

# Addressing Collective Robotics in Artistic Terms

by

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## ABSTRACT

Collective Robotics has been applied in the last decade in a variety of industrial-military fields. As opposed to this type of applications, it is put forward here a novel approach driven by the unproposeness that is characteristic of the artistic realm. This approach is applied to unmanned painting by using a group of 12 autonomous mobile robots to produce artworks. Examples of such artworks are shown for a variety of combinations of the relevant control parameters and results are discussed on the grounds of man/machine creativity.

## INTRODUCTION

If art is to be produced by mechanical devices, the main point to be addressed is that no teleological setting can be assigned to such an application, given its constitutive purposeless characteristic. When collective robotics is thought as an artistic medium, no ‘utility’ or ‘objective’ function should be considered. Hence, the criteria usually used in the industrial/military domain – where, *ceteris paribus*, a multiple-robot

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system composed of ‘simple’ agents is more effective than a simple ‘sophisticated’ unit ( Beckers *et al.* ) - do not apply.

Also, bio-inspired algorithms that have any flavour of ‘fitness’ in neo-Darwinian terms - like those based on ‘swarm intelligence’ ( Bonabeau *et al.*, 1999) - should be carefully avoided, in the line of Duchamp’s dictum that “art has no biological source”. From Langton’s aLife paradigm (Langton, 1987), the point to be stressed here is “life as could be” and not “life as it is”. However, the idea of process-based or generative art may be grounded on some aLife concepts, like stigmergy (in Grassé’s terms<sup>3</sup>), bottom-up approach, self-organization, non-hierarchy, decentralization, autonomy and interaction between agents via the environment.

Taking these concepts as a basis and Ronald Brooks’ methodology for behaviour-based robotics (Brooks, 2002) as a tool, it was conceived an experiment to perform paintings using a group of 12 robots as an ‘artistic medium’ (Moura&Pereira, 2004).

The experiment consists of performing artworks by means of the interaction, through the environment, of a set of robots, carrying two marking-pens as a painting device. The foundation of the algorithm, uploaded to each robot’s microcontroller through a PC serial interface, consists basically of a positive feedback mechanism that leads to the reinforcement, by a current robot, of the colours left in the canvas by the previous passage of another robot. The process is initialised by a random procedure and it is stopped by the human feeling that the artwork is ‘complete’.

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<sup>3</sup> This means that the production of a certain behaviour in agents is a consequence of the effects produced in the local environment by previous behaviour , *cf.* Grassé, 1959.

## DESCRIPTION OF EACH ROBOT

The basic architecture of each robot contains three components: The sensors, the controller and the actuators. The sensors receive signals from the environment, which are processed by the microcontroller in order to command the actuators, mechanical devices that produce motion.

The sensors are of two kinds: those that receive the signal from the key environmental variable chosen, which is colour, and those that perceive the proximity of obstacles.

In regard to ‘colour’ sensors, there are two of them in each robot, directed to the floor. They are called RGB sensors, because they are able only to distinguish between Red, Green and Blue (Fig. 1).



Fig. 1 - RGB sensors

Each colour sensor is composed by one LED (Light Emmiting Diode) for each colour. In this case, since at the end of the process it is required to discriminate “bright” from “dark” colours<sup>4</sup>, a fourth LED was added, directed to White. The function of each LED is to measure the intensity of reflected light. Given that a surface of a certain colour reflects more intensively the light of the same colour, each LED captures ‘only’ (in practice, ‘mainly’) the colour it is directed to. For each cycle of the sensor, the four LEDs are fired sequentially and an integration of the correspondent intensity values provides the RGB (and White) evaluation of the surface

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<sup>4</sup> “Bright” colour corresponds to an intensity  $< 128$ , encompassing yellow, red and green, whilst “Dark” covers blue, violet and rose.

covered by the sensor. Since there are two sensors of this kind, a new integration is needed before the signal is transmitted to the processor.

