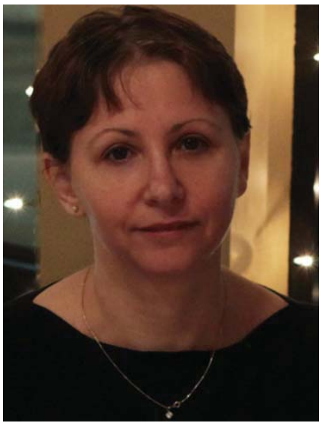
D. Sirbu	*Paper:* **A Framework for Artificial Creativity in Visual Arts**



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The present paper looks at points of intersection between theories of artificial creativity in visual arts and control theory. The emphasis is placed on approaches based on evolutionary computation in the study of artificial creativity. Analogies and differences are analysed between closed loop models that adapt system behaviour in control engineering and evolutionary models that adapt system behaviour in relation to an estimation function. Computational models of individual and social creativity are analysed in relation to the reference model architecture proposed by Albus and Meystel for the development of computational intelligent systems with autonomous behaviour. The purpose of this analysis is to define a possible framework for the development of autonomous creative systems in a hybrid evolutionary computation and control theory approach.

Topic: Artificial Creativity

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Towards a Framework for Artificial Creativity in Visual Arts

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Abstract

The present paper looks at points of intersection between theories of artificial creativity in visual arts and control theory. The emphasis is placed on approaches based on evolutionary computation in the study of artificial creativity. Analogies and differences are analysed between closed loop models that adapt system behaviour in control engineering and evolutionary models that adapt system behaviour in relation to an estimation function. Computational models of individual and social creativity are analysed in relation to the reference model architecture proposed by Albus and Meystel for the development of computational intelligent systems with autonomous behaviour. The purpose of this analysis is to define a possible framework for the development of autonomous creative systems in a hybrid evolutionary computation and control theory approach.

1. Introduction

There is agreement in the research community that creativity is defined through the production of novel and appropriate ideas, behaviours, or artefacts [6], [10], [11], [15], [16]. This defines creativity as being inherently part of the adaptation and evolution processes, which are based on the production of new behaviours and continually evolving existing organisms into new ones with better capabilities to adapt in a given environment. Building on this idea, the goal of the present paper is to provide conceptual grounds towards a framework for the artificial development of adaptive systems capable to produce original visual compositions with artistic value. The process of artificial production of new artworks and designs is based on the principles of evolutionary algorithms [4], [7] and of the visual language shared by artists [3] and designers [19].

2. Evolutionary Concepts and Artificial Creativity

We look at creativity as the aggregation of processes by which artificial adaptive systems can produce new behaviours and modify themselves into improved systems or into systems which are different enough to be considered entirely new and with a better chance to survive successfully in the given environmental niche. Constraints in a given environmental niche are expressed as principles, rules, and concepts related to visual organization of art and design compositions.

We consider a multilayered system based on artificial ontogenetic developmental processes at lower levels, where agent interactions lead to pattern formation, and based on artificial phylogenetic developmental processes at the upper level, where expressed organisms form populations evolving in the given environment.

The agents, the ontogenetic and phylogenetic processes, as well as the environmental constraints at various levels are based on the visual language that provides the basis for art and design creation. Below are described the main ideas and principles at the basis of ontogenetic growth and phylogenetic evolution in the digital production of generative artwork.

3. Artificial Ontogeny of Generative Artworks

If we define a visual composition as an artificial organism, we can interpret the process by which the visual composition is generated as artificial morphogenesis or artificial ontogeny.

In the natural world, morphogenesis is a process of structure formation controlled by complex growth programs leading to the creation of new organisms. We look at artificial ontogeny as a process of pattern formation based on activities and dynamics of kinetic agents that populate the visual field. The growth programs that control this kind of pattern formation are based on sets of rules underlying principles of structuring and organization of visual designs and artworks.

In addition to the growth programs, the artificial morphogenesis is influenced by agents' interactions with the environment and environmental constraints, which could be expressed as sets of rules that dictate the placement and relationships established between components of a visual design or artwork, their relationships established with the boundaries within which the visual composition exists, and the visual field established within such given boundaries.

