# Mutator VR Exhibitions: Procedural Organic Art Evolves to Virtual Reality


## <> Abstract

*Organic Art*, first developed at IBM in the late eighties, evolved into *Mutator VR* from 2013 to 2019. We describe the graphics and audio systems, particularly procedural generation and visual effects, and their creative exploitation by artist William Latham in the art installation Mutator VR. The mix of “real” and “unreal” visual features and effects, inspired by Surrealist art, creates a highly immersive psychedelic organic experience.  The procedural approach contrasts with content-based approaches commonly used by VR artists. Interface simplicity and discoverability is critical for VR exhibitions;  as is the balance between tightly "artistic" curated user experience and freer (but riskier) user control.  Gallery installation of  Mutator VR creates special challenges.


## <1> Introduction and Background

This paper discusses exhibitions of *Organic Mutator* from 2013 to 2018. The exhibitions continue from earlier Evolutionary Art work at the IBM UK Scientific Centre in the late 1980s and early 1990s by the same artists [1]. The artistic style is based on the older works, but uses advances in technology to permit real-time interactive exhibitions in virtual reality (VR). The main topic of the paper is the creative work needed to exploit new capabilities and the challenges we faced.

### <1.1> Related Works

We use an interactive, generative approach to create “non-figurative” abstract worlds, in contrast to many contemporary VR artists using game engines such as Unreal to create figurative content, as in Paul McCarthy’s *Coach Stage Stage Coach* and Christian Lemmerz’s hanging golden Christ figure in *La Apparizione* [2]. The early computer art of Herbert Franke, Harold Cohen and other algorithmic artists from the 60s and 70s [3] influenced the procedural approach. The work shows strong surrealist influence [4] through  creative use of chance; with rich texturing, dramatic lighting and cast shadowing of objects. Nineties rave culture also influenced with psychedelic imagery, including William Latham's visuals for UK rave bands including The Shamen [5].

## <1.2> Summary of Earlier History

Two of the authors met at IBM UKSC in 1987 for artistic exploitation of scientific visualization software [6]. The FormGrow grammar, inspired by nature but generated by mathematical rules [7], was augmented with mutation for the subjective exploration of form space [8] and keyframe animation for video generation [9]. These early exhibitions involved large computer generated prints and videos [10]. The rendering times during that period were significant at half an hour per frame on an IBM mainframe and made interactive exhibitions infeasible.

## <1.3> Outline of Article

A new Mutator project started in 2013 (Figure 1). It preserves the essence of the old software but exploits modern hardware to permit real-time interaction and generation of 90fps stereo VR. This paper describes how our exhibitions evolved and the challenges involved in moving to each main phase:

- touch screen mutation,
- body interaction with Kinect,
- VR

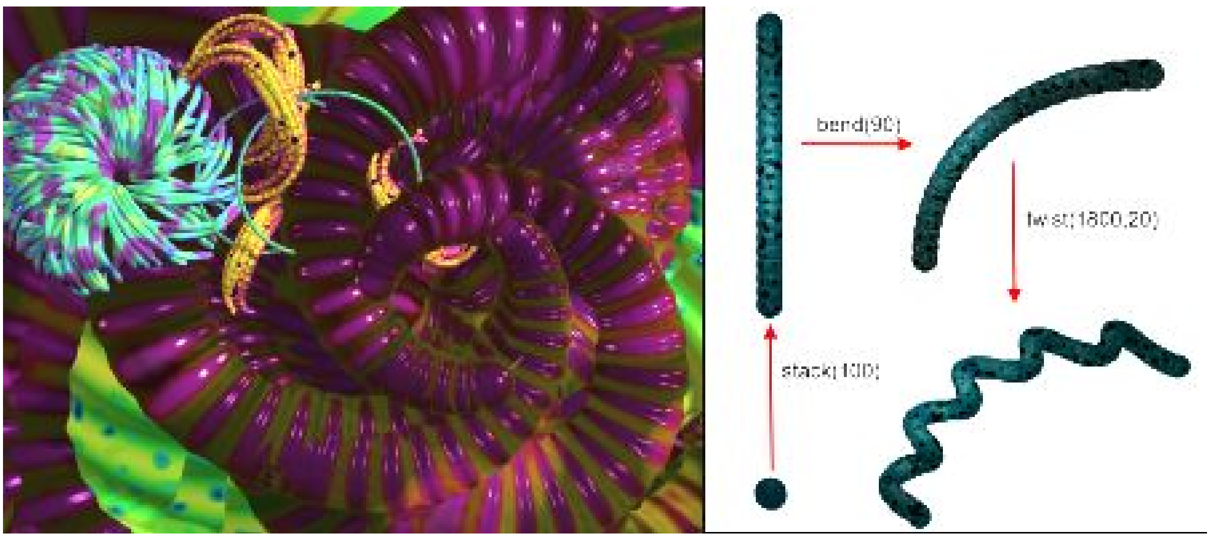


Figure 1. Image of new work (left) and primitive FormGrow construction methods (right).

