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ARTICLE

Digital interactions: Sound and three-dimensional forms

Eleni-Ira Panourgia, [a] Finbar Wheelaghan [b] and Xue Yang [c]

This article discusses a prototype that explores the simultaneous manipulation of three-dimensional digital forms and sound. Our multi-media study examines the aesthetic affordances of tight parameter couplings between digital three-dimensional objects and sound objects based on notions of process and user-machine interaction. It investigates how effective cohesion between visual, spatial and sonic might be established through changes perceived in parallel; what Michel Chion refers to as 'synchresis'. Drawing from Mike Blow's work On the Simultaneous Perception of Sound and Three-Dimensional Objects and processual art, this prototype uses computer technology for forming and mediating a creative practice involving 3D animation, sound synthesis, digital signal processing and programming. Our practice-based approach entails the rendering of a three-dimensional digital object in Processing whose form changes over time according to specific actions. Spatial data is sent via Open Sound Control (OSC) to Max MSP in real time, where sound is synthesised and then manipulated. Sonic parameters such as amplitude, spectral density/width and timbre are controlled by select spatial parameters from the three-dimensional object. Sound processing is realised based on the changing of the three-dimensional object in time through basic actions such as splitting, distorting, cutting, shattering and rotating. We use digital technology to look beyond basic synchronisation of sound and vision to a more complex cohesion of percepts, based on changes to myriad sonic and visual parameters experienced concurrently.

Keywords: synchresis; interactivity; cross-modality; sound synthesis; 3D animation

Introduction

This research is based on a prototype designed in the Digital Media Studio Project Masters course 'Developing Multidimensional Objects' supervised by Eleni-Ira Panourgia at Edinburgh College of Art. The focus of the course was on the development of multidimensional objects mainly by combining digital media that involve visual/spatial dimensions and sound. The aim of this ongoing research project is to explore coherent ways for the simultaneous manipulation of three-dimensional digital objects and sound and to explore how objects that combine such modalities are perceived. Having a three-dimensional object inform the character of a given sound might result in two perceptual objects, which may seem disconnected to the observer. Instead, we are striving to form and maintain a cohesion between sonic and visual as changes in each are experienced at the same time.

Crossing such modalities allows for working in environments that provide more sensory and perceptual possibilities for the making of works of art (Blow 2014). This also creates important challenges concerning the modalities themselves, as well as on how they can be simultaneously perceived. We have developed a hybrid creative tool that brings together visual, spatial and sound material. The centre of our approach is on exploring new creative processes and "perceptual relations", as it is discussed by Mike Blow (2014, 6). We are focused on material

[a] *Eleni-Ira Panourgia, PhD candidate and tutor at Edinburgh College of Art, University of Edinburgh, and scholar of the Onassis Foundation, e.panourgia@ed.ac.uk*
[b] *Finbar Wheelaghan, Postgraduate student at Edinburgh College of Art, University of Edinburgh, and scholar of the Carnegie Trust, finbar.wheelaghan@gmail.com*
[c] *Xue Yang, Postgraduate student at Edinburgh College of Art, University of Edinburgh, 609338225@qq.com*

manipulation from a digital yet action-based approach that strongly exists in the work of the sculptors Oscar Wiggli and Richard Serra. We are interested in actions and the way they inform processes of making as they bring changes to the material, which in their turn introduce a temporal characteristic to the three-dimensional objects.

Background

The background of this study draws on the one hand from theories of synchresis and perception and on the other hand, from creative practices and theories of process and processual art, as well as works that combine visual, spatial and sonic, including 3D animation, sound synthesis and digital signal processing.

Synchresis and perception

Michel Chion introduces synchresis as “the spontaneous and irresistible weld produced between a particular auditory phenomenon and visual phenomenon when they occur at the same time. This join results independently of any rational logic” (Chion 1994, 18). In his definition Chion mentions that synchresis it is a “forged” word that comes from the combination of synchronism and synthesis. He further states that synchresis exists as a result of congruent sonic and visual movements, which binds their forms together (Chion 1994). Synchresis may be perceived via a sequence of discrete events, such as the coincidental blinking of image and sound, or through a continuous event, where changes are perceived on a continuum. Mike Blow relates the act of perceptual bonding by pattern recognition to Gestalt principles of proximity, which infer that we automatically seek out a formal congruency between sonic and visual; it is this which results in a cohesion of percepts (Blow 2014).

