Real-time Hallucination Simulation and Sonification through User-led Development of an iPad Augmented Reality Performance

Alexis Kirke, Research Fellow (Permanent) in Computer Music, Joel Eaton, PhD Student, Eduardo Miranda, Professor of Computer Music, Interdisciplinary Centre for Computer Music Research, School of Humanities and Performing Arts, Plymouth University, UK, alexis.kirke@plymouth.ac.uk, joel.eaton@students.plymouth.ac.uk, eduardo.miranda@plymouth.ac.uk

Abstract

The simulation of visual hallucinations has multiple applications. We present a new approach to hallucination simulation, developed initially for a performance but which proved to have uses to sufferers of certain types of hallucinations. The system allows real-time visual expression, using iPad augmented reality. The system was developed focusing on the visual symptoms of Palinopsia, experienced by the first author. It also allows the hallucinations to be converted into sound through visual sonification. Although no formal experimentation was, we report on a number of unsolicited informal responses to the simulator from palinopsia sufferers and a charity.

Introduction

Palinopsia is a visual symptom involving trails in the visual field [1], as shown in Figure 1. In addition to this it can lead to very strong after-images [2], similar to when anyone stares at the sun and looks away – but this can be much stronger for Palinopsics and can be caused by objects which are not particularly bright – for example a door. One interesting aspect of Palinopsia is that it can occur in individuals who show no other ill effects. Palinopsia is a symptom rather than a condition. Oliver Sacks the author and neuroscientist, has had the symptoms of Palinopsia [3].

The academic study of Palinopsia is still in the early stages. Scientists are divided in their terminology, using alternative terms such as Polyopia and Visual Perseveration as well [4]. They also have different ideas about the causes of the condition. One possibility is a reduction of inhibition function in certain neurons in the visual cortex [5]. This could both explain how the after-image of a moving object is not cancelled out more firmly, and why the evolving patterns seem to come from nowhere, perhaps from under-supressed random firing of cortical neurons. There have also been interesting initial results concerning a common "visual trail rate" of 15-20Hz [6].
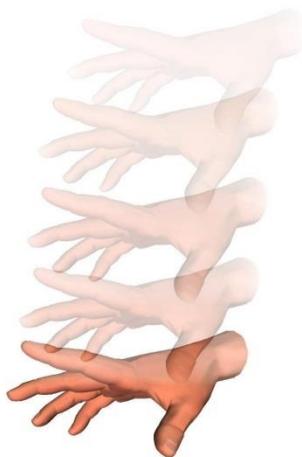

Fig. 1. Visual Trails in Palinopsia for a downward moving hand

For some the condition of Palinopsia is debilitating, for others they fail to realise the images are not real, and for many it is a lonely condition they are afraid to reveal to anyone. Oliver Sacks estimates that up to 90% of people with the hallucination condition Charles Bonnet syndrome do not mention their hallucinations to others [7]. Charles Bonnet syndrome is experienced by a number of people who go blind, creating very specific, in some cases cartoon-like, hallucinations. The lack of understanding of Palinopsia could perhaps be aided by tools to enable Palinopsics to express their visual hallucinations more clearly to others. Software that can enable some of these people to express and discuss their visual disturbances with a close friend, or perhaps a therapist or medical professional they are working with, may be beneficial. It could help medical professionals and neuroscience researchers to gain a deeper insight into visualising precisely what the subjects are seeing.

Simulators and Augmented Reality

Static hallucination simulators are used to help people express exactly what hallucinations they have. There has been some work in the use Virtual Reality to model hallucinations to help in teaching people about schizrophrenia [8] and the pharmaceutical company Janssen Pharmaceuticals have actually developed a system for laptop and stereo glasses to simulate hallucinations [9] for training. But neither of these systems are truly interactive, or based on real-time augmented reality.

Augmented reality is a method of combining live camera data on a smartphone or tablet with real-time generated images, both appearing on the screen simultaneously [10]. There are many applications available involving this, including some designed to help rehabilitate people with physical [11] or cognitive [12] disabilities. There have also been augmented reality systems to help visually impaired people navigate more easily [13]. What is more rare are applications which manipulate the visual field to simulate what people are subjectively seeing. This is the application which was developed here, which has been labeled the "Halluciphone".

