Swarm Intelligence and Weak Artificial Creativity

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Abstract

Swarm intelligence via its infamous struggle to identify a suitable balance between exploration and exploitation phases, provides a valuable mean to approach artificial creativity. This work deploys two swarm intelligence algorithms, one simulating the behaviour of birds flocking and fish schooling (Particle Swarm Optimisation) and the other mimicking the behaviour of ants foraging (Stochastic Diffusion Search) in order to lay the foundation for a discussion addressing the concepts of *freedom* and *constraint* within the topic of creativity in general, and more specifically their impact on the artificial creativity of the underlying systems. An analogy is drawn on mapping these two 'prerequisites' of creativity onto the two well-known aforementioned phases of exploration and exploitation in swarm intelligence algorithms. This is accompanied by the visualisation of the behaviour of the swarms whose performance are evaluated in the context of the arguments presented. Additionally in the spirit of Searle's definition of weak and strong artificial intelligence, a discussion on weak vs. strong artificial creativity in swarm intelligence systems is presented.

1 Introduction

Communication – social interaction or information exchange – observed in social insects and social animals plays a significant role in all swarm intelligence algorithms, including SDS and PSOs. Although in nature it is not only the syntactical information that is exchanged between the individuals but also semantic rules and beliefs about how to process this information (Kennedy, Eberhart, and Shi 2001), in typical swarm intelligence algorithms only the syntactical exchange of information is taken into account.

In the study of the interaction of social insects, two important elements are the individuals and the environment, which result in two integration schemes: the first is the way in which individuals self-interact (interact with each other) and the second is the interaction of the individuals with the environment (Bonabeau, Dorigo, and Theraulaz 2000). Self-interaction between individuals is carried out through recruitment strategies and it has been demonstrated that, typically, various recruitment strategies are used by ants (Holldobler and Wilson 1990) and honey bees. These recruitment strategies are used to attract other members of the society to gather around one or more desired areas, either for foraging purposes or for moving to a new nest site.

The parable of the 'Blind Men and the Elephant' suggests how social interactions can lead to more intelligent behaviour; this famous tale, set in verse by John Godfrey Saxe (Saxe, Lathen, and Chief 1882) in the 19th century, characterises six blind men approaching an elephant. They end up having six different ideas about the elephant, as each person has experienced only one aspect of the elephant's body: wall (elephant's side), spear (tusk), snake (trunk), tree (knee), fan (ear) and rope (tail). The moral of the story is to show how people build their beliefs by drawing them from incomplete information, derived from incomplete knowledge about the world (Kennedy, Eberhart, and Shi 2001). If the blind men had been communicating about what they were experiencing, they would have possibly come up with the conclusion that they were exploring the heterogeneous qualities that make up an elephant.

This paper uses two swarm intelligence algorithms (i.e. Particle Swarm Optimisation and Stochastic Diffusion Search) to present its argument. The scientific merits and technical details of the two swarm intelligence algorithms as well as their integration strategy are discussed in an earlier research (al-Rifaie, Bishop, and Blackwell 2011; al-Rifaie, Aber, and Bishop 2012).

The performance of the swarms herein illustrates the impact of freedom and constraint on the concept of 'creativity'. This work also addresses the issue of weak verses strong artificial creativity.

2 On Creativity, Art and Freedom

For many years there has been discussions on the relationship between art, creativity and freedom; a debate elegantly encapsulated in the famous German prose by Ludwig Hevesi at the entrance of the Secession Building in Vienna:

> *"Der Zeit ihre Kunst*
> *Der Kunst ihre Freiheit"*

That is: "To Time its Art; To Art its Freedom".

Which, centuries after, resonates an earlier observation from Aristotle (384-322 BCE) (Etzioni et al. 2007) emphasising the importance of freedom (here, having "a tincture of madness") in presenting a creative act.

