REAL-TIME HALLUCINATION SONIFICATION AND SIMULATION THROUGH USER-LED DEVELOPMENT OF AN IPAD AUGMENTED REALITY PERFORMANCE

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ABSTRACT

The simulation of visual hallucinations has multiple applications. For example in helping diagnosis, in helping patients to express themselves and reduce their sense of isolation, for medical education, and in legal proceedings for damages due to eye / brain injuries. We present a new approach to hallucination simulation, which was developed initially for a performance but proved to have potential uses to sufferers of certain types of hallucinations. The system allows 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. The system has been developed focusing on the visual symptoms of Palinopsia, experienced by the first author, and hence has initially been user-led research. However such an approach can be utilized for other conditions and visual hallucination types. The system also allows the hallucinations to be converted into sound through visual sonification, providing another avenue for expression for the hallucinating individual. A musical performance is described which uses the system, and which has helped to raise awareness and to comfort some people who have Palinopsia symptoms. Although no formal experimentation was done outside of performance preparation, we report on a number of unsolicited informal responses to the simulator from palinopsia sufferers and a palinopsia charity.

1. 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 differing terms such as Polyopia and Visual Perservation [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].

Figure 1. Visual Trails in Palinopsia

This lack of understanding of the condition could perhaps be aided by tools to enable Palinopsics to express their visual hallucinations more clearly to others. The Palinopsia Foundation in the USA 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."[7] Thus 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.

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 [8].
In addition an artistic performance involving this software by a Palinopsic may help to raise awareness of the condition and help those who have the condition, and are

unaware they are not alone, to seek help if they need it; or just feel comfort if the symptoms are not debilitating.

2. 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 [9] and the pharmaceutical company Janssen Pharmaceuticals have actually developed a system for laptop and stereo glasses to simulate hallucinations [10] 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 generatively generated images, both appearing on the screen simultaneously [11]. There are many applications available involving this. 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".

3. 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 hallucation 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 [12, 13] and also the sonification of medical data [14, 15]. The initial purpose of the sonification here was performative, and to draw attention to the hallucinations, giving them more 'reality'. However it may be that such sonification could help people to express their hallucations helpfully in a multi-modal way.

The augmented reality application that was developed could 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 includes 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 will be 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 is enabled to see some semblance of what is 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.

3.1 iPad

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 and also hallucination effects, which are updated in-line with the video feed.

