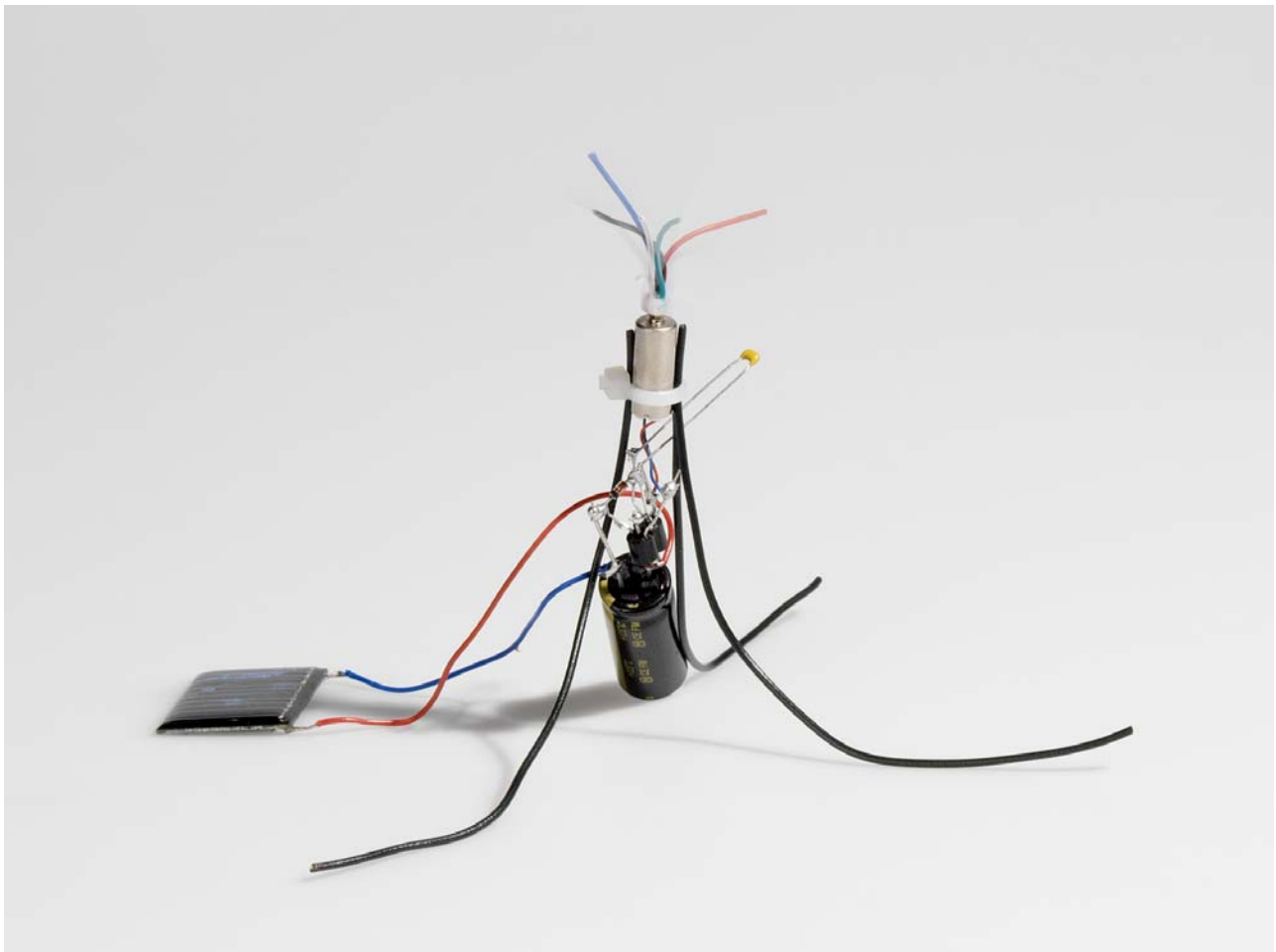


LEONEL MOURA: ROBOTARIUM X

Robotarium X, the first zoo for artificial life, approaches robots very much in the way as we are used to look at natural life.

*We met with **Leonel Moura** to discuss his original take on robotics.*

*Text by **Leonel Moura**, Questions by **Paula Lee***



Leonel Moura

Insect Robot, 2008, electronics, variable dimension Photo courtesy © Leonel Moura Studio

We can only see a short distance ahead, but we can see plenty there that needs to be done.
Alan Turing

Robotarium X is a strong idea with a straightforward production: to create a confined and sunny space for a set of autonomous robots to "live" in. Adopting the aquarium and the zoo as models I wanted to build a similar space focused on the newly born artificial life, i.e. a zoo for robots.