Through the temporal alignment of changes to forms that we see and hear we associate the location of the combined object with its visual component; we consider the sound to have emitted from the image we see, which may be on-screen, even if the sound in fact came from a loudspeaker on the other side of the room. Charles Spence documents perceptual crossovers between visual and sonic and argues that the basis for some, such as connecting pitch and amplitude with size, may be the result of the natural resonant properties of materials (Spence, 2011).

Following this, causality is embedded in the phenomenon of synchresis and is at the center of the perceptual bonding we are concerned with. It is restrictive, as to break free of this causal link is to lose what Chion terms “added value” (Chion 1994, 5). In his own definition, Chion describes this value as the enhancement that sound can offer in a visual experience so that “expression ‘naturally’ comes from what is seen, and is already contained in the image itself” (Chion 1994, 5). Blow reconsiders Chion’s “added value” as “the space between” the senses resulting from their “interaction” (Blow 2014, 7). We are interested in exploring the limits of this link as “a temporal cross-modal reinforcer” (Blow 2014, 54).

It is the necessity of change over time which makes synchresis an essentially temporal phenomenon. Blow draws attention to the term “weld” that Chion uses in his synchresis definition for “creating a single, new, combined perceptual event” (Blow 2014, 54). Blow considers how a sound could reinforce or change the characteristics of an object, means for the cohesive use of sounds and objects within a single work of art, and the cognitive results that are derived from such outcomes. He thus reconsiders the notion of synchresis from a three-dimensional point of view, an approach that is central in our research and upon which we seek to expand. In this case, space combines with time to form more complex perceptual relationships. For example, a blinking dot on a screen which remains static in space does not provide us with the same scope for interesting sound-visual couplings as if the dot were perceived to also be moving through two-dimensional or three-dimensional space. Our prototype features three-dimensional digital objects as the addition of depth provides a greater range of spatial-to-sound relationships to exploit.

Three-dimensional objects and sound

The combination of three-dimensional objects and sound in this project was approached from a process and action-based perspective. This entailed not only the mapping of parameters of the one modality to the other, but also the use of similar methods for working with both together. Mike Blow's work *Bleigiessen* focuses on the actions applied to a solid material and the sounds produced during the making. Based on Richard Serra's works *Splashing* and *Verb List*, Blow "traces" movement and time of the changes applied to the solid material through sound (Blow 2014, 26). Another important example is the work of Oscar Wiggli, who considers his sculptures and sound compositions together and uses similar making process in both forms. In this way, Wiggli's creative process in sculpture also exists in his sound compositions (Bosquet et al. 1995). Working with such a "parallelism" of visual, spatial and sound materials, Oscar Wiggli places both three-dimensional objects and music in "ephemeral space" (Kunstmuseum Bern 2007, under "Body – Space – Sound").

Such ephemerality is present in the digital works of Davide Quayola and Candas Sisman, which involve 3D design and sound. Sisman focuses on producing work that combines different modalities across sound, visuals and space, and also on the way such hybrid forms are perceived. Sisman's work *NOISEFLOOR*, which he also refers to as "Data Sculpture", concerns a three-dimensional digital form that was developed based on the sound's frequency and duration (Kaplangi 2014). This three-dimensional object is then used as the point of departure for further designing sound and animation. Quayola's *time-based sculptures* are in a dialogue with sound mainly depending on their manner of unfolding in virtual space (Quayola n.d.). He develops systems for manipulating his material based on algorithms, which he characterises as "…a synthesizer that I calibrate in order to achieve what I consider to be the 'richest" image'" (Shipwright 2016). Works such as *Flexure*, combine form, texture and sound with actions such as twisting and contorting. In this way, Quayola works with digital gestures across visuals and sound, which we seek to reconsider from a process-based point of view. Both examples bring aspects of solid material objects to digital objects in relation to sound and movement, which informs the way we are approaching parameter coupling and aesthetic decisions.