Agents are forms defined by visual elements such as shape, size, colour, and texture. Artificial ontogeny is the process by which kinetic agents acting in accordance with a number of pre-established rules develop themselves or interact with the environment or with each other leading to the creation of new more complex forms. The structure of these forms, and their placement and relationships with each other or with individual agents determine the structure of the visual field. At the intersection between evolutionary and visual languages, the structured visual fields determine the morphogenetic characteristics of the visual composition.

4. A Simple Example of Artificial Ontogeny

An example of artificial ontogeny creating a spiral structure developing depth, volume and apparent cast shadows is implemented by using simple agents based on primitive geometrical forms like the circle and the line. The small circle agents follow a placement rule based on the iterative increase of the circle radius with a very small amount at each cycle. These small increases offset the agent placement trajectory from a simple circle into a spiral path. The formula used to generate discrete points (x, y) along a spiral is based on the elements of the circle as follows:

$$x = cx + r\cos\theta$$
$$y = cy + r\sin\theta$$

where:

$r =$ circle radius

$(cx, cy) =$ centre of the circle

$\theta =$ angle between radius with end point (x, y) on the circle and the diameter.

Various uses of this method of discrete spiral construction are suggested by Reas and Fry [14] and Pearson [12].

The second agent type provides a population of lines of random length varying within a given reduced range. This agent type, being a line, implicitly has direction. The direction is randomized, but the starting point of the line agent is always placed in the centre of the current circle agent on the spiral. This way, each circle agent becomes the point from where a number of line agents diverge. Over a number of cycles, the randomized directions and lengths of the line agents produce a delicate texture counteracting the directional effect of the line agents. However, the convergence of line agents into circle agents generates a volumetric effect, which is strengthened with every cycle. The simple agents and the attached rules of placement and randomization create clusters distributed along a spiral path. The emerging new form has the appearance of soft bevelling effect on a textured paper surface (see Figure 1).