A series of robotic inhabitants provided with the greatest possible autonomy were produced from scratch, then I designed a structure in glass and steel based on one of the Johnson solids known as Bilunabiotunda. Autonomy and self-sustainability are the main concepts of this project, whose operationality depends strongly on the selection of an adequate energy system. It made no sense to use batteries, with limited duration, nor to resort exclusively to direct electric connections, which reduce robot's range. Other forms of energy production, like the use of bacteria that generate electricity, although fascinating, are still in their first steps and cannot produce enough power for a behavior that the human eye is fitted to perceive. Ecobot II, a robot that eats flies and one of the most interesting projects in this area, moves at a speed of 10 cm per hour.

The option was the photovoltaic energy. Solar energy and robotics make a powerful combination. Photovoltaic cells solve the autonomy question satisfactorily and endorse the general tendency for the use of clean and renewable energies. Solar power is one of the most practical and interesting solutions for the construction of autonomous robots. When compared with plant rate of exchange, its performance is already significant. In fact, the majority of plants retain, for their sustainability, less than 1 % of the solar energy they receive, while photovoltaic cells recover almost 15 %. With small silicon cells of 2,5 x 6 cm, in quantities that vary between two and four according to the species, robots can move, avoid obstacles and seek for the places with higher solar light incidence (phototaxis).

The majority of Robotarium X inhabitants belong to the BEAM (Biology, Electronics, Aesthetics and Mechanics) family, meaning a minimum of electronic components, a simple sensor/actuator system and solar power energy. With a small capacity for interacting with the environment, being the current species limited to the detection of obstacles and the search for sunlight, robots cannot do much more than move from one side to another. Provided that sun power is not completely absent, some of the robots are always in movement.

This low agitation is however not relevant. In this zoo life forms are slow, clumsy and unstable. They represent a primitive stage of evolution. But nevertheless we cannot avoid being amazed by its independent life.

To strengthen the idea of a new species I gave a Latin name to each type of robot. Fourteen species were born in a total of 45 individuals, named as follow:

Acrorhinomorpha, Araneax, Biluroseuor, Bucinaderm, Cerahetero, Curovigilo, Pendeopseudosaurus, Procedofrons, Protopedis, Reptumpacatus, Robotapondera, Superinflatas, Techmuris and Zoid.

This classification was based mainly on the morphological characteristics, which were determined by locomotion patterns and also by inner components. Although many of these robots present some similarities with existent animals (for example Araneax has the form of a spider despite having seven legs instead of six), the shape of their bodies resulted from adaptive conditioning. Locomotion modes were important, since associated to servomotors that demand a specific position. And, of course, the placement of the photovoltaic panels at the top were even more crucial.

Morphology was determined by environmental adaptation. If robotic components were left at sight, as it would derive from their condition of electronic and mechanical species, and if legs, wheels, threads and microchips were maintained without any coating, then it would be expectable that robots would be jammed and unable to move. Hence, a relatively smooth skin, was useful to work around this problem. All remaining lumps, feathers and horns, were also placed out of the reach of other robots. The body is adaptive and not decorative. The fact that the artificial finds similar solutions as the natural shouldn't be a surprise. Body building depends more on environmental conditions than on imagination, as seen in the next chapter.

In its essence in terms of an artwork, Robotarium X explores the relation between man and artificial life. It is a dynamic and "lively" piece that questions some conventional ideas about the artistic object and the notion of culture. The Robotarium X is not an installation - in the sense of contemporary art - but a manifestation of artificial living organisms. The shape and space configuration of this artwork is determined, jointly, by robots' "perception" of the movements outside the structure and through random relations among all different species established inside it. Despite intelligence and the general sensorial capacity being small we can say that this "sculpture" is always in a continuous organic mutation, performing a sort of dance in which the choreography is constantly defined by the non-human agents themselves.

The Robotarium X is the first of its kind in the world. Soon there will be similar projects in many other cities and places. Following the dazzle phase provoked by the simulation machine, the next step in human-machine symbiosis will be the issue of cooperation. Men and robots will build together new urban environments and new forms of individual and collective existence. The Robotarium X is an artistic vision of the future.