The paper contains three major sections. The first presents an artistic view discussing the balances between reality and unreality, the second covers the differences between curated and freer experiences and summarizes the system capabilities, the third covers the gallery experience, highlighting the VR aspects. The procedural nature of the system, pervades all these sections. The paper ends with a summary and pointers to future work.

## <2> Artistic Considerations

The artist's aims to create an immediate immersive experience for users entering a surreal space operating under unreal rules; users quickly realise that their actions directly impact what happens in that space. Once immersed the user should gain a sense of wonder, interacting with the dynamic 3D organic forms surrounding them. These forms are deliberately reminiscent of natural forms such as ancient fossils, orchids, skeletons and strange animal horns but are ambiguous and open to the users own interpretation. As the user spends more time in the experience, it is then hoped the user will experience occasional moments of unexpected visual beauty as their organic world unravels around them under their direct influence. The experience must work within a consistent artistic framework for many different visitors.

The section is in four parts: the artistic balance between reality and unreality; the balance between artist curated and public interaction; catering for different users; and the gallery environment outside the interactive system itself.

### <2.1> Real/Unreal

Reality mixed with unreality provides the surreal artistic experience; forms appear simultaneously natural and unnatural. This applies to our still images in the 1990s, and is especially important in VR which hugely increases the sense of immersion. Too real an experience is artistically boring, too unreal an experience leaves users uninterested and disoriented. Successfully mixing real and unreal elements in the same scene has been used previously in the surrealist paintings of Dali, Magritte and Max Ernst showing for example unreal floating objects lit with real lighting casting perfect shadows of those floating objects. Table 1 shows our balance used in Mutator VR.

<2.2> Artist Curation Versus Public Freedom

Artist-curated experiences provide relatively limited but guaranteed interesting user experiences. Freer user interaction gives more variety with greater risk of missing the best experiences. Traditional gallery experiences of still pictures and video exhibits are naturally fully curated.

In our exhibitions, the artist and and software designers curate the basic 3D form structures with associated ‘genes”, which determine for example the number of branches or the amount of twist. The procedural nature of our system allows varied levels of curation via ‘per gene limits’ which constrain animation and the rate of mutation of the form structure. Closer limits give less variety but more artistic curation; for example the artist may freeze many of the genes to prevent any change. We curate some limits separately for VR; for example setting narrower limits to prevent bad high frequency textures.  Curation also provides interaction mappings: relating controller buttons and movements to changes in the experience.

An easily accessible 'piste' of forms and effects provides a curated experience. A fuller UI gives user more control, including random mutation and animation trajectories, and forms transformed by user movements. Users like that what they are seeing has never been seen before.

<2.3> Different Users

Central to any experience is speed of change. Some users like stillness to savour the visual richness; others fast moving video game effects. Some users are novices, others experienced gamers.  Direct user interaction provides a variety of speeds in a natural way.

Even if the user does not follow interface details we avoid confusion by ensuring (a) each interaction has discoverable consequences and (b) as far as possible there is a natural (kinaesthetic) correspondence between cause and effect (Figure 8(b)). This is important in any user interface, more so in VR, still more when most users only have a few minutes experience.

<2.4> Full Gallery Environment

Our Mutator exhibitions used a projected view of the live form; we now use the largest feasible live view, at SHOOM 30 the live view projected onto the floor below the user.

For added impact the exhibition space includes related stills and videos, 3m high hung translucent curtains, and decorated walls and floor to the VR space (Figure 2).

Figure 2. Gallery environment of Mutator VR shows in Venice and Norwich, UK.

There are commonly gaps in an exhibition with no VR interaction; here, the system uses automated piste-based change for a good live view.

### <2.5> Evaluation

Users expressions during the experience and comments after ('weird' is the commonest) are our best guide to success. We have no formal evaluations, but have collected short questionnaires where practical. Table 2 summarises 100 surveys of the 2,500 visitors to our Norwich exhibition.

In the future, we will instrument the system to collect more details such as how long users spend within each experience and how rapidly they interact.