"*There was never a genius without a tincture of madness.*"

On the other hand Margaret Boden, in (Boden 2010), more recently argues that creativity has an ambiguous relationship with freedom:

"*A style is a (culturally favoured) space of structural possibilities: not a painting, but a way of painting. Or a way of sculpting, or of composing fugues .. [] .. It's partly because of these [thinking] styles that creativity has an ambiguous relationship with freedom.*"

Considering the many factors constituting the evaluation of what is deemed 'creative', raises core issues regarding how humans evaluate creativity; their aesthetic capacity and potentially that of other animals (e.g. as exhibited in, say, mate-selection). Galanter (Galanter 2011) suggests that perhaps the 'computational equivalent' of a bird or an insect (e.g. in evaluating mate selection) is all that is required for [computational] aesthetic evaluation:

"*This provides some hope for those who would follow a psychological path to computational aesthetic evaluation, because creatures with simpler brains than man practice mate selection.*"

In this context, as suggested in (Dorin and Korb 2011), the tastes of the individual in male bowerbirds are made visible when they gather collections of bones, glass, pebbles, shells, fruit, plastic and metal scraps from their environment, and arrange them to attract females (Borgia 1995):

"*They perform a mating dance within a specially prepared display court. The characteristics of an individual's dance or artefact display are specific to the species, but also to the capabilities and, apparently, the tastes of the individual.*"

However the question of whether *'mate selection behaviour in animals implies making a judgement analogous to aesthetic judgement in humans'* is perhaps (pace Nagel's famous discussion 'What is it like to be a bat? '(Nagel 1974)) a fundamentally unanswerable question.

In contrast, the role of education (or training) in recognising 'good' and 'bad', 'creative' and 'non-creative' has been experimentally probed. A suggestive study investigating this topic by Watanabe (Watanabe 2009) gathers a set of children's paintings, and then adult humans are asked to label the "good" from the "bad". Pigeons are then trained through operant conditioning to only peck at good paintings. After the training, when pigeons are exposed to a novel set of already judged children's paintings, they show their ability in the correct classification of the paintings.

This emphasises the role of learning training and raises the question on whether humans are fundamentally trained (or "biased") to distinguish good and/or creative work.

Another tightly related topic to swarm intelligence in this context is the creativity of social systems. Bown in (Bown 2011) indicates that our creative capabilities are contingent on the objects and infrastructure available to us, which help us achieve individual goals, in two ways:

"*One way to look at this is, as Clark does (Clark 2003), in terms of the mind being extended to a distributed system with an embodied brain at the centre, and surrounded by various other tools, from digits to digital computers. Another way is to step away from the centrality of human brains altogether and consider social complexes as distributed systems involving more or less cognitive elements.*"

Discussion on creativity and the conditions which make a particular work creative, have generated heated debate amongst scientists and philosophers for many years (Rothenberg and Hausman 1976); for a theoretical review on 'conditions of creativity', the 'systems' view of creativity, cognitive approaches, etc. see also (Sternberg 1988). Although this paper does not aim to resolve any of these issues (or even suggest that the presented work strongly fits and endorses the category of the 'artificially creative realm'), we investigate the performance of a swarm intelligence sketching system which, we suggest, highlights core issues inherent in exploring conceptual/artistic space(s).

3 On Creativity and Swarm Intelligence

This section focuses mainly on the significance of freedom and constraint in producing a creative work. These concepts are then mapped into the 'Swarmic' freedom which encompasses the freedom and constraint. The final part of this section touches upon the plausibility of producing artificially creative artworks (i.e. weak artificial creativity) using the swarm-based systems.

3.1 Freedom vs. Constraint

Both freedom and constraint have always been at the core of several definitions for creativity. Philip Johnson-Laird in his work on freedom and constraint in creativity (Johnson-Laird 1988) states:

"*... for to be creative is to be free to choose among alternatives .. [] .. for which is not constrained is not creative.*"

In swarm intelligence systems, the two phases of exploration and exploitation introduce the freedom and control the level of constraint. Pushing the swarms towards exploration, freedom is boosted; and by encouraging exploitation, constraint is more emphasised. Finding a balance between exploration and exploitation has been an important theoretical challenge in swarm intelligence research and over the years many hundreds of different approaches have been deployed by researchers in this field. In the presented work, two swarm intelligence algorithms are deployed: the algorithm which is responsible for the "intelligent" tracking of the line drawing is Particle Swarm Optimisation (PSO). This well-known algorithm, which mimics the behaviour of birds flocking, has an internal mechanism of balancing off the exploitation and exploration phases. However due to the weakness of the exploration in this algorithm, our system also deploys another nature inspired algorithm to overcome this weakness – Stochastic Diffusion Search (SDS), which mimics the behaviour of one species of ants (*Leptothorax acervorum*) foraging. Therefore, exploration is promoted by utilising the SDS algorithm, whose impact on different swarm intelligence algorithms has been reported using various measures and statistical analysis in several publications (e.g. (al-Rifaie, Bishop, and Blackwell 2011; 2012)). The technical information on the integration of the two aforementioned algorithms can be found in (al-Rifaie, Bishop, and Blackwell 2011).