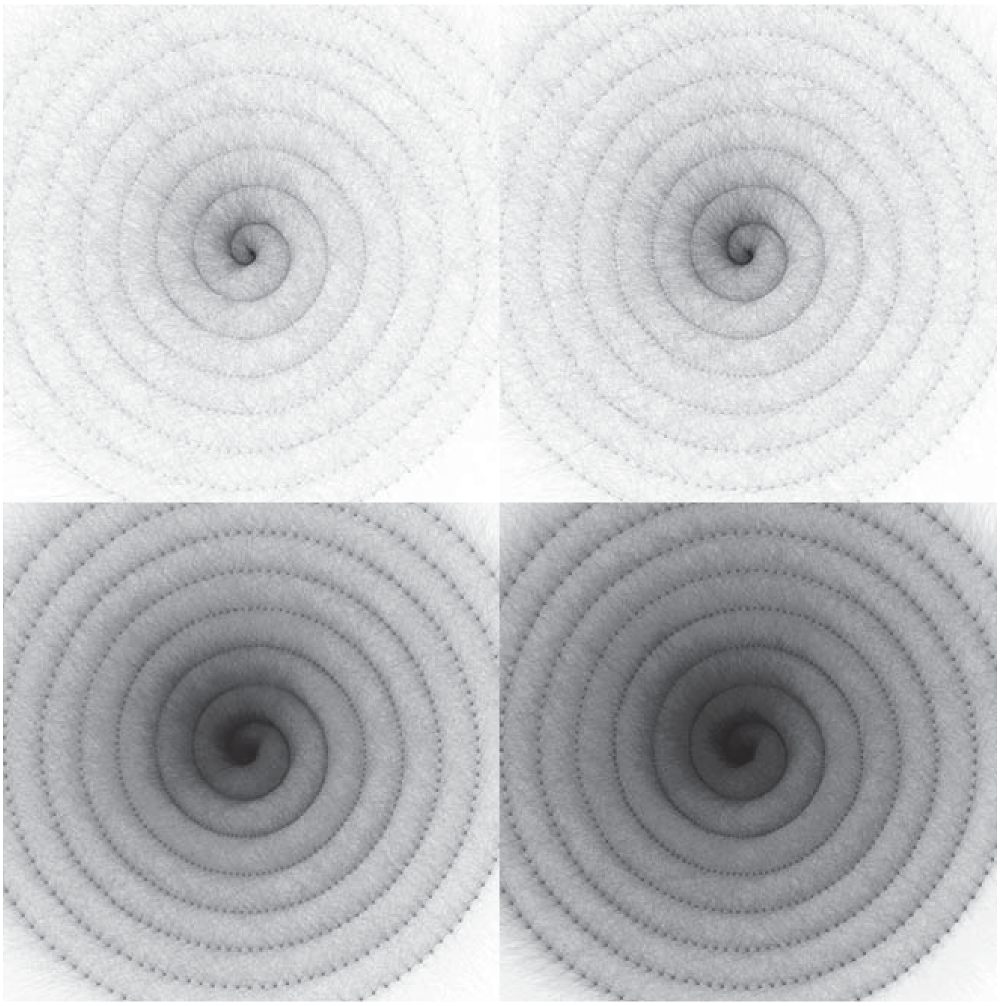

Figure 1. Example of simple artificial ontogeny producing the appearance of soft paper texture with gentle pillow-bevelling effect. Captured intermediary states illustrating various phases of development.

Using the same basic principles, but varying some of the interaction rules between agents may result in quite different results. By restricting the change in direction so that line agents diverge within a limited range on one side only of the circle agent will convey depth rather than the pillow-bevel effect (see figure 2). By varying the range of line length randomization, the depth of the resulting spiral structure can also be manipulated.