## <3> The System

The system uses the GPU for all geometry and graphics; mid-range (Nvidia 770) for interactive exhibitions and high-end (Nvidia 1080, HTC Vive) for VR. The browser based software uses JavaScript, WebGL, three.js and WebVR.

This section summarises software features. Subsection one describes the form and audio grammars and supporting graphical features. Subsection two discusses movement and users' interactive capabilities.

### <3.1> Procedural Models

This subsection summarises the underlying *Organic Mutator* form and audio generation models, and the graphical rendering environment.

The *Organic Mutator* form generation model is inspired by nature, especially twisting animal horns in London's Natural History Museum. It gives almost real structures but does not mimic nature, creating a tension between real natural and unreal geometric forms. Random elements in the shape move the balance towards reality; we favour a non-random unreal look. The concepts are close to those of L-Systems [11] and derive from FormSynth hand-drawn evolution [12].

The horn structure generates forms using simple geometric and trigonometric formulae with artist friendly names such as bend, twist and stack (Figure 1), composed into nested horns of horns (Figure 3).

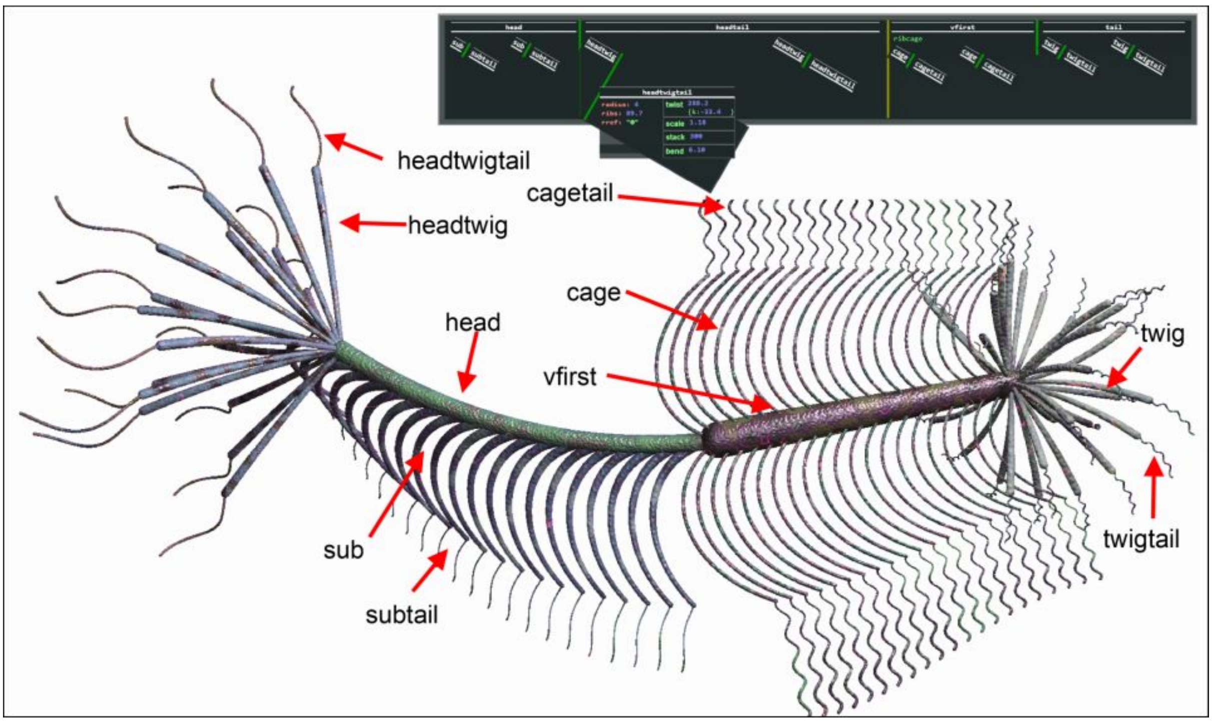


Figure 3. Complete horn structure showing parts, with structure schematic.

Original details of the horn structure are described elsewhere [13] with recent extensions discussed in the VR section.

FormGrow structures contain parameters (*genes*) describing the degree of each bend, twist, etc. Changing genes reshape the form; the underlying structure is unchanged but the external form is very different. Genes underpin the entire procedural system; form, colours, textures and audio structures. Control or freedom of these genes provides levels of curation of the experience.

