Opto-Phono-Kinesia (OPK): Designing Motion-Based Interaction for Expert Performers

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Abstract

Opto-Phono-Kinesia (*OPK*) is an audio-visual performance piece in which all media elements are controlled by the body movements of a single performer. The title is a play on a possible synesthetic state involving connections between vision, sound and body motion. Theoretically, for a person who experiences this state, a specific colour could trigger both a sound and a body action. This synesthetic intersection is simulated in *OPK* by simultaneity of body movement, and audio-visual result.

Using the Gesture and Media System 3.0 motion-tracking system, the performer can dynamically manipulate an immersive environment using two small infrared trackers. The project employs a multipart interface design based on a formal model of increasing complexity in visual-sound-body mapping, and is therefore best performed by an expert performer with strong spatial memory and advanced musical ability. *OPK* utilizes the "body as experience, instrument and interface" [1] for control of a large-scale environment.

Author Keywords

Immersive environments; motion-tracking; live audio-visuals; synesthesia; ephemeral interfaces; multi-modal experiences; interaction design; media art.

Figure 1 – Steve Gibson wears the two infrared trackers used in *OPK.* The position of the trackers is triangulated by four 100fps infrared cameras situated in the corners of a room (usually placed at height on a light grid). The trackers have different flash patterns so that they can be easily identified. The trackers are small and unobtrusive, and are fitted with Velcro straps that can be adjusted to be attached to different parts of the body (hands, feet, shoulders, etc.). The trackers can be programmed as spatial controllers using the FlashTrack software. This GUI-based PC application allows the user to program different media layers in 3D space and save these as 'Maps.' The different planes (x, y, and z) can be layered with media triggers and controls, therefore enabling the simultaneous manipulation of audio, video and lights via performer movement with the trackers. Photo by Liam Hardy, ©2017. Used by permission.

ACM Classification Keywords

J.5. Computer Applications: Arts and Humanities: Fine Arts; I.4.8. Image Processing and Computer Vision: Scene Analysis: Tracking.

Conference Themes

OPK responds to the following conference themes:

- Body as experience, instrument and interface
- Ephemeral interfaces
- Haptic and multi-modal experiences
- Aesthetic experience through tangible or full body interactions

Introduction

OPK is an audio-visual performance to be performed solo by an expert, trained performer. *OPK* consists of several shorter pieces that explore the relation of particular 3D planes to media control. Each piece takes a different approach to 3D motion and media control, thus relying on performer memory.

In contrast to most media art and interactive environments, *OPK* is not intended for interaction by the general public, but instead is a live performance that requires a trained body-based performer to execute it in real-time. *OPK* has embedded within it the possibility of musical timing errors, and contains complex spatial access points for media control, thus making it only suitable for an expert performer. *OPK* continues my 20-year project to design an interface strategy for body-based performance, in which all media aspects are controlled by a single user. *OPK* is body-based and immersive, but also employs a formal design strategy of multi-modal mapping via a simulation of the condition of synesthesia.

The Gesture and Media System 3.0 (GAMS)

OPK makes use of the Gesture and Media System 3.0 (GAMS) motion tracking system, and the FlashTrack 3D mapping software. With GAMS four infrared cameras are used to detect user position and velocity in 3D space. Up to four infrared trackers can be used simultaneously. Media can be mapped in different spatial zones using FlashTrack, and dynamic relationships can be established between user motion and common audio-visual parameters. Audio and video parameters are controlled by MIDI (for control of sound and video), and lights are controlled by DMX (the standard protocol for light control). Remote controls can be used to load new 'Maps' containing different media configurations. The software can also use other motion-based data – e.g. velocity of the trackers, proximity of the different trackers to each other - to change media parameters. Figure 1 shows the trackers and explains in detail about their functionality and use.