The Halluciphone

The Halluciphone was originally developed for a performance called "Insight". The basic system used in the performance consisted of an iPad with custom software allowing the first author to attempt to represent his hallucination effects. This data was sent to a laptop which then had MAX/MSP software for sonifying the visual effects. There has been previous work on sonification of visuals [14, 15] and also the sonification of medical data [16, 17]. The initial purpose of the sonification here was performance-based, and to draw attention to the hallucinations, giving them more 'reality'. However it may be that such sonification could help people to express their hallucinations helpfully in a multi-modal way. The use of cross-modal mappings in performance is a well-researched and explored area. Examples in include Dance Jockey for turning dance movements into music [18], a system to allow dancers to manipulate visual simulations to create sound [19], and the work of Tanaka [20]. The Palinopsia Foundation in the USA – talking about the Halluciphone – have said that the "therapeutic uses for this application are endless. It could significantly help spread awareness of Palinopsia and understanding for those living with Palinopsia."[21]

The augmented reality application that was developed can be made to 'hallucinate' in ways similar to the first author's vision. Whatever the iPad camera is seeing can be manipulated by my using the iPad multi-touch screen. Effects that can be controlled include having groups of pixels randomly switch on and off. When these are combined with other elements related to Palinopsia, including visual after-images (see Figure 2) and trails on the iPad, the screen is able to show a representation of the experienced visuals. This includes a simple interface to allow the performer to indicate where he is seeing patterns and images by touching the screen. Thus the audience was enabled to see some semblance of what was being experienced internally in what is usually "private" vision. It was this expression of private visual states which was the artistic motivation for the performance, but as time went on it became clear that many sufferers of hallucinations and their carers could gain benefits from having access to such a system.

iPad Software Description
The openframeworks development platform has advanced image processing features that can be integrated into the iOS platform for mobile deployment. This allows the Insight application to display a continuous video feed from the iPad's camera. The feed acts as input to the hallucination algorithms and provides a background layer to the hallucination effect

layers which are overlaid. This provides a real-time projection of a "reality layer" (what is actually being seen by the camera) and also hallucination effects, which are updated in-line with the video feed.
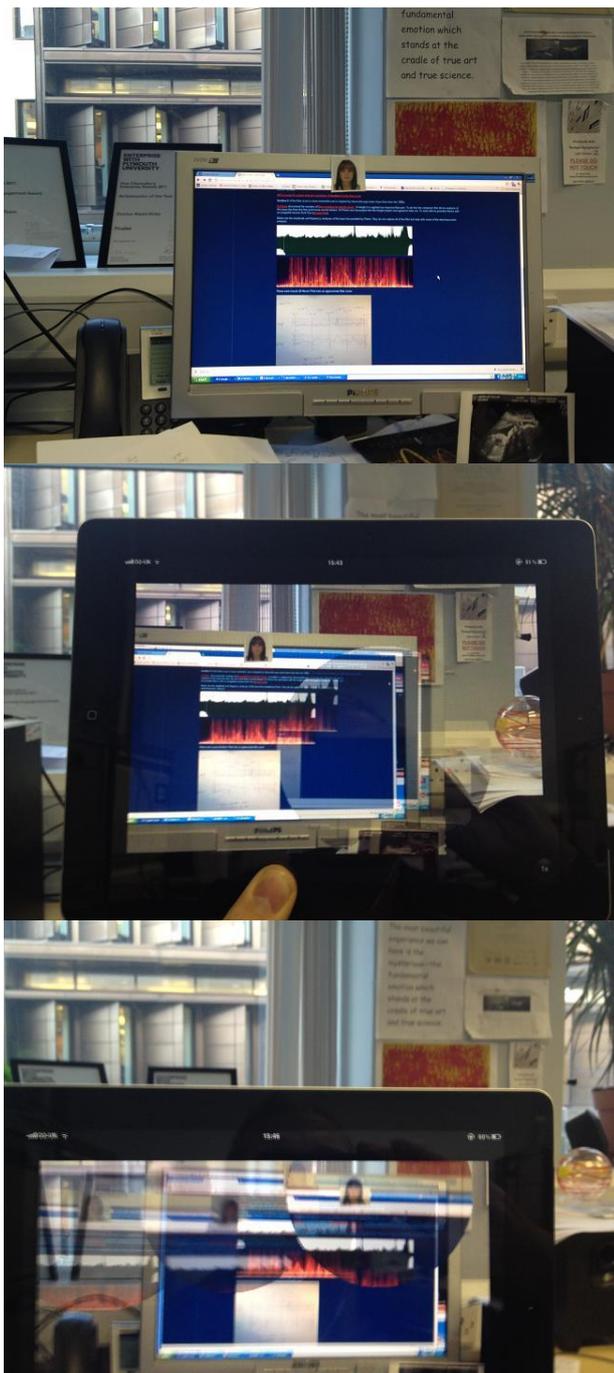