Leonel Moura

Inside view of Robotarium X © Leonel Moura Studio

The new species

All truth passes through 3 stages. First, it is ridiculed. Second, it is violently opposed. Third, it is accepted as being self-evident.

Arthur Schopenhauer

The Robotarium X assumes robots as a new species, with which we already share the planet. This species is yet at its first steps of evolution and shows many shortcomings. Among other drawbacks, it did not yet develop a true autonomic process. But that is a matter of time, not of purpose.

To show real autonomy, robots must accomplish the following minimum requirements:

- a) Be equipped with an independent body
- b) To accumulate energy by its own means
- c) Be able to gather data directly from the environment
- d) To avoid danger situations, blockage and prevent damaging components
- e) Have the capacity to self-restore small harms
- f) Learn from experience

Only from these basic conditions, a more advanced intelligence, capacity of reproduction and an embedded process of evolution can be considered.

Currently, we are the only evolution agents of robots, doing a job somehow similar to nature, though without the same patience and thousands of years of empirical investment. It is therefore a controlled evolution and, in that sense, rather incoherent.

Most of current scientific investment in this area is directed to top-down creations of configured robotic entities, for the satisfaction of immediate human interests and totally subject to our own will. Humanoid robots, those with more evident public success and a more bright short-term economic future ahead, are meant to reproduce human behaviors and to accomplish some social and cultural functions, such as hard work, public service, elderly and sick assistance and entertainment. To generate a singular robotic life based on such anthropomorphic trends is complex and may turn out to be slower than it is currently advertised. The creation of self-sufficient robots with unique morphologies, simpler emergent behaviors and a more resilient way of life seems to be much more promising. This kind of robotics

will probably stem from recombination between nano and biotechnologies, computation, random and emergent processes.

But futurology is not needed. Current reality is already overcrowded with many intelligent machines, though very gauche and frequently deceiving. Anyway, the new species is born, among us and grows. In a process somehow similar to the Cambrian explosion when Earth is "suddenly" occupied by bizarre life forms, most with strange shapes and feeble sustainability, but that in fact drove the course of evolution. Robots are not far from that, rehearsing the first attempts to its existence. Some may recall the *Hallucigenia*, an unbelievable "thing" full of thorns and tentacles of dubious function, that around 500 million years ago had its fifteen minutes of fame just before vanishing into the deep kingdom of the primitive fossils. Others look like agitated amoebae reacting to environmental stimuli or look like insects, spiders, fishes, dogs or imitate this stubborn anthropomorphism of ours. There are also some that experience the adventure of their own nature and come to light in shapes and behaviors quite unique. All of them set up a new kind of life that is here to stimulate and challenge us.

A kind of life that will only be fulfilled once it manages to acquire its own freewill and be detached from us. I don't fear that moment. On the contrary, the emergence of a new kind of life form, as much or more intelligent than us, will boost humanity's own evolutionary process. Intelligence confrontation means increment of global available intelligence. The process of generating a new kind of nature is thus unstoppable.

The construction of an "artificial nature" is not a novelty in human history. The urban environment, in which humanity lives at present time, is a kind of nature largely artificial, a Nature 2.0.

Cities with their buildings, streets, constructions, networks, communications and endless social and cultural interactions are an invention of our particular form of life. The novelty with the Nature 3.0 that we are now in the process of creating is that it is inhabited by artificial organisms that will compete with us for intelligence, planetary transformation and space exploration. Nature 3.0 competition will not be anymore about territory, food and sex, or in modern terms, wealth, power and sex, but for intelligence amplification. Our loneliness is about to end.

We would like to thank you for the opportunity to pose these questions, the complexities of which reflect the challenging nature of your work. By way of introduction, can you describe how you came to be interested in robotics as an artistic medium, and the process by which you conceived the robots in relationship to animals?

I have always been a conceptual artist, but by mid 1990's I thought that the so-called "contemporary art" was burned out. The dissemination of the Personal Computer and the Internet made clear that art need radical change. Not since artists would now have new tools, but because these new tools fuelled deep implications in knowledge and creativity. Science as changed a lot in the last decades, art not so much. For the first time in history art is staying behind.

This delay stems from some kind of resistance of "humanities" against scientific thought. It is common for artists to utter anti-technological statements that they pretend to be a defence of humans. But in fact they just reflect ignorance and superstition not very dissimilar from religious irrationalism.

In this context I became more and more interested in architecture and science. I have started working with algorithms to generate "buildings" which was feasible in the virtual world but not in the real one. These first rather frustrating experiments helped to define better the new field of interests. Morphogenesis, intelligence and autonomy appeared to me as the key concepts to generate intelligent and autonomous agents able to create their own artworks. Robots were the unavoidable choice.