Audio is rendered by the SuperCollider synthesis server [14]. Primitive synthesizer modules such as comb filters and oscillators provide sound generation and manipulation. As with FormGrow, these combine into higher level structures for audio processing, routing and spatialisation, with parameters controlled by genes. Correlating audio and graphical genes relates sound to vision. Hybrid physical modelling and subtractive synthesis combined with field recordings gives an unnatural but almost organic sound, forming a gradually evolving ambience with elements of the real and unreal.

The forms have surface attributes [15]. A 3D noise texture [16] sampled at the surface defines colour bands, which may be sharply separated or smoothly merged. Each band has genes to describe RGB, gloss, reflectivity and other features of a conventional lighting model. Another 3D texture seeds bump mapping. Iridescence and fluorescent bands enhance graphical richness. The surreal style derives from 'real' lighting combined with 'unreal' textures

Organic 3D forms in a void are effective with still images [17]; a surrounding room helps an interactive or VR environment. The walls use the same rendering model as the form.

Feedback gives low cost graphical richness; for example [18] creates a wide variety of patterns using only feedback. Extensive feedback enhances the *Organic Mutator* environment. Feedback strength varies over the surface, giving interesting interactions between feedback and texturing (Figure 4). Bump mapping feedback normals distorts the effect, and iridescence richens color variation. Superficially, feedback emulates real reflection, with lower performance hit.

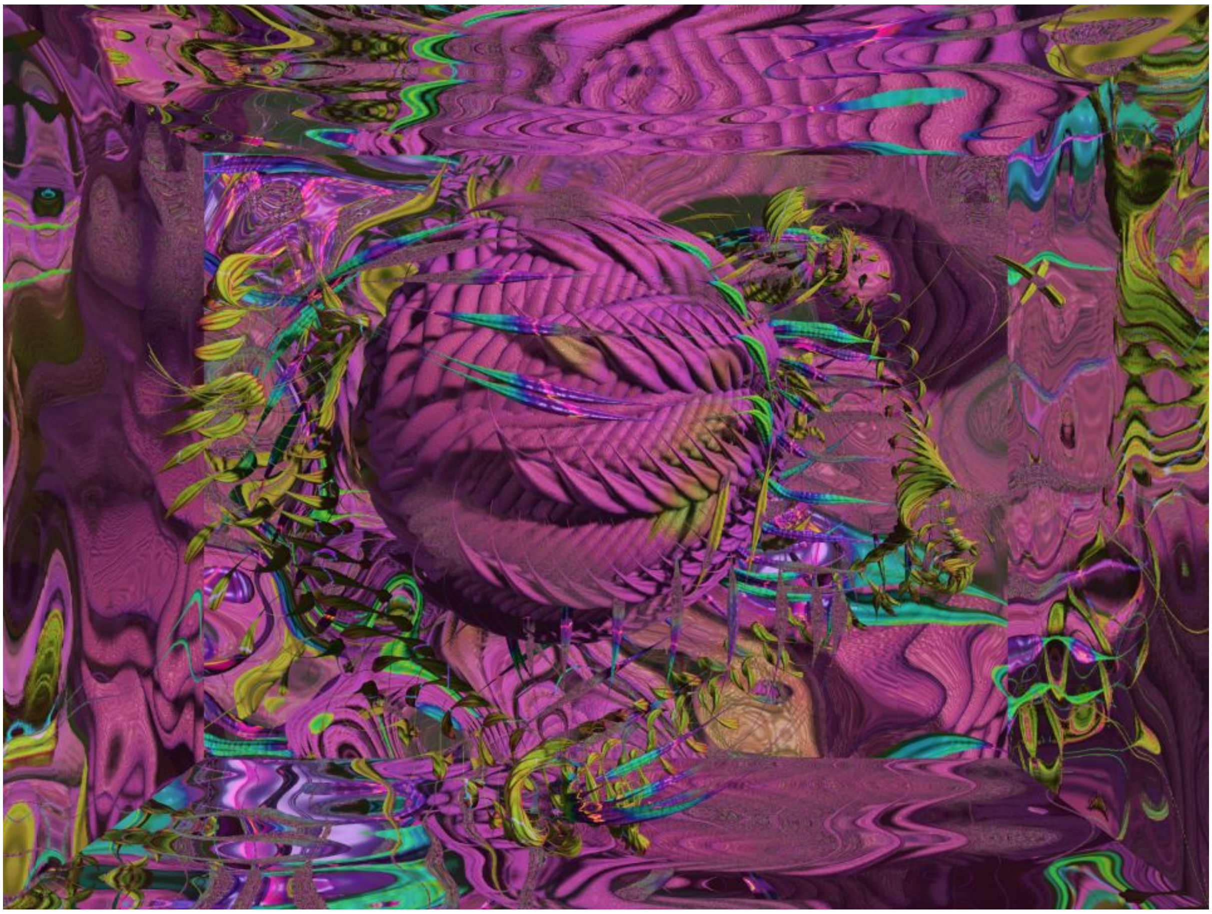

Figure 4. Feedback with distortions.