Synesthesia

Synesthesia is a condition is which a person experiences sensations from one sense in a second different sense. "How does it feel to hear music in color, or to see someone's name in color? These are examples of synesthesia, a neurological phenomenon that occurs when a stimulus in one sense modality immediately evokes a sensation in another sense modality. Literally, 'synesthesia' means to perceive (*esthesia*) together (*syn*)." [2]

Note	Colour
C	red (intense)
C#	violet or purple
D	yellow
D#	flesh (glint of steel)
E	sky blue (moonshine or frost)
F	deep red
F#	bright blue or violet
G	orange
G#	violet or lilac
A	green
A#	rose or steel
B	blue or pearly plue

Figure 2 - Scriabin's colour scheme for the 'chromola' used in *Prometheus: Poem of Fire.* The chromola was a keyboard instrument that was capable of changing two coloured lights simultaneously.

Figure 3 - Synesthesia map for two specific (related) melodies in *OPK*. The videos and light colours are matched to specific notes at specific spatial coordinates. Image by Steve Gibson, 2017.

Various devices have been created over the past 150 years to simulate the effects of synesthesia for non-synesthetes. "The British inventor Alexander Wallace Rimington (1854-1918), a professor of arts in London was the first to use the phrase 'Colour Organ,' in his patent application of 1893." [3] The Colour Organ played lighted coloured lamps by means of an organ-type keyboard. In the succeeding years following the invention of Rimington's Light Organ, other devices were created in order to play visuals simultaneously with music. The most well-known of these is Scriabin's 'chromola' used in his *Prometheus: Poem of Fire* from 1912 (see Figure 2). What these and other similar devices share in common is the ability to mimic the

Figure 4 - Steve Gibson uses two motion-trackers to perform *OPK*. The first tracker controls drums, and the second controls bass, melodies and samples. Audio events can be programmed to be triggered anywhere in 3D space. Similarly, robotic lights can be used as follow-spots, with the light parameters matched to the changes in sound parameters (i.e. sound volume could be matched to light dimmer). Simple geometric videos are also triggered in synch with each note of the melodies, and are matched to the robot light colours. The formal matching is based on a simulation of the effects of synesthesia. Photo by Liam Hardy, ©2017. Used by permission.

effect of audio-visual synesthesia through a single control technology. In *OPK* the audio-visual synesthetic simulation uses motion control instead of a keyboard or other musical device, extending the synesthetic experience into a third medium, that of the spatial - not precisely 'dance', but close (see Figure 3 for an example of a synesthesia map from *OPK*). Although the ephemeral nature of the interaction with the GAMS system does not produce any haptic feedback on the trackers themselves, in *OPK* the multi-modal connection between movement and the precise sound and visual response provides kinesthetic feedback through proprioception (joint/muscle senses, etc.).

Designing Interaction for Expert Users

My earlier work with GAMS, including *Virtual DJ* (2002-2005) and *Virtual VJ* (2011-13) [4], was primarily designed for general audience interaction. The user interface in these projects was deliberately simple, standardised and repeatable. For example, in *Virtual DJ* drums always faded in from zero volume in the back of the room to maximum volume towards the front. This was accompanied by a light dimmer that increased in intensity in a parallel manner. Similarly, all musical elements were 'quantized' to a very wide musical grid (usually to the bar), so that timing was always on the beat, even if the audience movements were slightly off rhythmically. The goal was to make the audience enjoy the experience without fear of making errors.

In contrast *OPK* is designed explicitly for a more rehearsed expert performer, in this case myself. I have over 20-years of experience in working with the GAMS system, and therefore almost certainly have a more developed spatial sense than the general population. In addition, I have a PhD in Music Composition and Theory and therefore my musical ability is likely higher than most of the general population.

My intention was to push myself as a performer so that an effort was needed to both keep the performance in synch, and to retain a level of musical coherence. This was partly achieved by setting the input quantization in the Ableton Live audio software to a much finer musical grid than I used in *Virtual DJ* (usually 1/8th notes for *OPK*), thus requiring me to pay very close attention to all of the rhythmic elements in order to keep them in relative time. This also enabled me to bring in musical elements in a syncopated fashion, thus getting away from an over-reliance on the 4/4 (time signature) grid. Another effect of using this finer grid was the possibility of errors, or at least the possibility of bringing in musical elements in an audibly 'wrong' manner - i.e. accidently starting a drum loop an 1/8th note early or late after a breakdown. The possibility of errors was key here: it increased the intensity of the performance and made it demonstrably more 'live.'

