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Robotic art as a vector for techno-critique

Practice-based PhD by published works

Discipline: Fine-Art

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List of published articles submitted

	Title	Subject	Process	Where published
1	**Performing with Machines and Machines that Perform**	Contextualisation of the author's art practice within technological arts and robotic science. Further reflections on the co-evolution of humans and machines, and the critical scope of autonomous performing machines.	Full paper submission on invitation followed by blind peer review	Peer reviewed international journal paper in ‘Tangible and Embedded Interaction’, a special issue of the *International Journal of Performance Arts and Digital Media*, 2008 ISSN 1479-4713 (print)
2	**Biting Machine, a Performance art Experiment in Human-Machine interaction**	Paper focused on an on-going art-science project involving an intelligent wild robot. Further reflections on the co-evolution of humans and machines in the age of intelligent machines.	Full paper submission on invitation followed by double blind peer review	Following conference presentation, peer reviewed publication in online proceedings of ISEA 2013 Sydney conference.
3	**Coy-B, an Art Robot for Exploring the Ontology of Artificial Creatures**	Detailed projection of the development of the renamed Biting Machine project, with further developments on the new ontology of artificial creatures and technical aspects.	Double blind peer reviewed extended abstract for poster presentation	Following conference presentation in the 14th TAROS conference (Towards Autonomous Robotic Systems), publication in Springers *Lecture Notes on Artificial Intelligence series* (2014).

4	**This machine could bite, on the role of non-benign art robots**	The paper examines the relevance and originality of non-benign robots made by artists to explore the relationship between humans and machines and the emergence of machinic life.	Full paper submission on invitation followed by double blind peer review.	Fibreculture journal, special issue on Creative Robotics, 2016
5	**Guido and am I Robot, a Case Study of Two Robotic Artworks Operating in Public Spaces**	Compared case study of two robotic artworks made by the author: Guido, a robot guide created for the MUDAM Museum in Luxemburg, 2015 and Am I Robot, a robotic installation comprising a hybrid intelligence robot .	Full paper submission on invitation followed by double blind peer review.	Published in the conference proceedings of the 4th International Conference on Live Interfaces, Porto Portugal 2018

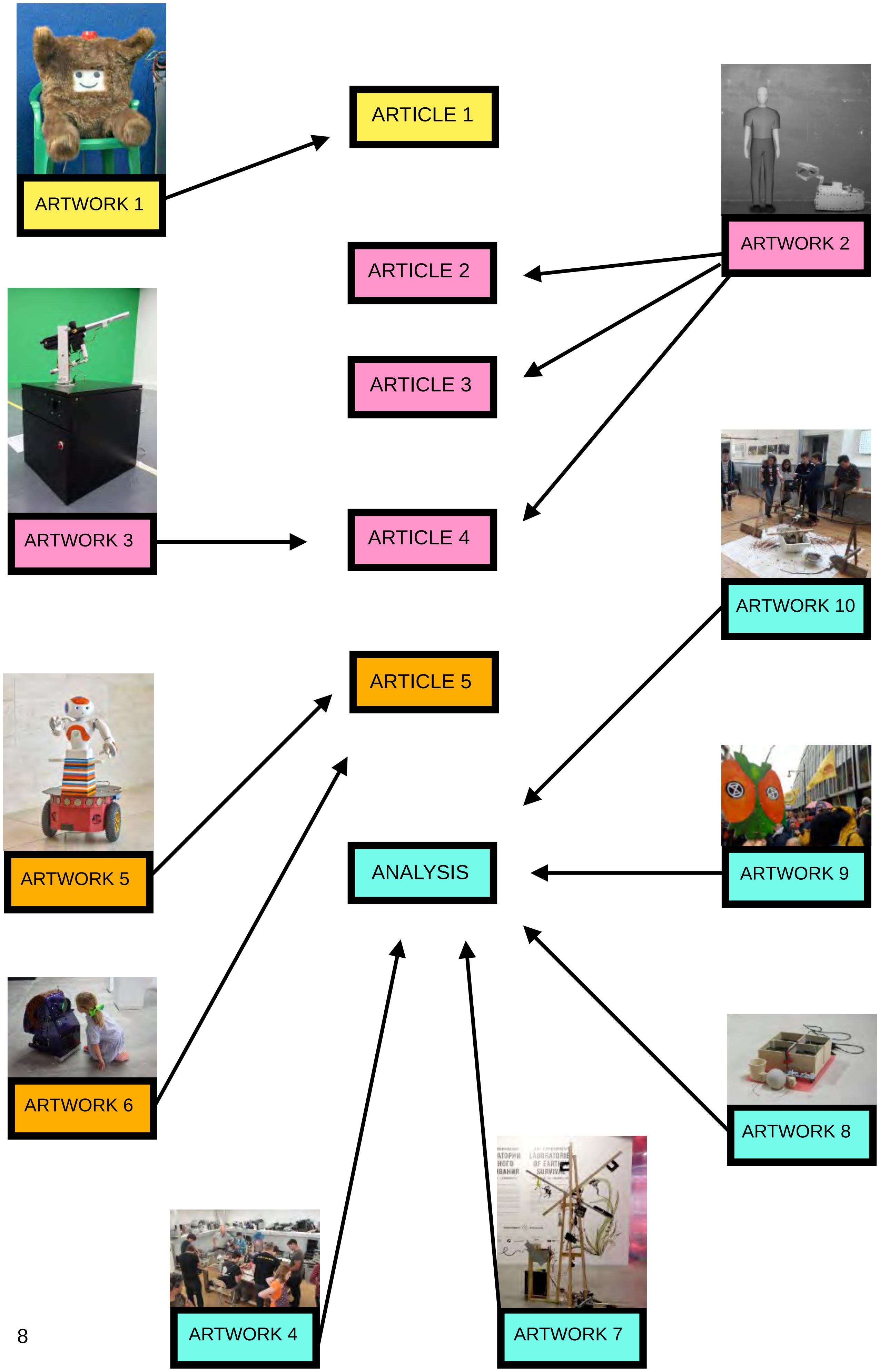
List of exhibited artworks submitted

	Work	Subject	Process	Where exhibited
1	***The Fluffy Tamagotchi*** Robot for video 1998	Functional robot inspired from the Tamagotchi toy, made for a single channel video.	Self-produced	The piece was part of series of 7 videos called ***2 Minutes of Experimentation and Entertainment*** that toured extensively the international electronic art and video festivals circuits between 1996 and the early 2000's. The piece was shown on national television in Wales, Sweden and Japan. The series was purchased for the permanent collection of the Arts Council of England in 2001.
2	***Wild Robot Coy-B*** Concept robot and performance 2009 - ongoing	Human-robot interaction experiment framed as a performance with a robot. The piece is inspired by Joseph Beuys' performance ***I Like America and America Likes Me*** (1976)	The piece requires collaboration with a robotic science unit. Prototypes have been developed in collaboration with artist Kanta Horio (2009) and programmer Alex May (2012).	The artwork is as yet unrealised. The concept was presented in conferences (Towards Autonomous Robotics 2013, International Symposium for Electronic Arts 2013). A funding bid developed with Grzegorz Cielniak from the Computer Science Dept at Lincoln University was shortlisted for a Leverhulme Bursary in 2016 but did not succeed in the final round.
3	***Robotic Gun*****,** Performance robot 2010-13	Functional autonomous weapon based on a paintball gun. The piece is inspired by military robot sentries. It comments on the advent of autonomous robotic weapons.	Commissioned for Sacred Festival, Chelsea Theatre London, 2010	Chelsea Theatre London, 2010, Chapter Arts Centre 2010, Brut Vienna Autria 2011, In Between Time Festival Bristol 2011, Digital Brainstorming tour Switzerland 2013.

	Work	Subject	Process	Where exhibited
4	***Oriel Factory***, Participatory project, 2011	Participatory exhibition whrere the gallery was turned into a making space, A team of volunteers was trained to build robots and other exhibits on-site using a combination of digital fabrication technologies and electronic waste upcycling.	Solo exhibition commissioned by Oriel Davies Gallery, Newtown UK	Oriel Davies Gallery 2011. The exhibition was accompanied by a documentary film by Chris Keenan.
5	***Guido the robot guide*** Semi-autonomous exhibition guide robot 2015	Robot guide for the exhibition *Eppur Si Muove*, Art meets Technique, MUDAM Museum Luxembourg. The robot presents technology-inspired contemporary artworks and historical technical objects from a robot's perspective.	Collaboration with the Computer Science department at Ecole des Mines de Nancy and Ecole des Beaux-Arts de Nancy, commissioned by MUDAM Museum.	The robot was an artwork in the *Eppur Si Muove* exhibition and delivered 5 visits per week to museum visitors. July 2015 to February 2016
6	***Am I Robot, s***emi-autonomous interactive robot installation, 2016	The installation comprises a mobile robot and a semi-hidden control room accessible to visitors. The robot operates seamlessly as an autonomous agent or as a telepresence device.	Installation commissioned by Manchester Art Gallery for the group exhibition *The Imitation Game* based on the article of the same name by Alan Turing.	*The Imitation Game* group exhibition Manchester Art Gallery 2016, Oriel Mostyn Llandudno 2016, *States of Play* group exhibition by Crafts Council UK Humber Street Gallery Hull 2017, *Y las Cosas que Hacemos* group exhibition Azkuna Zentroa Gallery Bilbao Spain 2018

	Work	Subject	Process	Where exhibited
7	***Electronic Wildertree Wrekshop*** Participative interactive installation, 2017	E-waste improvised interactive sculptures made with participants from the public over a three weeks period.	Commissioned for *Art Experiment, Laboratories of Earthly Survival*, group exhibition in Garage Museum of Contemporary Art Moscow	*Art Experiment, Laboratories of Earthly Survival* group exhibition Garage Museum of Contemporary Art Moscow 2017
8	***Mudbots, robotic installation 2018***	The installation comprises 11 mobile robots powered by microbial fuel cells	Commissioned as part of the robotic art exhibition *Y les cosas que hacemos* (and the things we do), Prototipoak Festival 2018	Azkuna Zentroa Gallery Bilbao Spain 2018
9	***Insect Buzz,*** Electronic placards 2019-20	Electronic placards made for environmental protest.	Developed as part of the EASTN-DC (European Arts Science and Technology Network - Digital Creativity) European research project	Used in environmental protests in Cardiff and London, 2019, Barry 2021. Workshop and exhibition in Arcade Campfa Gallery Cardiff, 2020, presented in EASTN-DC conference ZKM, Karlsruhe 2020
10	***Mud Machine Wrekshop,*** Creative technology participative artwork 2020	Creative technology participative artwork with improvised temporary interactive installation mixing mud and e-waste upcycling	Conducted following invitation from Peak Arts, Crickhowell	Delivered as part of the Celf programme of visual arts for young people, 2020

Relation between artwork and articles



Analysis

Robotic art as a vector for techno-critique

Abstract

Through the short history of robotic art, artists have produced non-utilitarian machines that offer cultural comments on our relation with increasingly intelligent artefacts. Robotic art, free from constraints faced by technologists and scientists, allows for a different perspective on this changing relation as well as a critical reflection on technological adoption.

The present analysis traces the development of my practice-based research in robotic art. I show how the practice aims at disseminating a critique of technics, specifically raising questions about gains and losses to human and non-human realms. The work is structured in three main strands:

Research on intelligent machines: an examination of the ontological shift that occurs when machines start to demonstrate lifelike behaviours such as adaptation and curiosity. The research leads to production of artworks and performances that use the tools of robotics for inviting critical responses to our relation with intelligent machines, uncharacteristic to the field.

Design of human-robot interaction situations: opening the scope of human-robot interaction to areas of investigation not commonly explored by scientific or commercial applications, I create situations where machines unbiased by a utilitarian or benign agenda operate in direct contact with humans. The work questions the limitations of current machines and the necessity of their deployment.

Participation: I create events that invite participation from audiences. Compared to more conventional outreach formats in art or science, the format allows for a broader range of human-machine interactions as well as a practical dissemination of critical reflections about technics. The unconventional aspects include hands-on processing of technological artefacts, shared experience with collective fabrication and direct dialogue.

The new perspective developed in my artworks and papers is founded on a broader ethos of the robotic as an art practice that can be a vector for techno-critique with a social impact agenda.

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Introduction

I have been working as a professional visual and performance artist since the early 1990s, defining the subject of my practice-led research as the co-evolution of humans and machines. The content of the artworks and the selection of technology required for their realisation originates from observing developments of technics and the impact of their dissemination. The results of these investigations are presented in the form of exhibitions, performance-lectures or participative events that generally include a robotic dimension. All aim to provide the audience/ participants with material for reflecting on and eventually altering aspects of their lives in a time of ultra-complex techno-scientific proliferation.

This thesis is a PhD by publication. It comprises nine bodies of exhibited art practice and five published articles, two of them about a yet unrealised artwork that is also included in the submission. I am bringing them together as a PhD thesis because I think that, collectively, they address two principal research questions:
1- How can a practice-based robotic art research generate new critical insights on technological developments and their effects on individuals and society from a non-utilitarian perspective?
2- What strategies can be used to share and disseminate the technical, social and environmental insights of a practice-based robotic art research in an effective and impactful way?

The current analysis starts with a clarification of my work's position within the field of practice-led research in the arts, with a specific emphasis on robotic art. This is followed by case-studies of a selection of robotic artworks and related research, highlighting how these contributed to the investigation of the overarching research questions. The sections are organised as follows:

- Methods and context: framing of the present PhD within the field of practice-based research, contextual aspects of a robotic art practice.

- Premises: key works that established the practice and its direction.

- Intelligent machines: artworks and writing investigating the emergence of intelligent machines.

- Robotic artworks operating in public spaces: case study of a practice-based research project that explores interaction with robots and questions public assumptions about intelligent machines.

- Robotic art as a participatory practice: evaluation of different dissemination methods ranging from exhibition to participatory events that aim at sharing practical skills as well as a critique of technics.

- Current and future directions: low-tech, ecological and subjective dimensions as priorities for further practice-based research.

Method and context

The practice-led PhD is a relatively new type of degree that has generated some controversy. From the outset such degrees were considered problematic largely due to the perception "that artwork cannot be as intellectually clear and accessible as writing" (Candlin, 2000:97). A report from the Higher Education Quality Council emphasised “the need to clarify the use of new doctoral titles and to protect the significance of the PhD/DPhil” (HEQC, 1997:98). Many articles and studies have been published since by proponents of practice-based research in attempts to prove the validity of practice-based research. A key notion brought to the debate is the existence of a praxical knowledge derived from physical manipulation of things. Praxical knowledge is related to Heidegger's idea of manipulability (*handlichkeit*), where

> If we look at Things just theoretically, we can get along without understanding readiness to hand. But when we deal with them by using them and manipulating them, this activity is not a blind one; it has its own kind of sight by which our manipulation is guided and from which it acquires its specific Thingly character (Heidegger, 1962:98).