<3.2> Movement, Change and Interaction

Most movement derives procedurally from changing genes, with some intrinsically time-related features (audio LFOs, pulse). There are several drivers of gene change:

- Continuous animation through keyframes (for video generation) or other trajectories (for continuous animation)
- Direct user interactions such as full body (Kinect) or controller (Vive) movements
- Mutation to a new form.

Our first interactive exhibitions in 2013 used Mutator software on touch screens. The 'live' image from the large Mutator pane was continuously animated and projected floor to ceiling for  non-interactive visitors (Figure 5), with use controlled rotation and animation speed.

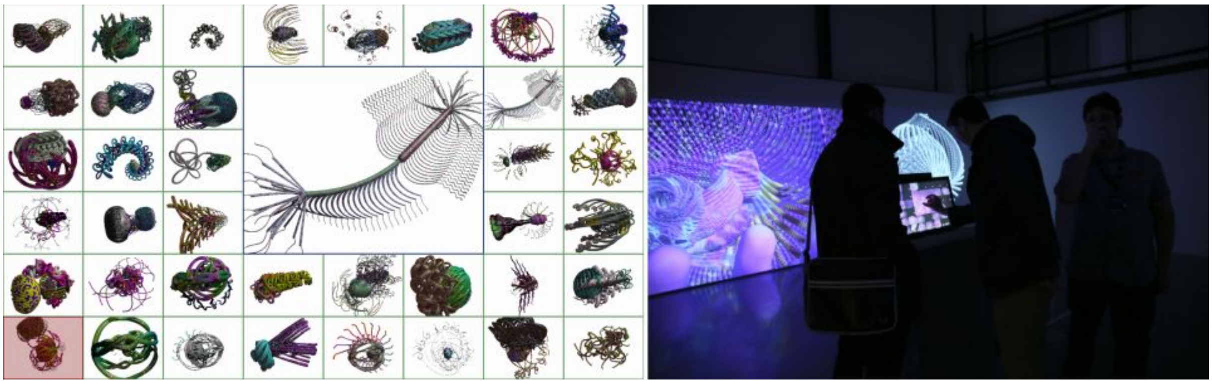

Figure 5. Mutation interface (left), touch screen user with projected image (right).

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We later used Kinect for direct user interaction over form genes. One person controlling mutation and another person interacting by body movement enabled a shared collaborative and creative experience.

Table 3 shows interaction and technology features used in our exhibitions. We tried to grow the experience for each new exhibition.

Audio follows the same pattern of change, from slow and gradual evolution to sharp rhythmic articulation. Complexity emerges from interactions with the user, the graphics, and between separate parts of the audio system.

## <4> Virtual Reality

The technical move to VR is straightforward given suitable hardware and software (for us: HTC Vive, WebVR). However, the sense of immersion makes a substantial impact on the user's experience, forcing significant changes to their style of interaction. This section discusses features to exploit and enhance the VR experience, including social and environmental presence [19]; and model and interaction changes introduced for VR.

### <4.1> VR Model Features

It is natural to wander close to the form in VR (Figure 6(a)). Going too close makes the viewer cross-eyed, and going through the object surface destroys the illusion of reality. A spherical *cutter* feature overcomes this; reducing horn radius around the cutter. The cutter centre has strongest reduction; horn regions are completely removed. A cutter on the headset clears the form ahead of the user resolves these issues. Another cutter on a controller allows the user to sculpt forms, revealing internal structure (Figure 6(b)).

