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A Conceptual Framework for Artificial Creativity in Visual Arts

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Abstract: The present paper introduces the conceptual framework for an artificial system for visual creativity addressing the idea of niche creativity that is domain specific and non-anthropocentric in its conceptual approach. We think that the visual creative output of the system reflects the artificial medium and the specific artificial processes engaged in its production and, therefore, it is an expression of the idea of embodied creativity with the proposed system offering in this sense an example of digital embodiment of creativity. Although our approach to artificial creativity is non-anthropocentric, the system design is inspired by processes in the natural world that lead to the production of new and useful structures in both living and non-living systems with human creative cognition being included among these processes. The main problem raised by this abstract approach to artificial creativity in visual arts is the compatibility of its artistic production with human aesthetics, the ultimate goal of the proposed system being to produce visual output that would aesthetically engage human visual perception.
Keywords: artificial creativity, computational creativity, stochastic processes, evolutionary computing, multiagent systems.

1 Introduction

Most approaches in computational creativity are concerned with emulating human creative cognition or processes of natural structure formation and growth in living organisms and non-living systems. This goes hand in hand with an equally great effort to understand in more depth these processes and the material base from which they operate and which conditions them. These approaches raise the question if human creative cognition can be emulated in an artificial medium and if such a transfer is the most effective approach to computational creativity. The same question is raised when transferring processes of structure formation and growth from the natural world into the computational medium with the purpose to produce visual output of artistic value.

Our conceptual approach to the design of an artificial system for visual creativity (ASVC) is different from this general trend in the sense that it is more holistic and is abstract in the interpretation of creativity, but remains more specific to the computational medium that embodies it. The purpose of this research is to demonstrate that no matter the form in which creativity is embodied, it is based on stochastic processes at its core, although the nature of its embodiment may affect the creative product due to the nature of influences exercised throughout its development.

We aim to demonstrate that the stochastic nature of processes involved in creativity is what makes this process unpredictable, mysterious, and intimidating and we hope to bring a small contribution in debunking the myth of creativity and accept creativity as a natural part of everyday life just as much as intelligence and the very fact of being into the world are natural processes that unfold in a general and continuous process of change.

We recognize the importance of approaching creativity research in interdisciplinary manner considering perspectives from cognitive psychology, neurobiology, learning, and complex systems as it has been previously suggested [13]. This approach allowed identifying some of the main aspects involved in creativity like: memory, divergent thinking, convergent thinking, and flow [13], which appear in previous theories and models of creativity [9], [1], [3], [10], [11], [14], [15], [23], [27], [37], although terminology and descriptions may vary. We also take into consideration Limb's viewpoint [13] that a general theory of creativity is hard to define because creativity is viewed as a "complex" with a multitude of facets involved. However, we think that there are some general principles and processes across many forms, if not all forms, of creativity in living and non-living systems. Our purpose is to identify these general principles and processes and then test their validity empirically through an artificial system for visual creativity. We can then go back to particular forms of embodied creativity, among which human creativity is most important, and analyze their specifics while backed by principles identified through our holistic approach. We also hope this approach provides the basis for a practical approach to developing systems of specialized creativity which are less complex, but effective in their application domains.

We present in this paper the fundamental concepts at the basis of ASVC design and the hypothesis that underlies our approach. We briefly review the means to implement these concepts into an artificial system for visual creativity, and synthetically discuss our empirical approach in testing and interpretation of results and how these support our initial hypothesis.

2 Background

Based on the general problematics identified in creativity research, we synthesize several aspects that are more relevant to our conceptual approach. There is a model of creativity based on four main stages [47] identified as preparation, incubation, illumination, and verification. This model is largely based on narratives from creative people [31] and therefore it is rejected by some authors [48], [49]. However, the model has continued to gain recognition in creativity research [23], [24], [25], [16], [14], [30] up to the present day. In our perspective, the Wallas [47] model is important in emphasizing stochastic processes at the core of incubation and illumination stages when the creative product is conceived. This view received support from psychoanaltic theories of creativity [17], [18] and through experimental data from more recent research [23], [24]. In this sense, we point out that the concept of adaptive regression [17], [18] describing the generation of new ideas in a process of shifting cognition on a continuum between consciousness and subconsciousness. This shift during creative cognition leads to a state where rules over the knowledge domain are weakened allowing free associations and combinations of mental structures. Therefore the generation of new ideas takes place through stochastic processes under some relaxed influences from the knowledge domain. The domain influence is manifested through the nature of the pre-existing mental structures and the limitations on the associations and combination between them.