In *Practice as Research, Approaches to Creative Arts Research*, E. Barrett states that "praxical knowledge implies that ideas and theory are ultimately the result of practice rather than vice versa" (2010:6). This view echoes the author's own experience, where early intuitive manipulation of materials and techniques led to a practice that integrates findings from academic research, aiming to share knowledge through artworks as well as publications. The artworks are documented, in some cases with interviews of viewers and participants, providing a source of qualitative primary data.
Smith and Dean observe that practice-related research can be categorised in three main trends: basic research carried out independent of creative work (though it may be subsequently applied to it), research conducted in the process of shaping an artwork, or research which is the documentation, theorisation and contextualisation of an artwork. (Smith and Dean, 2010). The

selection of writing and exhibited artworks covered in the present PhD by published works includes examples of research conducted with all three approaches above. It draws on some publications that documented and contextualised existing artworks and on others that detailed the research conducted in the process of developing an artwork. The work also includes research carried out independently of the creative work in order to update the contextualisation of the practice and identify future directions. I view the writing of academic papers and eventually of a practice-based PhD by published works as the unpicking of a loosely structured, organically grown body of work, aiming to articulate clearly what the questions investigated through the practice are, what the new insights are and how these are shared. The PhD is undertaken as a retrospective survey of the practice as well as a contribution to my personal and academic development.

The domain of creative arts my research belongs to is mainly robotic art, a type of art that incorporates robotics hardware and software technologies. The departure from the static art object inherent in robotic art belongs to a wider movement that started with kinetic sculpture in the first half of the 20th Century (Calder, Gabo, Duchamp), before incorporating theoretical and practical aspects of cybernetics and computer science. Jack Burnham highlights in *Beyond Modern Sculpture* the fundamental difference between kinetic art and what he calls ‘robot and cyborg art’:

> as for Kinetic Art, the machine communicates to us merely as we observe its motions. As we are able to steer or program the actions of a machine, and the machine reacts in sundry ways to our guidance, we attain higher levels of communication. In this respect a most important attribute of systems or machines is input and output (Burnham, 1968:318).

In his essay *Behaviourist Art and the Cybernetic Vision*, Roy Ascott observes how the addition of inputs to the artwork allows for a feedback loop where

> the system Artifact/Observer furnishes its own controlling energy; a function of an output variable (observer response) is to act as an input variable, which introduces more variety into the system and leads to more variety in the output (observer's experience) (Ascott1966:129).

Artists have appropriated cybernetic ideas and robotics technologies since the mid 1950’s. Recognised key works from this early period include *Cysp1* (1955) by Nicolas Schöffer, an interactive kinetic robot that responded to sound and light, Nam JunePaik’s *K456* (1964) remote controlled robot, a clumsy humanoid that excreted beans and spoke in the voice of J.F.Kennedy, Claude Shannon's *Ultimate Machine* (1966) which sole function was to turn itself off as soon as it was turned on, Gordon Pask's *Colloquy of Mobiles* (1968), a complex cybernetic system involving interaction between robots and between humans and robots, Norman White's *Facing Out, Laying Low* (1977), a motorless machine that asked humans for help, pioneering cyborg artist Stelarc's *Third Hand* (1980), a wearable robotic augmentation that set the foundation for exploring cyborg futures, and Survival Research Laboratories whose live shows staged loud and violent machines made from military and industrial rejects as early as 1978. The landmark exhibition *Cybernetic Serendipity* curated by Jasia Reichardt in the ICA London in 1968 included a section for "cybernetic devices as works of art" (Reichardt, 1968:5) with robots by Ihnatowicz, Paik, Schöffer, Pask, Tinguely, Seawright, Billingsey, Emett and Lacey.

Elisabeth Stephens traces the origins of robotic art back to the 18th Century automata of Vaucanson and Jacquet-Droz and their influence on the work of Descartes and other natural philosophers. In her view, "if the relationship between automation and art has such a long and rich history, it is because this relationship is also a cultural site at which the relationship between the human and technological can be investigated and experienced" (Stephens, 2015:43). This cultural dimension is further established by artist and theorist Petra Gemeinboeck who sees in creative robotics "a transdisciplinary practice that builds on the history of robotic and cybernetic art to explore human–robot configurations from a critical, socio-cultural perspective" (2016:2). For artist and theorist Simon Penny

> robotic art and related practices provide a context in which real-time computational technologies and techniques are deployed for cultural purposes. This practice brings the embodied experientiality, (so central to art) hard up against the tacit commitment to abstract disembodiment inherent in the computational technologies (Penny, 2015:47).

My own practice of robotic arts started in 1996. Operating in the socio-cultural dimension mentioned above, my artworks aim at providing reflection and critique on the co-evolution of humans and machines. The combination of an embodied outcome with the abstraction of coding highlighted by Penny allows for a diverse studio practice that intertwines mechanical construction, electronic design and computer programming. In the following sections I discuss a selection of my and other artists' robotic artworks and their arguably unique role for exploring and commenting on the relation between humans and machines.

I chose to give this analysis the title *Robotic Art as a Vector for Techno-Critique* because the main drive of my work is to trigger critical reflection and action on our relation and belonging to the world of technics. I have from an early point nurtured an active position towards techno-science, that I once defined as a “techno-engaged militant awareness” promoting "an engaged attitude towards technological progress, claiming humanity through being a learner-maker instead of a user-consumer” (Granjon, 2008:45). This position is grown from a hands-on, self-taught approach where the acquired knowledge is applied to making artworks that facilitate the sharing of critical questions with audience and participants. With its origin in the co-evolution of humans and machines, the critique is aimed at a wider scientific and technological societal system defined by philosopher Jacques Ellul as ‘technique’: “the term technique, as I use it, does not mean machines, technology, or this or that procedure for attaining an end. In our technological society, technique is the totality of methods rationally arrived at and having absolute efficiency […] in every field of human activity (Ellul, 1954:XXV). The meaning of this term’ technique’, with a clear distinction between the technological object and the ruling system that derives from technological development, is close to that of ‘technics’ as used by another critic of technological development, Lewis Mumford. For Mumford

> mechanization and regimentation are not new phenomena in history: what is new is the fact that these functions have been projected and embodied in organized forms which dominate every aspect of our existence. Other civilizations reached a high degree of technical proficiency without, apparently, being profoundly influenced by the methods and aims of technics (Mumford, 1934:4).

I find ‘technics’ less ambiguous than ‘technique’ for English speakers and will use that word when writing about the scientific-technological system at the heart of contemporary human civilisation. Overall I posit that robotic art can be a vector for techno-critique - a critique of technics - with a social impact agenda.

The three core themes listed above as ‘intelligent machines’, ‘robotic artworks operating in public spaces’ and ‘robotic art as a participatory practice’ are developed in the thesis in the following way:

My work on intelligent machines occurs most prominently in ‘Biting Machine - a Performance art Experiment in Human-Machine interaction’ (article 2), ‘Coy-B - an Art Robot for Exploring the Ontology of Artificial Creatures’ (article 3), ‘This machine could bite - on the role of non-benign art robots’ (article 4) and in the artworks *Wild Robot Coy-B*, *Guido the Robot Guide*, *Am I Robot*, *Robotic Gun* and *Mudbots.*

My work on robotic artworks operating in public spaces occurs most prominently in the article ‘Guido and Am I Robot, a Case Study of Two Artworks Operating in Public Spaces’ (article 5) and in the artworks *Guido the Robot Guide*, *Am I Robot* and *Mudbots*

My work on robotic art as a participatory practice occurs most prominently in the artworks *Oriel Factory*, *Electric Wildertree Wrekshop*, *Mud Machine Wrekshop* and *Mudbots*.

In addition ‘Performing with Machines and Machines that Perform’ (article 1) provides an insight in the emerging of the practice’s ethos with studies of earlier artworks, while the artwork *Insect Buzz* explores an application of robotic art to environmental issues.

Premises

The works referred to in this section were made over a period when my practice shifted from making single channel videos to the fabrication of functional machines for exhibitions and performances (1998-2007). I provide here a concise summary and contextualization of my practice at the time, with a more comprehensive account to be found in the book chapter ‘A Personal History of Art and Technology’ (Granjon, 2006) and the journal article ‘Performing with Machines and Machines that Perform’ (article 1, 2008). The *Fluffy Tamagotchi* (artwork 1, 1998) is included in the submission as a significant and representative foundation of my robotic art practice.

In the 1990s, following on the historical precursors mentioned in the previous section, a new generation of artists were getting to grips with including robotics in their work. For example Simon Penny created the robot *Petit Mal* in 1995, an artwork that “sought to move interaction off the desktop, out of the shutter-glasses and into the physically embodied and social world” (Penny, 2015:53). Visitors were encouraged to interact with a simple wheeled robot, “a behaving machine that elicited play behavior among people” (Penny, 2015:54). Ken Rinaldo and Mark Grossman’s bio-inspired installation *The Flock* (1993) was a “group of musical interactive sound sculptures which exhibited behaviors analogous to the flocking found in natural groups such as birds, schooling fish or flying bats” (Rinaldo, 2021:web). Louis-Philippe Demers and Bill Vorn created several robotic artworks between 1993 and 1999, a well-known example of which is *La Cour des Miracles* (1997) described as “a sensorial attack by many robotic entities and pieces that inhabited space loudly and reacted convincingly to a visitor's presence” (Plohman, 2001:web). In 1995 Stelarc staged *Ping Body*, a performance where half his body was wired with electrodes and controlled by internet users, questioning the obsolescence of the body in the age of advanced networked technologies. France Cadet created several bio-forms robots (*Scientific CredEbilities*, 1999) precursors to her modified toy robot dogs *Dog-Lab1* (2004) that offer a humorous point of view on artificial life and genetic design. The common denominator linking these practices is the will to explore and express machinic potential in a creative fashion, to make machines that reveal aspects of human relation to technology largely unaddressed by mainstream science and commercial production or addressed with a constraining framework.

I began to integrate robotic elements to my art practice in the late 1990's. A significant artwork from the period is *The Fluffy Tamagotchi* (artwork 1, 1998, fig.2 article 4), a video featuring a fully functioning robot. Starting from the observation that "the progress of artificial intelligence often produces side-effects that reach the general public" (Granjon, 1998), the robot is inspired by the late 1990s electronic toy that fitted a simplistic virtual pet in a plastic egg. *Fluffy Tamagotchi* brought the pet back to the physical world in a slightly ridiculous act of resistance against rampant digitalisation, where the digital faeces of the original Tamagotchi were made tangible as a blue custard excretion. Another early work is a set of wearable *Robotic Ears and Tail* (2003, fig.3, article 1) that I used to wear while performing a song called *Animal*, a crude attempt at reminding audiences that we humans, despite all our technological mastery, are animals. The installation *Automated Forest* (2001, fig.1, 2, appendix) was drawing attention to the inherent value of living biological wild ecosystems by providing a simplistic robotic version of a forest environment, complete with its own artificial day/night cycle, woodland wallpaper and a bench for the audience to enjoy a cyber-picnic or meditate.

Attending and presenting in robotics conferences, I met robotic scientists and visited several laboratories in the UK, Europe and Japan. My experience of robotic laboratories combined with interest in Grey Walter's *Machinae Speculatrix* (1940s) - a set of mobile cybernetic machines widely acknowledged to be the first autonomous robots (Brooks, 2002, Holland, 2003, Pickering, 2010) - and their biologically-inspired robotic descendants (see 1990s robots by Brooks, 2002, Floreano, 2008, Warwick, 1997) provided the starting point for my first robotic installation, the *Sexed Robots* (2005, fig. 4 article 4), examined in articles 1 and 4. The *Sexed Robots* have been described as

> a pastiche of Walter's work and similar autonomous behaviour-based robotic experiments. Granjon reminds us of this mechanical reduction of a living system by automating mating

> rituals into a mundane interplay of sensors and a reduced set of internal bodily states (Demers, 2015:44).

Article 1 offers an insight on the motivation for my practice that is still valid today:

> Presenting performances and installations based on a thorough if humorous investigation of contemporary technological progress, I intend to generate and convey a critical distance from the field of research. Marshall McLuhan wrote that ‘any invention or technology is an extension or self-amputations of our physical bodies’ (McLuhan, 1994:45). In that light I question the relevance of surrounding ourselves with an endless and increasingly complex amount of tools and prostheses. Simultaneously I recognise the irrepressibility of the human urge to discover, and, as an inventor, I enjoy the possibilities offered by the technology. This contrasted position is the main motor of my practice (Granjon 2008:47).

The works I produced at the time, while sharing some themes and techniques with those of other robotic artists, are original in two ways. First they possess an irreverent and humorous dimension yet address complex questions about humans’ relation with technology, as summed up by curator Karen McKinnon in her introduction to the solo exhibition *Z Lab 2001:* “Granjon's funny and bizarre approach may entertain, but this friendly surface lulls the viewer into a false sense of security. Sooner or later a feeling of unease develops that belies more complex concerns.” (McKinnon, 2001:3). The second original aspect is found in the live performances with robots, itself an uncommon form of robotic art. Unlike Stelarc who becomes a silent biological component of the cybernetic system he plugs himself into in staged live performances, I explicitly address the “more complex concerns” I am interested in when I talk to the audience, explaining ideas and illustrating them by demonstrating robotic props in a humorous manner (*Animal song* with *Robotic Ears and Tail* (2003), *Furman* the kicking robot (2003, fig.2, article 1), *Mofo* the disco dancing humanoid robot (2008, fig.3, appendix)), or demonstrating a common disconnection with the most basic technological knowledge by attempting to light a fire with the bow-drill technique (*Reflections of a Button Pusher*, 2005-2007, fig 4, appendix). At the core of these concerns is a questioning of the increased delegation of human functions to complex, opaque machinic systems, that simultaneously creates a gain in convenient functionalities and a loss of inherent human abilities such as memory, navigation, motor skills, handicraft, social interaction. This critical dimension was noted by media art specialist Andrzej Pitrus who writes that

> Paul Granjon criticises technological fetishism in all of his works. His artefacts are never ‘nice’. Instead, he explores junk aesthetics, kitsch, and constantly ‘recycles’ both ideas and objects. He realized that a contemporary human is helpless without technological prosthetics. We are no longer able to navigate in the city without GPS devices (Pitrus, 2013:133).

Additionally my performances are devoid of brutality and pain, hinting at a possibly friendly and humble symbiosis between human and machine, in line with Donna Haraway’s concept of "a cyborg world [that] might be about lived social and bodily realities in which people are not afraid of their joint kinship with animals and machine" (Haraway, 1991:154), yet one where the sophistication level of the technological systems remains within the grasp of the artist.

I have since these early days continued to investigate our entanglement with technics and to provide techno-critique in a variety of approaches.

Intelligent machines

This section covers the unrealised robotic performance project *Wild Robot Coy-B* (artwork 2, 2009-ongoing) analysed in the conference paper ‘Biting Machine, A Performance Art Experiment in Human Robot Interaction’ (article 2, 2013), the published conference poster ‘Coy-B, an Art Robot for Exploring the ontology of Artificial Creatures’ (article 3, 2014) and the journal paper ‘This Machine Could Bite: On the Role of Non-Benign Art Robots’ (article 4, 2016). The publications share a focus on intelligent machines and how robotic artworks can provide specific insights on their development. The *Robotic Gun* (artwork 3, 2010) also contributed to the reflection.