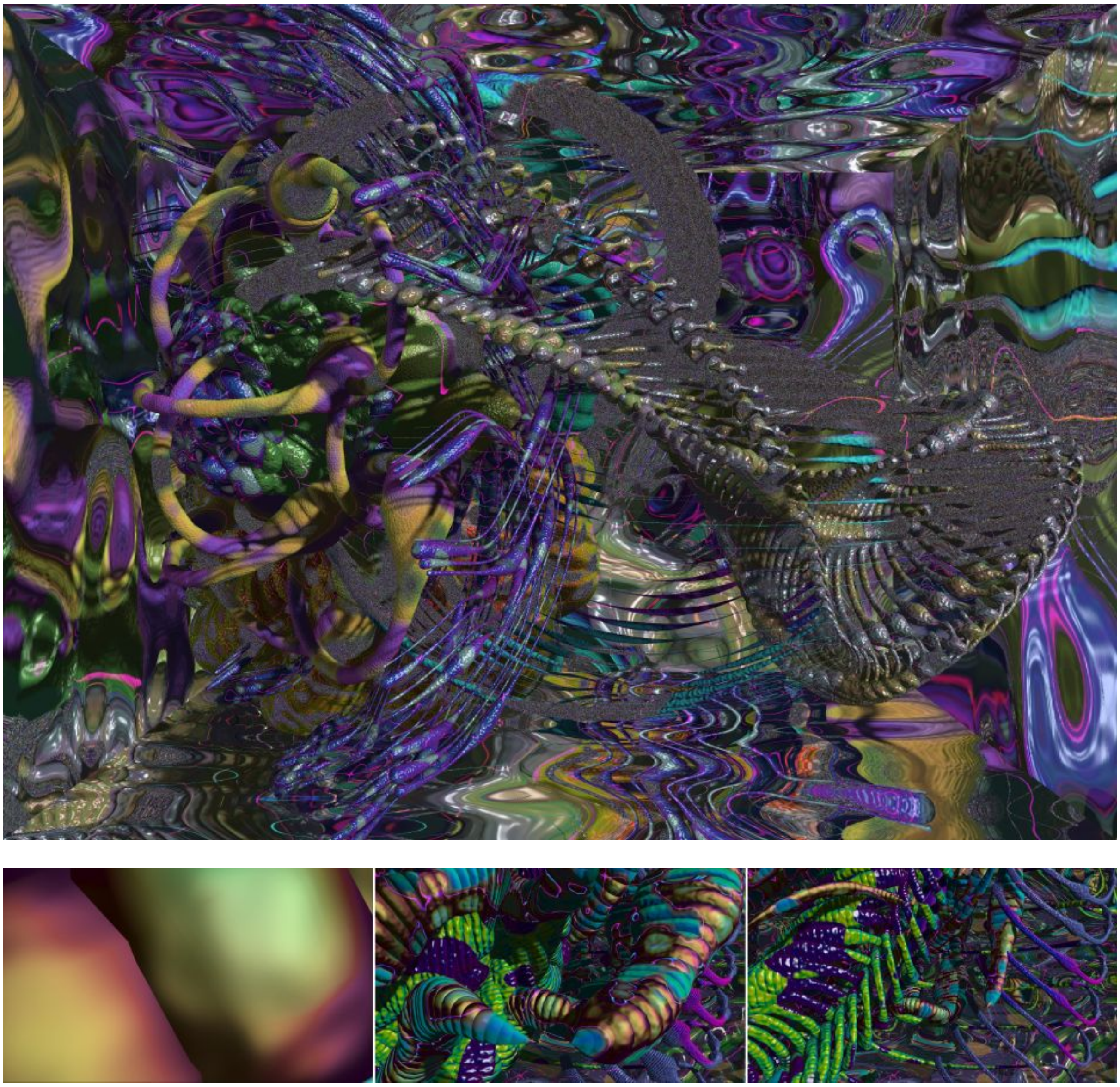

Figure 6. (above) Close to the form. (below) Too near form in VR (left), head cutter clears space around viewer's head (centre), hand-held cutter reveals more detail (right).

Limited continuous animation on wall and audio parameters provides variety without destroying the form. Direct controller user interaction modifies geometry, lights etc. Mutation is triggered by controller click. Outside VR we use a fixed (BBC) set of lights; headset and controller torches increase VR immersion.

*Pulse* and *breath* add life to the form. Pulse modifies the radius along the horn with time; progressively moving along the main horn and into subhorns. Breath distorts the form by expanding the central region outwards with time (modulating y and z by x).

VR gives a feel of scale missing from other computer graphics. We exploit this by fairly quick changes of scale (Alice effect [20]) from standard 6 $m^3$ room to 60 $m^3$ room to a 1 $m^3$ box trapping the user's head. The box effect needs a 'quick out'; some users find it disturbing. We even found a 3$m^3$ standard room matching Vive capabilities too claustrophobic.
Complex feedback makes form and background merge, so making 2d images confusing. Full 3D and motion in VR helps the brain interpret feedback. The room environment was initially rectangular; distorting it according to a superegg shape adds variety (Figure 7). Feedback is so effective visitors sometimes study wall patterns almost ignoring the form.

Figure 7. Room distortion from rectangle to superegg. The profile is not seen in VR itself.

