Visual Arts Creation Assisted by BICASSO: Brain-Inspired Computationally Aesthetic Selective Savant & Observer

François Lemarchand

Plymouth University
Plymouth, United Kingdom
francois.lemarchand@plymouth.ac.uk

Abstract

This paper describes the design of a computer program which will assist artists in producing aesthetically interesting pieces of visual art. In contrast of existing creative drawing computer programs, the proposed software will attempt to simulate the creation and perception of visual art. The program, called BICASSO, will be based on previous neuroaesthetics findings which offer an understanding of what the human brain considers beautiful. The program will include features representing the roles of the brain regions enrolled in visual perception, memory and decision-making. BICASSO will modify visual elements of the visual art being created, depending on aesthetic rules to render visual components easy to process by the human visual system. The aesthetic rules rely on the hypothesis that processing fluency and aesthetic pleasure are linked. The artist will give feedback so the program can learn and modify its behavior when its collaboration is not considered beneficial. As the program will only suggest aesthetic improvements (based on its knowledge, and ratings of the collaboration and the final products), we will be able to observe if this asynchronous collaboration can generate creative products which are considered as more valuable to the human eye.

Keywords

neuroaesthetics, collaboration, reinforcement learning, beauty evaluation, combinatorial creativity.

Introduction

This paper describes the specification and early design of a computer program which is currently in development to provide aesthetic expertise through asynchronous collaboration with a visual artist. The software will have its main features based on neuroscience findings. The software will represent the following cognitive phenomena: visual perception, memory, decision-making/learning. While many drawing artificial intelligence entities already exist, and aim to comprehend creativity, we focus on specific aspects of visual arts generation.

This report will first introduce some reflection about creativity and more specifically about combinatorial creativity. We then describe visual perception and related findings in neuroaesthetics in order to provide a better understanding of what is aesthetically pleasant in the visual modality. We will elaborate an aesthetic judgment procedure, as well as a strategy to aesthetically improve visual arts. The word "beauty" will describe a positive physiological reaction when exposed to an aesthetically pleasing visual stimulus, denuded of any embodied experience or context. To conclude, we will enumerate some of the questions raised by the proposed human-computer cooperation in visual arts creation.

Creativity, Neuroaesthetics and Visual Pleasantness

Combinatorial Creativity

The main factors in the assessment of creative works are: the person, the product, the process and the context [1]. A creative product can generally be assessed by its originality, usefulness and whether it is surprising or not. However, a creative product in visual arts does not follow the exact same criteria, as its beauty can be assessed objectively but also subjectively, relying on personal experience.

While novelty is crucial to creativity in general, we argue that novelty is much more valuable in a predefined context rather than in an open problem. For example, twitterbots which generate random sentences or images, are only appreciated by their audience when some context is added by media or history. Talking about contexts, a fundamental principle acknowledges that the social and spatial context will influence the way the audience appreciate visual arts.

One of the most popular strategies for generating creative solutions to problems is combinatorial creativity. This consists of selecting features from two or more existing concepts in order to create a new one. Even though it seems possible to combine features from two concepts, it is much harder to create an image which both respects socially established semantics and is aesthetically pleasing. That is why we decided to focus the project on visual grammar and aesthetic rules that can be used to guide the combination of different components.

While it is still unclear how the human visual system combines visual objects such as geometric shapes, one simple framework describes three different operations to merge geometric shapes (union, intersection and difference), similar to boolean operation on set [2,3]. We can also suggest another framework where two shapes would be combined in the same way as a noun and an adjective interact with each other, meaning that one would act as the main feature while the other would act as a modifier.

The main reason combinatorial creativity is so attractive for the model is that the process and the final product can be broken down into elements, while remaining sensitive to a given context.

Involved Brain Regions & Neuroaesthetics

Existing drawing computer programs and robots such as AARON or Paul do not rely on neuroscience to produce a creative behavior [4,5]. As mentioned previously, BICASSO will learn how to perceive beauty from the user's perspective. Taking into consideration that some objective visual features may help to predict the potential beauty of a visual stimulus.