The most influential notion informing the work at the time is that of 'machinic life', as explored by John Johnston who, following a survey of robotics, AI and artificial life identifies machinic life in "the forms of nascent life that have been made to emerge in and through technical interactions in human-constructed environments" (Johnston, 2008, IX). 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" (Johnston, 2008, IX) and that “we are poised on the brink of a new era in which nature and technology will no longer be distinctly opposed” (Johnston, 2008, 2). Machinically alive agents would occupy a blurry ontological position between the inanimate and the alive, being, as a child taking part in an early experiment with computers put it, “sort of alive” (Turkle, 1985:49). I examine succinctly how robots that demonstrate a level of intelligence, potential precursors of machinic life, are currently being deployed in commercial applications that include an increasingly social role. Social robots were defined as embodied benign agents belonging to a heterogeneous group of robots and humans, able to communicate reciprocally with both categories (Fong et al., 2003:144). I thus question how "the benign and anthropocentric bias of robotics research, combined with the commercial imperatives driving the deployment of social robots, leave researchers and developers little scope for exploring and understanding machinic life and its impact on society" (Granjon, 2016:45).

So as to address this issue I have developed the concept of a performance with a potentially dangerous robot for exploring the notion of machinic life from a non-benign perspective. The *Wild Robot Coy-B* project (artwork 2) is described in articles 2 and 3, with an extended analysis in article 4. *Wild Robot Coy-B* (figs.3, 4 article 3) is a yet unrealised

> 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. [*Wild Robot Coy-B*] 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 (Granjon, 2013).

The 2014 paper was originally a poster submitted at the TAROS (Towards Autonomous Robotic Systems) robotics conference with the aim of finding collaborators for developing the robot. Subsequently a collaborative research project started with a scientist working with the Computer Science department at Lincoln University. The project was shortlisted for a Leverhulme bursary in 2016 but was not successful at the final round. The eventual fabrication of the robot may be facilitated by the increased availability of mobile robotic platforms, for example at time of writing Boston Robotics' *Spot Mini* and the relative ease of use of ready to go, powerful AI modules such as Google's *Coral* line of machine learning products.

Research in current examples of machinic life and non-benign machines led me to investigate the field of military robotics, specifically the possibility of a truly autonomous weapon able to decide to open fire at a human target without supervision. This research informed the fabrication of the *Robotic Gun* (artwork 3, 2010-2013), an autonomous robot I made for live performances. Details on the researched material and analysis of the *Robotic Gun* are available in Article 4.

In the same article I highlight two additional inspirational notions:

- ‘Cybernetic performativity’ as developed by Andrew Pickering who posits that complex cybernetic machines cannot be observed by being taken apart, in. a modern scientific fashion, but must be observed in action. The feedback loops between the machine and the world it inhabits, that Pickering calls ‘a dance of agency’, being paramount for understanding complex machinic systems. My work relates to this performativity as machines performing for or with the public have been key to my practice from the start, the physicality of the encounter a crucial factor for tangible experiences investigating the co-evolution of humans and machines.
- ‘Maverick Machine’, a term coined by British cybernetician Gordon Pask for a "machine […] that embod[ies] theoretical principles or technical inventions which deviate from the mainstream of computer development but are nevertheless of value" (Pask and Curran 1982). In addition to the technological imagination involved, I see value in the capability a maverick machine has of exploring machine-related issues in a subjective way that would not be appropriate or relevant for academically and/or commercially driven science and technology projects.

Embodying technical inventions and firmly deviating from the mainstream of computer development, the *Sexed Robots*, *Wild Robot Coy-B* and the *Robotic Gun* qualify as maverick machines that perform, where the audiences gain understanding of their function and underlying concept through observation of and/or interaction with their activity. Yet the artworks’ respective relation to machinic life differs. In Article 4 I propose a classification of robotic artworks comprising three categories: iIlustrative, reactive and evolutive. At time of writing, the few robotic artworks that can claim to belong to the evolutive category (complex machines that can learn) are generally the result of a collaboration between artists and scientists. In addition to the examples cited in the article, one can mention the *Cube Performers* robots by Gemeinboeck and Saunders, non-anthropomorphic machines specifically designed “to investigate the generative potential of movement and its dynamic qualities to enact meaning with abstract robotic artifacts” (gemeinboeck 2021), *NORAA-Machinic Doodles* (2018) by Jessica In and creative technologist George Profenza, that uses a recurrent neural network combined with human interaction for learning to draw. More in line with my self-taught, hand-made approach, *Ungenau* is a mobile hand manipulator that explores the limits of open-source robots and machine vision (Hurkxkens and Bircher, 2019).

In summary my work and publications mentioned in this chapter acknowledge the existence of early machinic life representatives as studied by Johnston and identify a gap in the exploration of human interaction with such machines. Diverging from the view of a social robot as a benign servant (Fong, 2003), art robots can offer HRI scenarios that unfold in a non-utilitarian context. I posit that creating a situation for exploring the performative relationship between a machine that learns and a human in a shared physical territory as planned in the *Wild Robot Coy-B* project has the potential to generate new knowledge as well as to engage specialised and non-specialised audiences: the performance-experiment aims at providing qualitative data for scientists, conceptual material for the humanities and a type of more general entertainment prone to instigating reflections about the co-evolution of humans and machines.

I have addressed differently the notion of non-utilitarian intelligent machines in a practice-based research project examined in the next section.

Robotic Artworks Operating in Public Spaces

It is not uncommon for robotic artworks to operate in public spaces. For example Ihnatovicz's *Senster* (1970), Survival Research Laboratory's machinic shows, Penny's *Petit Mal*, Rinaldo's *Flock*, Velonaki's *Fish-Bird*, Gemeinboeck and Saunder's *Accomplice*, Robotlab's *Profiler* (2004), Vorn's *Mega Hysterical Machine* (2010), Pfähler and Liebl's *Vincent and Emily* (2012), Demers' *Blind Robot* (2012), Stelarc's *Articulated Head 2.0* (2019) all invite, at different degrees, interaction with the public. From 2015-17 I led a practice-based research project in human robot interaction with two artworks that featured functional robots operating in public spaces. *Guido the Robot Guide* (artwork 5, 2015, figs. 2, 3, 4, 8, 10 article 5) is a robotic artwork commissioned by and exhibited in the MUDAM Museum, Luxemburg for the *Eppur Si Muove* art science exhibition (2015). Evaluation of the ideas and techniques deployed in *Guido the Robot Guide* led to a more achieved iteration of the concept with *Am I Robot* (artwork 6, 2016, fig 5, 6, 7, 9, article 5), an installation commissioned for *The Imitation Game* robotic art exhibition in Manchester Art Gallery (2016). The artworks form the basis of a paper titled 'Guido and Am I Robot? A Case Study of Two Robotic Artworks Operating in Public Spaces' (2018, article 5). The article provides a concise contextualisation with details on technical and design aspects, observations of visitors' interactions with the artworks and an evaluation of a user-controlled/autonomous hybrid system's potential for creative robotics applications.

The project aimed to assess how the gap of non-benign, non-utilitarian intelligent machines might begin to be explored and to witness the form that speculative human robot interaction (HRI) might take when faced with non-utilitarian intelligent machines. The artworks pose the following specific questions about intelligent machines:

- Are humans prepared to interface naturally with robots, be it a robot fulfilling a practical function such as guiding visitors in a museum or a more open-ended conversational mobile machine?

- Are non-specialists' assumptions about the current state of the art of intelligent robots realistic, and if not can a robotic artwork offer a convincing version of an intelligent machine of the future as well as reality check about the respective capabilities of general artificial intelligence and human intelligence (HI)?

Guido the Robot Guide robot was made in collaboration with a team of computer science engineers. The concept was an irreverent robot that would guide visitors to an art-science exhibition, presenting the exhibits with a robot's perspective. The robot would switch transparently from autonomous mode to operator control (hybrid control), allowing for seamless natural interaction. The shortcomings of *Guido* led to the design and fabrication of a second robot exploring further the possibilities of hybrid control, free from the utilitarian agenda of being a museum guide. The *Am I Robot?* installation was commissioned by Manchester Art Gallery for *The Imitation Game* exhibition. Unlike *Guido*, I fully designed and built *Am I Robot?*. The installation features two parts: a mobile robot called *Combover Jo* and a semi-concealed control room where visitors can take over the motion and speech of the robot. *Combover Jo* moves freely among visitors and exhibits and at times speaks. At times, the visitors can engage in complex conversations as well as interactive motions with the robot. This intelligent behaviour occurs when a visitor has discovered the control room and taken control over *Combover Jo*’s motion and speech. Other visitors might not be aware of the existence of a control room and assume that the robot is intelligent, until they, in turn, find the controls and have the option of controlling the robot.

The research involved in developing the works covered four main aspects.

1. Appraising and responding to the benign bias of commercial and scientific social robotics where Fong’s definition of the social robot as a benign servant (2003), still largely applies to the field. The *Am I Robot*? installation actuates the *Combover Jo* robot as a non-utilitarian platform with a strong social potential. I touched upon the non-benign exception presented by fully autonomous lethal weapons that raises concerns even in military circles - see Galliott et al’s (2015) insistence on keeping a human in the loop of robotic weapon control - with the *Robotic Gun* performance. The literature covered in articles 4 and 5 includes publications exploring the current rise of robotics applications (Ackerman, 2013, Tsiatis, 2014, Miller, 1998), the role and characteristics of a social robot (Dautenham et al., 2005, Duffy, 2003, Kaplan, 2005, Trivedi,

2008), the possibility of autonomous robotic weapons (Johnson, 2003, Leveringhaus, 2014, Singer, 2011).

2. Ontology of intelligent machines in relation to the emergence of machinic life (Johnston, 2008), the importance of performativity for understanding our relation with such machines (Pickering, 2010) as well as views on human machine interaction and technological items identified as relational artifacts (Turkle, 2011) or behavioural objects (Levillain, 2017). The works informed my intention to create the conditions for an interaction with an intelligent social machine the likes of which are not available yet, an applied version of early machinic life that embodies the ambiguous object/life-form status of the new artifacts envisaged by Turkle and Levillain.

3. Reviewing and drawing guidance from the characteristics and critical potential of robotic art by art historians. For example the set-up of *Fish-Bird* by Velonaki contributed to the decision that the robotic artworks inhabit the same physical space as the humans. The open encounter, combined with the subsequent reveal of the human intelligence contribution, aims to generate an impact leading visitors to a critical reflection on intelligent machines. This is in line with the critical function of technological artworks recognised by Wilson (2007) and Zwijnenberg (2009). Additional research includes writing by Burnham (1968) and Reichardt (1968) on cybernetic art as well as artworks by Pask, Gemeinboeck, Penny, Kac, Rinaldo.

4. Survey of robot guides and collaborative robots studies. Practical aspects of audience engagement such as the robots' hybrid mode, the duration of *Guido*'s recorded presentations and its motion through the exhibition were informed by accounts relating the shortcomings of autonomous guide robots in terms of audience engagement (Falconer 2013, Karreman 2015) as well as findings by Lupetti et al (2015) who provided a richer experience for visitors though implemention of a hybrid mode in their robot guide *Virgil*. The survey included additional literature on robot guides by Bischoff (2002), Thrun (1999), Burgard (1999), Faber (2009), Ghosh (2014), and collaborative robotics by Johnson (2014), Schemerhorn (2009), Westlund (2015).

Given the emphasis on human-robot interaction, the original contributions made to the field are most evident in audience reactions to the robot installations. In relation to the first question the author observed visitors engaging naturally with *Combover-Jo*, for example in conversations, taking selfies, performing dance-like motions. The interaction with adults became significant in time and content only when the robot was under human control, while children also enjoyed playing with the robot in autonomous mode. Special moments occurred when the remote operator knew the person interacting with the robot and supplied personal information in the conversation. This resulted in sheer puzzlement in some cases while in others the visitor suspected that the robot was remote-controlled. Overall, it appeared that many visitors were ready for natural interaction with an intelligent machine, and that the degree of engagement was directly related to the degree of intelligence of the machine. This engaged relation was facilitated by the lack of a physical boundary between the robot and the public, a relatively uncommon aspect of robotic art installations. All the artworks above, at the exception of *Fish-Bird*, are either mounted on a static platform and/or contained within a fenced area. If the implementation of a hybrid mode – often called Wizard of Oz (WOZ) mode (Rietz, 2021, Riek, 2012) – is fairly common in the field of HRI research (Hishiguro’s *Telenoid R1,* Westlund’s *DragonBots)*, artworks (Demers’ *Blind Robot*), and commercial applications (Engineered Arts’ *Robothespian*) none of these projects make the controls readily available, if at all, to the public. The granting of robot control to the public is a key feature used in the *Am I Robot* installation for delivering a comment on the respective abilities of AI and HI.

While visitors entering the control room in the *Am I Robot* installation surely notice that the robot’s smarts are provided by human brains, the installation does not provide any information about the current state of conversational machines. It can be argued that AI-based conversational machines applications have entered the public realm with for example voice-controlled assistants in homes and communication devices. Consequently a percentage of visitors will have been exposed to such technology and will be able to compare the performance of Apple’s *Siri* or Amazon’s *Alexa* with that of *Combover Jo*.

In summary the non-utilitarian quality of the *Combover Jo* robot ensures that the interaction with visitors is not goal-driven, thus allowing an open-ended practical exploration of human-robot interaction with a ‘behavioural object’ (Levillain, 2017). The interaction is in line with that envisaged for the *Wild Robot Coy-B* project as a mean of exploring HRI scenarios with machinic life representatives (Johnston, 2008). Inspired by ‘Wizard of Oz’ HRI experiments (Lupetti, 2015, Rietz, 2021, Riek, 2012, Demers, 2014, Westlund, 2015) and deployment of mobile robotic artworks in public spaces (Velonaki), the encounter with *Combover Jo* features natural interaction qualities not available at time of writing on any fully autonomous robot or software. The reveal that the robot’s perceived intelligence is provided by humans aims at raising questions about the respective capabilities of AI and the yet unrivalled general applications of HI.

Robotic art as a participatory practice

This section covers practical work about which I have not yet published writing. We have seen that I find important for my art practice to communicate views on technics, a techno-critique, to a variety of audiences. In the artworks covered above this took place mostly through exhibitions and performances. Both formats possessed a deliberate humorous content, aiming to engage a wide range of audience. The performances were sometimes referred to as performance-lectures due to their mixed content of spoken word and performative actions (Manchester Art Gallery, 2016). At the time I found those to be a more direct and responsive way of engaging with the public than the exhibitions. Interested spectators often came and gave feedback or engaged in conversation at the end of the show. The robots were in some cases made available to try after the performance (*Robotic Ears, Robotic Perception Kit for Sexed Robots* (fig.5, 6 appendix)). The published articles also disseminate a techno-critical content, with references to Céline Lafontaine's *Cybernetic Empire* (2004), Evgeny Morozov's *To Save Everything Click Here* (2014) and Bernard Stiegler's *Technics and Time* (1998). The publications share a call for action against a cybernetic ideal of total efficiency leading to a formatting of society and individuals that brings upon losses of a subjective dimension, of imperfection as a fundamental constituent of humanity and of a knowledge-informed grasp of technics.

Willing to increase dialogue with the public and dissemination further, I have experimented with formats where diverse participants take part in an activity that facilitates sharing of skills and ideas. This type of projects can be categorised as participatory art, where

> the artist is conceived less as an individual producer of discrete objects than as a collaborator and producer of situations; the work of art as a finite, portable, commodifiable product is reconceived as an ongoing or long-term project with an unclear beginning and end; while the audience, previously conceived as a 'viewer' or 'beholder', is now repositioned as a co-producer or participant (Bishop, 2012:2).