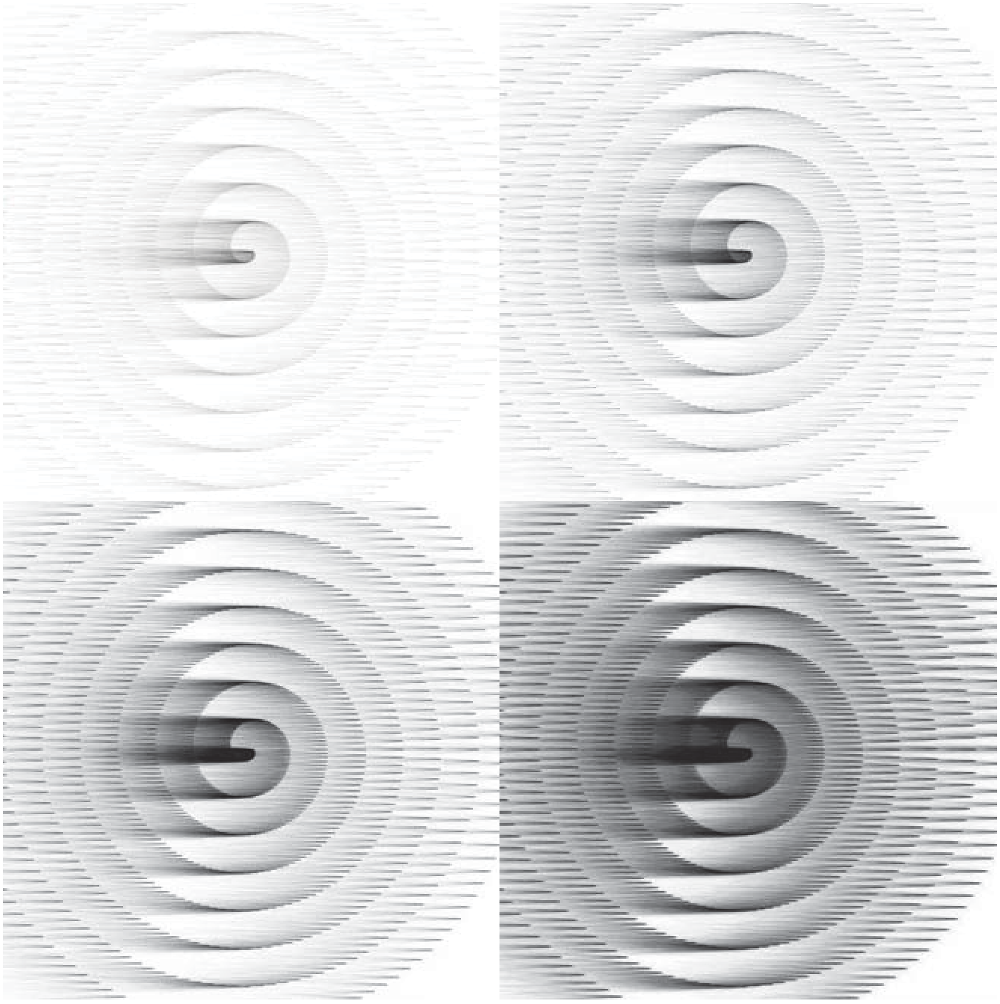

Figure 2. Example of simple artificial ontogeny producing the appearance of depth in the spiral structured form. Captured intermediary states illustrating various phases of development.

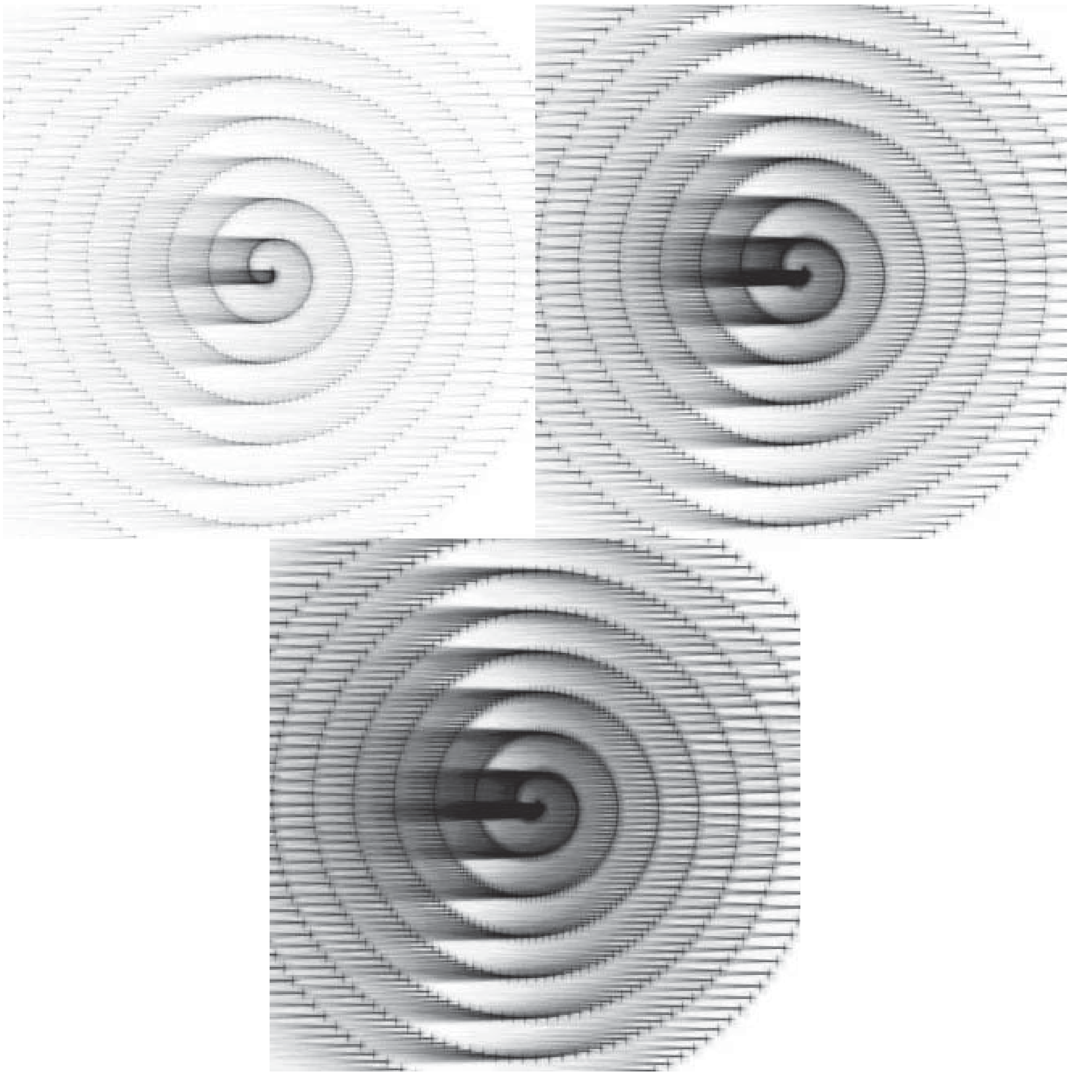

Figure 3. Parametric manipulation producing depth variation in the simple artificial ontogeny presented above. Captured intermediary states illustrating various phases of development.