Process

The movements that occur in our objects happen as a result of specific actions, which create simultaneous changes to the form of the shape and sound. When referring to such changes we are interested in the notion of process as a creative practice. We are looking at changes which occur as a result of actions applied to the objects. An important example of such actions is Richard Serra's *Verb List Compilation: Actions to Relate to Oneself.* This list includes the infinitives of verbs and possible contexts for the manipulation of materials (McShine and Cooke 2007; Friedman 2011). According to Serra, the *Verb List* can function "as a way of applying various activities to unspecified materials" for working on pieces in relation to the verbs "physically in a space" (Serra 2013). The *Verb List*'s focus on actions and processes influenced our approach on the action-based manipulation of our material as well as from a conceptual point of view. Using verbs that indicate how material is being worked, we are looking at applying these actions in both visual/spatial and sonic modalities. The difference here is that the actions are applied through digital means and not with physical manipulation.

Ursula Damm mentions that the main aspects of both process and processual art are "the action, the activity and the performance" (Damm 2017). According to Damm, processual art differs in the introduction of such actions in systems whose operation can happen in various levels of autonomy. In our project the actions are being processed in a system programmed by the artist. The process is then controlled by the system, which releases our artistic intention to the world. We can observe similarities between the concept of process and the term *procedural* as it is applied in the digital design and computing communities, particularly in videogame design. Andy Farnell defines procedural audio as "sound qua process, as opposed to sound qua product" (Farnell 2007, 1). He further states that "procedural audio is non-linear, often synthetic sound, created in real time according to a set of programmatic rules and live input" (Farnell 2007, 1).

In the case of this study, rather than representing processes with sounds which are pre-rendered as audio recordings and simply triggered to coincide with an action such as a tearing action with a tearing sound effect, we are binding the parameters of sonic objects to spatial parameters and modifying those objects in real-time through digital signal processes. Combining the above mentioned aspects of process art, processual art and procedural audio, we aim to interpret these processes sonically.

Verbs that are used to describe each process tend to pertain inherently to visual space rather than sound. For instance, we understand how to rotate a visual object with little need for interpretation. However, when applying these verbs to sound they become metaphorical. How do we rotate a sound? A sound designer's interpretation is likely to be different to that of a composer or even from another sound designer. This makes our approach different to that of Richard Serra, whose interpretation of processes is direct and primarily concerned with the material and visual domain. Our chosen couplings are derived therefore partly from personal preference. Other interpretations draw on acoustic phenomena relating to the reflective properties and behaviors of objects and spaces, which adheres to Spence's consistent cross-modal correspondences. Some focus on connections established through media practices such as animation, while some others explore more oblique mappings of spatial to sonic. Our objective is to use digital technology to establish ways in which to experiment with these couplings and processes.

Digital design

We have designed a digital three-dimensional object and mapped select spatial parameters from said object to sonic parameters of a synthesised sound, so that as processes are applied to the visual object in real time, a relative action is applied to the sound. This results in simultaneous changes over time and a fusion in their perceived forms. The primary cross-modal couplings we explored for this study were: width and length with spectral range; width and length with loop/grain length; spatial volume with amplitude; three-dimensional object rotation with audio phase; rotation with grain position and multiplicity with polyphony.

In terms of developing the digital three-dimensional objects and transforming them into particular shapes, Processing was used along with the PeasyCam library so as to drag and view the objects from any angle (Feinberg 2013). Interaction with the objects was achieved with the computer's mouse. The study employs Max MSP as its sound design platform, interfaced with Processing in real time via Open Sound Control (OSC). Max MSP provides a workspace of elementary synthesis tools which allowed us to create and map multiple highly nuanced, customisable parameter couplings and to control their curves and severity. Our prototypes explore two methods of synthesis, granular and subtractive. These methods are manipulated alongside a three-dimensional model via processes of reshaping, rotating, splitting and distorting. Experiments have been performed at the audio stage, with a variety of sound parameters linked with a base set of visual parameters.

Prototypes

Prototype 1 explores mappings of a three-dimensional cube with sonic parameters of a sustained tone generated via two pulse-wave oscillators[1]. The cube is rotated upon horizontal movement of a mouse. As the cube rotates the

[1] https://www.youtube.com/watch?v=2L-q4-HLu3o

oscillators are detuned, creating a shift in phase and a perceivable rotation in the sound. More specifically, it generates complex, minute sonic movements, which amount more to a shifting in texture than a complete change in form. As the rotation of the object stops, the oscillators revert to their original frequencies and a *freezing* of both visual and sonic objects can be perceived. Acceleration is considered so that the faster the rotation, the more severe the detuning of the oscillators, creating a tight connection between user interaction and perception of three-dimensional rotation and sonic movement.

