Biting Machine, a Performance Art Experiment in Human-Robot Interaction

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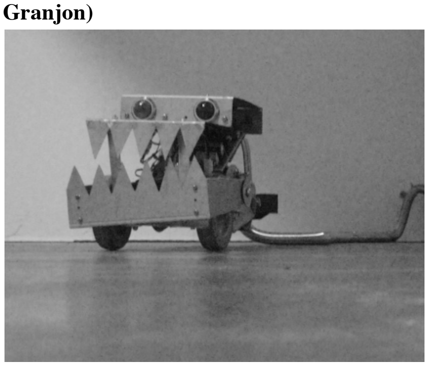
Abstract
The author is a performance and visual artist whose interest lies in the co-evolution of humans and machines, a subject he explores with self-made machines. The paper describes the aims, method, and context of Biting Machine, a performance art experiment in human-robot interaction loosely based on Joseph Beuys' I Like America and America Likes Me (1974) where the artist shared a space for several days with a wild coyote. Biting Machine will be delivered as series of durational performances for an autonomous mobile robot and a human, where the robot will take the role occupied by the coyote in Beuys' piece.

Keywords: Performance, Art, Robot, Artificial Intelligence, Machinic Life, Pickering, Johnston, Beuys

Fig.1. ***Biting Machine 1*****, Granjon and Horio 2008, (© Paul Granjon, photo Paul Granjon)**



Introduction
Since the late 1990s I have defined my artistic research as the co-evolution of humans and machines, based on a strong interest in the way humans create a technological environment of exponential complexity and how the developments of techno-science in turn affect human experience. The subject for future artworks and the selection of technology required to produce them emerges from observing techno-scientific developments and their dissemination. The results of my investigations are presented in the form of performance-lectures and/or exhibitions of machines that aim to provide the audience with material for reflecting on aspects of our ultra-complex techno-scientific lifeworld.

Currently in development, *Biting Machine* is inspired by Joseph Beuys' performance *I Like America and America Likes Me* (1974), where the artist shared a space in a New York gallery with a live coyote for several days. For *Biting Machine* the coyote will be replaced by an advanced autonomous robot which should feature a convincing adaptability and dangerous potential. Beuys' piece was motivated by a critical reading of contemporary western society, particularly how fundamental instinctual values and instinctual relations to nature are being eroded by capitalist society and industrial development. The artist attempted to connect with untainted natural powers by sharing a space-time segment with a wild animal, delivering a comment on industrial society's disconnection from the same powers. The coyote was chosen as a symbol of the primordial force of nature, connected to an ideal, disappearing natural dimension. The *Biting Machine* robot can be seen as a diametrically opposed agent of technique and artificiality, at a time when the complexity of artificial life, artificial intelligence and robotics technologies heralds the emergence of intelligent cybernetic creatures.

One of my first robots was inspired by a tamagotchi, the hand-held virtual pet that was popular with children in the late 1990s. The *Fluffy Tamagotchi* was a reaction against the commodification of the animal companion, bringing back physicality in the toy in a humorous fashion (Fig. 2). Fifteen years later, the *Biting Machine* continues to investigate the possibilities of artificial animals and their relation to humans. If core questions about delegation to machines and about how machines increasingly replace organic functions and creatures are still at the heart of the work, the parodic, tongue in cheek tone of the *Fluffy Tamagotchi* is replaced by an open position. My assumptions about the inherent inadequacy of the artificial animal have made way for questioning a robotic creature's genuine potential for being in the world, sharing presence and territory with humans and animals.

The *Biting Machine* performance is an experiment in human-robot interaction that will generate empirical material for a cross-disciplinary reflection on the ontology of artificial creatures.