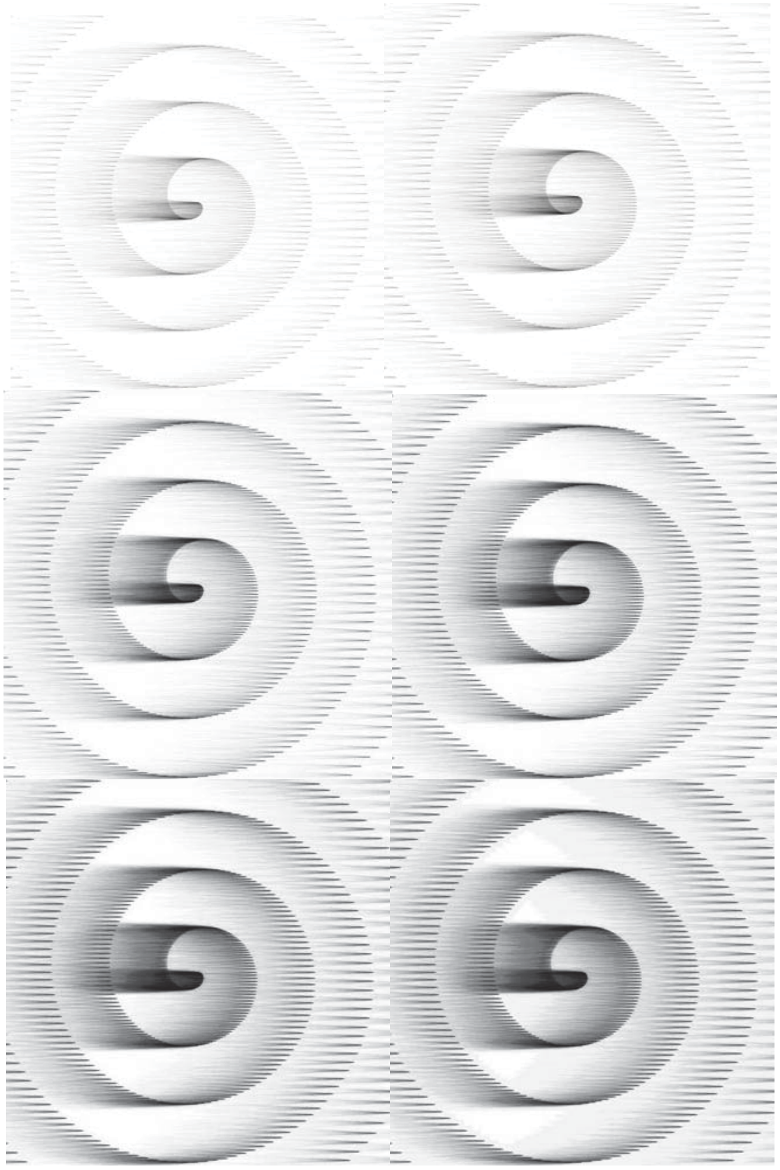

Figure 4. Parametric manipulation producing depth variation in the simple artificial ontogeny presented above. Captured intermediary states illustrating various phases of development.

5. A Generative Landscape – Work in Progress

In the previous examples, the texturing effect and the feeling of volume or depth is built from one cycle to another in a rather linear manner. We try to give a representational touch to the emerging visual composition by creating the backbone structure of a generative night landscape suggesting non-geometrical natural forms and movement. This night landscape is made of generative components, however, some relational elements like for example a sense of separation between the ground, atmosphere, and the sky are predesigned (see Figure 5).