My take on participatory art is principally informed by the following concepts:
- Guy Debord's critical view of the passive role of the spectator, inciting instead "this spectator into activity by provoking his capacities to revolutionise his own life" (Debord, 1957:47) through the creation of specific situations
- Joseph Beuys' notion of social sculpture aiming "to build a social organism as a work of art" (Beuys, 1990:) where the creative potential of every individual will contribute to the full realization of democracy.

- Tanya Bruguera's applications of Arte Util (Useful Art) drawing "on artistic thinking to imagine, create and implement tactics that change how we act in society" (2019, web)
- Above cited Clare Bishop, who posits that successful participatory art "has the capacity to communicate on two levels – to participants and to spectators – the paradoxes that are repressed in everyday discourse, and to elicit perverse, disturbing and pleasurable experiences that enlarge our capacity to imagine the world and our relations anew" (2012:289).

Positive Activities (figs. 7, 8, appendix), my first artwork involving participants took place in 2006 in Le Lieu art gallery in Québec City, Canada. Based on the premises that the

> contemporary outlook on the present and the future tends to be rather pessimistic, with growing concerns about the environment, energy, demographics, extremisms, consumerism, developments of science and technology, the project aimed to counterbalance this negativism, focusing on empowering, de-mystifying, physical, communal activities (Granjon 2006:web).

I offered open access to several activities that took place in the gallery over a duration of three weeks: kinetic and robotic artworks constructions from electronic waste, primitive fire-making and collaborative disco choreography. Using methods of participatory art such as shared authorship and dialogue through collective making, *Positive Activities* was a significant step for my practice.

I have continued exploring participatory formats with upcycled electronic waste in various contexts. I usually call such events 'wrekshops', a combination of "wrecking" and "workshop" that hints at a non-precious way of handling the technology on offer. According to Bruno Latour, "when a machine runs efficiently […] one needs focus only on its inputs and outputs and not on its internal complexity. Thus, paradoxically, the more science and technology succeed, the more opaque and obscure they become" (Latour, 1999:304). In an attempt to disturb the opacity evoked by Latour, my main intention is to guide participants to a more investigative relation with technological artifacts, highlighting both the creative potential and environmental impact of electronic waste. Wrekshops start with a creative activity where freedom is given to break and make. Tools and materials are loosely available, supervision is minimal and guidance available on request. No outcome is expected, but constructive experimentation is encouraged. As a result, participants can be seen engaging autonomously, the most interested ones becoming keen to make a contribution to the collective object in progress. Conversations take place between participants, between participants and myself. The most common topics, beyond technical considerations, are the novelty of taking a discarded item of consumer electronics apart, planned obsolescence, issues related to electronic waste and usage of high technology artefacts such a mobile phones.

For the *Oriel Factory* commission (artwork 4, 2011) the art gallery became a participatory factory. Half the gallery was fitted as a manufacturing unit where volunteers processed e-waste for making the artworks to be exhibited in the other half. A documentary film following the project since its inception was produced (Keenan, 2011). The film features interviews with participants and members of the public that provide evidence about the effectiveness of the project for bringing a different perspective on electronic waste and its creative potential. The following quote is from a participant who made a sound and kinetic object from old printers and programmable electronics:

> it's given me lots of ideas, using all the junk, like I've got several printers at home and I'd love to just take these apart and make things out of them, and yeah it has just opened so many possibilities I'd never really thought about (Keenan, 2011).

and the next words from a visitor commenting on the exhibition during the opening:

> We take things for granted don't we, in this world, everything we do, everything that's going on around us, we're not necessarily aware of it so, to see things like this, to see old computer parts and old videos and things being used in a different way, I think, you know, I will go away from this and I'll now see things, I'll see these old pieces of electrical machines in a slightly different light because I know now what they can be made into (Keenan, 2011).

It happens regularly that participants get involved in assembling electronics and writing code for their contribution to the project. I also learn techniques and facts from participants. In some instances, the results of the workshop become a temporary exhibition where I stabilise and integrate the participants' constructions within an improvised installation such as the *Electric Wildertree Wrekshop* (artwork 7, 2017) that I delivered in the Garage Contemporay Art Museum in Moscow and became part of the *Art Experiment, Laboratories of Earthly Survival* exhibition (2017). I have run *Wrekshops* and *Factory* events in an outdoor market (*Afrikandermaarkt Big Band*, Rotterdam, 2009), a shopping arcade (*Dynamo Wrekshop*, Cardiff, 2014), primary schools (Arts Council of Wales Lead Creative School Projects 2017, 2018, 2019), universities, art galleries (Campbelltown Arts Center, Sydney, 2012, Manchester Arts Gallery, 2016, Neuer

Kunstverein Aschaffenburg 2016, Azkuna Zentroa, Bilbao 2018), festivals (Deershed Festival yearly since 2013, International Symposium for the Electronic Arts Sydney 2013) and maker spaces. The content and public of the *Wrekshops* are flexible, ranging from basic break-and-make sessions for children to masterclasses for artists. The most recent one was the *Mud Machine Wrekshop* (artwork 10, 2020), where a temporary machine made of mud, sticks and recycled electronics was built as part of the Criw Celf visual art project for young people in Crickhowell UK. The wrekshop included collection of natural materials on outdoor sites, dismantling of e-waste and construction of the large collaborative remote-controlled kinetic drawing and splashing *Mud Machine*. The organizer found the activity a “thoughtfully designed workshop that incorporated sustainability, environmental issues and making together.” We will see in the next section how the environmental and sustainable agenda observed in *Mud Machine Wrekshop* is becoming more prominent in my practice.

In summary, my participatory artworks operate in a framework informed by Debord’s notion of ‘situation’ as the creation of the conditions for experiencing a novel perspective, Beuys’ idea of social sculpture that taps into every human’s creativity aiming for social change and Bishop’s views on participation art as a creative tool that can boost the imagining of alternative socio-cultural conditions.

The activities taking place during a successful *Wrekshop*:

- stimulate a curious, creative and non-precious approach to electronic items
- disseminate through the collaborative creation of a robotic artwork a range of skills that can include hand tools operation, e-waste recycling, programmable electronics, kinetic sculpture.
- facilitate discussion about sustainability issues related to consumer electronics and the wider environmental situation
- facilitate critical discussions about our own and our civilisation's dependency on and entanglement with technics.

The delivery of such practical and critical content through robotic art methods, occurring during accessible participatory events with a social impact agenda is an original proposition in a field where most practitioners favour exhibiting finished robotic art installations in dedicated art venues.

Current and future directions

AI and robotics expert Rodney Brooks wrote in 2019 a blog post titled ‘AGI has been Delayed’ where he assesses the current capabilities of AI systems. Brooks believes that artificial general intelligence (AGI) possessing at least the same versatility and adaptability as human intelligence, a superintelligence sometimes denounced as an existential threat (Musk, 2017, Hawkins, 2018, Bostrom, 2014), will not occur before 2300 at best. In his view,

> we have plenty of existential threats to humanity lining up to bash us in the short term, including climate change, plastics in the oceans, and a demographic inversion. If AGI is a long way off then we cannot say anything sensible today about what promises or threats it might provide as we need to completely re-engineer our world long before it shows up (Brooks, 2019:web).

I share Brooks' view about the short-term bashing potential of environmental issues, and how this can be seen as a more pressing priority than AI development. The way I now address the co-evolution of humans and machines aims to better integrate the evolution of socio-environmental factors. This direction is not a radical departure as sustainability and ecology have always been part of my work, for example with the affirmation of the value of real animals and natural environments versus their technologically commodified counterparts (*Fluffy Tamagotchi*, *Automated Forest*) and the use of recycled materials and sustainable power in participatory events (*Oriel Factory*). Two artworks illustrate different approaches for exploring this direction.

Mudbots (artwork 7, 2018) is a pivotal artwork that touches upon the three main topics discussed above while adding an ecological dimension. As I have not yet published writing about *Mudbots*, the present text is outlining potential context for and analysis of the work. Developed with a citizen science approach in collaboration with a bio-engineer (Melo and Granjon, 2016-2017), the piece consists of 11 small robots operating in a public space. They use on-board microbial fuel cells (MFCs), also known as ‘mud batteries’, as a power source. Loosely inspired from dung beetles, the *Mudbots*' activity consists of pushing a ball of clay in front of them across the exhibition space. The visitors also can give the robots energy with hand-operated dynamos, thus participating in a live system together with microbial and machinic components. The robots’ bodies are mostly made of 3D printed clay, a design solution that echoes the contrasting nature of the piece: the clay is closely related to the primal mud used as a power source yet shaped by cutting-edge digital fabrication technology. Machinic life here is addressed from an organic angle. Live microbes provide the power required by the computational and motor functions of the machines. These become bacterial cyborgs that process a basic set of inputs and outputs, making visible the activity of microorganisms.

Mudbots is also a practical experiment in using an unusual sustainable energy source for powering a robotic installation. MFCs generate very small amounts of electricity, in the order of a few milliamperes per day. The design and functionality of the robots had to be adapted for such a frugal diet. *Mudbots* move only when they have stored enough power from the MFC (unless a human is giving them power). I must note here that the MFCs rapidly showed reliability limits for a four months-long exhibition. I am currently investigating a collaboration with Euka Sustainable Design Studios in Mexico. Euka's director Toni Gutierrez has created *Mosby*, "a domestic symbiotic photo-bio-electrochemical system" (Gutierrez, 2021:web) that uses the growing of moss for sustaining the activity of the bacteria in an MFC, a promising development that might lead to a more reliable mud battery for small robots or other applications, possibly architectural. Other artists who used MFCs include Smite and Smits with *Biotricity* and *Fluctuations of Microworlds* (2012-2017). The work demonstrated microbial fuel cells functionality in art installations with microscopic imagery and data readings inspired from scientific displays, aiming to "inspire our senses and emotions to connect us to the invisible living environment around us" (Smite and Smits, 2020:188).

Another work including electronics derived from robotic art with an environmental perspective is the *Insect Buzz* (artwork 9, 2019-2020), electronic sound placards made for street demonstrations. The insect-shaped, colourful hand-held objects emit a sound that evokes generic insects, a reminder that the insect population is rapidly declining (Sanchez-Bayo and Wyckhuys, 2019). These were used in environmental marches in Wales and London in 2019 and 2021. I also ran an *Insect Buzz* workshop in 2020 with the aim of disseminating the design. The placards are made of found and recycled materials, run on recycled batteries and use energy efficient programmable electronics. Their aim is to make some noise for ecological causes and to generate a sense of community through sharing the design. They are made cheaply and are not to be treated as precious art objects, fitting within a tradition of props for demonstration. Artistic props used during the October 2019 Extinction Rebellion actions in London include a large structure with screen printed signs that was installed in front of the Tate Modern gallery (London SE1 Community Website, 2019), while artist Joanie Lemercier applied his practice of large scale video-mapping to projecting Extinction Rebellion logos on the British Parliament (Lemercier, 2019). *Insect Buzz* placards are my first attempt at bridging a gap between robotic art and environmental activism, a type of 'useful art' (Bruguera, 2021) designed for socio-environmental impact.

The activities above, together with the *Mud Machine* mentioned in the previous section are representative of three strands for future practice-based research:

- exploration of resource-frugal, sustainable energy and very low power solutions for robotic arts and other applications.
- application of robotic art techniques to environmental causes
- delivery of participatory activities that combine outdoor and bio-diversity aspects with low-tech robotic art

In all new work the use of materials is carefully considered, aiming to significantly reduce utilisation of new stock. This approach is informed by the work of Philippe Bihouix, author of *The Age of Low-Tech, Towards a Technically Sustainable Civilisation* (2014). Developing an analysis based on projections of resources availability and re-use potential, Bihouix argues that purely technological solutions to current crisis are unrealistic due to resources depletion. He makes a case for the necessity of global reduction in resources consumption, with a direct impact on western civilisations' way of life. The finitude of resources and other environmental issues put into question the sustainability of our civilisation, with an increasingly recognised impact on mental health (Obradovich, 2018, Arcanjo, 2019, Panu, 2020). As a result psychologists encounter manifestations of a condition identified as climate anxiety or eco-anxiety, "a fairly recent psychological disorder afflicting an increasing number of individuals who worry about the environmental crisis." (Castelloe, 2018). Including research in such psychological aspects, some of my new work will also aim at tackling eco-anxiety both in myself and in the participants/viewers.

Finally, over the past few years, my participatory and educational projects have taken priority over more ambiguous artworks where subjectivity is unconstrained by agenda and the aesthetic content more prominent than the direct message the work might carry. In parallel to my useful art and gentle activist activities I am re-activating a more clearly artistic practice. The forms this art will take are likely to be multiple, carrying core features of my past practice - such as performance and making of playful objects - into the future.

The combination of environmental activism, participatory art and a subjective art practice echo loosely the notion of ecosophy that Félix Guattari's developed in his book *The Three Ecologies*. Guattari posits that three ecological registers, the environment, social relations and subjectivity must be addressed together so as to tackle "the dangers that threaten the natural environment of our societies" (Guattari, 1989:27). I intend to research further ecosophy and modalities for its application to our current civilisational situation through creative methods derived from my robotic art practice.

Conclusion

It is my hope that the narrative unfolded in the above sections provides some clarity on how my practice-based research addresses the two questions identified in the Introduction.

The first question is: how can a practice-based robotic art research generate new critical insights on technological developments and their effects on individuals and society from a non-utilitarian perspective? This is addressed by:
- identifying themes of interest through an ongoing appraisal of and research on cultural and technical aspects of techno-scientific developments and their deployment, with a focus on intelligent machines, low-tech, sustainable futures. Methods for this investigation apply the praxical knowledge mentioned in the first section as well as scholarly activities.
- the construction of non-utilitarian robotic artefacts that explore aspects of the co-evolution of humans and machines informed by the research findings. The artefacts are conceived for public dissemination through exhibitions, performances or participative activities.
- the integration within the research and development process of the qualitative data findings gathered during dissemination activities.

The second question is: what strategies can be used to share and disseminate the technical, social and environmental insights of a practice-based robotic art research in an effective and impactful way? This is addressed by:
- demonstrating robotic artefacts in public performance lectures, thus disseminating critical reflections about the relation between humans and intelligent machines, the ontological status and desirability of such machines, the delegation of human capabilities to technology.
- exhibiting robotic artworks in public spaces where the experience of encounters with non-benign representatives of machinic life allows examination of the relation and understanding of the artefact’s ontological status, thus raising questions about the respective capabilities of AI and HI and about the robot as convincing social agent.
- creating situations where creative and collaborative making with electronic waste becomes a platform for sharing technical skills, dialogue and reflection on our relation to technics.
- adopting a humorous and irreverent approach that facilitates engagement by diverse audiences.

- integrating an ecological, sustainable and activist agenda within a robotic art practice that expands into further dissemination streams such as environmental activism and educational projects.

I posit that the original dimension of my practice, the new perspective it provides on understanding our relation with intelligent machines in particular and with fast moving technics in general lies within an unusual combination. On the one hand, a personal take, often playful, on practical research and experimentation with machines, appropriation of developing technologies for cultural purposes. On the other a techno-critique with a social impact agenda where ideas about our relation to technics are questioned at the occasion of various activities, some of them creating an unusual connection between robotic art and ecology.