Furthermore, behaviorist [4], [37], historiometric [38], [39], [44], and systemic [7], [8] approaches in creativity research link creativity to external factors and lead to evolutionary views of creativity. Natural evolution is intrinsically based on stochastic processes under environmental influences and therefore creativity is viewed as such an adaptive process.

In summary, we emphasize that interpretations of creativity as both intrapsychic and extrapsychic process link creativity to stochastic processes under influences that ultimately express in weak form the domain knowledge. This aspect is taken into consideration in computational models of creativity. It has been recognized [2], [30]- [35] that computational models of creativity based on evolutionary computing paradigms typically build on the Wallas model [47]. Some of these models emulate natural evolution processes without particular reference to human cognition [41], [42]. Other models in this category focus on certain known or assumed processes in human creative cognition e.g. analogy making [28], [29], [14], [29], [22], or curiosity [34], while other models focus on the evolutionary paradigm and define a systematic theory for the development of self-improving algorithms as models of innovation [12].

3 Fundamental concepts in ASVC design

In our approach to artificial creativity, a central idea is that creativity reflects in its processes and output the organization of matter and processes that lead to structure formation in living and non-living natural systems.

We believe that most processes in the natural world are stochastic in nature and pressures exercised due to physical phenomena lead to the formation of structures at all dimensional scales and complexities. These structures have intrinsic usefulness within the systems where they emerge. However, the notion of usefulness is a human construct and responds to human value systems. From a very holistic standpoint, there is nothing more or less useful in nature in the process of change that unfolds on a continuous basis. Forms that seem to be destroyed or disappear under the influence of natural forces are, in fact, simply changing to become part of new structures. Sometimes, or most of the times, we cannot even comprehend these new structures and the processes that lead to their formation due to their very small or very large scales in relation to our plan of observation. This is best described by the fractal theory advanced by Mandelbrot [20] and further developed by other authors [5], and which describes features of self-similarity in natural forms at different scales in the visible world.

Therefore, we believe that creativity, in its strict definition as a process that produces new and useful artifacts, is intrinsic throughout the entire visible living and non-living systems as a process of change and structure formation. As similar ideas are expressed in most areas of human exploration, it is natural to turn to practical means made available in control engineering and computer science in order to empirically explore artificial forms of creativity in visual arts.

The fundamental concept in our approach to ASVC design is to create artificial stochastic processes which are then exposed to the influence of forces within the system leading to structure formation in the artificial world. Our hypothesis is that if influences manifested on stochastic processes are integrated into an aesthetic system that governs loosely the artificial world, then there is a high probability that emerging structures are organized in visual compositions with aesthetic value. This way we unify in ASVC design the stochastic nature of artificial processes with a system of influences that respond to human aesthetics and, therefore, to the idea of usefulness of the ASVC output deeming the system to be creative.

The research approach in exploring these questions is empirical. It is based on applying the principles that we hypothesize to underlie creativity to the development of artificial systems that are expected to have creative capabilities expressed in the production of new and aesthetically valuable visual compositions. These systems are then tested experimentally and results are analyzed based on an aesthetic system adapted to the specifics of artificial creativity.

While the proposed system for artificial creativity is abstract in the sense that natural processes are not closely emulated, the system design is, however, inspired by principles and processes, which are effective in producing new forms in the visible living and non-living systems in the real world.

In doing so, we approach the design of the artificial system for visual creativity using stochastic models based on random walk algorithms and evolutionary computation and create artificial ecosystems in which aesthetic principles are manifested through relaxed pressures on the artificial stochastics. The main research contribution is based on the idea of embedding aesthetic knowledge in the system in a relaxed way that allows great stochastic freedom. This is key for the ASVC capability to generate a large number of new visual compositions with aesthetic value. In this approach creativity is viewed as an adaptive process embodied in an artificial ecosystem with stochastic substrate and functioning for aesthetic performance.

