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Morphogenetics: generative processes in the work of Driessens and Verstappen

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Abstract

Dutch artists Erwin Driessens and Maria Verstappen work with generative techniques in a range of media, from digital imaging and software to sculpture and robotics. In their own words, they pursue "an activity that explores the unseen, the unthought and the unknown?" To this end they create rich, elegant, self-constraining generative systems, which draw on, and re-engineer, techniques from the field of artificial life. This paper sets out a critical survey of the artists' generative work, and shows how their application of a-life techniques destabilises, and enriches, some of the problematic aspects of those techniques. Specifically, where a-life frequently ignores complex morphogenetic processes, dematerialising them into a formal and instantaneous moment of genetic expression, the artists demonstrate the possibility and potential of richer, more complex and more 'materialised' models.

Keywords: artificial life, cellular automata, generative techniques, genetic algorithms, morphology.

1 Introduction

Over more than a decade, artificial life has provided a rich source of techniques, architectures and metaphors for artists working with generative computational processes. In fact a-life art has come to be recognised as a distinct sub-genre within the wider electronic or 'new media' art world, as evidenced by, for example, the annual *Life x.0* competition (Fundación Telefónica 2002). This category encompasses a diverse range of practices, approaches and agendas. Some artists have taken on a-life as both a technique and a project, and set out to realise its aims, in their strongest form, in their own practice. Many more have adopted a-life techniques while drawing and elaborating on the metaphors built in to those techniques; more rarely, artists apply those techniques critically and reflexively, asking about their wider meanings and implications. A-life art, as a field, both adopts and adapts artificial life, in parallel with Christopher Langton's exhortation to explore "life as it could be" (Langton 1992).

However one of the key problems for a-life art is the way in which any sense of "life as it could be" is constrained through its inscription into relatively fixed formal architectures and templates. Forms such as artificial evolution (genetic algorithms), agent-based ecosystem simulations and cellular automata are often taken up unaltered in a-life art practice. They are recast, reclothed, couched in new agendas and contexts, but the core formal mechanisms remain. So too do the ideas of life embedded in those techniques — particular notions of heredity, evolution, morphogenesis, genetics, agency, interaction, determinism and contingency.

Dutch artists Erwin Driessens and Maria Verstappen take an unusual and instructive approach to the generative techniques of artificial life (Driessens and Verstappen 2002). They apply central a-life techniques — artificial evolution and cellular automata — though they leave the biological analogies involved in those techniques aside. Further, these generative forms have been rewired and rethought; formal and conceptual structures have been inverted, bypassed or collapsed. These processes suggest alternative morphogeneses, notions of genetic expression and developmental time; above all, though, they are clever, elegant and richly generative.

2 Breed

Breed (1995–2000) is a project which spans both process and product, comprising generative morphological software and the virtual three-dimensional forms which that software generates, as well as physical fabrications of those forms. As the name suggests the project involves a form of artificial evolution, though one quite unlike that used in other 'breeders' of aesthetic forms (such as those of Karl Sims (2002), William Latham (Todd and Latham 1992) or Steven Rooke (2002)).

Breed generates intricate three-dimensional forms through a stepwise process of spatial differentiation which the artists describe as 'cellular'. The process begins with a solid, cubic volume — a single cell. When the cell 'divides', its volume is partitioned into eight smaller cubic cells, units of space which may be either solid or empty; so the space occupied by the initial cube is coarsely differentiated — a chunky, blocky assemblage is formed. The same process continues for each of the eight new cellular units, which divide in turn into eight, and the resultant form is again more detailed and differentiated. This process continues, being applied to rapidly increasing numbers of smaller and smaller cells. Viewed as an animated process, the initial cube carves itself away in ever-finer cellular chunks, finally resembling a complex sculpture assembled from cubic Lego blocks — a 'pixelated' mass perforated with irregular hollows and voids.

This morphogenetic process is controlled by a set of parameters which, as in other breeders, are treated as the form's genome. These parameters are in fact simple rules governing the process of cellular differentiation. At each step in the process, a cell's subsequent differentiation is controlled by the presence (or absence) of neighbouring cells; the morphogenetic rules simply dictate how every possible combination of present or absent neighbours influences the next split. This is a highly elegant form of artificial genetics, one in which a compact 'genome' generates a complex form through recursive application at ever-finer scales, rather than through a high-level or global specification. Of course these parameters still entirely determine the resultant form — a given genome will give rise to the same form every time — but the process of 'expression', the transition from code to form, is tightly bound to the phenotypic context of the virtual form. The formation of a certain void or bump at a certain level of detail depends not on an explicit representation encoded in the genome, but on the genetically-specified interaction of neighbouring units of volume. In an architecture which follows a-life's 'bottom-up' maxim, a set of simple, micro-scale rules gives rise to a complex macro-scale result.