Fig. 2. Halluciphone simulation of after-images

The hallucination controls are split into three modes that can overlap creating multi-layers of hallucinations. These modes are defined by their methods of user control and their resultant visual and audio functions and effects. Modes are entered via display-area specific touch commands on the reality layer. This allows for a continuous reality layer on screen, avoiding the need for any navigation menus or buttons that may obstruct an audiences' view of the projected mirrored display and detract the conductor from the hallucination experience. Mode specific commands provide control for instigating and manipulating layers of hallucinations. The three modes; single touch, multi-touch and visual echo; dictate the type of hallucination that can be applied to the display.

Single touch mode allows for an area of the video feed to be mapped into an after-image layer. The location of a users' touch dictates the on screen position of the after-image. The size of the after-image is defined by the time of the touch command, and the on-screen duration of the after-image is defined by the distance of a swipe movement after the initial touch command. Multiple instances of single touch commands can be initiated and over-lapped.

Commands in multi-touch mode generate clusters of small after-image areas akin to stochastically arranged groups of circles. The cluster size and duration are, again, user definable, whereas individual after-image positioning within a cluster is fixed to a random ordering to mirror the randomness and blurring that occurs within Palinopsia.

Within the visual echo mode the video input is processed and generates echoes of delayed images. This creates the effect of visual trails surrounding a moving object whilst motionless background content is unaffected. Controls allow for speed of echoes and the duration of the effect. A feature of the visual echo mode is layers containing clusters of after-images, triggered and still visible before any echoes have been initiated, are also echo affected and echo simultaneously with the primary visual trails.

The technical implications of a software algorithm designed to emulate states envisioned only by a subject of Palinopsia offered a number of design and implementation issues. Successfully interpreting a neurological condition based upon text and conversational based descriptions required considerable attention to detail as development was undertaken using limited references. A descriptive framework defines one persons' ultimate reality, so wide margins for constant adjustment and refining needed to be employed.

Laptop Software Description

The performance's success lay in the communication of the visual effects of Palinopsia to an audience. This allowed for experimentation in how the visual effects of the condition can be musified. A dynamic framework of mapping visual effects to audio parameters allowed for the user to select controls based on aesthetics. This assisted in creating a more engaging experience for an audience, where the performance was true to the condition, whilst allowing for creative artistic interaction

The MAX patch provides 6 audio modules and a separate interface to act as a patchbay to allow the performer to design the mappings between the iPad visualisations and the musical parameters of the audio modules, and even alter them during performance. This patching approach is shown in Figure 3 highlights black objects residing in the top half of the patch that receive data from the iPad related to the onscreen activity, via OSC. These data streams can then be connected to the inputs of the musical parameters, displayed in the various colours in the bottom half of the patch. These connect to the controls for the audio modules, shown in Figure 4. This provided a flexible platform for control during performance as mappings could be reassigned, removed or fixed providing a richer creative palette for musical experimentation than systems with a fixed point mapping system.

The actual mappings for the performance were selected through experimentation by the composer. This involved a process of setting up potential MAX/MSP mappings using the patch in Figure 3 and trying them out in rehearsal and in the studio. The top half of the figure shows the various inputs from the iPad touchscreen. For example the brightness and variation on average across the screen, or the size of area over which an afterimage was switch on. These could be mapped onto the filter or effects parameters below. One of the most perceivable effects, in terms of linking it to hallucinations, turned out to be the delay near the bottom of Figure 3 – in particular as feedback loops built up. Levels of loudness were also significantly affected by the various visuals.

Score Development and Structure

The score has three elements. The performance involved a flute player, the first author controlling electronics via his laptop and the Halluciphone, together with a lighting design controlled by an engineer off-stage, so as to create a contrasting set of visuals for the Halluciphone. The composer's motivation for selecting the flute was to make the

performance more organic, as well as sonically and visually dynamic for the audience. The flute sound also has an element of ephemerality which it was felt captured the unreal feel of the hallucinations. The flute score was in the idiom of contemporary classical music.