4 General requirements for an artificial system for visual creativity

Based on the problematics identified in creativity research and computational creativity systems, we synthesize the following set of requirements for the ASVC design:

- The system must incorporate in some form specialized domain knowledge, which, in this case, is visual aesthetics.
- ASVC processes that lead to the production of new visual compositions must reflect the knowledge domain.
- The same processes that lead to the formation of new visual structures must incorporate stochastic aspects.
- The system must implement a digital process that effectively executes the drawing/painting as a counterpart of the drawing process in real life.
- ASVC must develop its own visual concepts.
- The system must integrate the computational concept development process and the artificial drawing process.
- The system must develop new visual output through computational processes that are adaptive in response to influences from a given artificial environment.
- The ASVC creative process must be best adapted to the computational medium that embodies it.

These requirements define ASVC creativity as an abstract process that liberally uses a blend of examples of structure formation in the living and non-living systems in the real world, but it is focused on the final product in the sense of synthetic creativity [19], [6] that is typical in the artistic domain.

5 ASVC general architecture

Considering the requirements formulated above for an artificial system for visual creativity, we suggest a generic architecture (Figure 1) that can be particularized for many versions of ASVC depending on computational paradigms employed for the implementation of various components in its structure. This architecture is based on two main components as follows:

- The kinetic drawing systems (KDS).

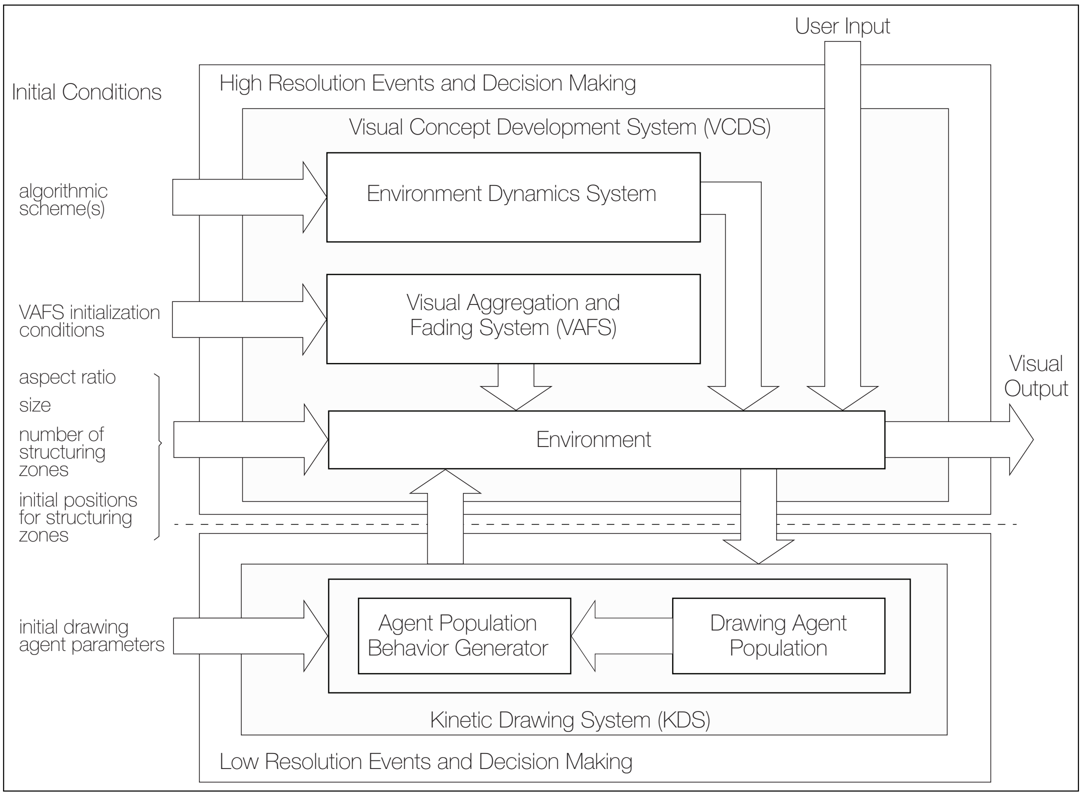

Figure 1: Generic ASVC architecture showing main system components and their functional correlation.