Later on - to answer to the second part of your question - I started looking at robots as a new species evolving to colonize our planet. Although robots are frequently meant to mimic animals - by simulating behaviours and appearances -, I see them as a distinct species.

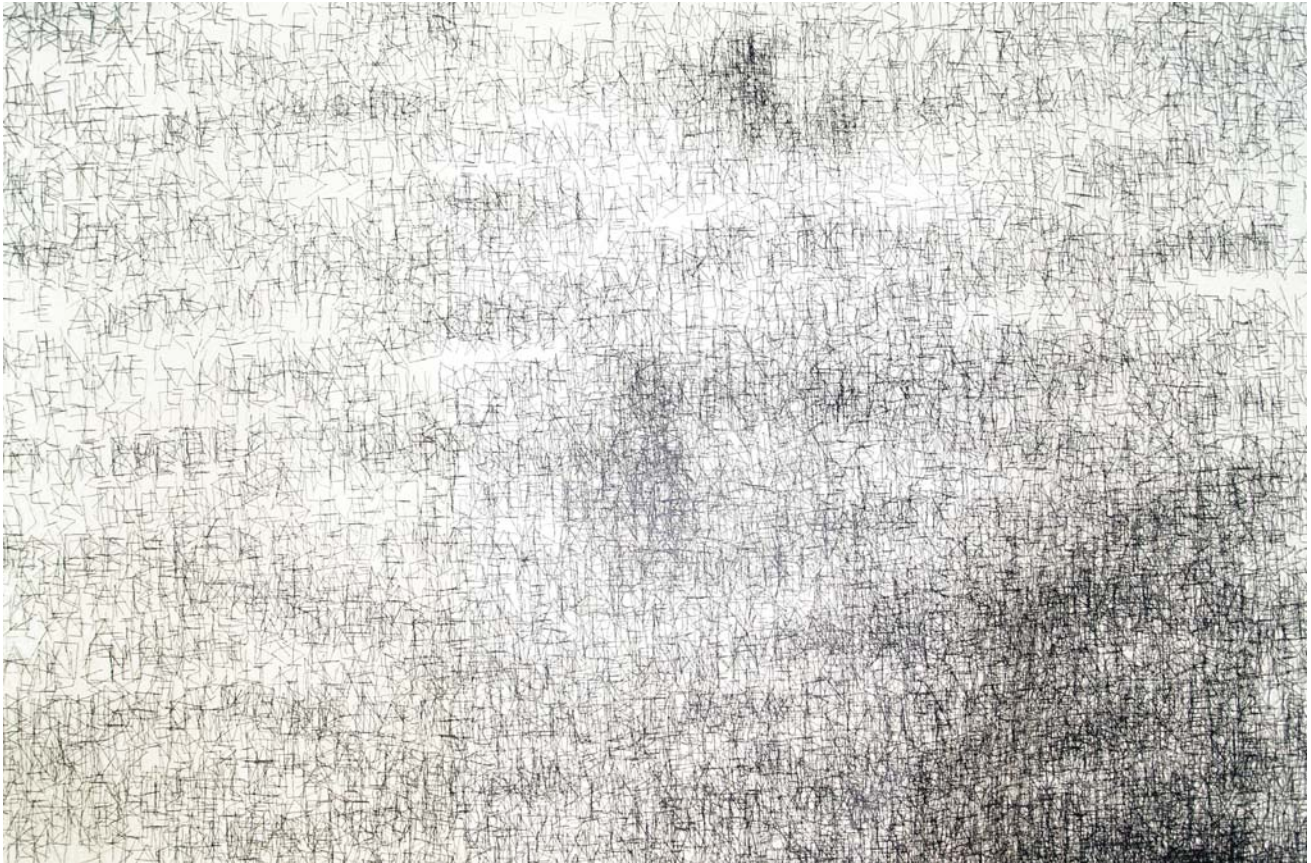
In the post-Cartesian history of modern robotics, "the animal" has served as a model for mechanical systems rather than as part of an embedded environment linked to survival strategies and behaviours. Do you see your robots as challenges to this formulation?

When we shift from the animal as a mechanical model to life as an autopoietic system, we understand that it is not so important to simulate mechanics but rather to trigger self-sustained processes. If we speak about autonomous robots, the question – as Christopher Langton put it – is not life-as-it-is but rather life as-it-could-be.