In regard to proximity sensors, there are four of them, located in the robot's front. They consist of an IR emitter/receptor that produces a signal which is proportional to the distance from a white wall. Hence, the bounding barriers of the *terrarium* where robots evolve must be white, as well as robots' enclosing boxes. Since solar light may interfere with the sensors, robots should function in a small intensity artificial light setting. The range of distances perceived by this type of sensors is 1 to 15 cm.

The controller is an on-board PIC 16F876 from Microchip, which reads signals from sensors, processes them according to a program, and transmits the result to the actuators. The program is uploaded into the robot's chip, prior to each run, through the serial interface of a PC. This program is developed based on the PC graphic interface shown in Fig. 2, consisting of a flowchart where test blocks for sensors and actuators are combined according to a certain sequence, that can obviously be changed whenever wanted. Each test block compares a given variable with a previously defined control parameter and executes an IF...THEN rule.

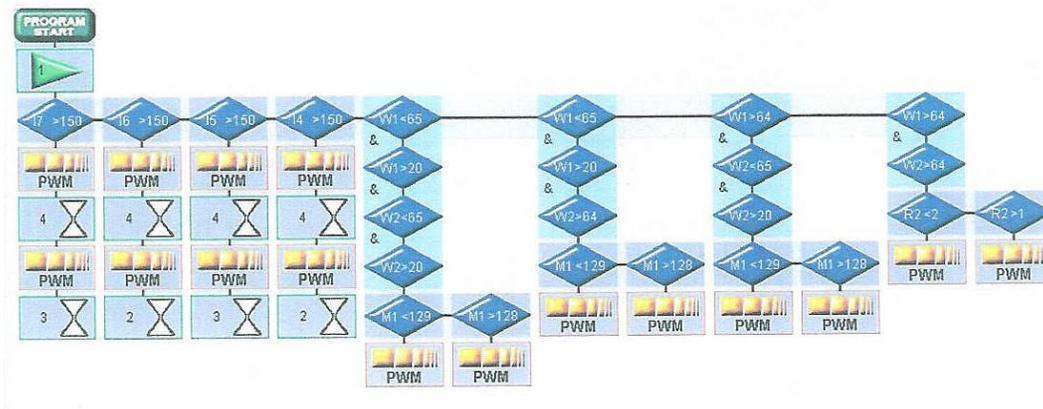


Fig. 2 – Programming graphic interface

The actuators consist of two servomotors producing movement by differential traction based on velocity control and one servomotor for

manipulating the two pens that execute the action of painting. The latter is commanded by a signal analogous to the one sent to traction motors but, in this case, an angular position control is used. The function of this actuator is to rise or drop each pen, according to the signal provided by the controller.

The above described elements function according with the diagram shown in Fig. 3.