The first and third movements of the flute were constructed using motifs quoting classical electronic dance music from the late 1980s and 1990s. The second and third movements were written with some help from DJ Pierre, credited with developing the first "Acid House" [22] bass-line for the track "Acid Trax" as a member of the band Phuture. He sent an acapella version of a higher tempo version of the bassline from Acid Trax which was used as raw material for electronics in the third movement. The second movement was actually loosely based on the approach taken in DJ Pierre's bassline in Acid Trax. In acid house music, filtering is often used to change bassline characteristics – sometimes called "filter sweeps". The filter sweeps in the "Acid Trax" bassline can be seen in Figure 5. An excerpt from the 2nd Movement is shown in Figure 6. The second movement was largely made up of the flute playing the repetitive bass loop from Acid Trax. Parts of the line are played with notes having extended or reduced duration and loudness, reminiscent of the effect of filter sweeps.

The broader artistic implementation of the piece was envisioned as giving the flautist opportunities to use extended techniques and to improvise on some of the themes. It was also desired to structure the piece so as to introduce various visual and sonic elements gradually, reaching a climax in the finale. Each movement consists of a mostly pre-scored flute section, followed by an improvisational section. To create the desired arc for the flute, the flautist was instructed to not utilize any extended techniques until the third movement. The first movement involved a relatively normal contemporary classical flute score, which was based on the number of themes from contemporary dance music. The second movement might be interpreted as minimalist, but as has already been stated, was more of an homage to the electronic dance music pioneers in the 1980s. Artistically, it is a form of 'calm before the storm'. The final movement is written so as to be more chaotic. It is made up of segments based on the themes from the first movement, but interspersed by a number of bars of improvised extended techniques. It ends with a vigorous improvisation from the flautist incorporating extended techniques.