The evolutionary process in *Breed* occurs as a form generated by a random genome is evaluated according to a set of spatial criteria. An automatic measurement is made of properties such as volume, surface area and connectivity — the degree to which different parts of the form are joined to each other. These values are stored, and the genome for that form is randomly altered. A new form is generated, and its fitness values measured and compared with those of the initial form — if it's fitter, the new form is retained, if not, the initial form is mutated again. Through repetition of this automatic loop, a form will eventually be generated which has ‘maximal fitness’, meeting those predetermined formal criteria. While this process gives the impression of a highly linear, progressive drive towards an optimal ideal, this is not the case: the relatively open nature of the criteria (volume, surface area and connectivity) mean that any single set can be met by a large number of different forms. In another elegant twist, the structure of the artificial evolutionary process mirrors that of the morphogenetic process: rather than searching for a single, absolute goal, this simple stepwise evolution uses only a local comparison; as it forms a sequence of incrementally ‘better’ forms, the process effectively paints itself into a corner: the final ‘optimal’ form is in fact only the most optimal form that a specific sequence of random alterations had produced.

This represents an interesting inversion of an a-life convention. In the jargon of artificial evolution, a range of possible forms for a given system is sometimes described in terms of a ‘fitness landscape": imagined initially as a flat, two-dimensional plane, different areas can be assigned a ‘height’ which corresponds to the fitness of the forms at that point. The flat plane becomes a hilly landscape, one that may have numerous individual peaks of various heights, separated by valleys. In utilitarian applications of genetic algorithms, the central aim to arrive at a solution which has maximal fitness — which occupies the highest peak on that hilly landscape. One of the main problems for these systems is that without exhaustively searching the space of possible forms — and such spaces are often very large — it may be impossible to tell whether a certain evolved solution sits on the highest peak in the entire space, or only on a medium-sized foothill. The random mutations of artificial evolution can be thought of as exploring the area around a certain solution — its locality, in this imaginary landscape. If a process searching for ever-better solutions, like the one in Breed, finds itself on a local fitness maximum — the highest hill in the immediate neighbourhood — it will stop. In all likelihood, subsequent mutations will result in forms with a lower fitness value, and since this process cannot ‘climb down’, it will stay stuck at that hilltop. In utilitarian applications of genetic algorithms, the phenomenon of evolution halting at a ‘local maximum’ is a problem (see for example Flyvbjerg and Lautrup (1992), or for a more general discussion Kauffman (1993)). In *Breed* Driessens and Verstappen turn this problem into a virtue, for it is in finding local maxima — backing itself inexorably up the nearest hill — that this automated evolutionary process can produce a variety of forms which meet these open spatial criteria. Rather than defining a fixed formal or aesthetic optimum, the artists frame the fitness criteria in a way that involves a kind of loose control over the results, where the details of the evolved forms are unguided even as global attributes such as volume and surface area are firmly specified.

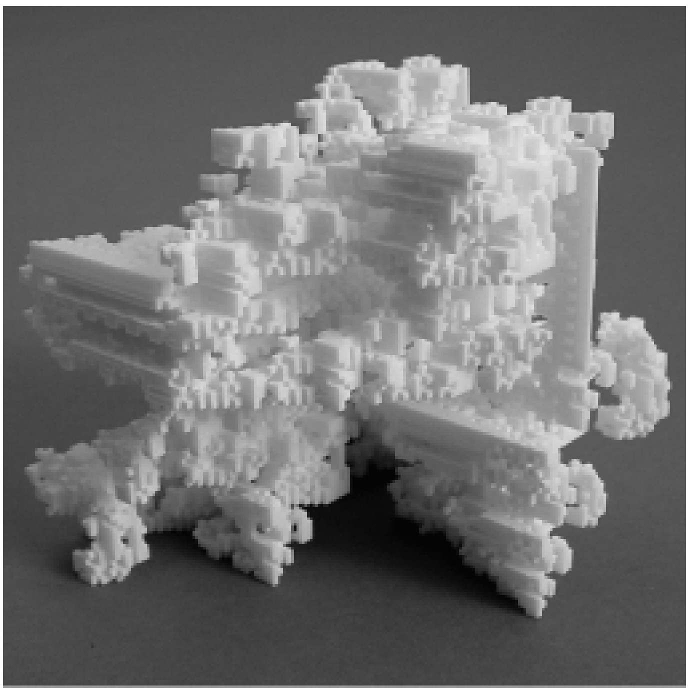

Figure 1. Erwin Driessens and Maria Verstappen, Breed 1.1 (1999), detail. Image courtesy of the artists.

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Driessens and Verstappen have brought this project to a sculptural conclusion by fabricating a selection of the evolved forms. Originally the artists used plywood, which was hand-cut and assembled into forms with 32 0.6-centimetre voxels to a side. More recently, they have used a computer-controlled rapid prototyping process (selective laser sintering) to generate forms which are more delicate and intricate, occupying 10cm. cubes with 64 voxels per side (Figure 1). Even here, the resolution of the forms is limited by the physical realisation: as Verstappen (2002) writes,

> *it would be nice if you could hardly see the voxel elements, to see that come parts really get an organic structure like coral or broccoli.*

3 Tuboid

Another experiment in computational morphogenesis, and a similar transition from the immaterial to the material occurs in *Tuboid* (1998–99). Here, the spatial template is a tube, rather than a cube, though as in *Breed* it is a form that shapes its own development through space and time using a simple artificial evolutionary process. Here, a worm-like shape is formed from a sequence of cross-sections — two dimensional slices — which accumulate over time. The structure which underpins those slices is ingenious and elaborate. Each slice is defined by a group of up to 256 articulated spokes; each spoke has four segments, which can vary in length, and the outer three segments of each spoke can also pivot through any angle. The outline of each slice is formed by joining the endpoints of these elastic, articulated spokes, as illustrated in Figure 2. The configuration of the spokes is defined in turn by a set of parameters controlling the length of each spoke segment and the rotational speed of the three pivoting outer segments.