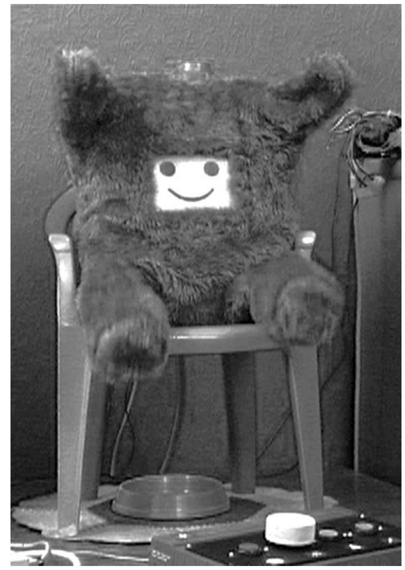


Fig.2. ***Fluffy Tamagotchi*****, 1998, (© Paul Granjon, photo Paul Granjon)**

Simultaneously, the durational unfolding of a performative relation between an intelligent mobile machine and a human aims to create a metaphor for our relation with technology in the age of what John Johnston identifies as 'machinic life'.

I Like America and America Likes Me
Invited to present work in the René Block Gallery, New York, in May 1974, Joseph Beuys' response was a performance artwork called *I Like America and America Likes Me* where he shared the gallery space with a live, wild coyote for seven days and nights. Over that period, Beuys and the coyote developed a form of inter-species relationship. The piece remains one of the most iconic performance artworks of the twentieth century with a wide dissemination of photographic, filmic and written documentation material recorded by Caroline Tisdall [1].

The performance took place behind a floor-to-ceiling fence. Beuys and the coyote occupied one side of the fence while gallery visitors stood on the other side. When Beuys first arrived in the gallery the coyote was already in the space, agitated and exploratory. A constant vigilance is prominent in most parts of the footage. Beuys established a pattern of actions which he repeated during the performance. The coyote responded to the pattern and developed specific behaviours in response, ranging from a playful engagement to plain agressivity. At other times the footage shows the coyote sleeping or lying down. There is no evidence of conflict over territory. Beuys sometimes throws food to the coyote, an element which probably influenced significantly the dynamics of their relationship. By the end of the performance, coyote and man seem to have established a mutually accepting relationship based on a set of significant interactions.

If the wild vitality, the sophisticated physicality and the complex activities of the animal serve as inspirational guidelines for developing the *Biting Machine* robot, the machine is not designed to be a synthetic version of the coyote. Instead, the coyote's behaviour provides a set of objectives for a design which capitalises on recent scientific and technological developments in an attempt to produce a convincingly life-like, aware, wild non-biological presence.

Tortoises and evolutionary robotics

From the excreting duck automata built by Vaucanson in 1739 to the self-directed, insect-inspired micro-flyers currently developed in the labs of Ecole Polytechnique Fédérale de Lausanne [2] , a wide range of animal species continue to influence the design of machines. In the late 1940s cybernetics pioneer Grey Walter built a set of small autonomous wheeled devices which he called *Machina Speculatrix*, more widely known as 'tortoises'. The machines generated a great deal of scientific and media interest at the time, mostly due to their convincingly animal-like presence. The first model called *Elmer* was described by Walter in 1953 as 'an electro-mechanical creature which behaves so much like an animal that it has been known to drive an otherwise not timid lady upstairs to lock herself in her bedroom' [3]. Based on an ingenious and simple electronics structure, the robots were able to demonstrate autonomous complex patterns of actions based on phototropism and obstacle avoidance. Even though the *Machina Speculatrix* were developed as a tool for understanding the operation of the brain cell, their impact of on the field of robotics and artificial intelligence is significant.

Directly referencing Walter's work, MIT's Rodney Brooks invented the notion of subsumption architecture for robots. Embodied behavioural controllers operating at different levels of complexity interact in such a way that the robot's behaviour emerges from its physical interaction with the environment (bottom up), in opposition to traditional artificial intelligence approaches where the environment had to be fully mapped and appropriate responses pre-programmed into the robot prior to the interaction (top down). Brooks built *Genghis,* an insect-inspired robot based on the principles of subsumption architecture. *Genghis* achieved a human-tracking, obstacle avoiding behaviour through clever connection of sensors and actuators combined with a layered, de-centralised modular digital design. '[*Genghis*] had a wasplike personality: mindless determination. It chased and scrambled according to its will, not to the whim of a human controller. [...] to me and the others who saw it, it felt like a creature. It was an artificial creature' [4].