In the visualisation, the swarms are presented with a set of points (which constitute a line drawing – see Fig. 1a) and are set to consider these points (one at a time) as their global optimum. In other words, the global optimum is dynamic, moving from one position to another and the swarms aim to converge over this dynamic optimum (Fig. 1c).

In order to visualise the performance of the swarm without the added exploration capacity (via SDS), in Fig. 1b, only PSO algorithm is used to produce the sketch. This experiment is run in order to highlight the impact of the lack of exploration (i.e. 'freedom') induced by SDS.

As stated in the introduction, there have been several relevant attempts to create creative computer generated artwork using Artificial Intelligence, Artificial Life and Swarm Intelligence. Irrespective of whether the swarms are considered genuinely creative or not, their similar individualistic approach is not totally dissimilar to those of the "elephant artists" (Weesatchanam 2006):

> "*After I have handed the loaded paintbrush to [the elephants], they proceed to paint in their own distinctive style, with delicate strokes or broad ones, gently dabbing the bristles on the paper or with a sweeping flourish, vertical lines or arcs and loops, ponderously or rapidly and so on. No two artists have the same style.*"

Similarly if the same line drawing (see Fig. 1a) is repeatedly given to the swarms, the output sketches made by the swarms, are never the same (see Fig. 2 to compare different sketches). In other words, even if the swarms process the same input several times, they will not make two identical sketches; furthermore, the outputs they produce are not merely randomised variants of the input. In order to demonstrate this claim qualitatively in an experiment, the output of the swarm-based system is compared against a simple randomised tracing algorithm, where each point in the line drawing could be surrounded with lines at a random distance and direction.

3.2 Swarmic vs. Random Freedom

This part presents an experiment with the goal of contrasting the behaviour of the swarms to that of a group of random agents. In this experiment, the freedom of the swarm (i.e. *Swarmic Freedom*) is maintained by the swarm intelligence algorithms used in the system, whereas the freedom of the agents in the randomised algorithm is controlled by what we call the *Random Freedom*. These definitions are utilised here to highlight the potential of the swarms in exhibiting artificial creativity.

The sketches in Fig. 3 (left and middle) show two outputs from a simple randomised algorithm when configured to exhibit limited 'random' variations in their behaviour (i.e. there is only small random distance and direction from the points of the original line drawing); comparing the two sketches, we note a lack of any significant difference between them. Furthermore, when more 'freedom' is granted to the randomised algorithm (by increasing the range in the underlying random number generator, which allows the technique to explore broader areas of the canvas), the algorithm soon begins to deviate excessively from the original line drawing. For this reason such randomisation results in a very poor - low fidelity - interpretation of the original line drawing (Fig. 3-right). In contrast, although the agents in the swarms are free to access any part of the canvas, the swarm-control mechanism (i.e. Swarm Freedom) naturally enables the system to maintain recognisable fidelity to the original input. In the randomised algorithm, contra the swarms system, it can be seen that simply by giving the agents more randomised behaviour (Random Freedom), they fails to produce more 'creative sketches'.

The Swarmic Freedom or 'controlled freedom' (or the 'tincture of madness') exhibited by the swarm algorithms (induced by the stochastic side of the algorithms) is crucial to the resultant work and is the reason why having the same line drawing does not result in the system producing identical sketches. This freedom emerges, among other influencing factors, from the stochasticity of SDS algorithm in picking agents for communication, as well as choosing agents to diffuse information; the tincture of madness in PSO algorithm is induced via its strategy of spreading the particles throughout the search space as well as the stochastic elements in deciding the next move of each particle.

In other words, the reason why the swarm sketches are different from the simple randomised sketches, is that the underlying PSO flocking component-algorithm constantly endeavours to accurately trace the input image whilst the SDS foraging component constantly endeavours to explore the wider canvas (i.e. together the two swarm mechanisms ensure high-level fidelity to the input without making an exact low-level copy of the original line drawing). Although the algorithms (PSO and SDS) are nature-inspired, we do not claim that the presented work is an accurate model of natural systems. Furthermore, whilst designing the algorithm there was no explicit 'Hundertwasser-like' attempt (Restany 2001) by which we mean the stress on using curves instead of straight lines, as Hundertwasser considered straight lines not nature-like and tried not to use straight lines in his works to bias the style of the system's sketches.