Of course the encoding of a parameter for speed implies a structure that changes with time — and this is where *Tuboid* is most interesting. A sequence of slices accumulates over time to define a three-dimensional form; each new slice, however, is a mutation of the previous one, so that the spoke lengths and pivot rates will vary slightly from one slice to the next. These values are only constrained by a single criterion: that the outline of the slice must not intersect itself; it must always describe the perimeter of a single two-dimensional form. This mutational sequence of profiles is projected through a third dimension to define a single smooth, wobbly, organomorphic form. The complex inner architecture of articulated spokes, and the encoding of rotational speed in the genome, combine with this spatial constraint to generate sequences (and thus tuboid forms) that are highly coherent, with smoothly undulating bulges and ridges. As in *Breed*, these forms are not quite specified by the genome but rather emerge from the interaction of that genome — and in this case its mutational sequence — with its past activity and with a spatial constraint.

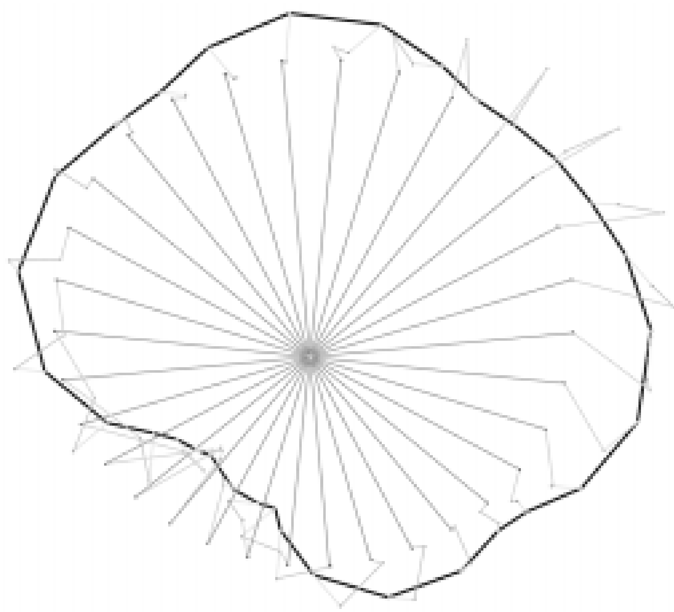

Figure 2. Diagram showing the articulated spokes (in grey) which generate the outline (in black) of a single layer of a Tuboid structure. Image courtesy of the artists.

Tuboid exists in both virtual and physical manifestations. In virtual form, these tubes can be viewed either from the ‘outside’, as solid extrusions, or from within, generated in real time as enfolding, continuously unfolding tunnels (Figure 3). Once again, Driessens and Verstappen have fabricated a selection of these forms as physical objects — in this case weird, slightly eerie, shiny white towers around a metre high (Figure 4). These are built up from 4

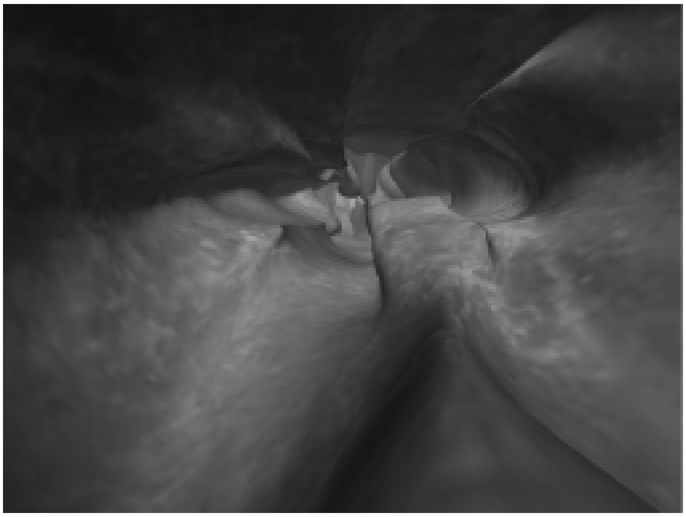

Figure 3. Erwin Driessens and Maria Verstappen, Tuboid (1998-99), detail from real-time 'tunnel' mode.