Let me give the example of the famous – but lost – Vaucanson mechanical duck constructed in the 18th century. This duck seemly could eat and defecate. But the simulation of digestion was in fact nothing more than a clever magic trick, consisting of discarding some kind of pre-prepared material, which looks like faeces.

The most interesting autonomous robots of today are bio-inspired but what they do is not an illusion. It is the real thing.

In 2006, for the Museum of Natural History in New York, you created a work that featured RAP ("robot action painter") who was also



Leonel Moura

Isu070607, 2007, permanent ink on canvas, 250 x 450 cm © Leonel Moura Studio

able to sign its own creations. How much randomness in a process (albeit a programmed randomness) removes the hand of the programmer? At what point does the robot become that which is no longer you or yours, and thus capable of authorship?

My problem was how to build a system able to generate autonomously original and distinctive paintings. Hence, decisive in this robot is not randomness, but its ability to gather by itself the information it needs to build a pictorial composition. What you call the “hand of the programmer” is meant to provide decision making skills, not to give precise instructions.

In this case, it is adequate to put forward the issue of artificial creativity, meaning the ability of a machine to simulate human or animal creativity, but showing also some characteristics of its own (I make an analogy between artificial intelligence as an ontological property and artificial creativity).

One of these characteristics stems from stigmergy. Stigmergy is a form of indirect communication through the environment. The robot only “sees” a small and local part of the painting – the environment – , but that information is enough to generate an original composition that it is not random but also not deterministic. Hence the author of such a composition is

obviously the robot, using some kind of creativity that does not depend on the human action that has launched the process.

A core question posed by the affirmation of the animal as artist (the bee as architect, the bowerbird as builder, the beaver as engineer, the dolphin as dancer, the elephant as painter, etc.), is also provoked by your robots: does must art be informed by intentionality, consciousness, and historicity on the part of the maker, or is the (human) audience’s capacity to provide these elements both a necessary and sufficient requirement to the conditions of art-making? Put another way: can robots be spectators? Does it matter if the robots, like the rabbits in Watership Down, neither know nor care to call the shapes they’re making “art”?

Intentionality and consciousness are not indispensable concepts when we speak about morphogenesis. Termites don't know that they are building their impressive Termitaria. My robots don't have any idea who Pollock was. Anyway, we humans can appreciate what Termites or RAP do, as aesthetical, artistic or creative constructions. The distinction between human art and animal or machine art is the result of the

anthropocentric ideology that has always dominated human religion and philosophy. My work tries to express a critical view to that perspective by making the point that creativity – like intelligence – is inherent to all living organisms, including the artificial ones.

As a way to contextualize robot art, many of your writings invoke Surrealism's exploration of "pure psychic automatism" as affirmed by André Breton. However, a closer analogy to the totality of the installations might be Duchamp's demonstrations of "controlled chance," an experiment later taken up by American avant-garde artists such as choreographer Merce Cunningham. Cunningham's dancers followed movements he patterned but were mutually indifferent; they were free to do what they wanted as long as they stayed on stage, their actions thus defined by the parameters he had set out for them. Your robot installations would seem to inherit the legacy of performance art in an age where chaos theory seeks to complicate linear models of mechanistic determinism. Would you agree with this observation, and if not, why?

I have quoted several times the surrealist concept of "pure psychic automatism" just to demonstrate that art can be made minimizing consciousness. But I would not speak about a "controlled chance" here, because the real issue is precisely to "lose control". Though randomness and determinism – like positive feedback and thresholds – are present in my algorithms, what really matters for the outcome is stigmergy and emergence.

Historian of science Minsoo Kang has noted the robot's "uncanny" ability to blur structural binaries such as human/animal, man/woman, and other artifacts of human culture influentially described by anthropologist Claude Lévi-Strauss. Even as your robots gray the area between man and (other) animals, does this open up the eventual possibility that they will rely on neither for meaning?

I am absolutely convinced that the more robots will become autonomous, the more they will establish their own kind of behaviour, intelligence, creativity (and even individual and collective goals). Some will appear to be familiar to us, in the same way that we tend to anthropomorphize animals and objects. But some will gain distinctiveness and novelty to the point of becoming incomprehensible to us. We will need to build a new science dedicated to the comprehension of robots' behaviour. It could be coined Robotology if the name wasn't already spoiled by a youngster television series.