The co-evolution of humans and machines and growing importance of technics has been a key factor in the critical degradation of the ecosphere we are currently experiencing. Applying an ecosophical approach to my current and future practice I intend to address in a granular, grassroots fashion current challenges where individuals globally need to rethink and transform their lives from within a profit-driven, data-controlled system. In this system the freedom of the artist can be seen as an act of resistance in itself, a tool to, in Bishop's words, "enlarge our capacity to imagine the world and our relations anew" (Bishop, 2012:289). I hope that the sharing of this capacity to imagine can in turn trigger non-imaginary changes towards sustainability and resilience, contributing to a more creative humanity and to limiting the damage being done to the planet.

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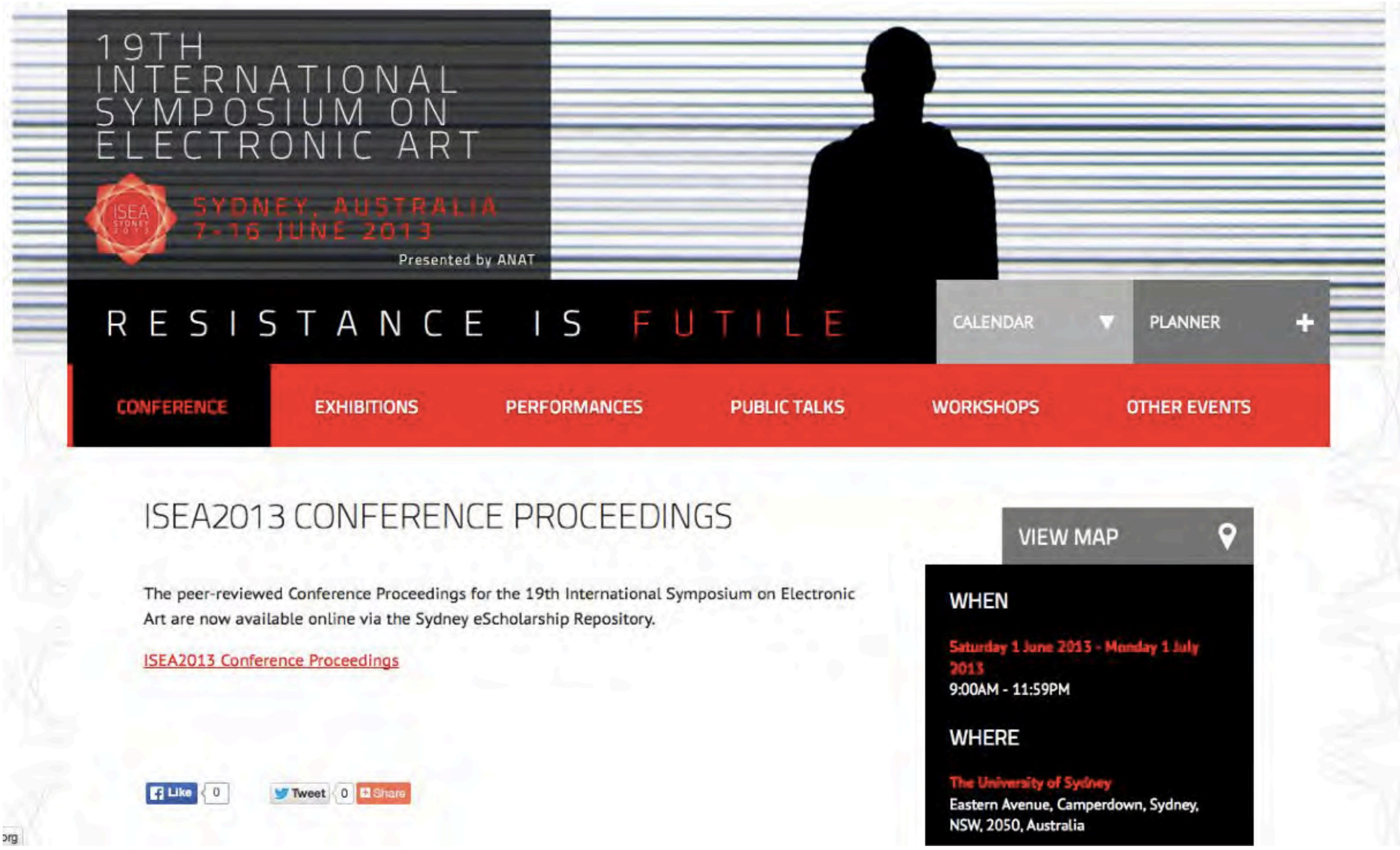
Articles

Article 2: Biting Machine, a Performance Art Experiment in Human-Robot Interaction



Biting Machine, A Performance Art Experiment In Human-Robot Interaction

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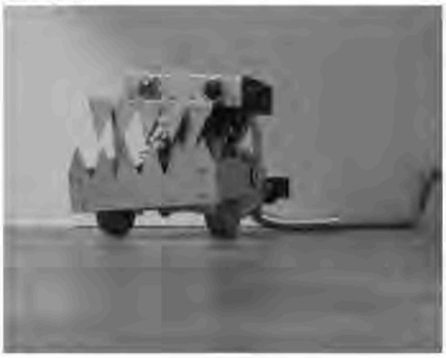
Abstract

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)

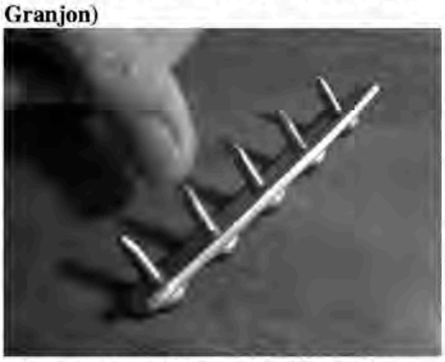
The *Biting Machine* robot

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.

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localisation, sound processing and recognition. The robot will detect touch on key parts of its body with contact sensors. It will also feature an olfactory organ and will be able to mark the territory in a similar way to a mammal, Finally the machine might be given the ability to detect some of the human's cerebral activity with a brainwave sensor system, enabling it to react to variations in mood or peaks in cerebral activity triggered by fear or surprise.

Coy-B will be an intrinsically motivated learning robot, able to develop and adjust idiosyncratic behaviours according to its interactions with the environment, including the human. Its behavioral design draws from several examples in cybernetics and robotics sciences. Bottom-up approaches such as the non-representational, hard-wired navigation of W. G. Walter's cybernetic turtles, the adaptive capabilities of R. Brook's behavior-based robots and the emerging fitness aspect of evolutionary robotics are complemented with more computing-heavy functions inspired by MIT's Kismet's synthetic nervous system [3], the curiosity function of Frédéric Kaplan's Aibos [4] and the use of adaptive resonance theory (ART) neural networks for implementing associative memory predictors as seen in the motivated reflex agents developed by Rob Saunders [5]. The starting point of the project was the *Biting Machine*, a simple automaton built by the author in 2008 [6] (Fig. 2). A more complex prototype platform was built in August 2012 in collaboration with artist programmer Alex May in order to test the suitability of a Microsoft Kinect three-dimensional vision sensor for differentiating a human figure from other objects. An on-board Linux machine and an Arduino board were used for processing the data and interfacing with the hardware.

The prototype robot called *Toothless* (Fig. 2), is able to locate and approach a (slow-moving) human in its environment. The experiment demonstrated that the Kinect was not sufficiently effective for human detection when mounted on a mobile platform and too power-hungry for the application. A simpler solution involving a combination of IR beacon, 2d video camera and distance sensors is now considered. A fully functional machine is not expected before 2015 and the author is open to suggestions and collaborations.

As well as philosophers and sociologists who are engaged in understanding the changes brought upon by technical evolution, visual artists investigate the field of techno-scientific progress and its dynamic interaction with humanity and the world,

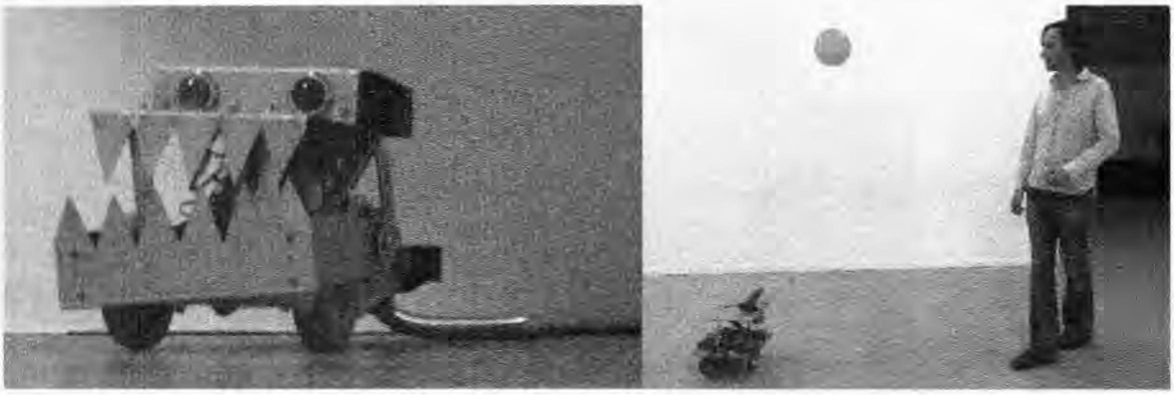

Fig. 2. left: Biting Machine (2008), right: Alex May and Toothless (2012), (photographs by Paul Granjon)

Article 4: This Machine Could Bite, on the Role of Non-Benign Art Robots

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EDITORIAL

Issue Edited by Petra Gemeinboeck, Elena Knox, Jill Bennett, Andrew Murphie

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Introduction by **Petra Gemeinboeck** of the Creative Robotics Lab, National Institute for Experimental Arts, University of New South Wales.

'I like your dress. You must be a fashionista.' 'Really? Thanks', I reply, looking into the enormous, cartoony eyes of a child-sized robot with soft, explicitly feminine contours and a perky, human voice. This isn't a subject of conversation I expected at a male-dominated robotics conference, and initiated by a robot of all things. 'I also like your shoes', the robot "girl" continues. 'I can't wear shoes because I don't have feet.' Pepper, as the robot is called, looks down, dramatically swinging both arms to point me to "her" lack of feet. Then, the robot girl gently tilts its head and starts talking about animals. I begin to wonder if it

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FCJ-208 This Machine Could Bite: On the Role of Non-Benign Art Robots

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Abstract: The social robot's current and anticipated roles as butler, teacher, receptionist or carer for the elderly share a fundamental anthropocentric bias: they are designed to be benign, to facilitate a transaction that aims to be both useful to and simple for the human. At a time when intelligent machines are becoming a tangible prospect, such a bias does not leave much room for exploring and understanding the ongoing changes affecting the relation between humans and our technological environment. Can art robots – robots invented by artists – offer a non-benign-by-default perspective that opens the field for a machine to express its machinic potential beyond the limits imposed by an anthropocentric and market-driven approach? The paper addresses these questions by considering and contextualising early cybernetic machines, current developments in social robotics, and art robots by the author and other artists.

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This paper explores the phenomenon of social robots from the perspective of an electronic artist, a practitioner making robots and other machines within an artistic context. My art objects are vehicles for reflecting on the co-evolution of humans and machines, a reflection informed by observation and experience. Intelligent robots are of particular interest to my practice as they combine mobility, service, social interaction and adaptive skills so as to integrate with the fabric of human society as embodied semi-autonomous agents. They also have captured the imagination of a wide public through works of fiction, wherein advanced robot characters have been commonplace for many decades. People, it appears, are curious about the capabilities of intelligent robots.

Buoyed by techno-scientific progress and financial interest, the field of robotics is fast gaining visibility and maturity, undergoing a tremendous development effort for research, industrial, military, civil and social applications. Indicators of this trend are, for example, Google's acquisition of several robotics and artificial intelligence companies since November 2013 (Ackerman, 2013) and the economy-focused Policy Exchange think tank event *Rise of the Robots* held in London in July 2014. Many of the currently developed or foreseen applications for robots are social, aimed at supporting humans, with roles such as butler, teacher, elder-carer, receptionist and security guard being the most common (Dautenhahn et al., 2005). These roles share a fundamental anthropocentric bias: the robots are providing a service to humans. As a consequence, human–robot interaction is commonly designed to facilitate a useful transaction provided to a human by a benign machine.

The global network of connected devices, often called the Internet of Things (IoT), is emblematic of the progressive integration of computing machines in many areas of human society. Founded on an exponentially widespread machine-to-machine network (M2M), the 'traffic generated for M2M devices is predicted to grow 22-fold from 2011–2016' (Tsiatis et al., 2014: 4); this trend complements the global adoption of sensing and connected technologies within private and public environments as delivered by the smartphone. Motivated equally by scientific research and the quest for financial return, the development of smart machines and the potential consequences of their global deployment raise many questions that are not necessarily relevant to the promoters and developers of the technologies. Of particular interest to me is the notion of machinic life. The capacity of a machine 'to alter itself and to respond dynamically to changing situations' (Johnston, 2008: ix) has, until recently, been found solely in living organisms. We may now need to create a specific ontological category for these new machines, that acknowledges the idea that 'people and things are not so different after all' (Pickering, 2010: 18). But the benign and anthropocentric bias of robotics research, combined with the commercial imperatives driving the deployment of social robots, leave researchers and developers little scope for exploring and understanding machinic life and its impact on society. In contrast, artists working with robotics, being largely free from commercial and scientific constraints, are well positioned for investigating the potential of non-benign machines.

Machinic life

Electronic artist Ken Rinaldo wrote that he is looking forward to 'the day when [his] artwork greets [him] good morning when it has not been programmed to do so' (Rinaldo, 1998: 375), an encounter with a live artwork which has, to my knowledge, not occurred yet. Although the quest for artificial life has been of interest to scientists, artists, writers and inventors since antiquity, it is only recently that scientific and technological developments have made "living" artificial creatures a realistic possibility and a rich field of research for the 21st-century robotic artist. This article focuses on non-biological systems or constructs that may demonstrate aspects of machinic life as defined by John Johnston. Having examined a comprehensive set of examples from the fields of robotics, artificial life and new artificial intelligence, Johnston (2008) posits that the evidence points toward the emergence of radically new machines (software and hardware). With a family tree rooted in the work of W. Grey Walter and other post-WWII British cyberneticians, the new machines, possessing adaptive characteristics that used to be found solely in biological living organisms, do not fit comfortably in the categories of either alive or not alive. According to Johnston, these liminal machines are the tremors announcing a genuine machinic life. The notion is not new, having brewed throughout the 20th century in the realms of fiction and cultural studies. Johnston refers directly to the 'becoming machinic' and 'machinic phylum' coined by Deleuze and Guattari (1980: 406), claiming that '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' (Johnston, 2008: 20).