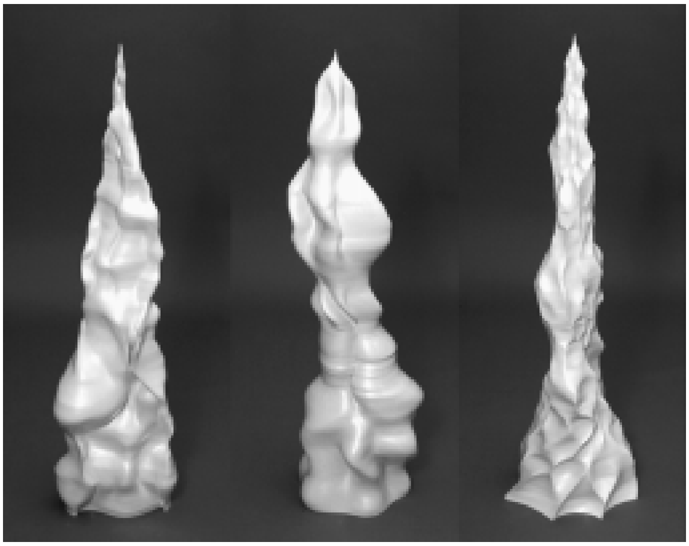

Figure 4. Erwin Driessens and Maria Verstappen, Tuboid (1998-99), detail showing three physical models. Image courtesy of the artists.

millimetre slices of fibreboard, hand-smoothed and sprayed with glossy automotive lacquer. They almost resemble stalagmites cast in plastic, but with their bulbous protrusions and rippling ridges they also have more bodily connotations — like tapering sections of intestinal tract.

4 Ima Traveller

Ima Traveller (1996-8) is another work which uses a morphogenetic process derived from a-life techniques, though where *Breed* and *Tuboid* are both form-machines, *Ima Traveller* is an image-machine. Like *Breed*, *Ima Traveller* uses a virtual 'cellular' structure: initially a single cell — a pixel at the centre of the screen — births new cells, neighbours. These split in turn, and the reproductive cycle continues until the screen is quickly filled with proliferating masses of pixels. As in *Breed*, a set of rules controls the way in which each cell reproduces, and here too those rules draw on each cell's own state and its current environment — its neighbours. In *Breed* a cell could have only two states — on or off, solid or void. In *Ima Traveller* however, each cell is a pixel, a point of colour, and it can have one of millions of possible colour states. In *Breed* the process of cellular differentiation works inwards, refining the original volume in ever-finer detail; here, the cellular space itself grows, expanding beyond the edge of the display; cells crowd each other out in an ever-spreading pixelated mass. The artists have engineered the splitting rules so that the dividing cells form blossoming masses of colour which differentiate endlessly, opening up into ever-greater detail: the visual effect is of a relentless zoom, a sense of diving into a continuously-unfolding picture plane. The nearest visual analogy is with the 'fractal zoom' — that computer-graphic cliché which tunnels into the filigreed coastlines of a Mandelbrot set image, revealing endless ever-tinier coastlines and curling filaments. The graphic quality of *Traveller* is less slick, more pointillistic — suggesting coloured clouds or variegated mats of lichen (Figure 5). The software interface also allows this diving zoom to be steered with the mouse, so a path can be woven through the most interesting zones. The interactive pleasure of this process is in the way these zones continually explode, expand, differentiate and refine themselves. An apparently uniform patch of sky-blue is soon peppered with darker specks, one of which opens into an inky void, which in turn lightens to a cloudy grey mass, which in turn sprouts islands of green.… Emanuelle Lequeux

