility, sensory perception or cognitive status. The program is designed to operate with a simple user interface and be adjustable for those with visual or auditory impairments.

Residential aged care facilities are accredited for Australian Government care subsidy based on their meeting of 44 standards under Government regulation. Of these, the VR program is an initiative that directly addresses standards related to continuous improvement in care recipient's lifestyle, leisure participation, and environmental comfort. [47]

This process will create virtual environments for people unable to safely access or experience natural environments, as a demonstrator of responsive virtual environments, and as a platform for art-oriented projects. It has a strong grounding in the aims of holistic, client centred health and well-being programs already in place at residential and community aged care facilities in Australia.

In traditional aged care settings, the artificial environment is generally limited in perceptual diversity or stimulation. This VR environment is designed to operate at low cost, low personnel oversight and minimal invasiveness to the existing facility infrastructure and the residents themselves.The authors consider that a system that can work effectively in such an environment, should work as effectively in any GLAM or performance environment.

## Developing the Sound, Shadow and Light system

Sound, Shadow and Light system has minimal parts: a Raspberry Pi or similar running AV software such as PD or Processing, a micro-projector, a convex reflective surface, two Bluetooth speakers, and one or two USB fans. This system, shown in Figure 5, provides visual, aural and kinetic cues similar to those being experienced in an external, natural environment.

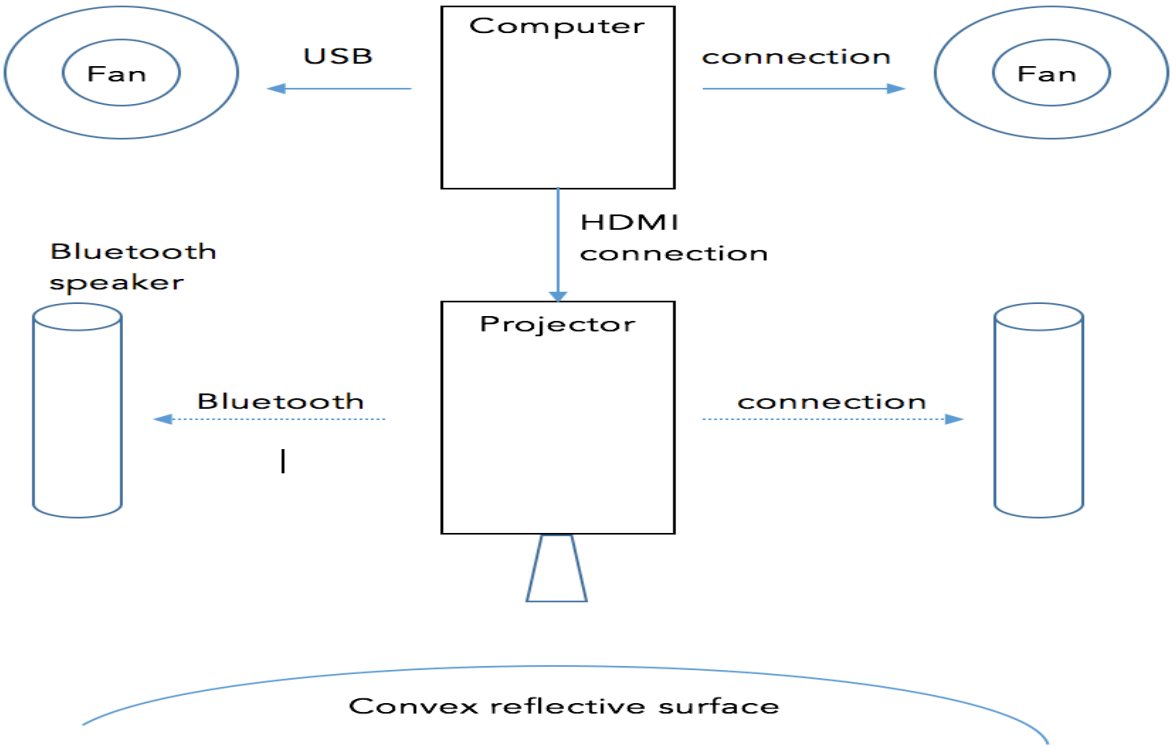


Figure 5 Design of Sound, Shadow and Light system

An example of the prototyping Max patch can be found here. When a robust and tested software system, that is extensible and can accommodate changes in technology and the specific needs of different clients has been beta tested, a bespoke system, including software, will be fabricated. As it is intended that the image and audio create and immersive experience for those in the chosen environment, the projection on a convex reflective surface will allow images to be seen as reflections on the interior space. The use of Bluetooth speakers will allow the sounds to be heard from different locations within that space, and the fans will provide changes in air pressure, similar to those of a breeze.