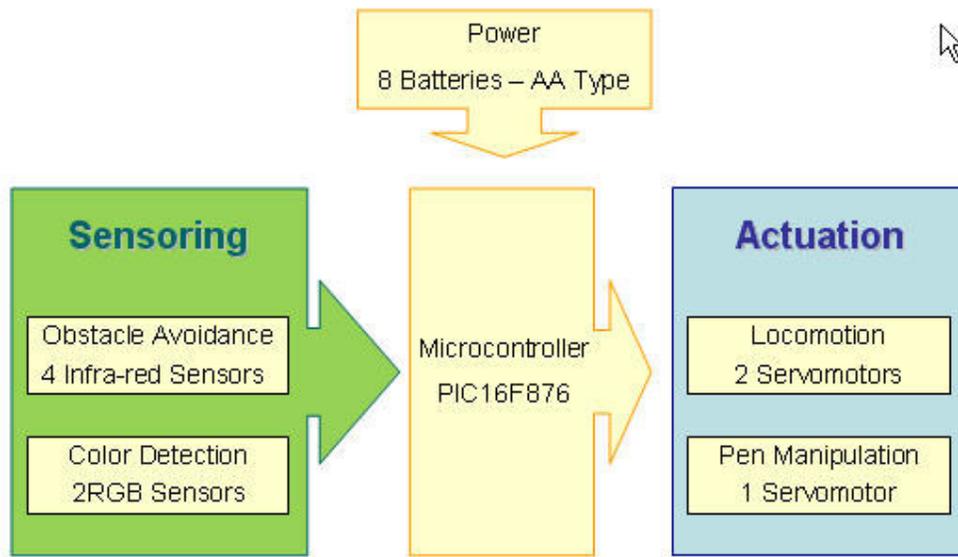


Fig. 3 – Functional diagram of each robot

The chassis consists of an oval 20X15 cm platform, moved by 3 wheels and carrying two pens, as shown in Fig. 4. Each robot is 12.5 cm tall and weights 750 g . The life-time of the robot robot endowed with the 8 AA type batteries is 4 hours.

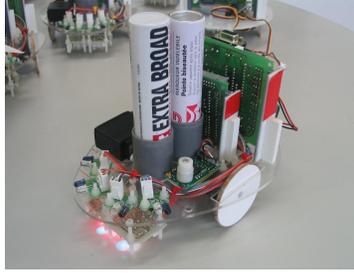


Fig. 4 – General display of the robot

## COLLECTIVE BEHAVIOUR OF THE SET OF ROBOTS AND EXAMPLES OF THE OBTAINED OUTPUTS

Prior to launching any collective experiment, the following procedure is followed:

- Parameterisation of the control program in the graphic interface with the same values, compilation and transmission for each robot.
- Calibration of all sensors of each robot in the programming interface
- Provision of fresh batteries for each robot.

This procedure guarantees that all robots have the same individual behaviour, in order to meet the non-hierarchic requirement. Obviously, autonomy and self-organisation are other pre-conditions assured by this procedure. In regard to how stigmergy is achieved in the experiment, it is worth noting that robots interact only via the environment. In fact, they avoid each other through the effect of the proximity sensors and ‘communicate’ only through the trail left in the canvas by a previous passage. Given that this signal is amplified through the positive feed-back mechanism and that no ‘fitness’ function is included in the process, the problem arises of how to stop the experiment. If the battery power was infinite, the canvas would be completely full after a certain time. Hence, an exterior stopping criterion must be applied. The more ‘natural’ criterion is

the familiar attitude of the painter, when he stands back from the canvas and realizes that the painting ‘works’.

The experiment was performed in the same conditions, driven by the following combinatory of rules (introduced by a trial-and-error parameterisation of the programming interface of Fig. 2, leaded by experience):

- If both RGB sensors read a colour, then the pen whose colour corresponds to the same range as the average intensities is activated and the robot goes ahead.
- If the left RGB sensor reads a colour and the right reads white, then the pen whose colour corresponds to the same range as the average intensities is activated and the robot turns left
- If the right RGB sensor reads a colour and the left reads white, then the pen whose colour corresponds to the same range as the average intensities is activated and the robot turns right
- If both RGB sensors read white, then the random module is fired and a pen is activated with the probability of  $2/265$
- If any of the proximity sensors detect an obstacle nearer than 10 cm, then the robot turns to opposite side of that sensor

Examples of the results provided by this experiment are given in Fig. 5, for a variety of control parameters combinations.

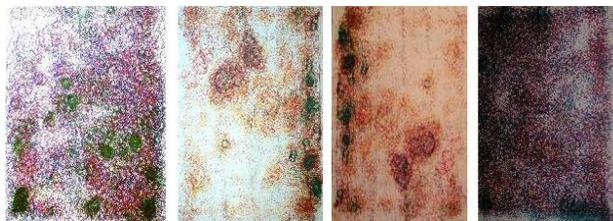


Fig. 5 – Examples of paintings executed by the group of robots

## DISCUSSION OF RESULTS

The results of the experiment are prone to pass the Turing Test for intelligent machines. In fact, it is not possible to discriminate the paintings shown in Fig. 5 from human hand made art.