Seeding feedback from the previous frame in VR makes head movement create nauseous image movement on the wall, and leaves uninteresting feedback looking away from the form. We seed feedback in VR with an extra view from a relatively fixed camera.
Sound is spatialized and related to the form in VR, particularly in the correspondence of the relative size of the entity to overall pitch.

<4.2> Interaction in VR

Simplicity and discoverability are critical for interactive software in the exhibition environment, where many users have only a few minutes of interactive experience. This is especially so in VR, where invigilators cannot easily communicate with and help users. A companion work (*Mutator VR: Vortex* [21]) was conceived for VR with very simple interface.
Our VR exhibitions use an HTC Vive with two controllers. Figure 8(a) shows how controllers' buttons trigger various experiences. In our first VR exhibition it was difficult to explain the buttons and get the correct controller in the correct hand. This confused users and limited the experience. We now use a *piste* of predefined effects assigned to the triggers with

mainly randomly selected features available on other controller buttons. It allows a wide experience with almost no training, but permits experimentation by experienced users; piste trigger clicks quickly turn 'bad' scenes into good ones.

Figure 8(b) shows an intuitive and discoverable mapping of body positions to genes. Genes for most of the form are controlled by arm movement, genes for the tails by red controller rotation; green controller rotation rotates the form.

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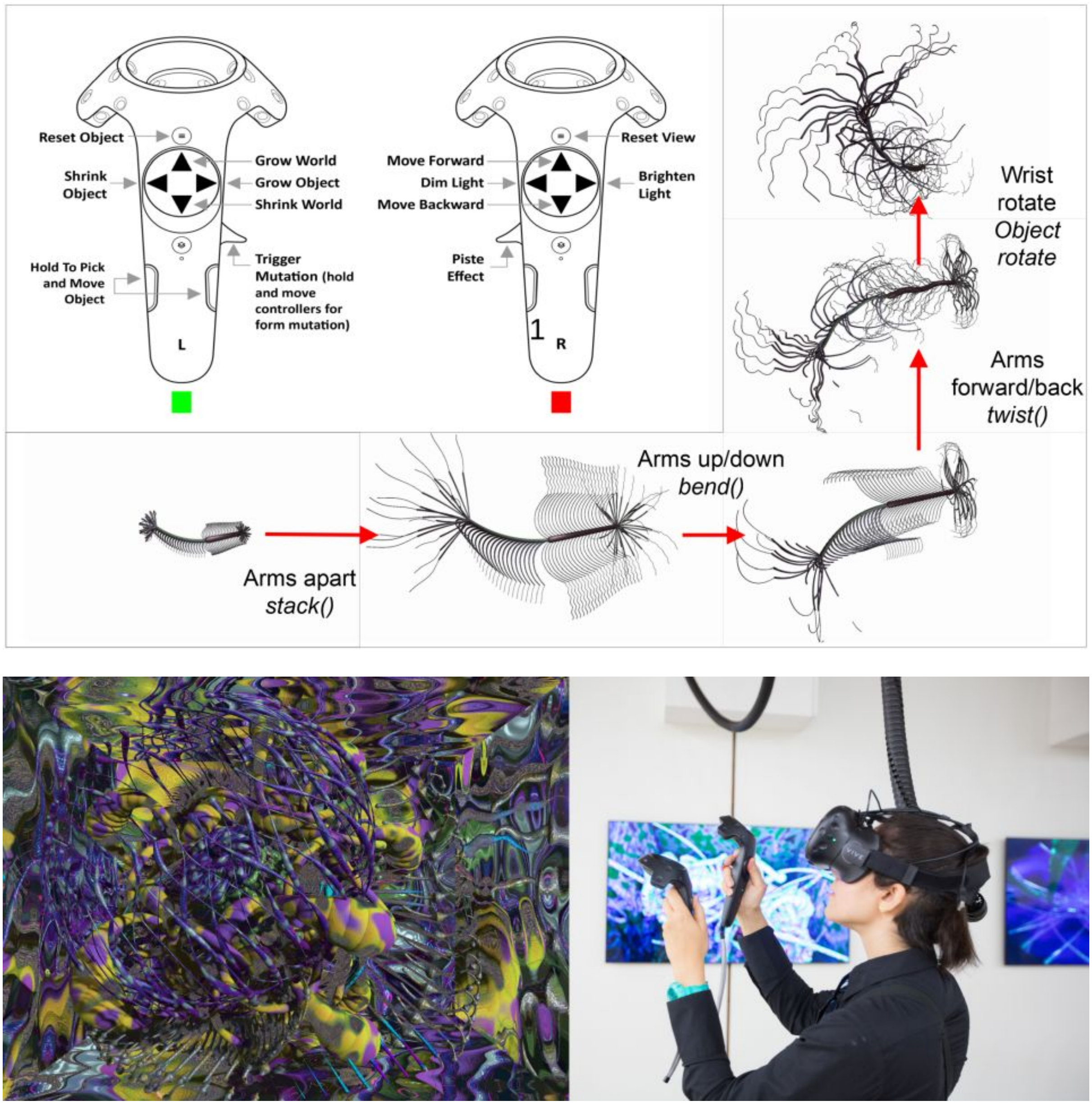