- The visual concept development system (VCDS).

These two main components suggest a hierarchical structure based on generating visual concepts at higher hierarchical level and their implementation at lower hierarchical level. We emphasize that the most important aspect in this architectural organization is, in fact, the level of resolution involved defining ASVC as multiresolution system in the sense described in [26]. In this sense, the low resolution corresponding to KDS is identified through local actions with corresponding small scale or micro influence in the system. The high resolution is related to actions that influence the visual development at large or macro level and this is associated with VCDS (see Figure 1 and Figure 2).

The important aspect is that both the virtual drawing through the KDS and the artificial concept development through VCDS are exploratory in nature being based to a large degree on stochastic processes that are under environmental influences.

6 Kinetic drawing through a virtual ecosystem

To further particularize the description of the generic architecture, ASVC can be described as a virtual ecosystem populated by drawing agents. The motion of the drawing agents in the environment takes place at micro level in the system, which can be associated with a primary perceptual level where drawing agents seem to be independent in their actions, but responsive to environmental influences. The drawing process takes place through recording the motion trajectories of the drawing agents in the system. The motion of drawing agents is self-generated.

Therefore, the KDS output at low perceptual level is influenced by the computational paradigm that underlies agent motion. There are a number of pre-determined parameters that decide the agent appearance, which has a role as a unit form in visual structure aggregation and therefore has impact on the visual output from the system. This aspect is described in more detail with reference to a particular ASVC implementation based on random walk algorithms in [43], but other computational paradigms can be employed.

7 Design principles and visual concept development in ASVC

Aesthetic principles are manifested in ASVC through environmental dynamics. Traces generated by the drawing agents in motion are steered towards aesthetic organization of form aggregations through interactions between the drawing agents and the environment. Therefore, visual concept development in ASVC depends on the structural elements in the environment configuration and the overall dynamics of the environment.

If we employ an evolutionary computing paradigm, which is not mandatory, but is very intuitive, then defining a certain configuration and dynamics for the artificial environment means defining an environmental niche. In this case, the development of a visual concept in ASVC can be described through an environmental niche in the virtual world. We re-emphasize that once the environmental niche is configured and the underlying computational paradigm is defined, this does not mean that the environmental niche is static. By design, the dynamics of the environmental components is largely based on stochastic processes that continuously unfold. This is meant to facilitate within aesthetic constraints a large variety of possible compositional developments.

8 Artificial creativity as a feedback loop system

Starting from the idea that both intelligence and creativity are processes of adaptation to the environment and both are functions of the brain, we can discuss an interpretation of creativity as overlapping in many respects with intelligence as an adaptive system functioning in interaction with a given environment. The main difference between intelligence and creativity is that intelligence operates within the knowledge domain, while creativity operates to expand the knowledge domain. Based on this interpretation, we can adapt the representation of intelligent systems as adaptive feedback loop systems [26] to incorporate aesthetic knowledge and relaxation of aesthetic principles through randomized algorithms at various levels in the ASVC system as presented in Figure 2.

9 Implementations

The conceptual framework discussed in the paper provides the basis for the development of several systems for assisted and autonomous artificial creativity based on random walk algorithms, genetic algorithms, and hybrid systems, which combine several computing paradigms through various components of the ASVC generic architecture presented in Figure 2.

9.1 Random walk ASVC

A Random Walk ASVC (RWASVC) has been developed based on KDS with the motion of the drawing agents based on random walk algorithms. This is integrated with an environment with randomized areas of interaction that fracture the random walk continuity and reinitialize the algorithm with the agent placed in high recurrence areas. RWASVC systems have been extended into hybrid systems that incorporate drawing agents engaged in physical simulation systems in addition to the random walk drawing agent population (Figure 3).