The electronics utilized the audio provided by DJ Pierre directly, and also simple sounds which were chosen by the composer / first author for aesthetic reasons, but also because he knew from past experience that he found them hypnotic and they could therefore potentially focus him on any hallucinations. They were Binaural Beats, Sub-bass and White Noise. These were loaded into three of the sample channels shown in Figure 4. It was these electronics which were manipulated by the Halluciphone signals' patching using Figure 3.
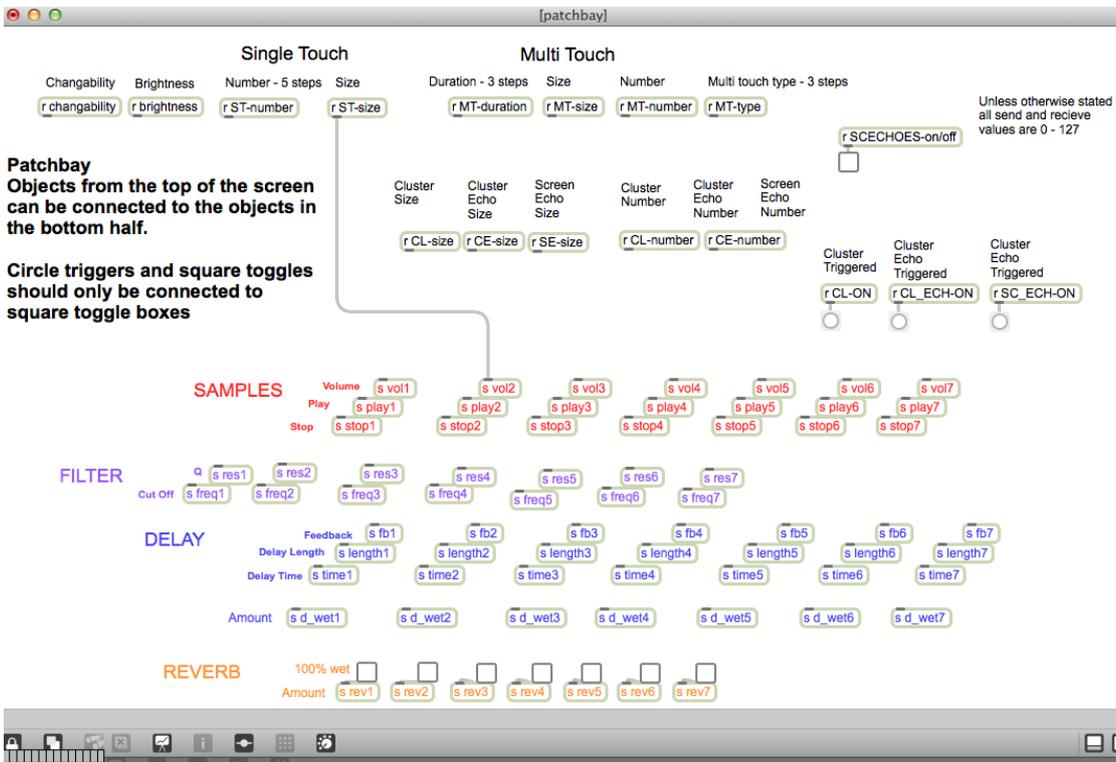
Fig. 3. Mappings Available for Visuals Sonifications. This MAX patch demonstrates how visual parameters are mapped to musical parameters. This example shows that the after effect size in single touch mode is mapped to affect the volume of sound sample 2.
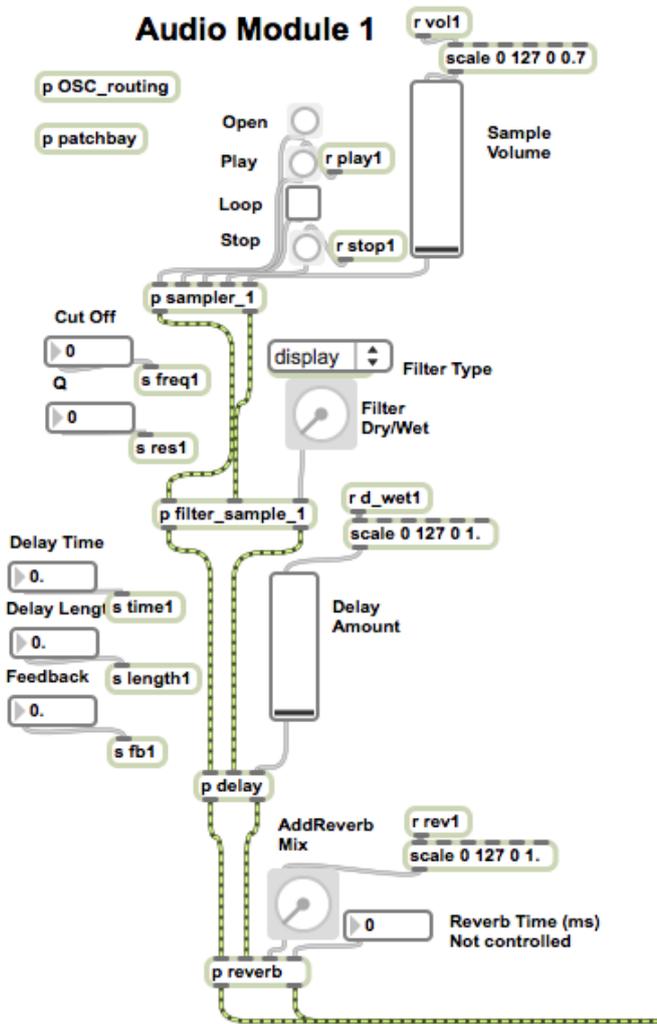
Fig. 4. One of the audio modules that comprises the electronic composition. The parameters of the module receive their control signals from the iPad visuals via the performers configuration as specified in the patchbay (Fig 3.)
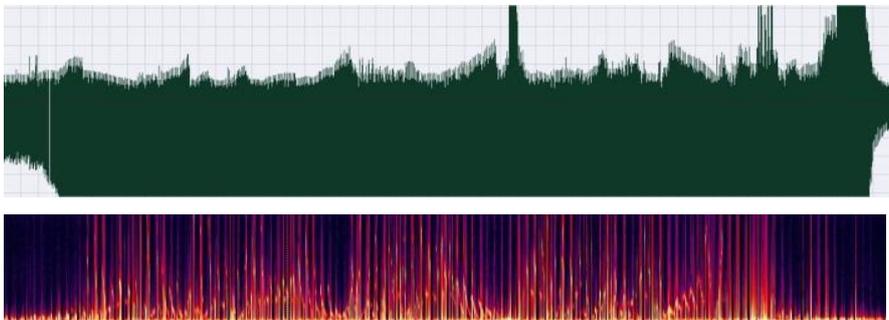