3.3 Weak vs. Strong Artificial Creativity

Before approaching the topic of weak or strong artificial creativity, the difference between weak and strong AI is highlighted. In strong AI, the claim is that machines can think and have genuine understanding and other cognitive states (e.g. "suitably programmed machines will be capable

Figure 1: (a) Input: series of points that make a line drawing – sample line drawing after one of Matisse's sketches; (b) Output: sketch produced by the swarms without SDS exploration; (c) Output: sketch produced by the hybrid PSO-SDS swarms

(a) (b) (c)

of conscious thought" (Callan 2003)); weak AI, in contrast, does not usually go beyond expecting the simulation of human intelligence. I.e. instantiating genuine "understanding" is not the primary concern in weak AI research.

An analogy could be drawn to artificial creativity, extending the notion of weak AI to weak artificial creativity, which does not go beyond exploring the simulation of human creativity; emphasising that genuine understanding is not the main issue in weak artificial creativity. In strong artificial creativity, the expectation is that the machine should be creative, have genuine understanding and other cognitive states as well as being capable of conscious thought.

Having a machine with conscious thought has provoked many critics, among whom John Searle made the most famous attack against strong AI in his Chinese Room argument (Searle 1980). Bishop (Bishop 2004) summarises Searle's Chinese Room Argument (CRA) as follows:

> The central claim of the CRA is that computations alone cannot in principle give rise to understanding, and that therefore computational theories of mind cannot fully explain human cognition. More formally, Searle stated that the CRA was an attempt to prove that syntax (rules for the correct formation of sentences:programs) is not sufficient for semantics (understanding). Combining this claim with those that programs are formal (syntactical), whereas minds have semantics, led Searle to conclude that 'programs are not minds'. [. . .]
>
> Searle argues that understanding, of say a Chinese story, can never arise purely as a result of following the procedures prescribed by any computer program, for Searle offers a first-person tale outlining how he could instantiate such a program, and act as the Central Processing Unit of a computer, produce correct internal and external state transitions, pass a Turing test for understanding Chinese, and yet still not understand a word of Chinese.

We suggest that Searle's famous thought experiment similarly targets the notion of 'strong artificial creativity'. I.e. Searle using a similar "room" could gets so good at following the rules that the strings of symbols he outputs from the room successfully control a 'Strong computer creative art' system producing works judged to have artistic merit by people outside the room; even though Searle-in-the-room remains ignorant of art and art practise. Hence, until the challenge of the Chinese room has been fully met, the authors urge caution in predicating 'strong' notions of creativity to any computational system.

Figure 2: Swarms' different sketches of a single line drawing. Looking at the sketches although they might look the same when seen in a glance, they are the result of a completely different set of movements by swarm in two independent instances, tracing the points of the initial drawing.

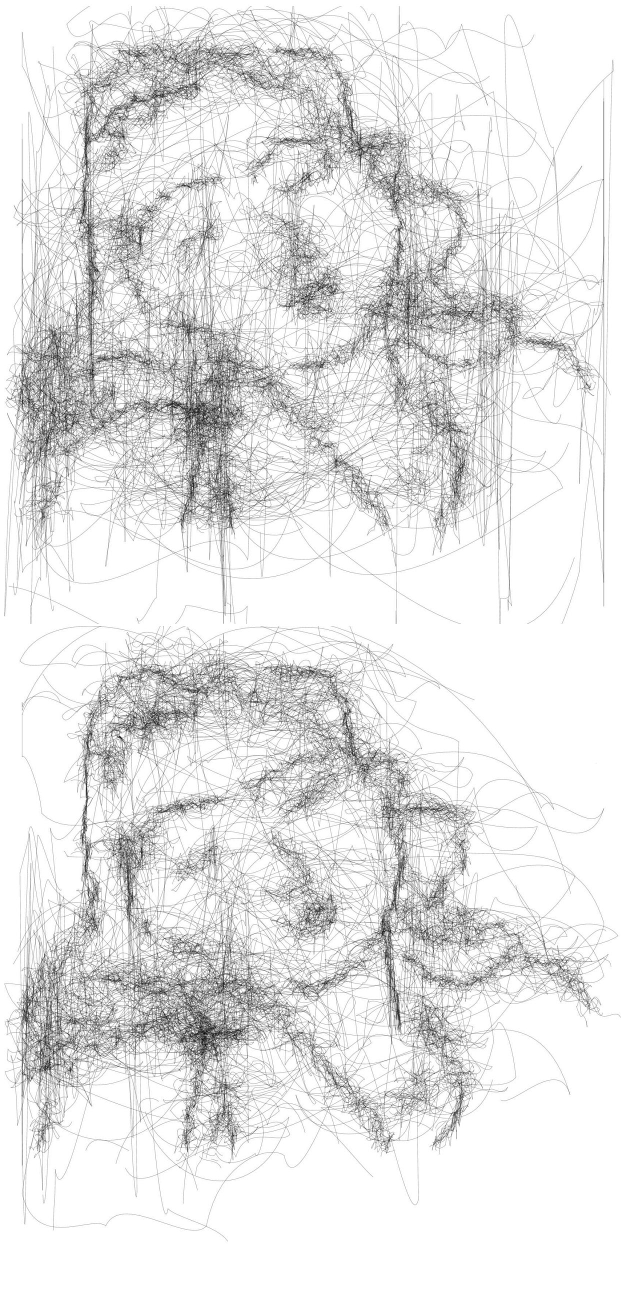
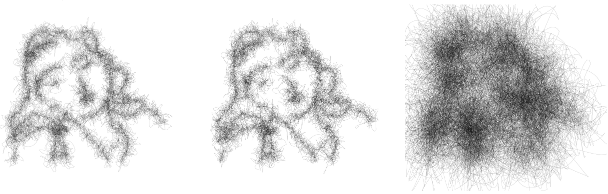