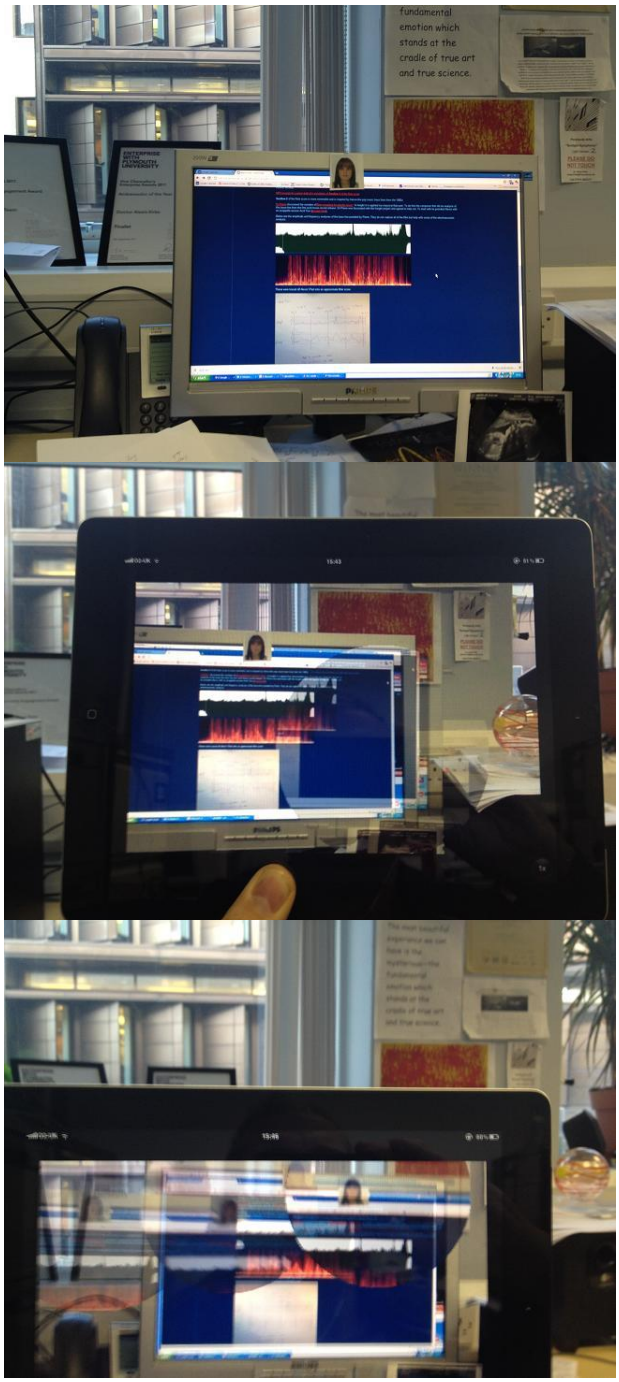

Figure 2: Halluciphone simulation of after-images

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 overlapped.

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 offers a number of design and implementation issues. Successfully interpreting a neurological condition based upon text and conversational based descriptions requires considerable attention to detail as development is undertaken using limited references. A descriptive framework defines one persons' ultimate reality so wide margins for constant adjustment and refining need to be employed.

3.2 Laptop

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

Figure 3 shows a view of a MAX patch to give an idea of how the various hallucination effects could be mapped onto the parameters of the synthesis units on the laptop. Figure 4 shows one of the 5 units which were available to the composer. Each unit could be loaded with a WAV file, which was then processed live by the mapped information from the iPad.

The actual mappings for the performance were selected through experimentation by the composer. This involved a process of setting up possible MAX/MSP mappings using a patch of the form shown Figure 3 (though the patch has been compressed here to fit into page) and trying them out in rehearsal. The top half of Figure 3 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 can 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 at the bottom of Figure 3 – in particular as feedback loops built up. Levels of loudness were also significantly affected by the various visuals.

4. SCORES

The score has three elements. The performance involved a flute player, the first author controlling electronics via his laptop and the Halluciphone, together with lighting design so as to create a contrasting set of visuals for the Halluciphone. The audio score style was motivated by the commission being from a contemporary classical music festival, and a desire to create a "mysterious" sound that would echo the "mystery" of our internal perceptions and how they relate to other peoples'.

The purpose of the flute was to make the performance more organic, and sonically and visually dynamic for the audience, as well as more accessible for those coming to it as a contemporary classical concert. The flute also had 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 movement was written with some help from DJ Pierre, credited with developing the first "Acid House" [16] 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 4. An excerpt from the 2nd Movement is shown in Figure 5. 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 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 6. It was these electronics which were manipulated by the Halluciphone signals' patching using Figure 3.