In addition to the above, the structure of *OPK* is such that it starts very simply, with a bass note, a few drum hits, and a few controls applied to each of these objects and their accompanying lights/videos via changing coordinates or tracker velocity. As *OPK* progresses the 3D space is filled with more and more sound, light and visual layers until the penultimate section, in which every part of the 3D space has an audio-visual layer, often with multiple layers on different parts of the z plane (floor-to-ceiling) in the same bounding x/y coordinates. Simultaneously the degree of dynamic control is increased as the piece progresses. Table 1 shows all of the MIDI controls that are sent via the GAMS system to Ableton Live.

OPK MIDI controls

MIDI continuous controllers (CC) are used to send MIDI data dynamically so that musical parameters can be changed smoothly in real-time. This list shows some common continuous controls used in *OPK.*

Filters – CCs 99 and 100
Filter Resonance – CC 101
Tremolo – CC 102
Beat Repeat – CC 103
Reverb Mix – CC 104
Delay Mix 1 – CC 105
Delay Mix 2 – CC 106
Delay Feedback – CC 107
Distortion – CC 108
Pre-Distortion – CC 109
Distortion Filter – CC 110
Beat Repeat Grid – CC 113
Auto Pan amount – CC 114
Vocoder balance – CC 115
Volcano Mix – CC 116
Synth 1 volume – CC 117
Synth 2 volume – CC 118
Resonator Mix – CC 119
Tempo – CC 120

Table 1: A list of MIDI continuous controls sent from GAMS to control audio parameters in Ableton Live. See Figure 5 for an example of how a MIDI control is mapped in FlashTrack.