We use, as we did in the previous examples, similar basic agents based on line and circle shape as well as the spiral principle to generate semi-random agent placements along a spiral path. We randomize and vary the randomization range for various parameters to obtain quite different generative forms with slight modifications applied to the same algorithm to convey living natural forms.

By distorting the spiral with Perlin Noise techniques [13], closing the spiral shape, and animating the centre from where the spiral emerges, we can obtain balls of grass-like texture spread over the entire visual field. In order to structure the randomized development of this grass-like texture, we restricted the movement of the distorted spiral centre to a line along the bottom side of the picture plane. This creates the appearance of a field of tall active grass regenerating itself from new positions to shine briefly in the night landscape.

We also convey a sky with shining and fading out moving stars using the same circle and radiating line agent clusters occurring all over the visual field at various distances from one small cluster to another. Also moving clusters of simple circle agents following a given semi-randomized path suggest tree crowns briefly shinning the moonlight. The moon itself is a generative element based on the same algorithm as the grass component, but the spiral remains close and the line agents have a larger variation range. The variation of the line agents' length is the element that makes this an active shining component in the night landscape.

6. Phylogenetic Evolution of Generative Artworks

The previous examples of artificial ontogeny model only to limited degree the kind of growth programs and interactions with environmental constraints that underlie the process by which natural organisms evolve from seed to complex organisms. The morphogenetic capabilities of a species are essential for the species' ability to evolve as a population.

In our model, the structured visual composition resulting from artificial ontogeny represents our artificial organism. This is seen as individual carrying morphogenetic capabilities characterizing a given population of designs or artworks.