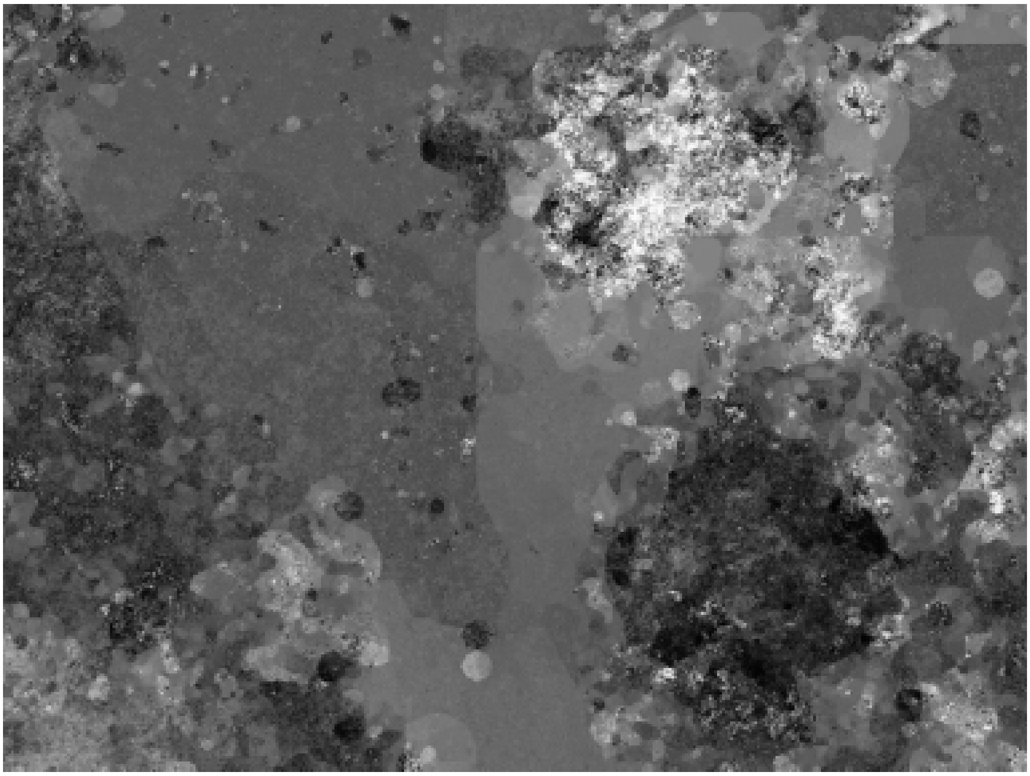

Figure 5. Erwin Driessens and Maria Verstappen, Ima Traveller (1996–8), detail. Image courtesy of the artists.

responds with justified lyricism:

> *Images give birth to other images, pixels to other pixels, without end. At each tremble of the mouse another universe is born.*
> (Lequeux 1999)

5 Tickle and other generative pleasures

At first glance, *Tickle* (1995-2000) appears to bear little relationship to the rest of Driessens and Verstappen's work. *Tickle* is a small, autonomous robot: a blank aluminium box about the size of a cigarette packet, it is fitted with a pair of nubbed rubber caterpillar tracks (Figure 6). True to its name, the robot's purpose is to tickle; with basic mechanical sensors and motors powered by rechargeable batteries, it crawls over a reclining body, reversing and pivoting to avoid falling off and tracing a wandering, unpredictable path. Based on the context of its documentation, and on its presence in venues such as the *Life 2.0* competition for a-life art, we can infer that *Tickle* is an art object; however at the same time, Driessens and Verstappen allow it to be interpreted as a purely utilitarian object, a pet robot massager — perhaps even a vaguely erotic plaything. Their web site discusses the prospect of limited commercial production — an idea that only arose, Verstappen says, in response to the interest generated by online documentation of the work. Interestingly, Verstappen also reports that the artists have experimented with automatic ticklers for some 13 years, trying out other solutions such as a motorised blade of grass suspended over the ticklee's back. *Tickle* refines a solution to this delicate sensory/spatial task; as Verstappen (1999b) writes, "an important aspect of good tickling is that it has to be unpredictable". While based on simple 'finite state' mechanical sensors — sensorimotor switches connecting the robot's orientation to its motion, designed solely to prevent it falling off the subject's body — *Tickle*'s behaviour is complex enough to be (reportedly) pleasurable. Still, the challenge of an automatic tickle remains: at the time of writing, the artists were working on a prototype for *TickleSalon*, a far more elaborate robot which revisits earlier tickling machines and suspends a small, mop-like stroking appendage over the subject's back. Four digitally-controlled stepper motors move the mop gently but precisely; the system uses tension detection to create a live, three-dimensional map of the body surface which the robot

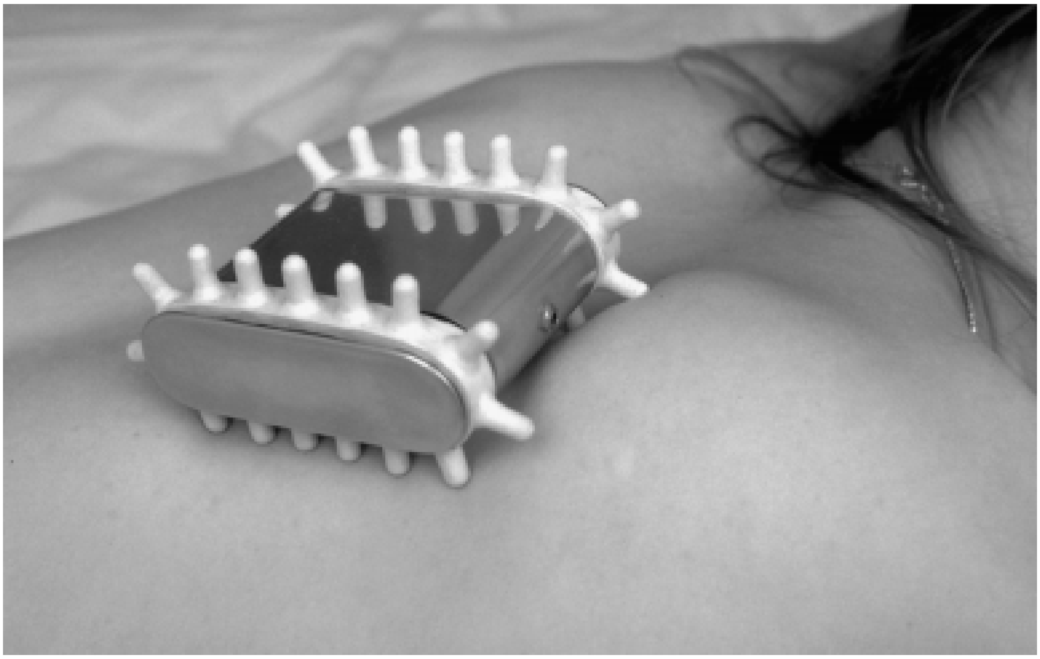

Figure 6. Erwin Driessens and Maria Verstappen, Tickle (1995–6), image courtesy of the artists.

will use to refine its tickling trajectory.