We pose here, something like a chicken and an egg problem: your writings affirm the robots as a new "species," and link their response habits to

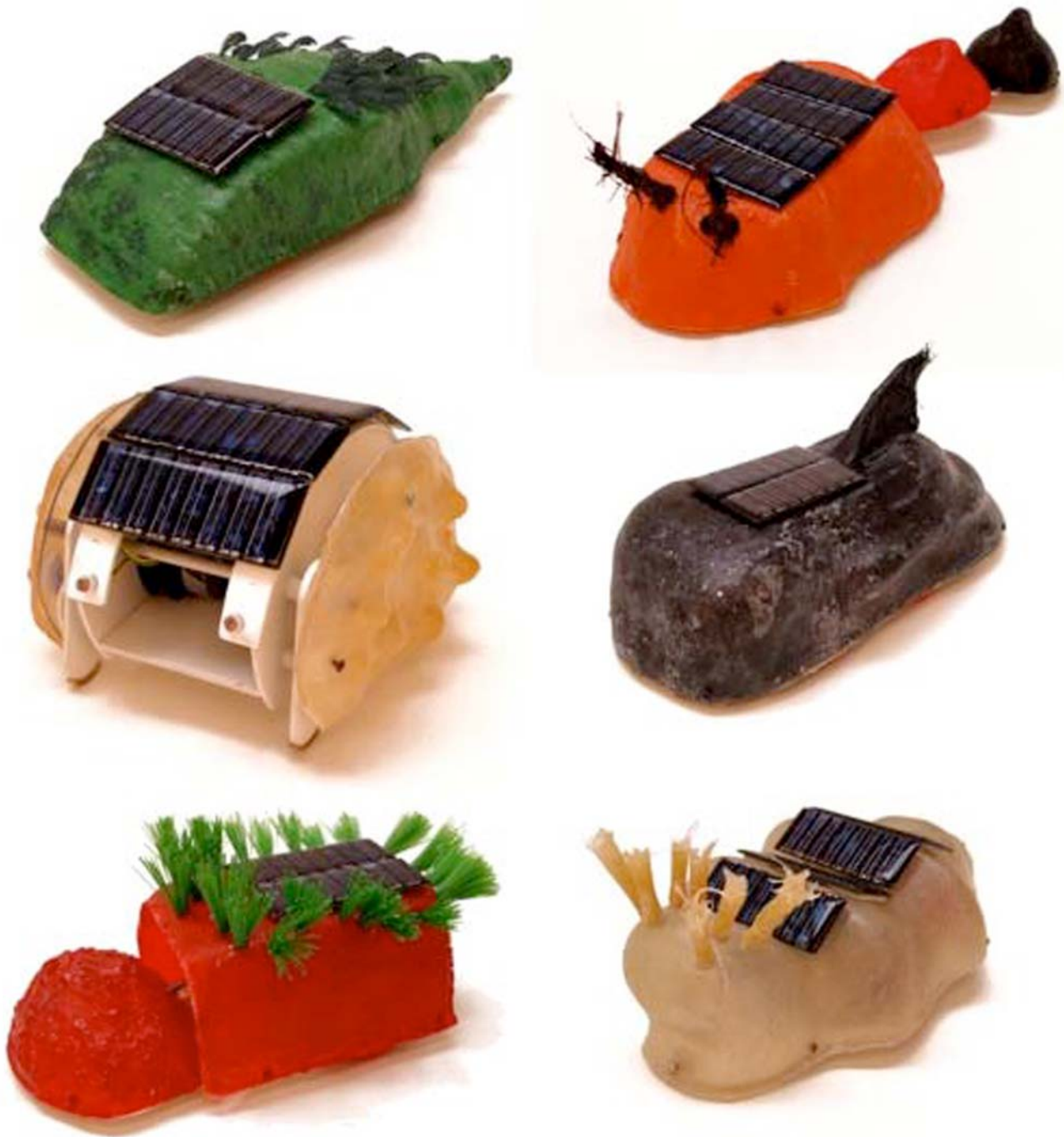
those demonstrated by social insects such as ants. It is arguably to that insecta in general that your robots bear the most physical resemblance. But is it necessary to understand robots through principles of resemblance in the first place? Are your machines meant to mirror biological processes in some way, or is this a corollary expression of other factors?