Evolutionary robotics also takes inspiration from the Darwinian principle of selective reproduction of the fittest. Programming techniques have been developed that allow successive generations of robots to refine their behaviour through artificial genetic evolution. The aptitude of the individuals of a given generation x of robots is assessed automatically with a fitness function. The genotype (artificial chromosomes) of the fittest robots is combined, with the addition of individual-specific variations, in the programming of generation x+1. Repetition of the process gradually leads to machines that fulfill the criteria of the fitness function without human intervention. Experiments conducted in the Laboratory of Intelligent Systems (LIS) in Lausanne, Switzerland, in the late 1990s produced genetically evolved robots capable of battery-charging, maze navigation, garbage collecting and predatory-prey co-evolution [5].

Human interaction with social robots

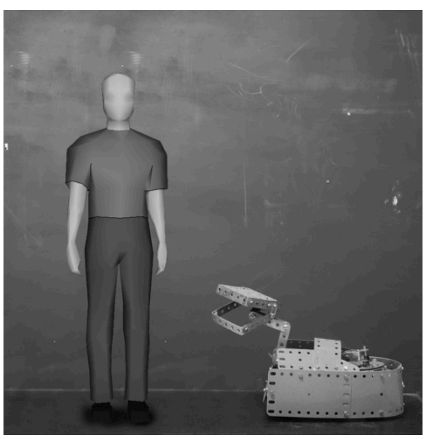
Research in social and emotionally-responsive machines aims to bring robots into homes to support the elderly, entertain the young, and more generally facilitate interactions with the technological layers of contemporary human existence. 'Social robot' is a term coined by MIT’s Personal Robots Group director Cynthia Breazeal who has been working on human-robot interaction since the mid 1990s. Breazeal’s research started with the development of 'a socially intelligent machine that can communicate with and learn from people'. *Kismet*, completed in 2000, is an expressive non-human robotic head that engages with its 'caregiver'. Its responses are inspired by studies of infant-caregiver interactions, largely based on non-verbal two-way communication with a strong affective dimension. Breazeal and her team developed a synthetic nervous system (SNS) based on real-time performance, self-motivated interaction and the ability to perform competent behaviours in unplanned situations. The SNS enabled *Kismet* to 'enter into natural and intuitive social interaction with a human caregiver' [6], a relationship facilitated by an anthropomorphic, cartoon-like face able to express easy to interpret emotions.

The first commercially available social robot toy was made in Japan. In 1993 Sony's Digital Creatures Laboratory started the development of a convincing robotic pet that could find its place in families. The resulting *Aibo* (**A**rtificial **I**ntelligence ro**BO**t, also translates as "partner" in Japanese) is a cute four-legged, puppy-like plastic machine. The onboard software is inspired by animal behaviour studies and relies on three main layers of operation: sensory input processing, motivation generation, action selection. The motivations of the robot stem from five basic needs and six emotions, an architecture complex enough for some owners of *Aibos* to grow a strong attachment to their robot, similar to a relationship with a biological pet. Yet in 2006 Sony entered financial difficulties and discontinued their non-profitable digital creatures programme.

As well as entering the homes of technology enthusiasts, *Aibo*s have been used in scientific research, for example in Sony Computer Science Laboratory's *Playground Experiment* (2000-2007) led by Frédéric Kaplan, who later wrote about his experiments with robotic pets in his book *Les Machines Apprivoisées* [7]. The project investigated the notion of entertainment robots, machines with no other function than that of being autonomous companions for humans, aiming to 'show how a robot equipped with an intrinsic motivation system can explore its environment autonomously and develop skills which were not pre-specified'. In order to be a worthwhile companion, the robot must be autonomous and able to learn, adapting its behaviour to the non-predictable socio-physical environment of a human home. One of the key concepts in Kaplan's research is that of intelligent adaptive curiosity, 'an intrinsic motivation system which pushes a robot towards situations in which it maximizes its learning progress' [8]. The integration of a curiosity function is combined with a focus on 'shared attention'. This involves monitoring in real-time the robot's perceptual data when it interacts with the human, for example when being taught a spoken command for fetching its ball. Understanding which parts of a shared experience are prominent in the cognition of each participant informs the design of a machine that can integrate with and contribute to a human social environment.