Fig. 5. Waveform of Acid Trax bassline, plus spectragram of Filter Sweeps

Fig. 6. Excerpt from 2nd Movement

The lighting was designed so as to give a variety of visual effects to trigger and highlight hallucinations. They were controlled live by the lighting technician who knew the score and timings, and followed a lighting score, part of which is shown in Table 1. The arc for the visuals was for the first movement to focus on static after-images, the second movement to focus on visual trails, and the final movement to incorporate all hallucination functionality. The lighting score reflected this aim, with lighting aimed at intensifying after-images in the first movement, and a spotlight trained on the composer's free hand in the second movement, allowing him to move it rapidly and attempt to generate visual trails. The final section had both types of lighting. An example photo of the visual echoes effect, highlighted by the lighting, is showing in Figure 7.

Cue	Track Time (sec)	State	Uptime (sec)	Previous state Downtime (sec)	Dwell time (sec)
0.5	0	Preset			
1	0	Blackout	0	0	30
2	30	Flute only	8	5	35
3	73		8	5	15
4	96		8	5	16
5	120	All audience at 45%	8	5	7
6	135	Just flute	5	8	105
7	248	Just flute	8	5	0
8	**262**	Stage flooded with light	1	0	1.5
9		Just Flute	0	0	0
10	**284**	Stage flooded with light	1	0	1.5
11		Just Flute	0	0	0
12	**305**	Stage flooded with light	1	0	1.5
Etc…					

Table 1. Part of the Lighting Score use in the Performance

Feedback

Because the project has so far been primarily performance-based in nature, no formal results are reported on the usage of the system as a hallucination simulator. However informal commentary from the Palinopsia Foundation and a number of sufferers of Palinopsia provide initial feedback together with motivation to extend the study into more formal realms.

The USA Palinopsia Foundation [23] are using a video demo of the iPhone version of our software to introduce their webpage. A link to the video of the Insight performance was placed on a forum frequented by people who said they had symptoms of palinopsia, and the following reply was received anonymously (sic): "*I have been suffering from these visals for about 14 years now, its only been in last few months that ive been learning about palinopsia and also hppd, i felt relieved knowing there was a name for something i have been suffering with for many years and just thought i was going mad...im really interested in talking to you i have just gone on the website you provided and was amazed by what you have done its exactly what i see.*" (sic) This also shows how the performance itself can be an effective vehicle for education as well as for raising awareness about the symptoms. A link to the video the person is referring to is given at the end of this paper. The next three quoted messages were unsolicited and were public Youtube comments from people who watched a demo video of the simulator (http://www.youtube.com/watch?v=ccPpezbdVis): "*hi, I watched your iphone/ipad hallucination software video. Never ever thought I would find anyone else with this condition. I too have been suffering with it for almost a year now. I don't experience the trails but definitely the afterimages.*" "*I have had visual echoes for a month now and this is comforting that this isn't something much more serious.*" "*Thank you so much for this video... it allowed me to show people i love what i see when i have palinopsia, which is quite hard to describe just with words. Thanks!!*" (sic)

Fig. 7. Visual Echo Simulation during the Performance Premiere

The performance premiered at Peninsula Arts Contemporary Music Festival 2012 at Plymouth University. It was found that the synthesizer at times suffered from feedback instability which needs to be investigated. It was also found that to create a sufficiently interesting performance the visual effects of the Palinopsia had to be slightly over-emphasized by the performer. However, allowing for this over emphasis, the performer in particular found that the visual echoes and the after images were quite often reasonable simulations, especially with the lighting score was implemented. The performance can be seen here: http://www.youtube.com/watch?v=a5cKUkDyR1U

Conclusions

We have introduced a performance which highlights a new approach to hallucination simulation, allowing real-time audio and visual expression, using an iPad. An individual can overlay their hallucinations in real-time on the iPad screen over the iPad's video camera image. Such an approach could be utilized for other conditions and visual hallucination types. The system also allowed the hallucinations to be converted into sound through visual sonification. The musical performance – for which the system was initially developed - was described, which has helped to raise awareness and comfort some people who have Palinopsia symptoms. Because the project has so far been primarily performance-based in nature, no formal results were reported on the usage of the system as a hallucination simulator. However informal

commentary from the Palinopsia Foundation and a number of sufferers of Palinopsia provide initial feedback together with motivation to extend the study into more formal realms.

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