The implications for human society of sharing the world with representatives of machinic life are profound and multi-faceted. Artificially intelligent creatures present a novel condition that calls for extensive study and scrutiny. I have identified three useful concepts in the works of Johnston, Donna Haraway and Sherry Turkle that inform this practice-led reflection on the subject:

> **Machine as assemblage:** for Johnston (2008: 111) 'the term machine designates an ensemble of heterogeneous parts and processes whose connections work together to enable flows of matter, energy, and signs ... Machines, first of all, are assemblages that include both humans and tools, or in modern societies, technical machines'.
>
> **Contact zones:** this term is coined by Haraway (2008: 186) to describe the common experiential dimension where 'animals, humans and machines are all enmeshed in hermeneutic labor (and play) by the semiotic-material requirement of getting on together in specific lifeworlds. They touch therefore they are. It's about the action in contact zones'. In a more technical fashion, robotic scientist Frédéric Kaplan (2005: 60) borrows from psychology the notion of shared attention (*attention partagée*) to assess the degree of interaction between a human and a robot by monitoring the robot's perceptual data while it is interacting with a human in the performance of specific tasks.
>
> **Sort of alive:** a term coined by an 11-year-old schoolgirl named Holly, referring to mobile robots navigating a maze during a study led by Turkle. 'Sort of alive' has since been used to describe an intermediary condition between that of an inanimate object and that of an animal (Turkle, 1998).

The socialisation of robots

"Social robot" is still a term open to interpretation, and this paper adopts the definition offered by Terrence Fong et al.:

> Social robots are embodied agents that are part of a heterogeneous group: a society of robots or humans. They are able to recognize each other and engage in social interactions, they possess histories (perceive and interpret the world in terms of their own experience), and they explicitly communicate with and learn from each other. (2003: 144)

Eleven years after this definition was written, social robots have not yet had a significant impact on human society, yet an emerging trend in industrial robotics indicates a growing socialisation of robots.

Unlike the nascent and still experimental social robots being developed worldwide or the prospective returns of Google's investment in robotics companies, industrial robots have been commercially viable since the 1950s and a mature industrial robotics market now exists. Recent numbers show a year-on-year growth of 12 per cent between 2012 and 2013, indicating a similar trend in 2014 (Modern Material Handling, 2014). Industrial robots, traditionally programmed to perform repetitive manipulation tasks with accuracy and speed in secure areas, are undergoing a significant change with the introduction of collaborative capabilities. According to Modern Material Handling,

> ... easy to use and easy to integrate robots will open up a wide range of new customers and new applications for robots. A main example for this category of robot use is the human-machine-collaboration. The robots working together with the worker in the factory or also in non-manufacturing sectors are capable of understanding human-like instructions (by voice, gesture, graphics) and have modular plug-and-produce components. (2014)

While practical applications of social robotics in domestic, health or corporate environments are not yet mainstream, the prominence of collaborative industrial robots signals that applications for human–robot social interaction are entering commercial maturity. First commercialised in 2012 by Rethink Robotics, Baxter the affordable, human-safe, collaborative industrial robotic arm with a friendly face is a recent commercial success. Baxter and its more advanced sibling Sawyer, launched in 2015, are being adopted by small and medium-sized manufacturing businesses worldwide. As robots are becoming social and ubiquitous, they deserve critical, artistic attention more than ever.

Anthropocentrism and benign robots

The open definition by Fong et al. of a social robot proposes a balanced state where humans and robots share a world in an even fashion and does not mention a utilitarian usage for robots. Although the terms of the definition still apply to recent research, the majority of current social robotics projects favour an anthropocentric, utilitarian perspective that does not leave much room for robots' histories to develop. In their survey of social robotics, Fong et al. have identified common characteristics of the field:

> ... social learning and imitation, gesture and natural language communication, emotion, and recognition of interaction partners are all important factors. Moreover, most research in this area has focused on the application of "benign" social behavior. Thus, social robots are usually designed as assistants, companions, or pets, in addition to the more traditional role of servants. (2003: 145)

It can be argued that these roles for social robots, as well as the adjective 'benign', sum up the current status quo in social robotics science, in which machines have to comply to rules of safety, friendliness and legibility in order to facilitate interaction with the humans.

Anthropomorphic design of body and behaviour is assumed to be an evident gateway to a natural relation between a human and a sociable robot. In Brian Duffy's words, 'it can facilitate rather than constrain the interaction because it incorporates the underlying principles and expectations people use in social settings in order to fine-tune the social robot's interaction with humans' (2003: 181). As a result, robots are often given a humanoid or animal appearance, ranging from very realistic (see the Geminoid series or Paro the robot baby seal) to mechanical humanoid (e.g. iCub, Asimo, Nao) to cartoon-ish (e.g. iCat, Baxter, Leonardo). With the exception of Paro, the "mood" of the all the robots mentioned above is indicated through an expressive face modeled on human features: eyes, eyebrows and mouth are used to model the expression of common emotional states such as happiness, sadness, boredom, etcetera. To further ease the integration of robots into a human environment, recent developments in the emerging field of soft robotics make use of materials such as rubber and electro-active polymers in the construction of body and actuators, allowing, for example, the creation of octopus-inspired manipulators. In a similarly soft fashion, a functional android prototype called Roboy, featuring joints fitted with flexible tendons instead of rigid motors, was launched in Switzerland in 2013. The ability of soft robots to "give" naturally when encountering obstacles 'makes them ideal for applications such as personal robots that interact with people without causing injury' (Trivedi et al., 2008: 99), thus embedding the benign, domesticated dimension mentioned earlier into the sheer materiality of the machine.

Understandably, it is of little interest to most engineers and robotics scientists to explore the possibilities of non-benign social machines. Scientific or commercially driven projects are essentially reductive, having to provide safe solutions, fulfil consumers' needs, and follow established methodological criteria. Early examples of creative machines designed for exploring human–machine interaction from a more open-ended and inclusive perspective can be found in the work of early British cyberneticians such as Gordon Pask, who coined the term 'maverick machine'.

Maverick machines

In 1968, Jasia Reichardt curated the landmark exhibition *Cybernetic Serendipity*, a show that dealt broadly with the demonstration of how humans can use computers and new technologies to extend our creativity and inventiveness. Reichardt commissioned Gordon Pask to produce a piece that would illustrate his ideas about cooperative action and self-organisation. If possible, it should also have some aesthetic merit. The result was as a work called *A Colloquy of Mobiles*: an interactive installation that 'represented an ecological, or perhaps ethological, fantasy' (Pask and Curran, 1982: 78). Pask had been exploring the notions of self-regulation and collaborative learning for years, creating educational devices such as *SAKI* the adaptive keyboard instructor (1956) or more artistic endeavours such as *Musicolour* (1953), a synaesthetic machine that produced a coloured light performance in response to musicians performing with traditional instruments. Described by Pask (in Reichardt, 1968: 34) as a reactive 'aesthetically potent environment', *A Colloquy of Mobiles* comprised five motorised modules made of fibreglass, metal and purpose-built electronics hanging from the ceiling over a surface of four by five metres. The mobiles, described as two males and three females, were able to engage in discourse, compete, cooperate and learn about each other using light beams and sound while moving on powered beams. Conceived as a social system where 'sharing takes place between people, between processors, or between people and processors' (Pask and Curran, 1982: 79), the installation was designed in such a way that the males appeared to be competing for female attention and the females responded to adequate light stimulation with specific sounds and motion. The visitors were invited to walk amongst the hanging robots and contribute to the interaction using mirrors and flashlights. Pask mentioned that:

> ... in order to remain a self-organising system, the mobiles had to steer a middle course between two extremes: no conflict resolution, in which case the system would fail to organise at all, and total organisation, total sharing of information, in which case the individual character of the machines would be destroyed. The introduction of ... the human element was a safeguard against total organisation. (1982: 79)

The mobiles can be considered 'maverick machines', a term coined by Pask to describe 'machines that embody theoretical principles or technical inventions which deviate from the mainstream of computer development but are nevertheless of value' (1982: 133).

In his book *The Cybernetic Brain*, Andrew Pickering highlights the originality of the early British cyberneticians' approach to knowledge generation as a counterpoint to that of modern science. Whereas modern scientific methodologies tend to isolate the subject of the experiment so as to reduce noise and ensure repeatability, the non-modern cybernetic approach is performative, being that the subject is observed in action within an environment. According to Pickering, the cybernetics perspective is one in which we are:

> ... enveloped by lively systems that act and react to our doings, ranging from our fellow humans through plants and animals to machines and inanimate matter, and one can readily reverse the order of this list and say that inanimate matter itself is also enveloped by lively systems, some human but most nonhuman. (2010: 20)

Pickering describes the black box, a staple of cybernetic theory, as 'something that does something, that someone does something to, and that does something back' (2010: 20). Cybernetic knowledge is produced not from opening the black box or from deconstructing it to its smaller sub-components but from engaging performatively with it as a partner in a 'dance of agency'. For a contemporary techno-artist working with robots, the notions of maverick machines and a cybernetic dance of agency have strong appeal. They evoke possibilities of real-time social interaction with autonomous artificial entities that operate on their own terms in a shared environment, gradually exploring communication and relationship through contact zones. Pask's maverick machines, entangling humans and processors in a physical environment (and sometimes in a non-benign fashion), are inspiring precursors for robotic art projects investigating these notions.

Non-benignity

As discussed earlier, the vast majority of robots are designed to be fundamentally benign, to either operate safely in isolation or integrate seamlessly within human society. A significant exception is the military robot. Military technology often drives techno-scientific progress, and robotics is a prominent area of weapon development as it allows deployment of forces with limited exposure of human soldiers (Galliott, 2015). Yet, the adoption of intelligent technologies that raise the possibility of autonomous killing machines challenges the strict military chain of command. Military forces and security providers insist that it is essential to keep a human in the loop (remote-control operation), or at least "on" the loop, 'where the operator is on standby and can override the robotic targeting process' (Leveringhaus and Giacca, 2014: 11). For example, British Aerospace, makers of the British Taranis unmanned stealth airplane, 'made it clear that, with regard to unmanned aircraft systems, there will always be a need for a human in the loop, in particular regarding any use of weapons, both now and in the future' (Leveringhaus and Giacca, 2014: 5). According to P.W. Singer in his book *Wired for War*, when it comes to truly autonomous weapons, 'both specialists and military folks tend to change the subject or speak in absolutes' (Singer, 2009: 123). He quotes Eliot Cohen, a recognised military expert at Johns Hopkins: 'People will always want humans in the loop' (2009: 123). Generals currently favour solutions that allow sensitive decisions to remain under operator control. A US Army report about future tactical autonomous combatants (TACs) states that, 'even though we use the term "autonomous", we do not envision total autonomy. The term "supervised autonomy" is more accurate. Humans will "supervise" the unmanned entities when objectives change or when decisions outside the bounds of the TAC's autonomy are required' (Johnson et al., 2003: 1). Given that they still involve humans in a supervisory role, I have excluded military robots from my discussion of non-benign intelligent machines below.

Non-benign maverick machines

A non-benign, non-military robot can be thought of as a maverick machine in that it deviates from the mainstream of robotics development. Looking at such machines presents the opportunity to investigate robotic invention and its role in society off the beaten track of market-driven or purely scientifically motivated development. Non-benign here does not stand for malign, but instead aims to define an area where a wide range of autonomous behaviours are possible, covering a full gamut of possibilities which may include aggressive as well as friendly traits. A non-benign maverick machine could thus be an interesting vehicle for exploring the manifestations of machinic life. Such a 'sort of alive' artefact is likely to develop a range of responses that will not resemble animal or human behaviours. This potential can be seen, for example, in the case of evolvable hardware, where engineers apply genetic algorithms to electronic design. Evolving electronic circuits using genetic algorithms allows the software to arrive at efficient solutions that significantly depart from those designed by humans. The weight of electronic circuit designers' experience leads them to:

> ... operate largely under assumptions of linearity, and consider only modularity and hierarchically-structured systems, though it is clear in many cases that the resulting performance is inferior to that attainable if we were able to transcend these limitations and exploit the vastly augmented design space and emergent properties attendant upon less constrained and more holistic conceptions. (Miller, Thompson and Fogarty, 1997: 105)

Similarly, the design of a social robot for the emulation of a support or service task traditionally undertaken by humans is likely to be limited by assumptions and past experience.

Creating a non-benign, intelligent machine presents the challenge of developing software and hardware architectures from which a non-biased, less constrained and more holistic machinic life system can evolve. Artistic practice is well suited to investigate the potential of such a machine as a concept as it addresses a mix of traditional subjects (life-likeness, performance, representation) and contemporary questions (exponentiality of technological progress, hegemony of scientific knowledge, relationship with machines, control society, post-humanity, singularity). However, the realisation of an art robot addressing these challenging questions calls for a collaboration between artists, scientists and technologists.

On the role of art robots

Art robots can shed a different light on contemporary robotic research and on our relation to machines, for example by creating speculative scenarios and experiments free of utilitarian function and not fully constrained by the methodical rigour of scientific research. The artist's contribution to deciphering techno-scientific trends provides a different perspective to a scientist's or a technologist's perspective. Electronic art specialist Stephen Wilson (2007) argues that 'in a techno-scientific culture, artistic probing of the world of research is a critical, desperate need. We need people looking at these fields of inquiry from many frames of reference, not just those sanctioned by academia or commerce'. Similarly, Robert Zwijnenberg in his preface to *Art and Technoscience* makes a case for a revitalised role for humanities and the arts in understanding and guiding societal choices presently driven by technologists and scientists. He argues that 'the eager and unrestrained artistic attitude vis-à-vis the life sciences ought to motivate scholars in the humanities to instigate and develop more sustained reflection about the life sciences' (Zwijnenberg, 2009:

xxvii).

Having attended and contributed to a significant number of international electronic arts events and exhibitions over the past two decades, my experience is that the field of electronic arts features more software-based and screen-based works than autonomous robotics works. A likely reason is the wide range of technical skills and resources required to produce reliable machines combining many complex hardware and software components. As a result, relatively few robotic artworks have been created, which, on the one hand, limits the scope of historical research and, on the other, leaves much to be explored with the medium. In *Robotic Art,* a joint statement published in 1996, artists Eduardo Kac and Marcel-lí Antúnez Roca wrote that:

> ... one of the crucial concerns of robotic art is the nature of a robot's behavior: is it autonomous, semi-autonomous, responsive, interactive, adaptive, organic, adaptable, telepresential, or otherwise? The behaviour of other agents with which robots may interact is also key to robotic art. The interplay that occurs between all involved in a given piece (robots, humans, etc.) defines the specific qualities of that piece. (Kac and Roca, 1997)

Although Kac's and Roca's extensive taxonomy offers a valid way of differentiating between robotic artworks, I would like to propose a simplified categorisation, comprising three categories, yet including a wider range of media:

> **Illustrative:** the work is not functional, instead representing robots through another medium such as photography, video, sculpture.
>
> **Reactive:** functional machines fitted with sensors and actuators inhabit a physical space. All their possible states are pre-programmed: they are finite machines.
>
> **Evolutive:** complex machines that can adapt, evolve and learn.

The reactive category encompasses the majority of existing robotic artworks, in which the machines' design and programming don't allow for true adaptation even if they are able to react to a changing environment. Reactive art robots can provide a rich form of interaction with the public, embodying possible human–robot relationship scenarios, conveying ideas about the role of machines in human society, or demonstrating technological possibilities. Yet, due to their deterministic design, reactive systems are closed and eventually predictable entities. More apt to produce representatives of machinic life is the evolutive category, where a robot's design includes adaptive intelligence that enables it to learn and evolve new behaviours from its interactions with the environment. The artwork results from the assemblage of robot, human participant and environment, a sum of connections and flows that, beyond sheer techno-scientific demonstration, conveys intentionality. The roots of such artistic endeavours can be found in last century's systems art movement. In the words of systems art proponent Jack Burnham, 'systems-oriented art will deal less with artifacts contrived for their formal value, and increasingly with men *[sic]* enmeshed with and within purposeful responsive systems ... [T]he system itself will be made intelligent and sensitive to the human invading its territorial and sensorial domain' (Burnham, 1968: 363). Almost 50 years later, the 'intelligent and sensitive' systems evoked in future tense by Burnham are reaching technical feasibility.