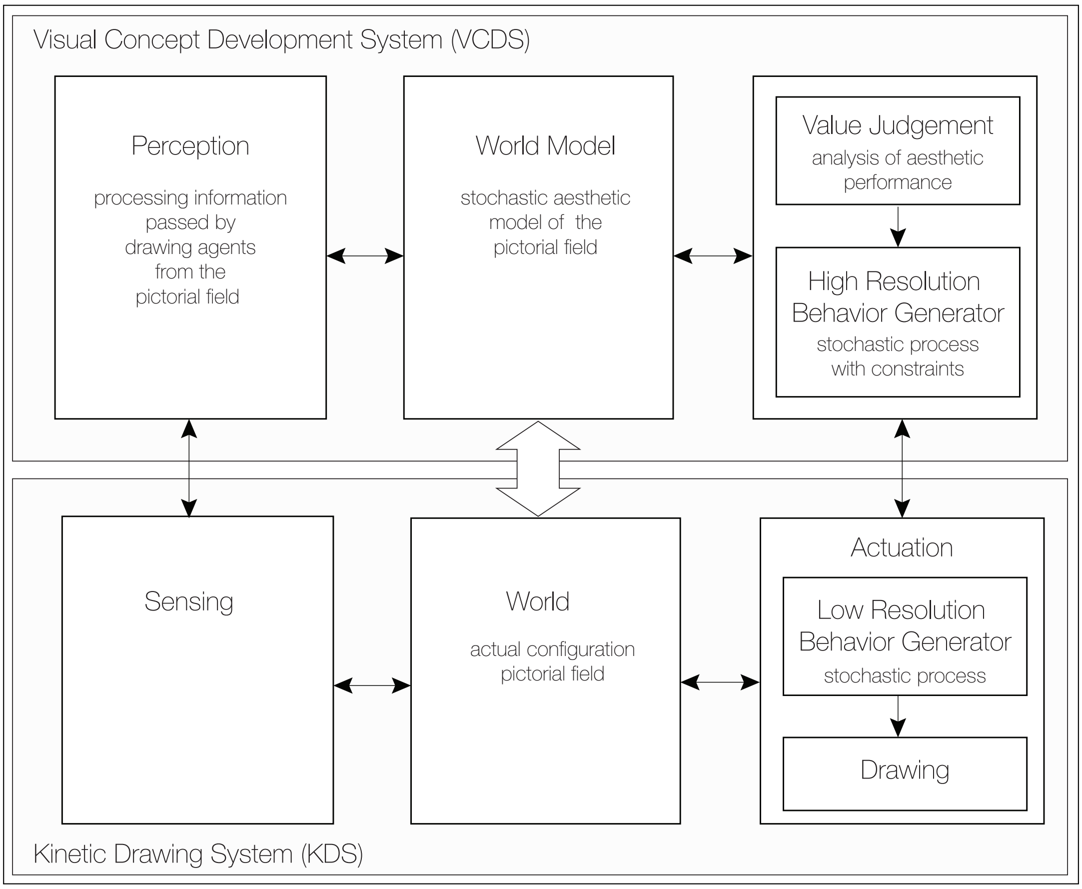

Figure 2: ASVC generic architecture adapted to emphasize computational creativity components and functionality in a feedback loop. This expands computational intelligent system representation proposed in [26] to accommodate rules relaxation over aesthetic knowledge domain in the world dynamics and drawing agents behavior in ASVC.

With this system we obtained the appearance of a natural garden fence with vegetation in continuous growth and having a distribution in the pictorial field that responds to aesthetic principles of visual composition organization. Experiments with RWASVC systems show that for a defined size of the frame of reference and a certain range of proportional relationships with the agent size, these systems are very reliable in producing a large number of visual compositions in a reasonable amount of time. Some recommendations for effective setups have been synthesized from these experiments. Hybrid RWASVCs incorporating physical systems extend the range of visual styles, but more refined correlations of the agent size and numbers must be performed.

9.2 Evolutionary ASVC

A number of Evolutionary ASVC (EASVC) systems have been developed with drawing agents in movement under an evolutionary computing paradigm and with the environment being characterized by non-deterministic dynamics. Experiments with these systems provide very interesting and consistent results based on experimental setups that allow a large degree of stochastic freedom in the environment dynamics and therefore in the visual concept development system of the EASVC. These experiments emphasize that the systems creativity and the output quality