My model is not based on insects in general but specifically on eusocial insects, such as ants, bees or termites. These particular species have developed a unique kind of social organization based on simple rules, stigmergy, cooperation and labour specialization. I took inspiration from some of these characteristics, aiming at performance rather than resemblance. In fact autonomous robots are still at the stage of a kind of Cambrian Explosion period. From all the current morphologies and behaviours, a few will evolve and most will perish. And of course we have not yet been able to introduce any kind of replication, a *sine qua non* condition for the robots to achieve their own evolution and "biology".

Engineers have created digital evolutionary systems that solve problems in ways humans have never considered, partly because of the ability of machines to process tremendous amounts of calculations without pause. To what extent do you believe that "robots will soon acquire their own freewill and be detached from us?" Is this a poetic notion, or is it truly believed that robots can exist in parallel to humans as autonomous agents?

With my robot RAP I have introduced a kind of freewill, given that it is the machine that decides when the work is finished. This is not done with a quantitative threshold - like time or amount of strokes -, but with a "perceptive" observation of the painting status. If the issue is true autonomy, some kind of freewill must be present. It does not mean, necessarily, our kind of conscious freewill but instead, the ability of a machine to make unpredicted decisions.

Your robot zoo, Robotarium, is a fascinating work, not only because the zoo model fetishizes by excision and isolation, implying that robot life is in need of protection, but it also thus signals that humans and robots are competing for status and resources, and humans are winning. Is Robotarium a form of activism, one that calls attention to our collective limitations, implying that the mutual survival of humans and other creatures depends on competition for finite resources? How much of the "art" here resides in the need and desire our brains have to seek order in the chaos, and the poetic in the ordinary? Is



Leonel Moura

A selection of robots featured in Robotarium X © Leonel Moura Studio

survival of the (robot) species postulated, and if so, how would this affect the politically-charged discourse of species and speciesism?

In fact the Robotarium spreads some flavour of domination, given that the robots are imprisoned inside a cage for human observation. But I would emphasize that our curiosity towards a distinct form of life is the first step for acceptance and respect. In this sense, I advocate an extension of the ecological awareness to include machines. Actually machines are already an essential

component of our ecosystem. It is unthinkable for us to live without them. And terrible boring too.

In Electric Animal, Akira Mizura Lippit posits the animal as a kind of already-undead being, one that is caught in a state of perpetual vanishing due to the incursions of language. The Robotarium might seem to be a commentary on, and a hastening of, the vanishing of animals. Insofar as living animals are going extinct at an alarming rate, do you see your robots as positive

successors filling the subsequent void, or as potential simulacrum hastening the “irrelevance” of carbon-based life?

The fact is that my mind does not work that way. I don't see robots with a minus but with a plus sign. We have humans, birds, fish, bees and now we must add robots. Robots will certainly replace humans and other animals in many tasks and ways, but not inevitably in the context of natural life extermination, which is a direct consequence of human behaviour.