Few robotic art projects have dealt with the complexity required by such systems, and the ones that have were often the result of art–science collaborations. Mentioned in order of increasing non-benignity, *Fish-Bird* (2006) by Mari Velonaki in collaboration with a team from the Australian Centre for Field Robotics, and* Accomplice* (2013) by artist Petra Gemeinboeck and computer scientist Rob Saunders, propose a strong artistic vision combined with advanced computer science. Velonaki's robots, wheelchair-like machines showing no visible circuitry or motors, move gracefully while dropping poetic printed notes on the floor. The artwork aims to induce 'a willing state of suspended disbelief, where [the visitor] is not conscious of interacting with a machine ... A successful interface enables fluent, intuitive communication between human and machine' (Rye et al., 2006). The fluid interaction between visitors and system and the use of the written English language by the robots still don't make for a fully benign machine in that the robot system's motivation remains alien. *Fish-Bird* offers the visitor a chance to be part of a cybernetic assemblage as an observer and participant and does not deliver a clear, goal-driven interaction, creating space for an open and personal human–machine relationship to exist.

The robots in *Accomplice* are more explicitly non-benign, laboriously destroying what appears to be a gallery wall. Embedded into the wall, the robots are programmed to be "curious" and to autonomously explore their environment. Once the environment has been memorised, however, the robots get "bored" and use their electro-mechanical punches to alter it, producing marks and holes in the wall. Over the duration of an installation, the gallery environment gets irreversibly altered and, as the walls get increasingly perforated, the robots become visible and exhibit a curious disposition toward the visitors standing on the other side. Gemeinboeck and Saunders (2013: 216) are interested in creating 'works that explore notions of autonomy and artificial creativity that may offer starting points for thinking about social settings that involve humans interacting and collaborating with creative agents'.

In different ways, the two maverick machines described above are non-anthropocentric systems, assemblages that offer environments for humans and sort-of-alive machines to share experiences, explore, and make manifest possible stories for humans and social robots. They cultivate contact zones. Together with the complexity supported by the collaboration with scientists, the open-ended, non-benign characteristics of these machines and their modes of staging offer an experimental playground for a first-hand experience of early machinic life.

Wild Robot Coy-B and its older relatives

At the time of writing, I am working on *Wild Robot Coy-B*, a collaborative project with an autonomous robotics scientist. The project aims to create an intelligent robot with a potential to be dangerous, that will interact with humans in live performances. I will first discuss three of my existing hand-made robots in order to clarify *Coy-B*'s lineage before describing the project in more detail.

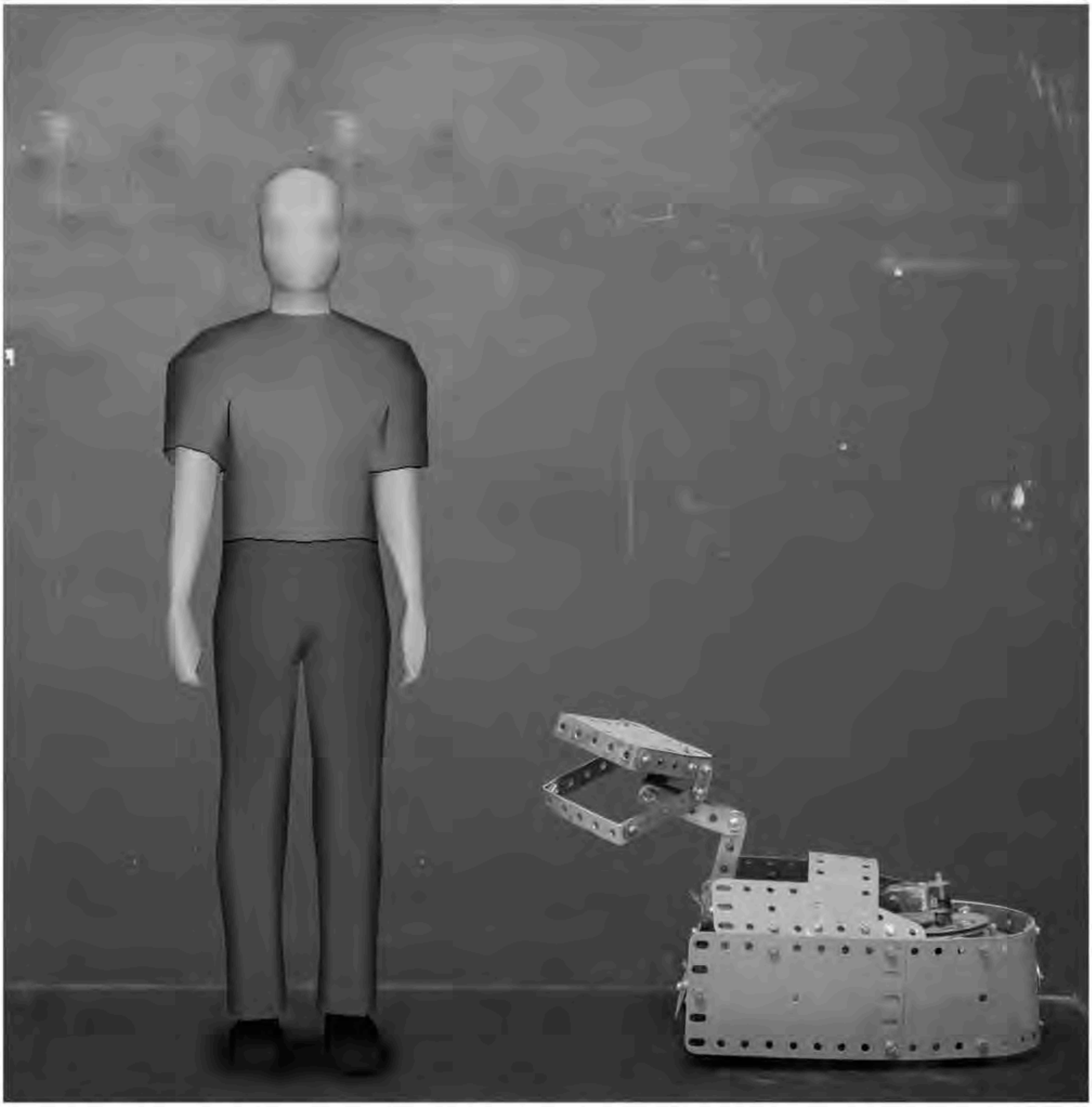
Figure 1: Wild Robot Coy-B, artist's impression, 2015, credit the authorFigure 1: Wild Robot Coy-B, artist's impression, 2015, credit the author

My practice of robotic art started in 1996 when I started learning techniques of interfacing and control that I applied to robots designed for video and performance. An early example is *The Fluffy Tamagotchi* (1998), a robot inspired by the famous electronic hand-held toy pet. Made for a short video, in my taxonomy *The Fluffy Tamagotchi* is situated half-way between an illustrative robot and a reactive one. While its features, inspired from the original toy, are functional, due to the use of video the robot in the artwork doesn't require reliability or maintenance. The video provides an overview of the robot's operation in a descriptive, deadpan fashion, contradicting the absurd nature of a five-kilo machine that excretes blue custard and cries loudly when its program needs attention. *The Fluffy Tamagotchi* is an early instance of a machine that offers a critical comment on a techno-societal trend, questioning the rationale of replacing living animals with commodified, artificial ones, packaged in plastic eggs and fitted with rudimentary AI.

Figure 2: The Fluffy Tamagotchi, screenshot from video, 1998, credit the authorFigure 2: The Fluffy Tamagotchi, screenshot from video, 1998, credit the author

The following two examples could be situated within the maverick machine category as their design has not been inspired by existing commercial products. *Furman* (2003) is a six-foot high machine that delivers karate-style kicks, powered by compressed air. A physical manifestation of a creature I saw in a dream, *Furman* is introduced and demonstrated in live performances where it fells me on a gym mattress with one powerful kick. The creature is both a friendly guardian and a machine that turns against its creator in a Frankenstein-like fashion. The hairy robot taps into unconscious images in a surrealist fashion and provides a humorous illustration of the duality of robots and technology in general. Despite being a simple anthropomorphic automaton whose presence is enhanced by a performer telling a story, at its heart, *Furman* is a non-benign machine that can harm a human standing in the way of its metal and epoxy foot.

Figure 3: Paul Granjon and Furman, 2003, credit J. SavageFigure 3: Paul Granjon and Furman, 2003, credit J. Savage

The next work displays non-aggressive robots that do not interact with humans. The "male" and "female" *Sexed Robots*, created in 2005, operate autonomously in a zoo-like enclosure. Their program takes them through a pseudo-random selection of different states that include roaming, singing, sleeping and being in heat. If two robots in heat find each other they will attempt to have intercourse, connecting their genital organs which are machined in industrial nylon stock to interlock in a complementary fashion. The intercourse ends when one of the robots changes state and disengages. A reactive piece of medium-level complexity, *Sexed Robots* questions, in an absurd manner, to what extent humans want to delegate some of their basic functions to machines. Simultaneously they provide an entertaining alternative to the robots I saw in robotics laboratories at the time: small wheeled platforms fitted with various modules such as grippers or cameras that slowly performed sorting or navigating tasks, unlikely to capture the attention of a non-specialised audience for more than a short time. Fitted with a genital module, the sexed robots perform an isolated algorithmic dance sometimes punctuated by a duet of penetration. They are not social robots as they don't attempt to establish a benign relationship with humans. Instead, their performance aims to draw parallels between human and machinic behaviours and trigger reflection.

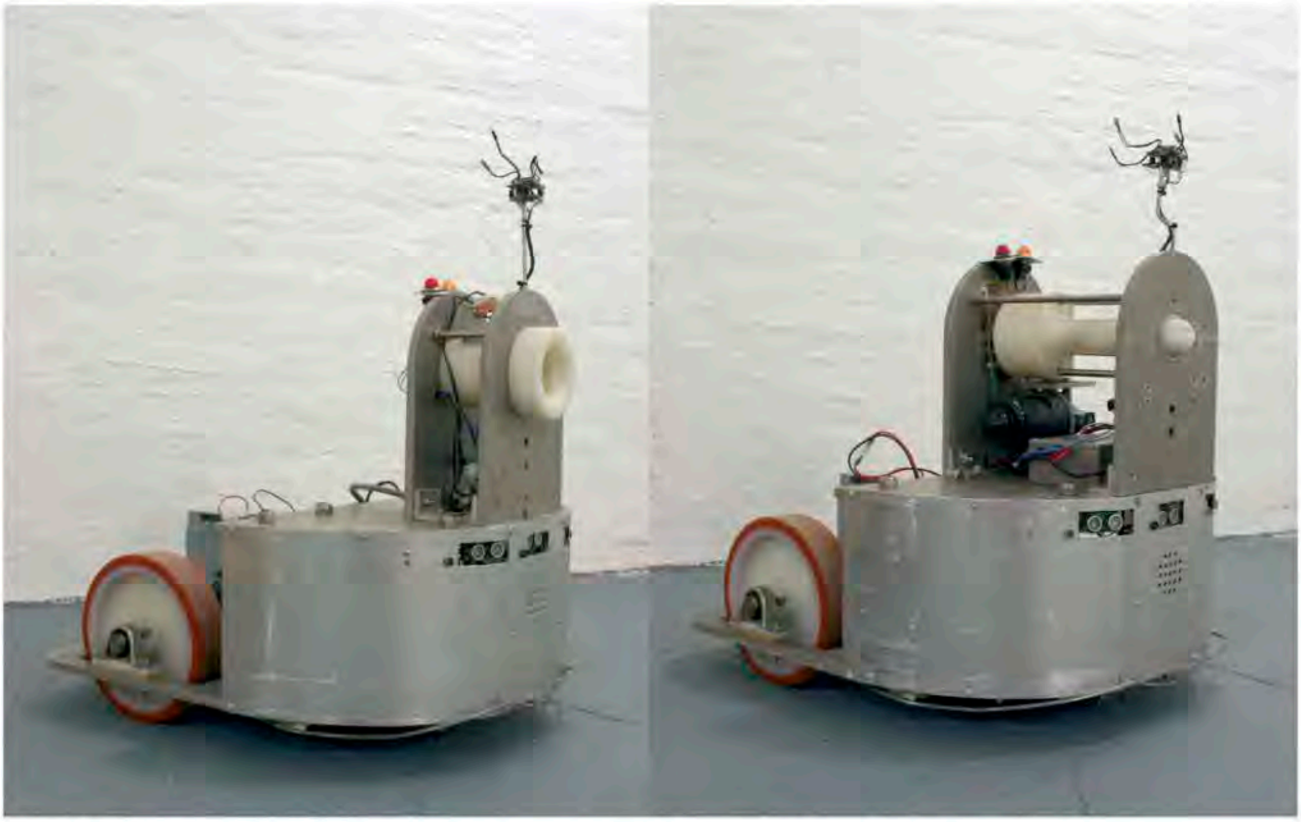

Figure 4: Sexed Robots, 2005, credit the authorFigure 4: Sexed Robots, 2005, credit the author

Imagined as 'an experiment in human–robot interaction with a metaphorical dimension that will provide material for reflection, dialogue and analysis on the ontology of artificial creatures' (Granjon, 2014: 30), *Wild Robot Coy-B* goes a step further than* Accomplice* and *Furman* with regard to its level of non-benignity. The project's initial inspiration was Joseph Beuys' *I Like America and America Likes Me _(1974), wherein the artist shared a space in a New York gallery with a live coyote for three days. Beuys chose to spend several days with the coyote in a shared territory in an attempt to metaphorically reconnect with natural wildness and instinct, dimensions lost to contemporary western humanity. In the _Coy-B* project, an evolutive autonomous robot of similarly dangerous potential will replace the coyote. Symbolically opposed to the coyote, the robot is a representative of up-to-date machinic life, the product of technics and artificiality. Performance creates a terrain for an open-ended relationship to unfold between a human and a smart, learning machine, programmed to be curious and to develop its own responses to internal and external stimuli. The programming and the physical design of the robot will involve genetic algorithms and other evolvable machine design techniques to limit the aforementioned anthropocentric bias. The *Coy-B* robot will be fitted with an arm-mounted gripper that could potentially double as a bite-inflicting actuator. Acknowledging a potentially aggressive, dangerous dimension is an important part of the metaphor that the work aims to produce, recognising the multi-faceted range of applications of any technology. In order to insure both conceptual robustness and scientific relevance, the work will be developed by a team comprising an artist, two scientists and a science and technology studies (STS) scholar.

A word of caution

Despite its inherent subversive element, a non-benign, intelligent machine artwork contributes to the general digital augmentation of our environment and its immense potential for monitoring and control. Denouncing 'Silicon Valley's quest to fit us all in an electronic straightjacket by promoting efficiency, transparency, certitude and perfection – and, by extension, eliminating their evil twins of friction, opacity, ambiguity and imperfection' (Morozov, 2014: xiii), activist writer Evgeny Morozov posits that the ongoing application of data-driven control to many domains of society, often presented as a *fait accompli*, must raise questions about the power held by the controllers. A technological art practice, with all the subjectivity, messiness and lateral thinking that characterise the artistic process, is well suited to inject noise into this perfect landscape – to make the straightjacket itchy in places.