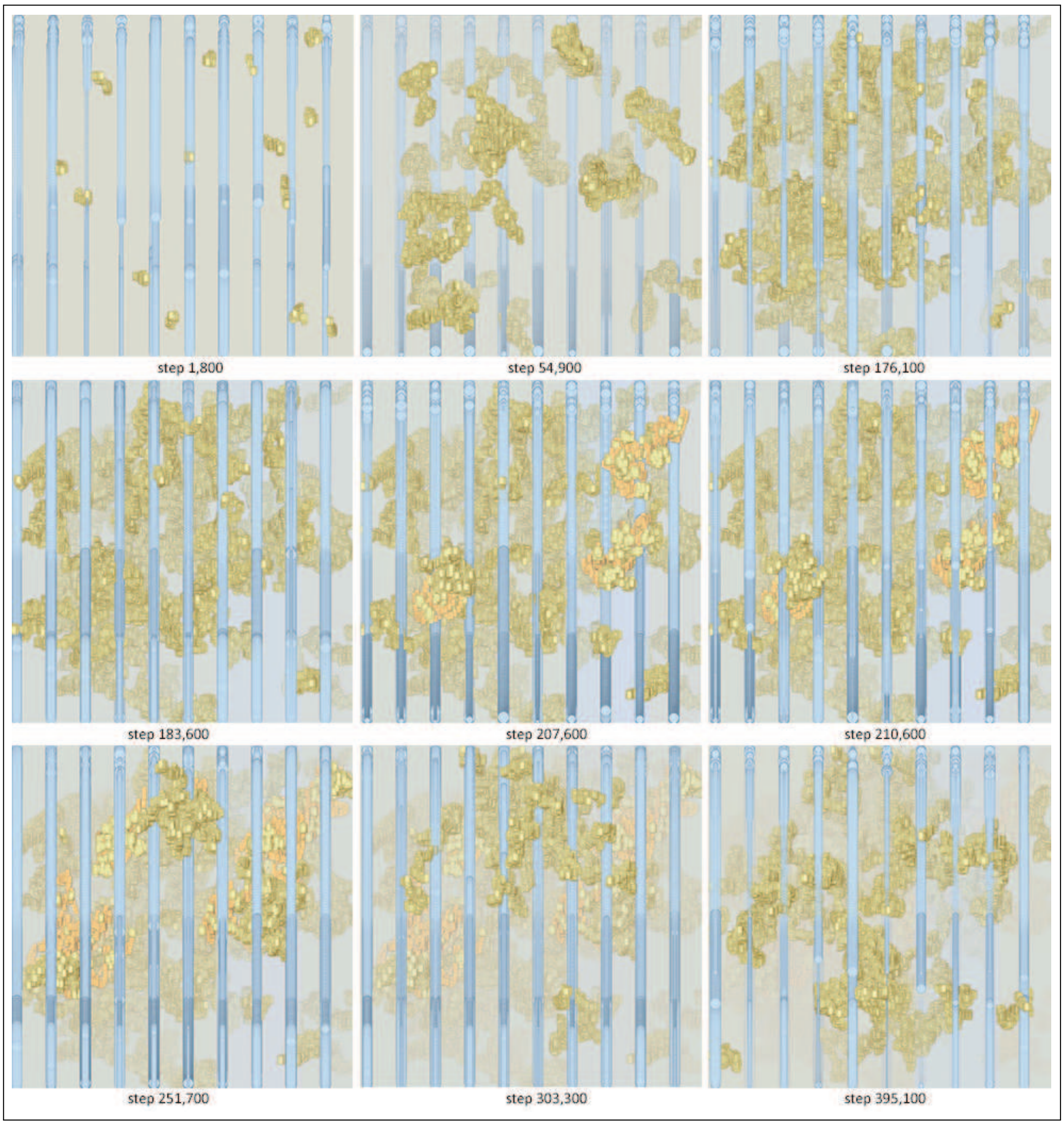

Figure 3: Selected cluster of sampled compositions generated by the hybrid ASVC - version 8 combining a random walk with 14 drawing agents and a physical simulation component with 10 drawing agents. Random walk drawing agent: rectangle, size 15 pixels x 25 pixels.