Figure 8 (a) Vive controller button functions. (b) Vive controller positions: arm movements map to gene changes which mutate the form. (c) Dynamic mutating form in VR manipulated by the viewer.

<4> Summary and Conclusions

We discussed how *Organic Mutator* brings an artistic gallery experience to today's interactive and VR world. A surreal balance of reality and unreality gives artistic impact, with a careful balance between artist curation and freedom of user choice. The VR environment changes the experience and impacts the interactive interfaces. Our main conclusion is that the procedural approach of Organic Art extends well into VR, but requires a really simple interface. Natural interaction provides a surreal but playful experience that is enhanced greatly by VR.
Looking forward, we will extend the system with multiple users in the same virtual space, interacting with an experienced performer in that space. We will also bring the subjective mutation experience into the VR space, augmented by machine learning to focus mutation.

<> References

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<> Tables

| **Feature** | **Real** | **Unreal** |
| --- | --- | --- |
| **FormGrow: pseudo-natural 3D Organic Forms** | | ● |
| Non-random: geometric forms | | ● |
| Forms self-intersect | | ● |
| Cutter: not realistic but feels natural | | ● |
| No gravity: surreal floating forms | | ● |
| **Standard perspective** | ● | |
| True eye height: avoids confusion | ● | |
| VR room orientation: matching reality avoids nausea | ● | |
| Room/viewer scale changes: *Alice in Wonderland* effect | | ● |
| **Lighting and Shadows:** in style of Salvador Dali | ● | |
| Torch and headlight: increase immersion | ● | |
| **3D textures: Objects move through texture** | | ● |
| Feedback: but not true raytracing | | ● |
| **Synthesized audio** | | ● |
| Recorded sounds | ● | |

Table 1: “Real” or “unreal” features of *Mutator VR* create a surreal aesthetic.

| | | | | | |
|---|---|---|---|---|---|
| *Have you tried VR before?* | **Yes** | **No** | | | |
| | 27 | 73 | | | |
| *Age* | **<18** | **18-24** | **25-39** | **40-59** | **60+** |
| | 7 | 47 | 21 | 14 | 10 |
| *Gender* | **Male** | **Female** | **X** | | |
| | 54 | 44 | 2 | | |
| *Rate the overall experience?* | **V. Good** | **Good** | **Fair** | **Poor** | **V. poor** |
| | 83 | 17 | 0 | 0 | 0 |

Table 2: Survey results from 100 Visitors to *Mutator VR* at East Gallery, Norwich, UK.

| **Year** | **Exhibition / Gallery** | **Touchscreen mutation** | **Body movement** | **Buttons, triggers** | **Live View** |
|---|---|---|---|---|---|
| 2013 | Phoenix, Brighton | Touch Screen | | | Wall Projection |
| 2014 | GV Art, London | | Kinect | | Large monitor |
| | iMAL, Brussels | Touch Screen | | | Wall Projection |
| -2015 | Centre Space, Dundee. | Touch Screen | Kinect | | projection |
| | Summerhall, Edinburgh | Touch Screen | | | Wall Projection |
| 2016 | New Scientist Live, London | | | Vive | Small Monitor. |
| -2017 | East Gallery, Norwich, UK | | | Vive | Small monitor |
| | Cyberfest, St.Petersburg, Russia | | | Vive +Piste | Large Screen |

| | | | | | |
|---|---|---|---|---|---|
| | Hyrbis, Venice. Italy | | | Vive +Piste | Large Screens |
| | Ars Electronica, Linz | | Vive Controllers | Vive +Piste | Large Screens |
| | Shoom 30, London | | Vive Controllers | Vive +Piste | Large Screens |
| | Pendoran Vinci Exhibition. NRW Forum, Dusseldorf. | | Vive Controllers | Vive +Piste | Large Screens |

Table 3: Interaction/experiences in the different exhibitions. All exhibits used FormGrow, animation and mutation.