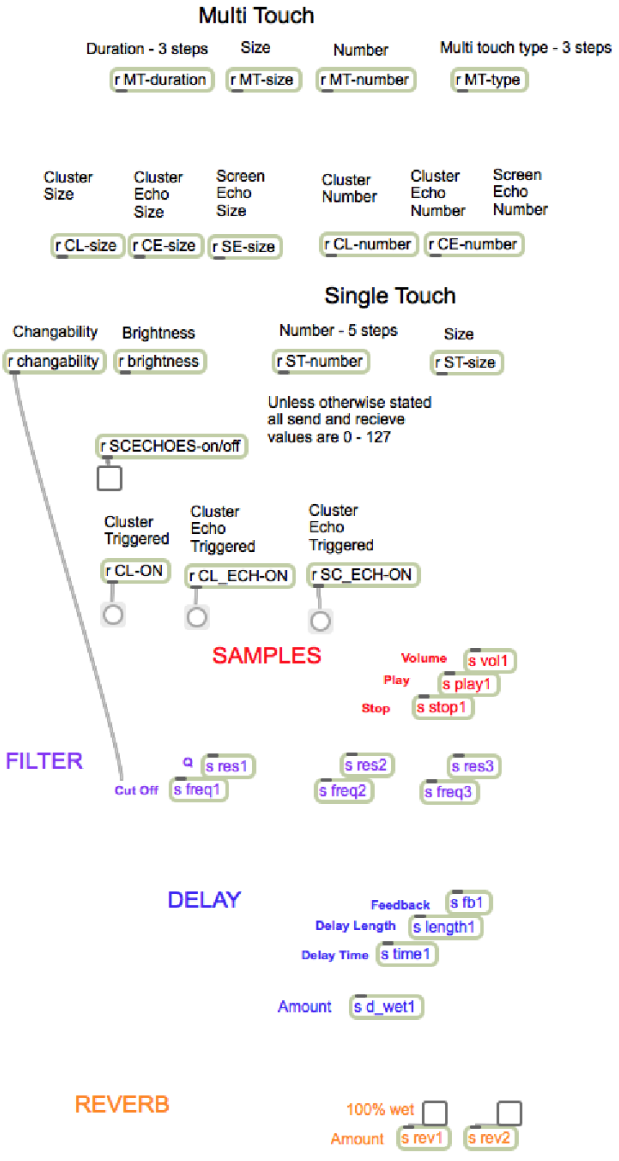

Figure 3: Mappings Available for Visuals Sonification

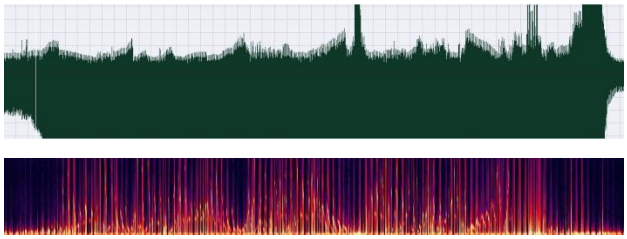

Figure 4: Waveform of Acid Trax bassline, plus spectragram of Filter Sweeps

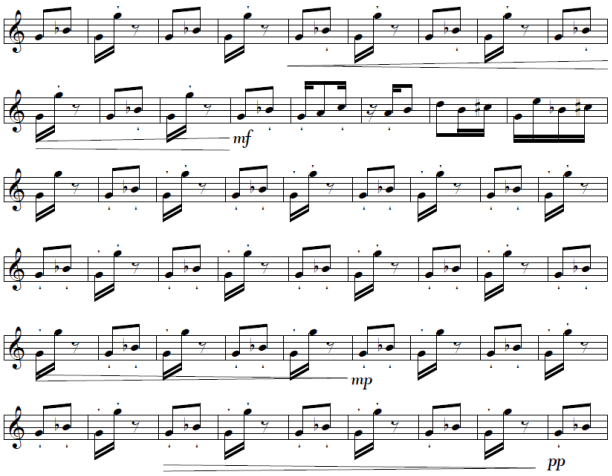

Figure 5: Excerpt from 2nd Movement

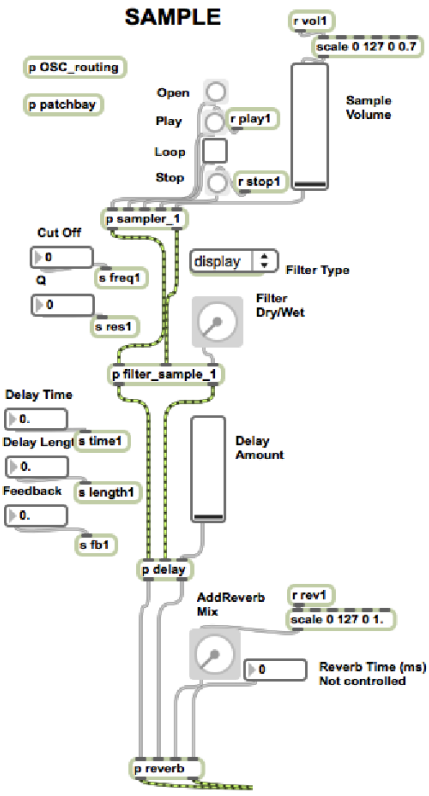

Figure 6: One of the Sonification channels on the Laptop

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 flood-ed with light	1	0	1.5
9		Just Flute	0	0	0
10	**284**	Stage flood-ed with light	1	0	1.5
11		Just Flute	0	0	0
12	**305**	Stage flood-ed with light	1	0	1.5
Etc…					

Figure 7: Part of the Lighting Score use in the Performance

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 Figure 7. An example photo of the visual echoes effect, highlighted by the lighting, is showing in Figure 8.

5. FEEDBACK

Because the project has so far been primarily performative 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 [17] are using a video demo of the iPhone version of our software to introduce their webpage. The following is a quote from a comment received anonymously as a result of the writer viewing a video of the Insight performance (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 are from people who watched a demo of the simulator on Youtube: "*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)

Figure 8: 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

6. 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 performative 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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