Figure 3: The sketches of the swarms with random behaviour: This figure shows the sketches made with a simple randomised tracing algorithm, using random distance and direction from the lines of the original line drawing. The first two sketches (left and middle) use the same random distance, d, and the right sketch uses the random distance of $d \times 6$.



4 Conclusion

In this paper, we have discussed the potential of the swarms in exhibiting 'weak artificial creativity'. This specific work described herein uses swarm intelligence techniques to explore the difference between deploying Random Freedom and Swarmic Freedom in the visualisation of the swarms 'tracing' line drawings; the aim is to highlight the features of *swarm-regulated difference* versus simple-random difference in the production of such 'sketches' by computer. We stressed on the significant impact of both freedom and constraint on the emergent creativity, and presented a discussion on how these two concepts are mapped onto exploration and exploitation, the two most infamous phases in the swarm intelligence world. The so described artificial artist is the result of merging two swarm intelligence algorithms (SDS and PSO), preserving freedom (exploration) and constraint (exploitation) respectively.

5 CODA

Leit-motif: Although we distance ourselves from claims of strong artificial creativity, in faint homage to Turing's Imitation Game and Harre & Wang's physical implementation of the Chinese room experiment (Harre and Wang 1999), we asked a human artist to adopt the 'style' of the swarms and to produce two sketches (Fig. 4) based on the 'style' of the swarms; the other two sketches are made by the swarms.

Figure 4: Two of the sketches are produced by the swarms and two are made by a human artist.

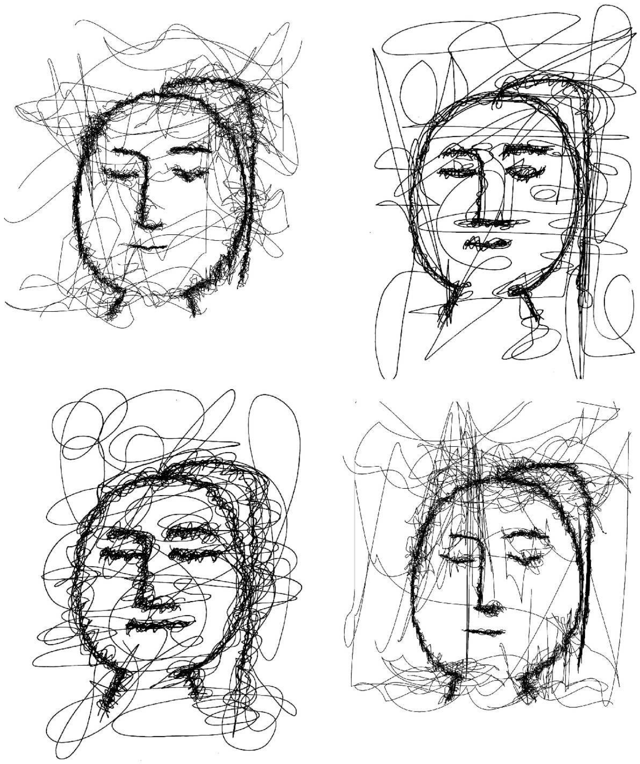


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Figure 5: This figure illustrates the stages during which a sketch is produced by the hybrid swarms.

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