As in textual pieces of art, grammar and semantic can be dissociated in the visual arts. Grammar is the set of rules about how visual elements are formed and combined, while the semantic is the meaning behind the visual elements and their combinations. Wishing to focus on visual arts, we decided to explore grammar rather than semantics. Perception of visual creative products are influenced by the way the different components of the piece of art are spatially organized and how they interact with each other. The human visual system is sensitive to the way pictures are organized. It implies that artists' decision making process is also altered by aesthetic pleasantness when producing a new painting/drawing, since they evaluate it throughout the creative process. Studies relating to visual perception of art are part of the emerging domain of Neuroaesthetics. This domain encapsulates studies looking for the source of aesthetic pleasantness, whether it is hidden in the semantics or the grammar of a piece of art [6]. Studies in Neuroaesthetics often split pieces of art into two categories: representational and abstract. Abstract works are themselves divided into two types. First, pieces of art which are purely abstract and do not aim to represent a particular idea. Second, artistic works that are defined as abstract, but which still represent concrete objects or scenes in an ambiguous manner [7]. A recent review has emphasized the idea that purely abstract paintings foster unusual conceptual associations, and no specific brain region was activated in relation to their exposure. Whereas in representational paintings, some brain regions are activated by object recognition processes [8]. Indeed, the advantage of purely abstract art is that its appreciation is mostly due to the visual components and their spatial organization.

Looking at a visual piece of art can involve in two processes: “seeing” and “contemplating”. Seeing is the instantaneous and unconscious reaction during the initial exposure to a piece of visual art, which might be more related to visual perception and activity in the visual cortex and the hippocampus. For example, some objective features (such as symmetry) can trigger different reactions. In contrast, during contemplation, beauty (from a subjective point of view) can trigger reactions in the medial orbito-frontal cortex [9, 10]. Indeed, we could define “seeing” as more objective than “contemplating” as the processing is unconscious, with less influences from emotions. Therefore, “seeing” might be more interesting in a computational context as it is more predictable and seems to depend less on the experience of individuals.

Whereas it is possible to analyze the semantic of a drawing, the placement of every visual component can also have its own meaning. The non-understanding of a pseudo-abstract painting can lead to differences in activity in visual brain regions and low activation in the right hippocampus, suggesting difficulties in encoding the scene [7].

Previous studies in neuroaesthetics have demonstrated that symmetry triggers positive feelings and could be used to prime positively the viewers [11]. However, not all types of symmetry have the same effect. Electroencephalogram (EEG) studies have shown that reflectional symmetry triggers stronger reactions, meaning that this type of symmetry could be easier to detect than rotational or translational symmetry [12]. We can suggest that pleasure provoked by symmetry could be due to the fact that visual perception and encoding of symmetric features might be easier than other visual stimuli.

Human-Machine Collaboration in Arts

The fact that visual artworks can be produced by non-intelligent entities is often a cause of discomfort among people, as creativity is considered as intrinsically human. The advantage of the proposed collaborative program is that it suggests computationally generated possibilities which would respect visual perception rules, so that the result looks attractive, pleasant and respects human perceptual grammar. Moreover, it could be used to constrain and modify the creative process such as in a recent example of human-machine collaboration in an enactive model of creativity [13]. In any case, whether the artist decides to follow the software's advice or not, their joint perceptions and memories will be modified and future creative processes will be influenced by prior experience.

Popular Painters, Aesthetic Improvements & Attractive Features

When searching for recurrent aesthetic features in paintings by famous artists, it can be tricky as some artists are known for social or innovative reasons rather than the actual beauty of their works.

While we are attempting to design and build a human-machine collaboration procedure that may improve the aesthetic aspect of the shapes in a visual piece of art, pioneers in computer and algorithmic arts such as Manfred Mohr or Frieder Nake have also explored shape generation with the only purpose of creating aesthetically pleasant artworks. It is interesting to point out that the artworks are fully attributed to the author of the computer program, which may be explained by the fact that the programs were executing tasks and no learning was involved. It would therefore imply that following the rules of a pre-defined visual grammar is not considered as a creative behavior.