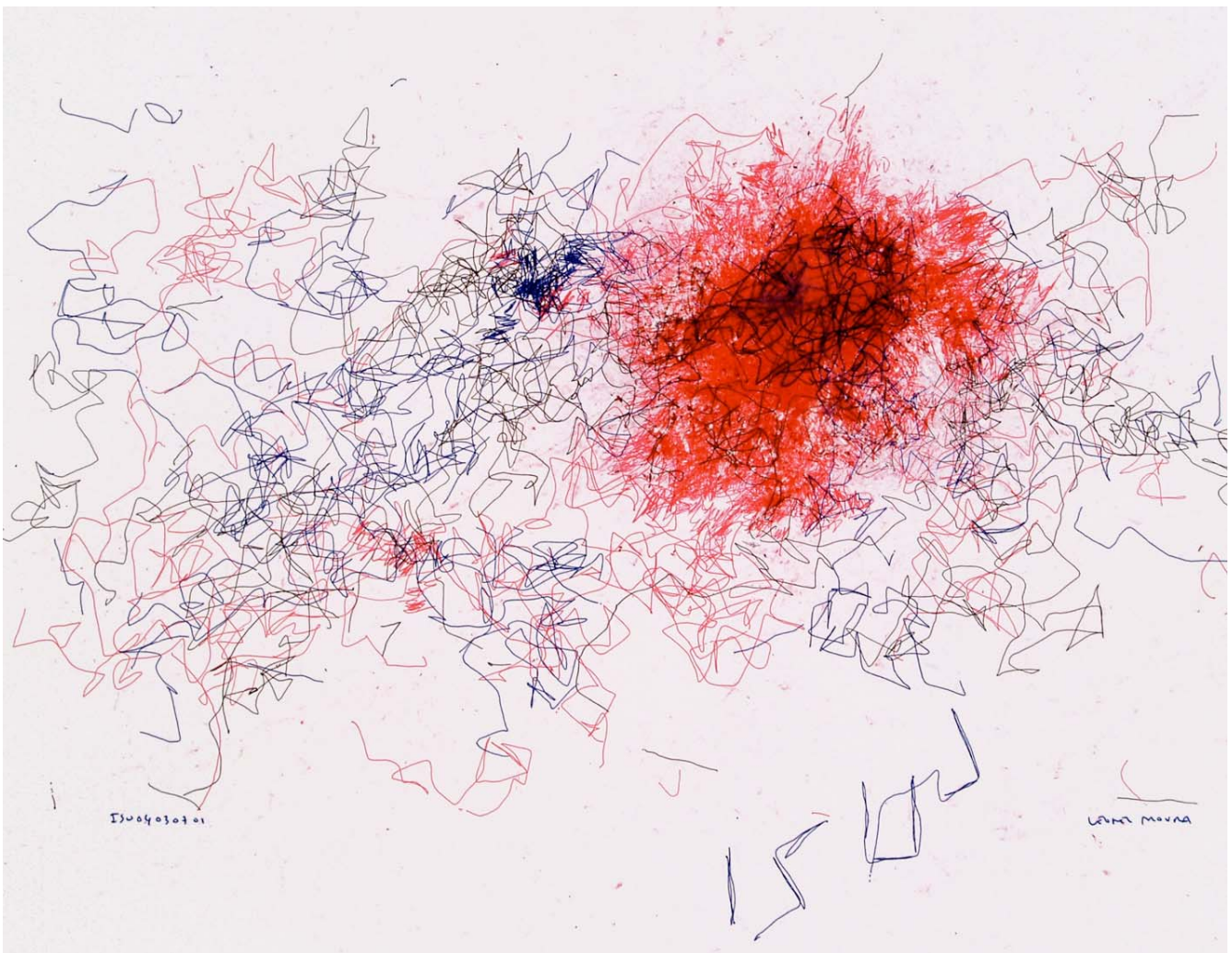
Anyhow, it is not very interesting to look at the rise of robots as a fictional conflict between artificial and natural life. More fascinating is to focus on the various forms of hybridization that are already occurring and will, for sure, increase greatly in the near future. The boundary between artificial and natural is not operative anymore. Just look at the so-called wildlife animals which are walking with a GPS collar around their neck, and cannot survive without the permanent human protection and assistance. Wildlife is now so much natural as it is artificial.

Hybridization affects bodies, minds, behaviours

and also common destiny. We cannot see it just as prosthesis. For example, the role of our first partner in space exploration – the dog Laika -, is now being played by robots. Space exploration will only be possible with the combination of human/robot skills. And probably the most important aspect of our interaction with robots and other very clever machines will be the enhancement of human intelligence.

How important is it to you to erase the boundary between the viewer and the work, prodding the audience into the role of active, invested participant in the aLife of these robots?

So far my focus point has been “taking the human out of the loop”, but the interaction between machines and humans is also an interesting field. Nevertheless, I don't see interaction as human control over the machine but rather as a kind of dialogue between equals, a matter that neither robots nor humans are yet prepared for. Most of the current interaction between humans and machines is a one way process. I am not interested in



Leonel Moura

Isu040307, 2007, permanent ink on canvas, 80 x 100 cm © Leonel Moura Studio

that, and certainly not in art. If there is any novelty in my projects, it stems from the fact that I don't see the machine as a tool, but as an author.

What are you currently working on?

As an artist I want to disseminate the concept of the Robotarium. As an artist/scientist I am developing a new system of painting robots adding specialization to a swarm of heterogeneous robots to see what happens...

Leonel Moura is a European artist born in Lisbon, Portugal, he created in 2003 his first swarm of 'Painting Robots', able to produce original artworks based on emergent behavior. Since then he has produced several artbots, each time more autonomous and sophisticated. RAP (Robotic Action Painter), 2006, generates random poems, very much in the style of the Lettrist Movement and of Concrete Poetry. In 2007 the Robotarium, the first zoo dedicated to robots and artificial life, opened in Alverca. Also in 2007, he inaugurates in Lisbon an Art Space [LMA] to show the works done by his robot artists. Leonel Moura has been appointed European Ambassador for Creativity and Innovation.

Leonel Moura was interviewed by Antennae in January 2009

For more information please visit www.leonelmoura.com