Of course it is the pleasure of unpredictability — as well as an underplayed humour — which connects *Tickle* very clearly to the duo's other work. Once again, following a-life's basic philosophy, a formal system with very simple constraints gives rise to a complex behavioural and phenomenal result. *Tickle* is a system for delivering tactile pleasure — and in the same way *Ima Traveller* is a kind of visual massage, an endless, automated proliferation of visual variety. A catalogue essay on *Ima Traveller* quotes Verstappen:

> *even if a work is conceptual, it must be good, to allow you to flee and to escape yourself. To submerge you.*
> (Lequeaux 1999)

Perhaps what makes Driessens and Verstappen's work both appealing and elusive is its balance of dry 'conceptual' constraint with the immersive pleasure of morphogenic and behavioural variety. There is a quite careful, deliberate structure to the processes undertaken: constraints are set, a minimal number of parameters placed in variation. There is a setting-aside of stereotypical artistic 'creation' in favour of a metacreation which is more controlled, and cooler, but which consequently addresses the limits of a creative process more directly. Driessens and Verstappen (1999) describe this approach very clearly:

> *We see a challenge in the question 'how can we express the longing for an activity that explores the unseen, the unthought and the unknown?' Not influenced by taste, style and meaning but also avoiding complete unpredictability.*
> *In this context, we are interested in dynamic processes: each change in a process is a reaction to the previous change, so it is really matter of feedback. On the one hand, this creates cohesion, on the other hand the system remains unpredictable as a result of coincidences. Small changes can sometimes lead to dramatic transformations.*

This quote emphasises an investigation of formal mechanisms, and a straightforward, blank approach to the 'unknown'. It indicates a paring-back of art practice to an impersonal, systemic exploration which might be taken as a naïve ignorance of the complexities of art's social and cultural involutions, its histories and discourses, and its contemporary political dynamics. However work such as *Exhibition* (1990) strongly counters this impression. In this multi-stage project, the duo firstly selected a set of photographs of European and American gallery spaces that had appeared in major art magazines such as *Flash Art* and *Kunstforum*. Based on those images, the artists created a set of physical models of the gallery spaces (minus the artworks) — detailed down to minute power points. The spatial punch line is that only the portion of the space visible in the photograph is

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modelled: only the wedge-shaped section of the room defined by the camera's field of view exists. As part of the project, the models were carefully lit and re-photographed from the original viewpoint, re-constituted as coherent spaces in the form of an image. These re-made images were then published in another art magazine (*Artscribe* no. 84). The other half of the project — *Model spaces* — involved an exhibition of the maquettes themselves at the Museum Fodor, Amsterdam. Here, they reveal themselves as partial, three-dimensional reproductions — spaces truncated by a field of view. Despite its characteristic coolness, *Exhibition* takes on the institutional mechanisms of contemporary art practice very directly, pointing to the crucial circuit between space and image, gallery and magazine, work and reproduction, which sustains the contemporary art world.

This project offers an interesting perspective on the duo's later work, and their use of a-life morphological techniques. Verstappen (1999a) describes the transition from *Exhibition* into the later generative and morphological works:

> *In ... works like* Exhibition*, we focused on the preconditions of the art system. ... At that time we felt ourselves so much confronted with [the social-political] reality of the art practice, that we had to deal with it in a very direct way. Then we thought, if all these spaces have necessarily to be filled up with art each month again and again, we can think of [how to] automate this production. Somehow very nihilistic in its approach we started to make our first attempts to make automatic artificial art. But very quickly we understood this was not an easy job, and then it became really interesting, an exciting adventure.*

Here, then, is the balance of generative pleasure and dry wit: what began as an attempt to satirise the art world's endless appetite for novelty, became an engaged investigation of the generative processes that might supply such novelty. Verstappen positions the artists' practice as post-Duchamp, post-readymade; she observes that even after Duchamp's work opened the way for "an aesthetic interpretation of everything", subsequent creative practice has dealt only with limited segments of this unimaginable 'everything' — "somehow they all end up defining rules [for] how to interpret reality". Of course a framework, a set of constraints is essential, and Verstappen does not suggest that this work aims to somehow access this aesthetic "everything" directly (as Steven Rooke's work perhaps does). Instead, it entails the systematic deployment of frameworks and constraints, the testing of different morphogenetic processes. By re-casting these constraints as computational processes and parameters, the artists make them transparent, manipulable and malleable; the computer is a kind of meta-framework, a framework for generating and testing frameworks which in turn pursue specific slices of this 'everything', "the unseen, the unthought and the unknown".