Spatial width or narrowness of the cube, which is controlled using vertical mouse movement, is coupled with spectral width of the tone; as the shape becomes thinner a high pass filter is applied to sound. Here we observe some parity between the application of these adjectives in the context of both modalities. The words *thinness* and *width* are often applied to describe both audio spectra and physical three-dimensional objects. Just as Spence posits that certain cross-modal correspondences exist as a result of real-world acoustic behaviors, for example the correlation between object size and pitch and spectral range (Spence 2012), we might explain the quality of this coupling as such. The phase to rotation pairing in this prototype illustrates movement in sound at a micro or textural level.

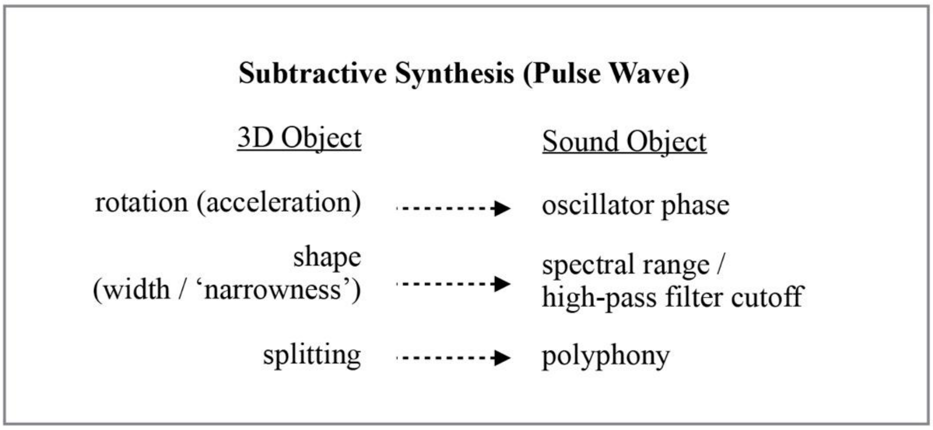

Figure 1: Parameter mappings of Prototype 1
Source: generated by the authors

Prototype 2 explores the same three-dimensional shape and actions as prototype 1, manipulated instead alongside a granular synthesiser applied to a vocal recording[2]. Here we observe an oblique mapping of percepts in the form of a link between grain length and object length. This coupling explores the forging of a temporal to spatial relationship; as we perceive the grain or audio loop becoming smaller in time we perceive the three-dimensional object narrowing. We track the sound's repetition and perceive around it a form, which develops as the grain size reduces. We simultaneously connect this with the form we observe as the three-dimensional shape narrows in space. Prototype 2 also exhibits a further example of a coupling informed by real-world acoustic behavior, where a low pass filter is applied to the audio signal in parallel with rotation, to create an occlusion effect. Every half rotation of the shape results in a top-down linear diminution in spectral range, a phenomenon we might expect to experience if the sound was emitting from two opposing faces of the cuboid. It is interesting to note that, alternatively, if the direction is reversed and a high-pass filter sweep is used, we still perceive sound and visual

[2] https://www.youtube.com/watch?v=l-USCpCCyRo

objects as one, instinctively forging the undulating form in the sound with the form created by the perceived depth of the object as it swings past our point of view.