While some painters like Wassily Kandinsky created abstract art with the intention of transcribing an idea, other artists only attempted to generate pieces of arts which are the most visually pleasant (e.g. William Dekooning). Paradoxically, Kandinsky's work also contains symmetry (reflectional, rotational and translational) even though it was not explicitly wanted by the artists. Likewise, some shapes in Dekooning's paintings can clearly be interpreted and identified as objects or animals. Even though these are only two examples, we can suggest that whatever the painters' point of view is towards abstract art, artists will tend to implement some symmetric and prototypical features in their arts [14].

When observing paintings, it is possible to distinguish some salient features that will attract the attention of the viewer. Francis Bacon was known to include more or

less abstract references to the representations of face and body in his works, which would intrigue the viewers [15]. In the case of optical illusions, like in the work of Bridget Riley, we can observe that our attention is attracted by a particular feature, but other visual components will become visually attractive as the attention is switched to another area of the painting.
Colors can also be used to influence the viewers' perception and make some components or areas of visual stimuli more salient. It can be noticed in paintings by Piet Mondrian and Brice Marden, for example. Piet Mondrian's paintings have been used to evaluate the importance of color in the global balance of a piece of art. Concluding that the larger a colored area is, the heavier the given color will be perceived by the viewer. This fact is especially true for red and yellow [16].

Design of BICASSO

The main goal of the project is to implement a computer program which can assist artists in the creation of drawings, while learning and giving aesthetic advice. From now on, our computer program will be defined as "Brain-Inspired Computationally Aesthetic Selective Savant & Observer", BICASSO. The Human-Machine collaboration will consist of having the artist draw a first element and then give control to the computer, which will attempt to find a matching pattern in its memory and make its own contribution by modifying the new element. The artist will have entire control over how much they want to draw before asking BICASSO for advice. The artist will then judge the suggestion and the program will tune its behavior to make the next aesthetic choice better.

As pointed out in a recent review [17], the main features of an objectively beautiful picture are balance and proportion, symmetry, informational content and complexity, contrast and clarity. The visual inputs could therefore be evaluated depending on those parameters but also depending on its prototypicality, as it has been shown that people prefer average-looking faces and objects [18]. Previous behavioral studies by Forsythe have shown that complexity ratings by humans can be estimated with image compression algorithms [19]. It also shows that complexity coupled with structural properties can give better prediction of how likely subjects are to find the visual stimuli beautiful [20].

In the drawing phase, BICASSO will search for patterns matching the new visual element in its memory, and suggest geometric modification which will bring aesthetic improvements to the initial input (Figure 1). The memory will consist of a gallery of images representing geometric shapes, classified by geometric features. The user will then be asked for feedback, allowing BICASSO to tune its behavior using reinforcement learning techniques. The user will then be invited to add other visual elements until they are satisfied with the product.

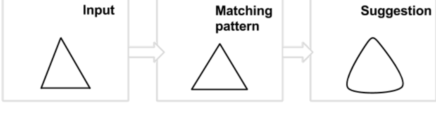

Figure 1: Example of suggestion procedure.

Looking for the most efficient and cheapest way to assess a creative product, a large number of novices have been proven to be as reliable as a small number of experts in term of evaluation of creative products [21]. The resulting drawings could be posted and rated by anonymous users on image rating websites. Our controls could eventually be drawings from the artist only, and drawings resulting from the human-machine collaboration but without any reinforcement learning. The ratings will indicate whether the collaboration is successful and if it improves the artists' creative process. As the model is thought to improve aesthetic features of a drawing regardless of the semantic, the artists will be advised to produce abstract or pseudo-abstract works (e.g. Wassily Kandinsky). While the model follows the artists' ideas, it will permit us to discuss about the influence of the decisions and aesthetic improvements brought by our computer program in the creative process, only relying on the beauty evaluation of the final creative product.