6 Tweaking artificial life: technique and concept

Of central interest here is the way that Driessens and Verstappen use a-life techniques towards this end, and the way their practice reinterprets and repositions those techniques. Their use of artificial evolution is particularly interesting, especially in comparison with the more generic forms of 'breeder'. The evolutionary processes in *Breed* and *Tuboid* are hybrids which complicate the usual transparency of the artificial genome, linking its action closely to an ongoing phenotypic process. The importance of morphogenetic time in these works — of a sequence of development — distinguishes them from the instantaneous expressive processes of most breeders. Further, where expression in those systems occurs once, in a single act of translation which specifies the entire phenotype, Driessens and Verstappen show that it is possible to have expression occurs repeatedly and locally, so that the artificial genome is not an explicit 'blue-print', but one element in a more complex, dynamic system. The use of a kind of three-dimensional cellular automaton in *Breed* is a perfect example of this extra complexity: rather than the gene acting on the form, this process has the gene specifying the form's ongoing interactions with itself. The artists bend the conventional model further in *Tuboid*, where the resultant form is not so much a 'phenotype' as a three-dimensional temporal record of a self-constraining evolutionary process. Rather than springing fully-formed from a single inner 'code', these blobby towers are accretions of slices in a sequence of mutated individuals — more analogous to colony structures such as stromatolites or coral reefs than individual organisms. The clean, simplistic, a-temporal notions of genetic expression which a-life generally adopts are thoroughly complicated, as is the taken-for-granted correspondence of code with genome and form with organism.

Richard Dawkins' *Biomorph* software, the ancestor of all form-breeders, uses a digital genome to generate forms made from linear elements; Dawkins (1986) used the rich variety of forms produced to support his arguments for the power of Darwinian evolution in *The blind watchmaker*. However Stuart Kauffman has argued that

> *there's less there than meets the eye … it's clear you can generate varieties of morphologies, if you have something called a genotype that makes something called a morphology. … The part I tend to dislike in what he's done is that there's nothing natural or self-organised or robust about the development mechanisms and morphologies that Richard posits. He simply has computer programs arbitrarily draw stick figures or whatever. That's not how real development works.*
>
> (Kauffman in Brockman 1996 72)

In the work of Driessens and Verstappen we find formal models for morphogenesis which are self-organised, and to that extent, perhaps more 'natural' than those typically found in form-breeders. While this artwork never claims to mimic 'how real development works', it does begin to suggest an artificial embryology; simple, locally-interacting architectures which unfold into rich forms and differentiated spaces, and which tightly articulate the code of the genotype, with the material specificity of the phenotype.

The discourse and philosophy around the techniques of artificial evolution is also quite different here. In general, evolutionary artists have emphasised generative potential — the vastness of an image- or form-space — rather than the constraints inherent in the language which allows access to that space (see for example Todd and Latham (1992)). The constitutive structures of each procedural-geometric grammar or mathematical image definition are largely ignored in the rhetoric around these works — instead, the dominant language of Darwinian evolution lends them an air of grand totality. Moreover, the presence and agency of a human aesthetic 'selector' is often a crucial element in that rhetoric. Driessens and Verstappen offer a striking contrast: here, artificial evolutionary processes act primarily to constrain morphological outcomes in a balance between unpredictable novelty and spatial coherence. As outlined above, the automated evolution in *Breed* uses a simple, self-limiting technique which, with successive runs, gives a variety of results for a given set of criteria. Rather than a desire-driven amplification of creative agency, the artists deliver a 'blind' process, a quietly automated factory for novel forms which meet a set of specific criteria. The forms themselves are invested with no special significance; they simply indicate that blank automatic process. Other breeders tend to figure evolution as akin to a manned spacecraft, a propulsive process steered by human aesthetic will which traces sweeping arcs through a vast hyperspace. Here, by contrast, 'evolution' is set up to self-organise, to coalesce and converge.

The artists also make some interesting innovations in their use of cellular automata. As they are conventionally deployed in a-life and its popular rhetoric, cellular automata (CAs) are understood as extensive matrices, spatial grids which define an artificial universe. In the best known cellular automaton, the *Game of life*, coherent formations within the lattice of cells are readily identified as autonomous, living entities (see for example Emmeche (1994)). ‘Gliders’, for example, are formations which traverse this grid on diagonal paths, continuing endlessly unless they collide with another group of cells. An entire catalogue of other characteristic formations — native life-forms — have been identified, such as the ‘blinker’, a small symmetrical oscillating structure, and the ‘rock’, a stable block of cells. Thus the *Game* is figured as a terrain for life, a deterministic grid which, remarkably, gives rise to a host of characteristic, coherent, emergent temporal and spatial patterns.