The concept and design of the *Biting Machine* robot is inspired by the non-representational navigation of Walter's cybernetic turtles, the adaptive capabilities of Brook's behaviour-based robots and the emerging fitness of LIS's evolutionary robots. The curiosity function implemented in Kaplan's Aibos and the associative memory predictors as seen in the motivated reflex agents developed by Rob Saunders [9] provide practical references for the elaboration of a behavioral engine.

Fig.3. ***Biting Machine 2*****, visualisation with model, 2012, (© Paul Granjon, photo Paul Granjon)**



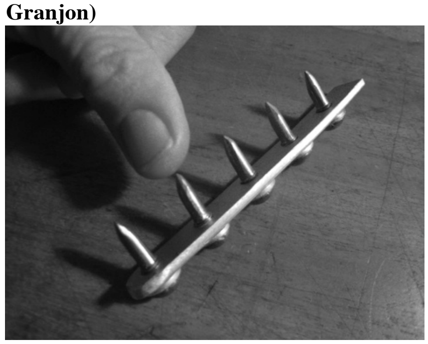
The *Biting Machine* robot

Following *Biting Machine 1* (Fig. 1), a simple automaton that was constructed in collaboration with Japanese artist Kanta Horio, I have built a scaled-down, non-motorised model of a new *Biting Machine* (Fig. 3) and a prototype mobile robot programmed to test the potential of embedded computing and sensing solutions. The prototype robot called *Toothless* features a Microsoft Kinect three-dimensional vision sensor which enables it to differentiate between a human figure and other objects (Fig. 4).

Fig.4. **Alex May and *Toothless* robot, 2012** ***(© Paul Granjon, photo Paul Granjon)***

The overall volume and weight of the final robot will be similar to those of a coyote, but the design will favor functionality and avoid artificial zoomorphic aspects such as fur, tail, eyes or ears. The body will be based on a wheeled platform mounted with an extending, rotating neck/arm. The robot will be able to move at a top speed of approximately two meters per second, stand on its rear end, and ideally should manage small jumps.Mounted on the neck, the jaws will be fitted with pointed teeth strong enough to pull at things in a way similar to the coyote and to provide an adjustably painful bite (Fig. 5).

Fig.5. Prototype teeth for *Biting Machine* robot, 2012 (© Paul Granjon, photo Paul Granjon)



The machine will extract information from its environment with a comprehensive array of sensors, enabling it to navigate the space, identify the human, and locate objects. Vision will be complemented by acoustic source localisation and touch detection. Additionally the *Biting Machine* robot will be fitted with an olfactory organ and will be able to mark its territory, spraying small concentrated amounts of ethanol on objects or fixtures. In a fashion inspired by the way canines can sense fear or relaxation in a human, the machine will be given the ability to detect some of the human's cerebral activity with a brainwave sensor system.

One of the most prominent aspects of the coyote's behaviour is his determined avoidance of physical touch with the human. The electronic design of the machine will implement this basic avoidance drive at the hardware level with a hard-wired behavioural layer implementing the other important traits which are resting, feeding and constant awareness and monitoring of the environment. These will operate at a very high priority level within the software of the machine. The need for feeding will be based on readings of the battery level. Below a set threshold, feeding will become the most prominent priority. Food will be provided by a charging station installed in the space. Additionally, the human will be able to give electric food pellets to the robot, providing instant gratification after a given behaviour. The resting behaviour will be closely linked to feeding, as the robot has to stay immobile, connected to its charger for at least an hour for the battery to fully charge.