Visual Improvement & Reinforcement Learning

The core of BICASSO relies on its memory, which is represented by a gallery of images, each image representing a geometric shape. Exploiting a reinforcement learning algorithm called Q-learning, each shape is connected to other shapes with similar geometric features, with the strength of the connection (Q-value) representing the possible aesthetic improvement. The feedback will be considered as a reward or a punishment, similar to the dopaminergic system. The system therefore acts to facilitate the most rewarded options. Thanks to this feature, the artist will be able to teach the program and direct it towards suggestions which fit their work. This means that more abstract painters might enjoy some symmetric additions while representational painters might prefer prototypical shapes. Moreover, as there is no absolute beauty and that the suggestions will have to contain similar geometric features as the initial input, our image gallery contains several optimal solutions (considered as goals). The existence of several local goals makes the learning phase of our algorithm significantly longer.

Moreover, one main issue in reinforcement learning is that it initially requires a considerable amount of training before converging towards the expected behavior. To make the training phase faster and avoid asking the user for thousands of inputs before reaching an acceptable training level, the complexity and the structural properties of each shape will be analyzed, in order to select potential aesthetically pleasant shapes. Complexity will be evaluated thanks to the GIF compression algorithm, while structural properties will be represented by the type of structures (reflectional symmetry, rotational symmetry...).

Combinatorial Creation

One of the initial goals of this project is to explore creative decision-making in the visual domain. Once the learning phase complete, the goal will be to expand the image gallery, by combining two or more shapes. Instead of opting for one of the previous solutions enumerated, we will attempt to decompose the existing visual shapes into geometric components, which will then be stored into a library, parallel to the image gallery. While we are exploring multiple ways of achieving this result, one solution would be to extract salient features (corners, curves...) of each shape.

The components in the library will be classified by beauty, and it will then include new visual elements into the gallery of images by matching the visual components of the shapes together. Once included in the image gallery, it will allow BICASSO to build grammar rules, thanks to the user's feedback.

Current Development

In the current state of the project, we have started developing a prototype including the image gallery and investigating ways to make the learning phase faster, as training by reinforcement learning with several goals can be long. BICASSO having no previous knowledge of what is considered as beautiful in its initial state, we are currently attempting to use objective measures (complexity and structural properties) to guide BICASSO in its first choices.

Future Implementations & Conclusion

The main idea of BICASSO is to design a computer program that can mimic the unconscious processing of images, so we can provide artists with a tool allowing them to reflect on their own process. Moreover, the outcome of the collaboration will permit us to have a better understanding on how well our different assumptions fit human visual perception. Saliency is also an element that will be observed in future iterations, as understanding the switch between local and global attention can be another key element to improve aesthetic.

The idea of a human-machine collaboration is also meant to challenge the idea that the author of the computer program is fully responsible for the creative product. The visual grammar that BICASSO will conceive will not only be built on arbitrary beliefs, as it will rely on neuroscience findings. Indeed, it is important to keep in mind that this is a high-level of modelling and therefore, we are implementing our interpretations of the findings.

To summarize, BICASSO will be built from an artificial intelligence perspective, but will appeal to broader audience than traditional studies. Hopefully, it will help to investigate the relationship between visual processing fluency and aesthetic pleasantness. On top of that, it could also be seen as a tool which will help to conceive future experiments about visual processing, from a psychology or cognitive neuroscience perspective.

Acknowledgements

I would like to thank my Director of Studies, Prof. Roman Borisyuk for his help and knowledge, and also Prof. Sue Denham, Dr. Robert Merrison-Hort, Diego Maranan and David Bridges for their useful comments. This work was completed as part of Marie Curie Initial Training Network FP7-PEOPLE-2013-ITN, CogNovo, grant number 604764.