Driessens and Verstappen use CAs in very different ways. Notably, they rupture the continuity and constancy of the cellular grid itself: they take the ‘cellular’ aspect of the CA literally, and treat the cells as dynamic, divisible entities rather than as symbolic elements supporting transitory higher-level patterns. In *Breed* and *Ima Traveller*, the cells which constitute each structure continually divide, refining their locality. The interesting patterns which arise in both these works are marks of an ongoing morphogenetic process rather than discrete metaphorical ‘life form’s. In a sense Driessens and Verstappen turn the cellular automaton inside-out (or rather, outside-in): in a conventional CA the emergent ‘life forms’ exist inside the fixed cellular grid. The plastic, differentiating cellular grids in *Breed* and *Ima Traveller* only exist inside their resultant forms. This change fits with the artists’ leanings towards the material: in a conventional CA, the emergent forms are mere epiphenomena — while they appear to be coherent, mobile and autonomous, they are simply patterns of activation travelling over a static array of formal elements. In the theories of Edward Fredkin this property of CAs is expanded into a speculative cosmological theory which he calls *Finite nature* (Fredkin 1992; see also Wolfram 2002). Under this hypothesis, the cosmos is itself a gigantic CA: our three-dimensional universe of matter, space and time is merely an emergent pattern generated by a formal array with a higher dimensionality. Matter, and life, are held to be ultimately manifestations of an underlying process of computation, an immanent logical substrate. Driessens and Verstappen, by contrast, use CAs in a way which puts matter, and morphogenesis, ahead of the logical array. In a process such as *Breed* there is no given array, only a certain level of detail, a certain number of cellular subdivisions. There is no underlying granularity: space continues to open up. In *Ima Traveller* the same process is at work, though here the array sprawls outwards endlessly, growing like a puddle of bacteria.

Thus even as the artists make use of core a-life techniques such as artificial evolution and cellular automata, they reconfigure and re-engineer those techniques. At one level, the changes that they make may seem to be simply arcane technical ‘tweaks’; these tweaks also entail important metaphorical and conceptual transformations, however. In reconfiguring artificial evolution, Driessens and Verstappen move away from the metaphorical structure which so dominates the use of that technique, both within a-life science and a-life art. Here there is no grand evolutionary trajectory, no sexual reproduction or family tree — not even a biomorphic aesthetic ‘organism’. While other breeders draw heavily on these familiar ideas, both as conceptual models and explanatory devices, Driessens and Verstappen apply the techniques without their figurative baggage. These notions are still present, but as Verstappen (1999a) explains their role is strictly explanatory:

In some works we use metaphors like cell-division, evolution, genetic code, and so on, to explain what happens. But on the level of the internal process, we work with this machine, the computer has its own physical rules.

What is most significant about this work is that in disregarding the conventional metaphorical structures around a-life techniques and treating those techniques as elements in a more abstract computational process, Driessens and Verstappen create systems which are more elegant and richly generative than many more conventional creative applications of a-life. They offer a powerful demonstration that a-life techniques (and their attendant metaphors) need not be simply received and applied by artists. Driessens and Verstappen also show that a-life's generative processes can themselves be unpacked, refashioned and explored more fully. In part these processes operate here as abstract morphological machines; however in rearranging a-life's templates the artists are also illustrating alternative notions of space, form, morphogenesis and evolution.

References

Brockman, J. (1996) *The third culture*. Simon and Schuster, New York.

Dawkins, R. (1986) *The blind watchmaker.* Longman Scientific and Technical, London.

Driessens, E., and Verstappen, M. (1999) Private Email. 2 September 1999.

Driessens, E., and Verstappen, M. (2002) *Notnot*. http://www.xs4all.nl/~notnot (accessed July 2002).

Emmeche, C. (1994) *The garden in the machine: the emerging science of artificial life.* Trans. Sampson, S. Princeton University Press, Princeton.

Fundación Telefónica (2002) *Art and Artificial Life International Competition*. http://www.fundacion.telefonica.com/at/vida/english/index.html (accessed July 2002).

Fredkin, E. (1992) *A new cosmogeny*. http://www.digitalphilosophy.org/new_cosmogony.htm (Accessed July 2002).

Flyvbjerg, H., and Lautrup, B. (1992) Evolution in a rugged fitness landscape. *Physical Review* A 46 6714–18.

Kauffman, S. (1993) *Origins of order*. Oxford University Press, New York.

Langton, C. G. (1992) Preface. In Langton, C. G., Taylor, C., Farmer, J. D., and Rasmussen, S., (eds.) *Artificial life II*. Volume X of SFI studies in the sciences of complexity. Redwood City, CA. pp. xiii-xviii.

Lequeux, E. (1999) Ima Traveller. Trans. Holmes, B. In Driessens, E., and Verstappen, M., *Ima Traveller*. Le Carre, Centre culturel des Ursulines, Chateau-Gontier.

Rooke, S. (2002) *The evolutionary art of Steven Rooke*. http://www.azstarnet.com/~srooke (accessed July 2002).

Sims, K. (2002) *Karl Sims home page*. http://www.genarts.com/karl (accessed July 2002).

Todd, S., and Latham, W. (1992) E*volutionary art and computers.* Academic Press, London.

Verstappen, M. (1999a) Private Email, 28 October 1999.

Verstappen, M. (1999b) Private Email, 2 November 1999.

Verstappen, M. (2002) Private Email, 22 July 2002.

Wolfram, S. (2002) *A new kind of science*. Wolfram Media, Champaign, IL.

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