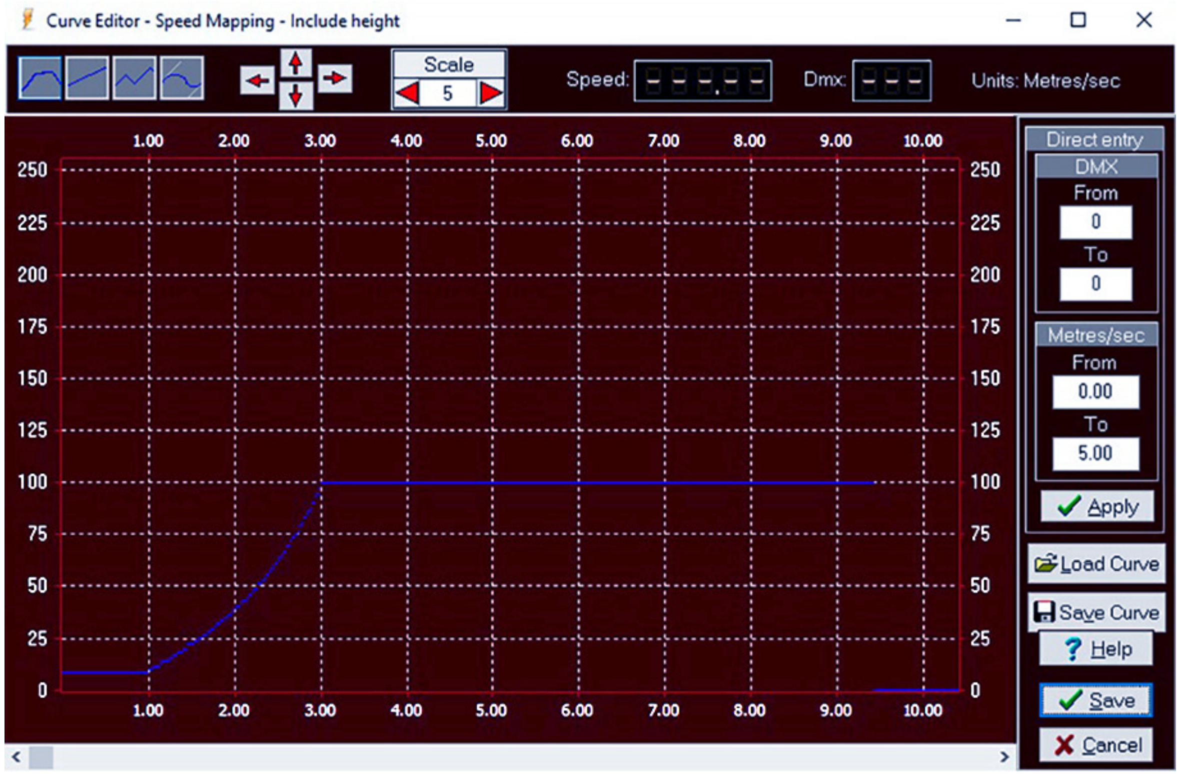

Figure 5 - This screen shows how dynamic controls are mapped in FlashTrack. In this case tracker velocity is used to change the amount of delay applied to the drums. When I move between 0-1 metre per second there is a small amount of delay. The delay amount increases from 10-100 when I move between 1-3 metres per second, and tops out at 100 when I move 3 metres per second or faster.

As a performer, I have to be continuously aware of these controls. It takes a mental, musical and visual effort to recall the planes to which these controls are attached, and which controls may be active at any time. This includes many instances in which controls are being applied on multiple sound channels and different lights simultaneously.

The use of multi-modal mapping between the sound, light and video elements, using a synesthetic strategy, assists in bringing coherence to the performance, both for the performer and the audience. For example, at the start of *OPK* a very soft bass note is triggered in the back of the room. As I move forward (on the y plane) the bass filter is opened, and the dimmer on the light

<u>Audio-Light pairing in OPK</u>
This shows how one audio track is paired to a light, with the MIDI and DMX mapped to the same tracker data.

FlashTrack Layer 1
Audio - Synth Filter CC99 (y)
Light - Dimmer (y)

- minimum at -250 y, and values change smoothly to maximum at +100 y

FlashTrack Layer 2
Audio - Beat Repeat CC113 (point)
Light **–** Rotating Prism (point)
(Defined Point – x = 0 cm; y = +100 cm; z = +100 cm)

- minimum >200 cm from point, and values change smoothly to maximum <50 cm from point

FlashTrack Layer 3
Audio - Reverb Mix CC104 (z)
Light - Focus (z)

- minimum <130 z and values change smoothly to maximum at 200 z

Table 2: A list of Audio and Light parameters controlled by specific tracker movements, attached to one Bass sound at the start of *OPK.*

becomes brighter. As I near a specific point at the front of the room the bass note is repeated and bent (Beat Repeat), which simultaneously causes the light prism to rotate. As I lift my hand up beyond 130 cm (on the z plane) reverb is applied increasingly to the bass, and the light becomes increasingly unfocused. Table 2 shows how the audio and light controls are mapped to specific 3D movements, as described in the example above.

These synchronized actions between the audio-visual domains are what provides the formal coherence in *OPK,* and they are also what gives the performer feedback on how his movements are affecting the audio-visual elements. Only through logical and careful mapping of motion to audio-visual parameters does this control become instinctive and intuitive for the performer.

Finally, much of *OPK* requires considerably physical exertion to achieve an effect. For example, some control changes are spread out of over longish distances (5-6m), therefore requiring me to make a physical effort to change the audio-visual parameters with a degree of coherence.

Conclusion

The different factors described above promote the 'liveness' of *OPK*, and are an effort to humanise both immersive interactive media and audio-visual performance. The technique of synesthetic mapping between audio, visual and movement domains allows for the intricate performance of an immersive environment by one individual performer. While we might instinctively presume that controlling two mediums with a third (movement) might be more difficult than controlling one, with thoughtful and careful mapping of movement to sound and visual result, the multi-modal performance is actually simpler for the performer and more rewarding for the audience. Similarly, the audience perception that the piece is open to performer variation, error and physical exhaustion re-humanizes digital audio-visual performance, creating a more genuinely live experience via the displacement of the body in 3D space.

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Documentation

Video documentation of *OPK* can be viewed at https://vimeo.com/228634638. A full performance of one piece from *OPK* can be viewed at https://vimeo.com/228541508

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