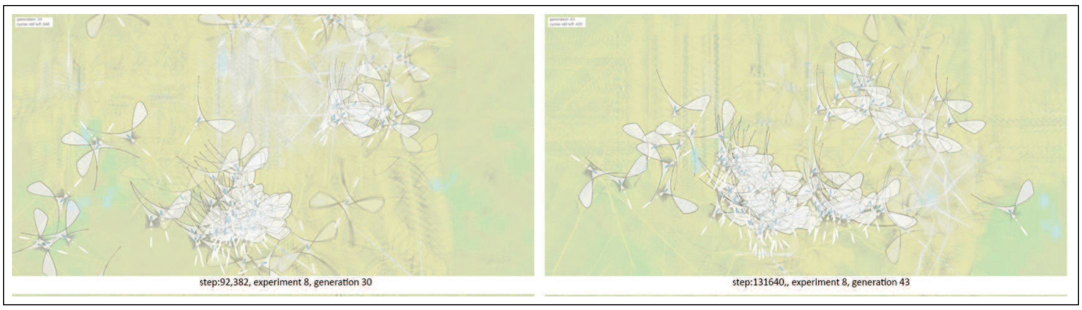

Figure 4: Dominant compositions with dense forms created during experiment number 8 with the EASVC system.

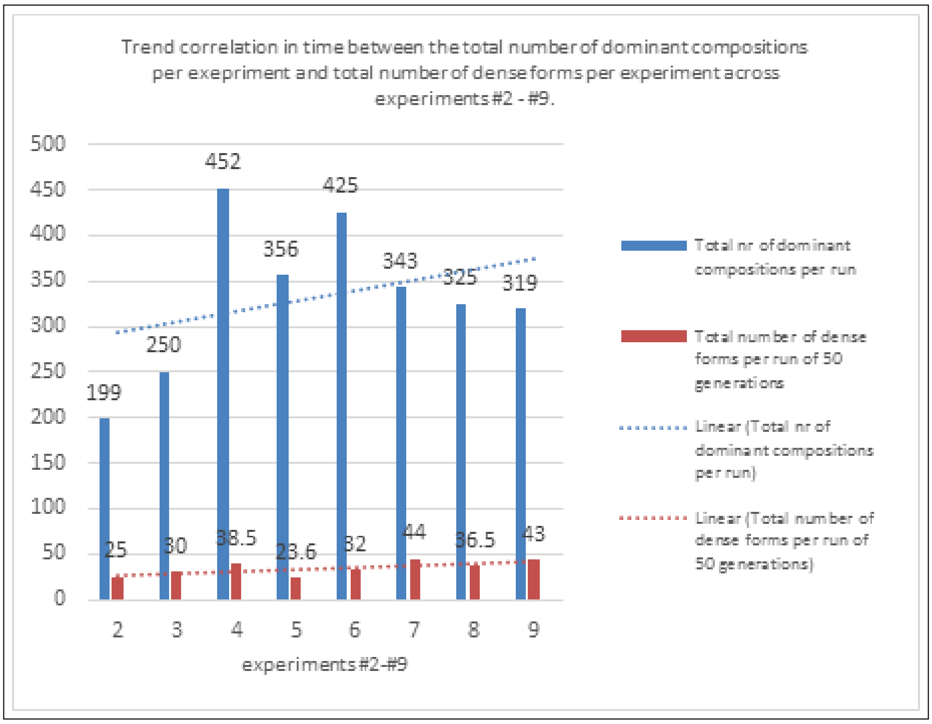

Figure 5: Correlations between total the number of dense forms per run and the total number of dominant compositions per run across experiments 2-9, case study 1. Each run is of 50 generations of drawing agents.

increases when aesthetic rules are loose allowing more freedom in creative combinations and associations of forms. Sampled images from this experiment are presented in Figure 4.

Experimental results are synthesized in Figure 5 showing correlations between the total number of dense forms, which express better quality through better form definition, and total number of dominant compositions, which show quantitative increase of system productivity over generations.

10 Conclusion

We conclude emphasizing that experimental results support our hypothesis that stochastic freedom catalyzes ASVC creative behavior when manifested both at conceptual level (visual concept development through the environment) and execution level (drawing through agents), provided that stochastic processes are under a system of aesthetic influences within ASVC. Therefore, the synthesis of a number of guidelines that allow the computational implementation of general creativity principles allow specialized forms of creative behavior in visual arts to be manifested within a non-anthropocentric ASVC. This can provide a basis for the development of specialized forms of computational creative behavior related to a large range of other application domains.

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