Figure 6 to Figure 9 show a still image from a movie used in the prototyping of Sound, Shadow and Light. Here the movie is zoomed in to show the changes in shadow and light. Figure 7 shows a black and white reduction of Figure 6 to further highlight the alternating shadow and light. Originally it was anticipated that a similar image would be projected, and the effect of the convex reflective surface would influence the shapes, making them more varied and less recognisable. It was then considered that the projected shapes could be varied by software-based enhancements such as extreme zooming in, shown in Figure 8, blurring, shown in Figure 9, colour enhancement, varying motion and so on, this would depend on the desires of the artist and/or venue.

Figure 6 Enhanced image from Figure 4

Figure 7 Colour black and white image from Figure 5

Figure 8 Developed image from Figure 6

Figure 9 Alternate developed image from Figure 6

When developing the sound aspects of the system, the approach taken is to reflect the sounds that may best coincide with the environment being represented. Figure 10 shows an amplitude graph, in yellow and showing higher amplitudes as spikes, and a melodic graph, in blue and red showing a spectral frequencies, with the red frequencies being louder than the blue frequencies. This provides 15 seconds of sound recorded with the images shown in the previous figures. These graphs are overlaid to show amplitude and spectral information. This kind of information will be used to ensure a firm relationship exists between the sound and vision.

Figure 10 shows areas of periodicity in the later part of the image, which coincide with louder ‘melodic’ fragments, seen in red; these are the sounds of a bird warbling. Other lower amplitude spikes are seen, and these relate to other birds and ambient sounds such as a car horn or child yelling.

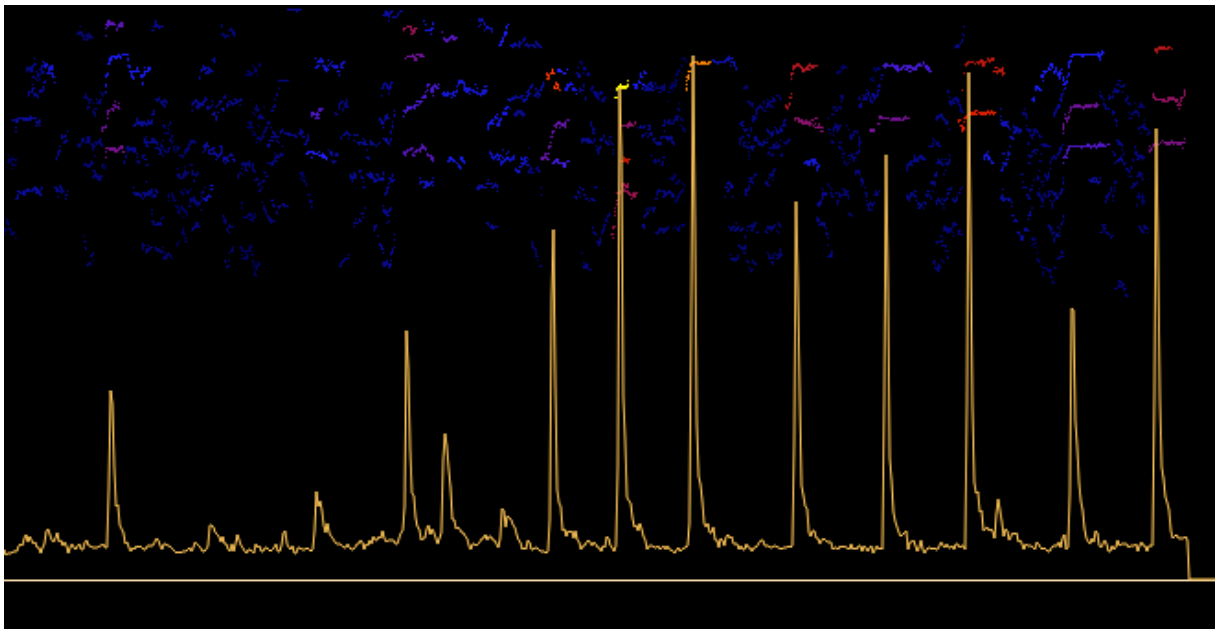

Figure 10 Plot of 15" of sounds at location in Figure 1

As the image and sound are experienced fans may be activated to provide a kinetic sense of the outdoor space. While developing Sound, Shadow and Light for an aged care facility, it is intended that the experience be subtle and not interfere with the normal activities of the facility, however the system is designed to be extended for other indoor environments, such as GLAM and performing arts venues.

As Sound, Shadow and Light is developed, additional attributes, such as responsivity and user extensibility, will be added. This is also dependant on hardware developments, such as more effective projectors and increased computing power.

## Notes

The prototyping Max patch link can be found at:
https://www.dropbox.com/sh/angrmifhq0zdxpp/AAAOGCKNNackqpCMwGAOCdtya?dl=0

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