The robot will also possess a memory module, a key part of a dynamic action weighing system where mood and personality traits are constantly adjusted according to present and past stimuli. The memory module will also enable an intelligent adaptive curiosity function driven by a 'pleasure to learn': the robot will explore its environment, programmed so as to prioritise new experiences. The curiosity engine will be most active when, relaxed and charged, the robot will engage in playful activities, focusing its attention mostly on the human.

The combination of the physical, analog and digital aspects described above should allow for the construction of a sufficiently responsive, evolving platform. Ideally several machines will be constructed, each of which will perform with different human partners so that different narratives and different artificial personalities can emerge in close-to-identical robots.

Cybernetic performativity and machinic life

In *The Cybernetic Brain* (2010), Andrew Pickering explores the legacy of W. Grey Walter and other British cyberneticists. He describes a 'black box ontology' where knowledge on a given opaque system is generated from performative experimentation with its inputs and outputs in order to represent its inner workings. Pickering's definition of a black box is 'something that does something, that someone does something to, and that does something back, a partner in (…) a dance of agency'. The dynamic reciprocity of action and reaction (feedback), and the use of the terms 'partner' and 'dance' point towards what Pickering posits as the fundamental originality of early cybernetics: a 'concern with performance *as performance*, not as a pale shadow of representation', with 'a vision of knowledge as part of performance rather that as an external controller of it' [10]. According to Pickering, the benefit of cybernetics' performative approach compared to the representational methods of more traditional sciences is the ability to address 'systems that are so complex that we can never fully grasp them representationally and that change in time, so that present knowledge is anyway no guarantee of future behaviour'. Complexity as a key aspect of contemporary technology is explored by John Johnston in *The Allure of Machinic Life* (2008) - a book that also recognises the importance of early cybernetics. For example the emergent complexity of Grey Walter's tortoises paved the way for what Johnston defines as 'machinic life', 'the forms of nascent life that have been made to emerge in and through technical interactions in human-constructed environments'. Johnston provides a comprehensive survey of recent research in the fields of artificial life, artificial intelligence and robotics, highlighting the 'emergence of complexity'. He posits that 'while machinic life may have begun in the mimicking of forms and processes of natural organic life, it has achieved a complexity and autonomy worth of study in its own right'. Then, expanding on Deleuze and Guattari, Johnston defines the notion of 'becoming-machinic': 'If we follow [Deleuze and Guattari's] idea that becoming-animal is not a mimicking of an animal but an entering into a dynamic relationship of relay and a parallel evolution with certain animal traits, it becomes possible to theorise how becoming-machinic is a force or vector that, under the guise of imitation, is directing and shaping not only ALife experiments and contemporary robotics but much of the new technology transforming contemporary life' [11].

Pickering and Johnston provide frameworks that are complementary to the terrain I want to explore with the *Biting Machine* experiment. Under 'the guise of imitation' - re-enacting a performance with an animal - the *Biting Machine* performance operates within what Pickering calls 'ontological theatre', a space-time where the machines and the world perform 'as aids to our ontological imagination, and as instances of the sort of endeavours that might go with a non-modern imagining of the world' [9]. The co-evolution of human and machine through the course of the performance is an instance of a relational endeavour with a 21st century cybernetic machine, the opportunity to experience a meeting with a species that blurs boundaries between natural and artificial.

Conclusion

In parallel with the generic dimension of Beuys' coyote, the symbolism attached to the *Biting Machine* reaches beyond robotic research, into the more general field of artificial agents, the world of technics. The changes brought by the rapid, constant development of complex and pervasive technologies are deep and not easy to monitor, and even more difficult to evaluate. In Bernard Stiegler's words, 'today we need to understand the process of technical evolution given that we are experiencing the deep opacity of contemporary techniques' [12]. The *Biting Machine* experiment is the latest development in an artistic practice anchored in science and technology that promotes a hands-on, performative approach to the subject in an attempt to shed some light on the opacity mentioned by Stiegler.

References and Notes

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