The case to be made by the proposed approach is that creativity emerges in the set of robots as a consequence of self-organization, driven by their interaction with the environment. Actually, the random walk of each robot is only interrupted by the ‘appeal’ of a certain colour spot, trace or patch that was previously left in the canvas by another robot. Given that the robot only ‘sees’ a limited region of the canvas, if no colour is detected in that region, it follows its way, putting down a mark of its passage only in the case that its random number generator produces a value that exceeds a given threshold, with a small probability ( $2/256$ , in the experiment reported here). In statistics language, each one of the outcomes of the experiment is regarded as the realization of a Random Function (RF), i.e., as a Regionalized Variable (RV). The RF is defined as the infinite set of dependent random variables  $Z(\mathbf{u})$ , one for each location  $\mathbf{u}$  in a certain area  $A$ . In this case, the area  $A$  is canvas, and the random variable is discrete, taking only three nominal colour values – “Bright”, “Dark” and “White”. The underlying feedback process leads to the spatial dependency of the random variables and explains why clusters are usually formed in most of the RF instances. These instances are the mapping of the RV onto the

canvas, depicting its hybrid structural/random constitutive fundamental nature.

## MAN/MACHINE CREATIVITY

From the results of this experiment, one can draw the concept of the **thing who feels**, the **thing that plays**, and, *a fortiori*, the thing – the group of robots – that interacts with the environment in an arty way. This line of thought can be derived from the original idea of Asger Jorn that individual creativity can not be explained purely in terms of psychic phenomena. In his critique of Breton's surrealism, Jorn made the point that explication is itself a physical act which materialises thought, and so psychic automatism is closely joined to physical automatism (Jorn, 2001). What is surprising is that this attitude goes along the fresh approach developed recently by Rodney Brooks in the field of robotics (Brooks, 2002). Conversely, it is worth noting how Brooks's approach influenced computer-based art in its 'materialization' aspect (Shanken, 2001). In fact, the MIT researcher considers that human nature can be seen to possess the essential characteristics of a machine<sup>5</sup>, even though this idea is usually rejected instinctively by our putative uniqueness, stemming from some kind of "tribal specialness".

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<sup>5</sup> A multi-use machine whose adaptableness allows to simulate the environment, in addition to respond to its stimuli.

In spite of its specific character, the proposed art-making mechanism shares obviously some characteristics with a large range of creative activities.

In first place, if the urban science context is called upon, the way robots evolve evokes irresistibly situationists's *dérive*, a haphazard drift in a city performed since the 1950s by any group of persons in compliance with their psychogeographic emotional penchants (Sadler, 1999). Indeed, the positive feedback mechanism may be seen as the drive for revisiting certain spots of the city, which were considered particularly appealing in former passages. In addition, both in the *dérive* and in the robots' pseudo random walk, there is always place for the **surprise** that is the core of art (and of that collective artform developed by situationists by viewing their strolls as an aesthetic experience, *cf.* Careri, 2003). Also, the 'emogram', a map of emotive impressions, produced by the participants in the *dérive*, is the analogue, in urban psychogeographic terms, of the final artwork produced by the robots.

Also, this novel artistic medium may be thought as a way of "using space in order to waste time" - in accordance with Veronique Vienne's dictum on architecture (Vienne, 2000) -, if a *détournement* of such a dictum is performed by adding: "and engendering dreams".

Another way of looking at this experiment is inspired by the surrealists' *cadavre exquis*<sup>6</sup>. This 'game' involved a group of persons that contributed to the eventual collective artwork of which they only knew, until the final outcome, their individual part. When one of the players finishes his contribution, the sheet of paper upon which he had drawn is folded, in order to prevent the next player from seeing the previous composition, except in a small part, which is the starting point for his input to the collective artwork. Similarly, in our experiment, each robot does not have the 'general picture', he 'must' rely on the clue left by a previous passage of another robot.