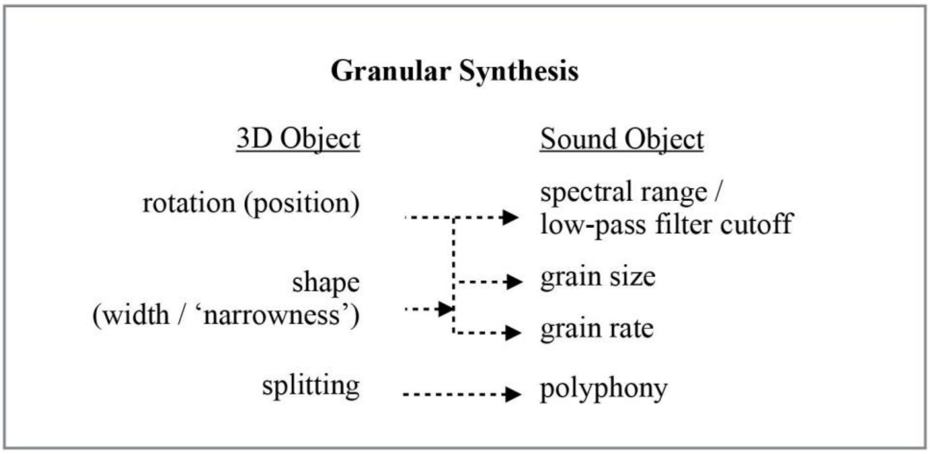

Figure 2: Parameter mappings of Prototype 2
Source: generated by the authors

Both prototypes exhibit a uniform interpretation of the action of splitting, translating it to polyphony, where frequencies above the main frequency are chosen arbitrarily and new voices instantiated upon the click of the mouse. This approach is unsatisfactory as it comes from a traditionally musical interpretation of multiplicity. The process is also discreet, as the action occurs instantaneously. An animation of the split appearing from nowhere and widening gradually, with the severity and speed of the split controlled by user input, might have resulted in a more interesting study of this particular action. This will be revised in future iterations.

The action of distorting was explored in a further prototype[3] in which an object is transformed from one basic shape into another, specifically, a sphere into a cube. We observe in the sound object a detuning of tones in tandem with the visual transformation. The cube eventually separates into component planes, at which point we observe a complete opening of a low-pass filter. This, as a result, gives the impression that the sound originates from inside the cube.

In some cases, direct, linear relationships between spatial and sonic parameters were found to be less congruent than curved relationships, in the examination of perceptual interplay and synchresis. Bonds which relate to real-world acoustic phenomena seem primed to result in synchresis. These bonds, which we have explored by redrawing curves or by inverting shapes and forms also prove to be robust. Works like Quayola's and Sinigaglia's *Flexure* challenge this robustness, juxtaposing mismatched sonic and visual objects in semi-sync, while exhibiting and exploiting synchresis. Our work isolates and scrutinises this phenomenon, testing its limits further in myriad directions across studies, such as the connection of temporal and spatial domains of repetition and looping with shape and size. Processes drawing from the manipulation of three-dimensional objects are integrated through this study into sonic thinking. In terms of processuality, actions are transferred to the design of the prototypes through parameter mapping, while the output depends not only on the mapping itself but also on the input of the user.

[3] https://www.youtube.com/watch?v=jWOx9kcFfMg

Conclusion and further development

Over the course of this study we have developed methods for sonic and spatial parameter coupling. Our prototypes explored the simultaneous combination of three-dimensional objects and sound in several ways, while maintaining congruency between percepts and achieving added value. To create a constantly evolving multi-sensory experience, these prototypes spoke for concurrent transformation of three-dimensional forms through listening. This work achieved an action-based digital approach that allowed precise and direct mapping of parameters of the transformation of both modalities. It went beyond sonic-to-spatial translations such as in Sisman's work *NOISEFLOOR*, by introducing a method of digital sound manipulation through a succession of actions that formed processes, which allowed to shape this material and expand their possibilities both visually and sonically.

Challenges faced by this exploration were present primarily in the interfacing of technologies, specifically the mapping of spatial to sonic parameters across platforms. This required the isolation of visual characteristics as variables in Processing, to then be passed on to Max/MSP, which we achieved with mixed success. Limited access to aesthetic parameters embedded in geometric functions meant that couplings from some of the more complex actions, such as distorting, produced less nuanced relationships between parameters, while also limiting user interactivity and the visual design. With the ability to isolate more 3D parameters as variables, we would be able to generate more dynamic shape-to-sound relationships and expand this exploration toward more complex structures.

Further development of the study will extend parameter mappings to design features such as colour, focus, texture, translucency and overlay, as well as sonic parameters such as spatialisation, multichannel mixing, wave-shaping and frequency modulation. Future work may also experiment with additional actions, such as shattering, rolling, stretching and tearing, and look at how this work could function in alternative setups such as in installation or performance environments. Finally, the study's focus on process might be expanded by incorporating new forms of user-machine interaction, with the use of sensors. All of the above may lead to a deeper understanding of the research question.

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