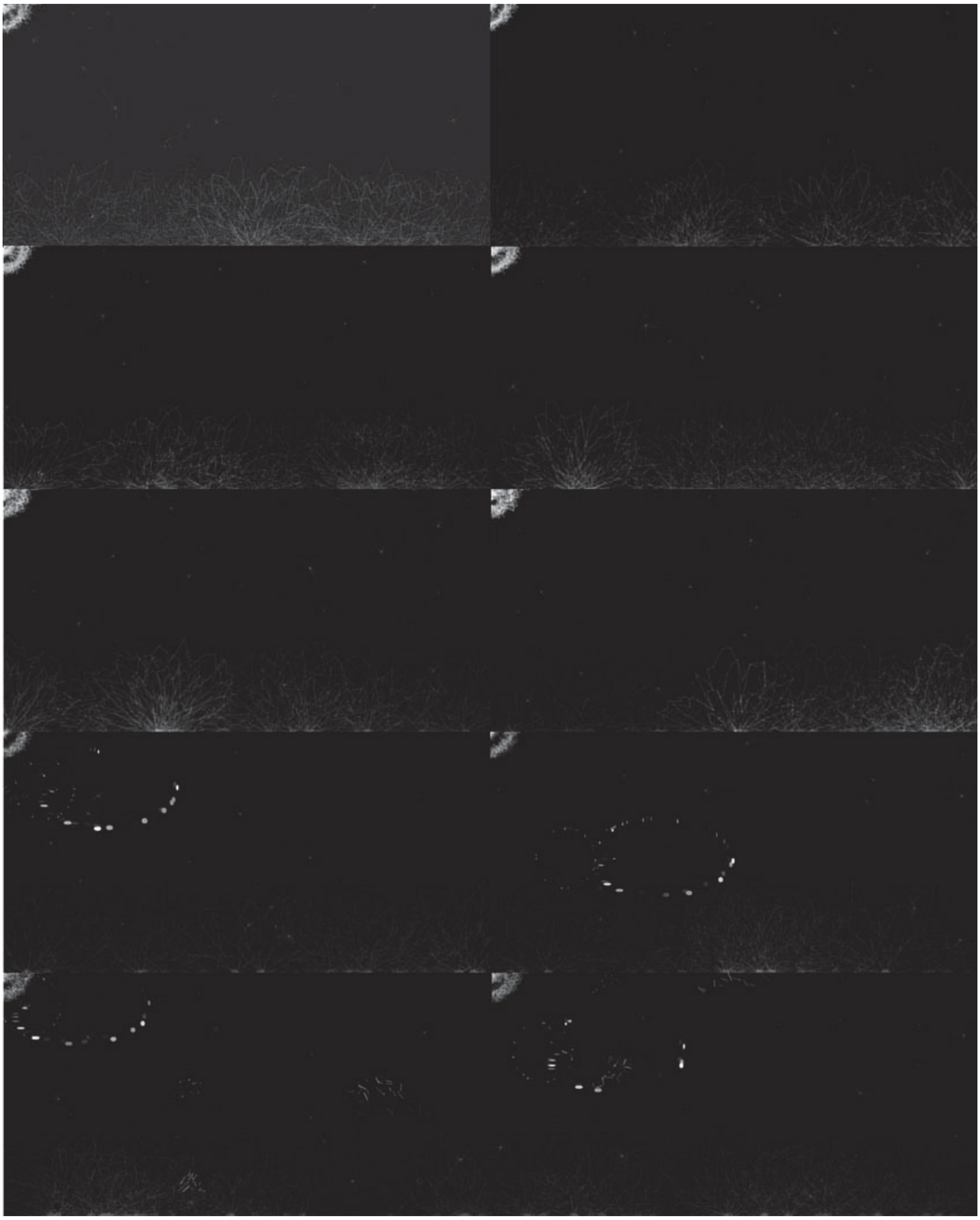

Figure 5. Generative night landscape. Captured intermediary states illustrating various phases of development.

So far, these visual compositions are based on generating a simple emerging form or if multiple generative components are used, like in the night landscape, these are linked through predefined relational components. Further developments of the model require achieving emerging rather than predefined relational elements. These could provide devices to link meaningfully generative components in the structure of the visual composition. It is an important goal to generate visual compositions based on a modular structure organized along directional forces and centres of attraction in the visual field as described by Rudolf Arnhem in his explanation of the structural skeleton of the square or of the spatial organization using such devices as isometric perspective [3]. Modular compositions may also provide a basis for exchanging components and thus create variation in future generations.

Structured modular compositions create a population of flexible adaptive systems capable to evolve in relation to environmental constrains. These constrains could be encoded as rules that express principles of two-dimensional design like repetition, similarity, gradation, radiation, anomaly, contrast and so on. An environmental niche is defined by a partial set of such rules. Visual compositions with modular structures allow reconfiguring the modules along the structural skeleton of the given format in response to changed environmental niches.

7. Artificial Creativity at the Intersection between Evolutionary Computation and Control Theory

Various authors agree [18] that intelligence and creativity overlap to a certain degree, but remain overall different processes. The principal aspect distinguishing creativity from intelligence is what Kris [8] and other authors [9] define as regression into a state of semi-consciousness in order to freely associate and combine ideas in the process of generating new ones. However, testing and validating new ideas, concepts and so on, require long periods of conscious thinking based on previously accumulated knowledge. Intelligence, on the other hand, is always intentional and characterized by conscious thought.

We know that evolutionary processes are blind and that complex organisms and behaviours emerge in a bottom top manner during very long periods of evolution. In order to develop a model of artificial creativity based even lightly on the human model of creativity, it is necessary to combine the two aspects of free association and combination of ideas during regression, which can be largely based on evolutionary computation, with conscious rational thinking during testing and validation stages of creativity.

We think that these two aspects can be linked based on the conceptual framework provided by such a model as the 4D/RCS (Real Time Control System) cognitive architecture for intelligent systems presented [1], [2]. This reference model architecture is based on a theoretical model of the cerebellum, meaning that it is an artificial model of a part of the brain that controls conscious motions and fine motor coordination. The 4D/RCS is a multi-agent system based on hierarchical organization on multiple layers of the computational agents. This system is based on sensory reactive components at the lower levels of the hierarchy while plans of action are generated in a top down manner. We think that such a system may combine generative approaches both at high level for plan generation and low level for emergent behaviour.

8. Conclusion

The present paper maps fundamental concepts in evolution theory, evolutionary computation, creativity, and visual arts and design with the purpose to advance towards a framework for artificial development of visual design and artwork. The next step is to formalize these mapping concepts as a step towards laying down the backbone for developing artificial adaptive systems capable to evolve artificial art and designs.

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