References

1. Mel Rhodes, "An analysis of creativity." *Phi Delta Kappan* (1961): 305-310.

2. Lisa Aziz-Zadeh, Sook-Lei Liew, and Francesco Dandekar. "Exploring the neural correlates of visual creativity." *Social cognitive and affective neuroscience* 8, no. 4 (2013): 475-480.

3. James D. Foley, "12.7 Constructive Solid Geometry", *Computer Graphics: Principles and Practice*, Addison-Wesley Professional, (1996): 557–558

4. Harold Cohen, "The further exploits of AARON, painter." Stanford Humanities Review 4, no. 2 (1995): 141-158.

5. Patrick Tresset, Frederic Fol Leymarie. "Portrait drawing by Paul the robot." *Computers & Graphics* 37, no. 5 (2013): 348-363.

6. Anjan Chatterjee, "Neuroaesthetics: a coming of age story." Journal of Cognitive Neuroscience 23, no. 1 (2011): 53-62.

7. Scott L. Fairhall, Alumit Ishai. "Neural correlates of object indeterminacy in art compositions." *Consciousness and cognition* 17, no. 3 (2008): 923-932.

8. Vered Aviv, "What does the brain tell us about abstract art?." *Frontiers in human neuroscience* 8 (2014).

9. Hideaki Kawabata, and Semir Zeki. "Neural correlates of beauty." *Journal of neurophysiology* 91, no. 4 (2004): 1699-1705.

10. Lea Höfel, and Thomas Jacobsen. "Electrophysiological indices of processing aesthetics: Spontaneous or intentional processes?." *International Journal of Psychophysiology* 65, no. 1 (2007): 20-31.

11. Anna Pecchinenda, Marco Bertamini, Alexis David James Makin, and Nicole Ruta. "The pleasantness of visual symmetry: Always, never or sometimes." *PloS one* 9, no. 3 (2014): e92685.

12. Alexis DJ Makin, Moon M. Wilton, Anna Pecchinenda, and Marco Bertamini. "Symmetry perception and affective responses: A combined EEG/EMG study." *Neuropsychologia* 50, no. 14 (2012): 3250-3261.

13. Nicholas Davis, Yanna Popova, Ivan Sysoev, Chih-Pin Hsiao, Dingtian Zhang, and Brian Magerko. "Building Artistic Computer Colleagues with an Enactive Model of Creativity.", *5th International Conference on Computational Creativity,* 2014

14. Willem De Kooning, "What abstract art means to me." Museum of Modern Art Bulletin 18, no. 3 (1951): 4-8.

15. Semir Zeki, and Tomohiro Ishizu. "The "Visual Shock" of Francis Bacon: an essay in neuroesthetics." Frontiers in human neuroscience 7 (2013).

16. Paul Locher, Kees Overbeeke, and Pieter Jan Stappers. "Spatial balance of color triads in the abstract art of Piet Mondrian." *Perception-London* 34, no. 2 (2005): 169-190.

17. Rolf Reber, Norbert Schwarz, and Piotr Winkielman. "Processing fluency and aesthetic pleasure: Is beauty in the perceiver's processing experience?."*Personality and social psychology review* 8, no. 4 (2004): 364-382.

18. Gillian Rhodes, and Tanya Tremewan. "Averageness, exaggeration, and facial attractiveness." *Psychological science* (1996): 105-110.

19. Alex Forsythe, Gerry Mulhern, and Martin Sawey. "Confounds in pictorial sets: The role of complexity and familiarity in basic-level picture processing."*Behavior Research Methods* 40, no. 1 (2008): 116-129

20. Alex Forsythe, M. Nadal, N. Sheehy, Camilo José Cela-Conde, and M. Sawey. "Predicting beauty: fractal dimension and visual complexity in art." *British Journal of Psychology* 102, no. 1 (2011): 49-70.

21. James C. Kaufman, John Baer, David H. Cropley, Roni Reiter-Palmon, and Sarah Sinnett. "Furious Activity vs. Understanding: How much expertise is needed to evaluate creative work?." *Psychology of Aesthetics, Creativity, and the Arts* 7, no. 4 (2013): 332.