Giving up definitively of the anthropocentric identitary prejudice<sup>7</sup> that underlies the creation of human-like robots, the points that are retained here from the aLife attitude are *stigmergy* (in Grassé's terms<sup>8</sup>), decentralization, autonomy, self-organization emergence and interaction between agents via the environment.

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<sup>6</sup> The first experience of this type was performed in 1925 by Duhamel, Prévert and Tanguy in literary terms. The first sentence that emerged was "*Le cadaver exquis boira le vin nouveau*".

<sup>7</sup> In regard to the issue of his own identity drift, Duchamp said by 1963 that the notion of anti-art annoyed him because "whether you are anti- or for-, it's two sides of the same thing" (Cameron, 1992). Moreover, he had momentarily 'changed his identity' in 1921, when – as a pioneer of what is nowadays currently performed in the Net – he asked Man Ray to photograph him as a woman named "Rose Sélavy". Also, his famous "Fountain" was sent to the 1917 exhibition of the American Society of Independent Artists by someone called R. Mutt. In fact, Duchamp wrote to his sister: "One of my female friends under a masculine pseudonym, Richard Mutt, sent in a porcelain urinal as a sculpture" (Duve, 1992).

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Also, the case of ‘imitation’<sup>9</sup> is to be addressed here, leading to complexity via the ‘explosive’ accumulation and recombination of simple unitary actions. The positive feed-back, coupled with a hint of randomness<sup>10</sup>, produces novelty by unexpected change in the spatial arrangement of traces in the canvas<sup>11</sup>. Since no pre-defined plan commands the global behaviour of the group of robots, this experiment can be interpreted at the light of Lefebvre’s idea that “*Topos* is prior to *logos*” (Lefebvre, 1968).

Aesthetic creation is defined here as set of transformative rules that claims for a vital examination of all stages of the aesthetical production/consumption process, instead of overrating the output (as used to come about when art was considered as a ‘matter of taste’).

In the scope of the experiment presented here, it can be stated that if an **idea becomes a machine that makes the art**, then there is no point in imitating Nature, but to perceive the “beauty of the idea” (Le Witt, 1967). If a self-referential art that does not care for objects is to be made, then the point is to simulate those artificial features of life (as it could be) that are

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<sup>9</sup> The point of the importance of ‘imitation’ in human societies was raised by the often neglected French sociologist Gabriel Tarde (1843-1904). In Tarde’s approach, what is meant by ‘culture’ stems from the reinforcement of a given stimulus, caused by the imitation of a certain behaviour or idea (Tarde, 1890)

<sup>10</sup> The roots of randomness in art may be found in the technique behind a pictorial practice that appeared in ‘minor’ circles of the Italian 16<sup>th</sup> century mannerism – the “*pittura a capriccio*”. This technique consisted of applying on the canvas, without referent, quick and successive ink spots, “picked up directly from the artist’s mind”. All the ‘automatic’ surrealist approach stems from this basic attitude, by adding sometimes a light psychoanalysis flavour.

<sup>11</sup> According to Duchamp, “art ought to shock”. For Constant, the unexpected and the unpredictable are precisely the constitutive elements of his *oeuvre*.

driven by creativity. And creativity is not the capacity of arranging objects and forms, it is the invention of new laws on that arrangement. Now, in unmanned art, not only the artwork depends on the idea that generated it, but a complete symbiosis occurs between the artist and the machine<sup>12</sup>. The human being behind the idea is the SYMBIOTIC ARTIST, the one who brings about the conditions for ‘situations’ to be constructed.

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<sup>12</sup> Human and robot bodies are ultimately related to a common phylogenetic line: Deleuze & Gutarri’s “Machine phylum”. In the late 1960s Deleuze realized the philosophical implications of three levels of the phase space where man and machines co-evolve. These are specific trajectories, corresponding to objects in the real world; attractors, corresponding to the long term tendencies of those objects; and bifurcations, corresponding to spontaneous mutations occurring in those objects (Deleuze & Guattari, 1980).

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