Nevertheless, artists adopting contemporary cybernetic tools need to be aware of the potential pitfalls. Digital artist and theorist Simon Penny, writing about artificial life and interactive art, warns that 'artists must be careful not to unconsciously and unquestioningly endorse the value systems and narratives hidden in scientific discourses, where they often lie hidden, disguised as axioms' (Penny, 1996). One of the challenges faced by artists working with science and technology is the risk of spending much of their time and resources on the acquisition and application of new technical knowledge, sometimes to the detriment of their original artistic intention. The possibility of confusing the means for the end is very real and too often demonstrated in the technologically heavy world of electronic arts. Artistic adoption of contemporary technological tools must not lead to losing sight of the intended artistic and critical content. The artwork is likely to be more evocative and multi-layered if it embodies a reflection on the medium and its context, going beyond an application of sophisticated tools. I believe that it is a grand challenge for artists and their collaborators working with robots to devise non-benign, ambiguous, maverick machines to produce awareness, resistance and knowledge, and that in so doing we can impact societal choices for a future in which human and non-human agencies can dance freely. * *##*Biographical Note* Paul Granjon is an electronic artist and educator working and living in Cardiff, Wales. He teaches at all levels of the Fine Art course at the Cardiff School of Art and Design and runs regular workshops and public events. He has presented robots and other machines for performances and exhibitions since 1996.

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Guido and *Am I Robot?* A Case Study of Two Robotic Artworks Operating in Public Spaces

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Abstract
This article is a case study of two artworks that were commissioned for and exhibited in art venues in 2016 and 2017. The first artwork, *Guido the Robot Guide*, guided the visitors to an art-science exhibition, presenting the exhibits with a robot's perspective. *Guido* was the result of a collaboration between artists and engineers. The concept was an irreverent robot guide that could switch transparently from autonomous mode to operator control, allowing for seamless natural interaction. We examine how the project unfolded, its successes and limitations. Following on *Guido*, the lead artist developed the robotic installation *Am I Robot?* where the idea of a hybrid autonomous/remote-manual mode was implemented fully in a non-utilitarian machine that was exhibited in several art galleries. The article provides a concise contextualisation and details technical and design aspects as well as observations of visitors' interactions with the artworks. We evaluate the hybrid system's potential for creative robotics applications and identify directions for future research.

Keywords
Robotic Art
Robot Guide
Collaborative Robotics
Dynamc Robot Autonomy
Telepresence
HRI
Robot-human Interface

Introduction

What is a robotic artwork? As some readers may not be familiar with the term, it is important to begin by stating clearly what type of robotic systems belong to the category. Traditional media such as painting or sculpture are just some of the means used by contemporary artists, whose practice can be expressed through many different media. In a similar way to how video art was invented by artists who, in the 1960s, chose to make art with television sets and video cameras, robotic art is made by artists who choose robots as their medium. The artworks thus produced often comment on the relation of humans and technology, providing metaphors, unfolding speculative scenarios or exploring technical possibilities in a non-scientific or commercial manner. The practice of artists working with robots has sometimes been described as creative robotics, "a transdisciplinary practice that builds on the history of robotic and cybernetic art to explore human-robot configurations from a critical, socio-cultural perspective. It brings together concepts and methods from experimental arts and engineering, performance and the social sciences" (Gemeinboeck, 2017). This artistic integration of robotics and computer science started in the 1950s. Notable examples include Nicolas Schöffer's *Cysp1*, (from Cy-bernetic and Sp-atiodynamic) a mobile sculpture that responded to sound and light (1956), Nam June Paik's *K456* remote-controlled flimsy humanoid (1964), Edward Ihnatowicz's *Senster* (1970) a large scale pneumatically driven beast that moved its long neck towards visitors, as well as Stelarc's cyborg-like *Third Hand* (1980).

Figure 1. The Fluffy Tamagotchi, video still, P. Granjon, 1998

Paul Granjon, the lead artist for both artworks discussed here, has been making robots for live performances and exhibitions in galleries and museums since the mid 1990s. Self-taught in coding and hardware, he makes simple programmed machines that aim at provoking in the audience a reflection on what he often refers to as the co-evolution of humans and machines (Granjon, 2013). For example one of his first working robots was the *Fluffy Tamagotchi* (1998) [Figure 1], a teddy bear-sized noisy and messy robot that claimed to bring back the physicality of pets to the sterile interactive toy. The robots he made since continue to raise questions about our needs and uses for robots and other contemporary technologies while exploring in a practical manner some of the possibilities offered by these technologies. We will examine two robotic artworks operating in public spaces : *Guido the Robot Guide* (2015), a museum guide robot created in collaboration with a team of artists and engineers, and *Am I Robot?* (2016) an art installation featuring a talking mobile robot.

Museum guide robots have been tested in real guiding situation since the late 1990s. Some of them are wheeled platforms fitted with more or less expressive "faces", for example *Rhino* (Burgard W. et al, 1999), *Minerva* (Thrun et al., 1999) and more recently *FROG* (Karreman et al., 2015). Humanoid robot guides are also tested such as

Robotinho (Faber et al., 2009), *TT2* [7], *ASIMO* (Falconer, 2013). A common design of existing robot guides is a centaur-like set-up, where a full size humanoid, with or without legs, is mounted on a motorised base as seen in *Hermes* (Bischof et al., 2002), the working version of *Robotinho* and *TT2*. The guide robots mentioned above operate autonomously for both navigation and audience interaction. They are all research robots and are presently not active in galleries and museums on a full time basis, if at all.

There are cases of autonomous mobile robotic artworks sharing space and interacting with members of the public, unburdened by the task-based function of being a museum guide or another utilitarian function. Examples include Max Dean and Rafaello d'Andrea's *The Table* (1984), a mobile table interfering with visitors motions, Simon Penny's *Petit Mal* (Penny, 1997), an awkwardly balanced machine that visitors could approach for playful interaction, Maria Velonaki's *Fish Bird* (Rye et al., 2005), a pair of graceful wheelchair robots that dropped poetic notes on the floor while engaging in motion with visitors, Kacie Kinzer's *Tweenbots* (Kinzer, 2011) that were left free in Central Park, depending on the public's good will to reach their destination, as well as Carsten Holler's *Two Roaming Beds (Grey)* (Kennedy, 2015) that visitors could book for a night in the Hayward Gallery in London. All the examples above provide situations where humans and robots can share a space and interact in real time in a playful and/or exploratory fashion.

Interest in physical implementations of AI is widespread among the general public, as evidenced by the commercial success and the abundance of films, graphic novels and novels featuring intelligent machines. Celebrity robot expert Rodney Brooks has identified "a mismatch between what is popularly believed about AI and robotics, and what the reality is for the next few decades" (Brooks, 2017). Both the artworks described in the article recognise this gap and the lack of an even remotely satisfactory general artificial intelligence, the intelligence of "autonomous agents that operate much like beings in the world" (Brooks, 2017). To address the issue, both artworks use a concealed (*Guido*) or semi-concealed (*Am I Robot?*) hybrid autonomous/remote-manual mode that makes use of human intelligence in a basic implementation of collaborative robotics.

Concealed remote-control can be traced back to Baron Von Kempelen's *Mechanical Turk* automata (1770), a seemingly autonomous chess playing humanoid that was in fact operated by a short person hidden under the chess board. *The Wonderful Wizard of Oz* (Baum, 1900) is a concealed host, monitoring and affecting Dorothy and her friends' environment. Closer to us, children taking part in MIT's Personal Robots Lab experiments with cute *Dragonbots* are actually interacting with hidden researchers who control the robots' speech and motion. The set-up is semi-concealed as, after the experiment, the researchers "show [the children] the teleoperation interface for remote-controlling the robot. All the kids try their hand at triggering the robot's facial expressions" (Kory-Westlund, 2017).

The growing field of collaborative robotics provides numerous examples of approaches to partial autonomy, for example with the notion of dynamic robotic autonomy explored by Schemerhorn and Scheutz, where the sharing of a given task between the robot and the human operator varies according to the complexity of the task and the abilities of the robot and of the human. Their experiments in human-robot collaborative tasks demonstrated that subjects "accepted robot autonomy and seemed to prefer it [to non autonomous mode], even going so far as to ignore instances of disobedience and attribute greater cooperativeness to the autonomy mode" (Schemehorn et al., 2009). A related approach to dynamic autonomy is coactive design, "a way of characterizing an approach to the design of HRI that takes interdependence as the central organizing principle among people and robots working together in joint activity" (Johnson et al., 2014). In both cases the system aims at optimising the output of a robot-human team by dynamically allocating tasks to the human and/or the robot according to their strengths and weaknesses.

In the field of robotic museum guides, the collaborative approach has been explored by a transdisciplinary team in the Politecnico de Milano with a robot guide called *Virgil* (2015) that combines a human museum guide and a telepresent robot. *Virgil* possesses navigation and obstacle avoidance algorithms that operate jointly with the museum guide's commands. The authors' "new robotic service implements the concept of human-robot collaboration [...]. Conversely to many robotic solution applied in museums [...] the storytelling activity continues to be entrusted to the museum guide and a robot assumes the role of a remote collaborator, which explore the areas inaccessible for people." (Lupetti et al., 2015).

Guido the Robot Guide was commissioned as an artwork for a science-art exhibition in Luxemburg. Granjon's brief was to lead the creation, in collaboration with team of engineering and fine-art students, of a mobile robot that would guide the public through parts of the exhibition. The concept was to provide information on the artworks from the imagined perspective of an intelligent robot with an irreverent sense of humour. Unlike the robot guides mentioned above, *Guido* did not use machine vision or speech recognition. The artist's intention was that, operating by default as an autonomous machine with pre-programmed paths and speeches, the robot's voice and aspects of its motion and navigation could be over-ridden by a professional human museum guide at the touch of a button. This hybrid autonomous/remote manual mode was intended to provide the robot with a flexible, knowledgeable and responsive presence, akin to that of a human guide. A full account of the project is provided below.

Some aspects of *Guido*'s concept were developed further in another robotic artwork by Granjon called *Am I Robot?* (2016). The *Am I Robot?* installation features two parts: a mobile robot called *Combover Jo* and a semi-concealed control room. *Combover Jo* is let loose in the exhibition space, moving freely among visitors and static exhibits. Unlike *Guido, Combover Jo* has no utilitarian function, no job. It cruises at a leisurely speed, pronounces randomly selected sentences and navigates around obstacles and visitors. At times, the visitors can engage in complex conversations as well as interactive motions with the robot where for example the robot follows a specific individual or responds to verbal commands. This intelligent behaviour occurs when some visitors have discovered the control room and realised that they can control *Combover Jo*'s motion and speech. Other visitors might not be aware of the existence of a control room and assume that the robot is intelligent, until they, in turn, find the controls and have a go at driving the robot if they wish.

Am I Robot? relies on the playful dimension of the interaction and on the unfolding of the manual control trick to question visitors' assumptions about the current state of AI and robotics. The mismatch between most people's expectations and actual possibilities of contemporary robotic systems is significant, as was confirmed when observing *Combover Jo* moving among visitors: although incredulous about the insight of the robot ("How does it know my name?!!" was a comment heard several times), a majority of individuals did not question the autonomy of the robot. The hybrid autonomous/remote manual mode is an effective way to not disappoint audiences' science-fiction-fed expectations, yet the control room operation offers a playful reminder that artificial general intelligence is not available yet and that HI (human intelligence) still has the upper hand.

In its current state the *Am I Robot?* installation offers a simple and effective system for implementing experimental HRI in real situations. The basic structure of the system provides a clear platform for observing public engagement and for testing different relational scenarii in research or commercial contexts. Future developments, discussed below, will likely imply a more advanced autonomous mode integrating aspects of Levillain and Zibetti's concept of "behavioural objects" (Levillain et al., 2017) and a co-active mode (Johnson et al., 2014) instead of the simple remote-controlled manual mode.

1. Results

Guido the Robot Guide

In 2013, Clément Minighetti and Marie Noëlle Farcy, curators at the MUDAM Museum in Luxemburg, started to work on an ambitious exhibition project titled *Eppur Si Muove* — and yet it moves — amous sentence attributed to Galileo. The show was going to pair science and technology artefacts from the collection of Musée des Arts et Métiers in Paris with contemporary artworks exploring scientific or technological aspects related to the artefact. In 2014 the curators commissioned Granjon to develop a robot guide for the exhibition, in collaboration with engineering, fine-art and business students from the ARTEM Alliance of higher education institutions in nearby Nancy, France (http://www.alliance-artem.fr/). The MUDAM curators had contacted the ARTEM alliance and it had been agreed that the robot guide development would be run as an ARTEM project in 2014-15. Granjon's role as lead artist for the project was to design the overall objectives for the robot, its personality, liaise with the engineering team, led by Patrick Hénaff, for hardware and interface design aspects, and to supervise the deployment of the robot in the museum. Granjon proposed that the robot was to present the exhibits from a robotic perspective, with a slight superiority complex and a deadpan sense of humour.

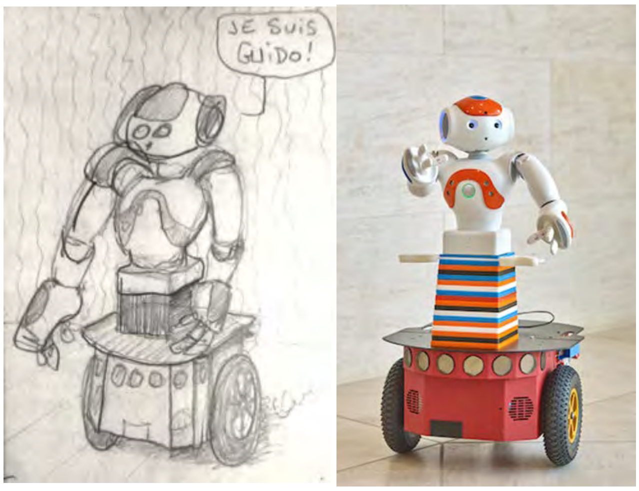

Figure 2. ***a.*** *Original sketch for Guido, Granjon 2015*
b.*Guido the Robot Guide in MUDAM Museum, P. Granjon 2016*

The budget did not allow for the fabrication of a bespoke machine. The Computer Science department at l'Ecole des Mines de Nancy owned several *Nao* robots and two Pioneer wheeled platforms that they agreed to lend for the duration of the project. After assessing the *Nao's* walking capabilities, it was quickly established that the robot's speed and balance were not sufficient for robust delivery of guided tours. Two of the lab's *Naos* were torsos, identical in specifications and looks to full *Naos* but deprived of legs. The team tested mounting one of these on the Pioneer platform and decided that *Guido* would be built on that model. The centaur design [Figure 2b] combines the robustness and precision of a differential drive wheeled robot with the appeal of *Nao*'s cute humanoid features and access to its built-in social robot capabilities such as speech, speech recognition, touch sensors, realistic humanoid motions and prehensile hands. Granjon decided to call the robot *Guido*, a friendly name that refers to its job in the museum.

The engineers' main interest in the project was to program a mobile platform for pre-determined navigation task using odometry to access a series of via-points, while being able to deviate from and return to its route if an obstacle blocked it. They were also keen to devise a

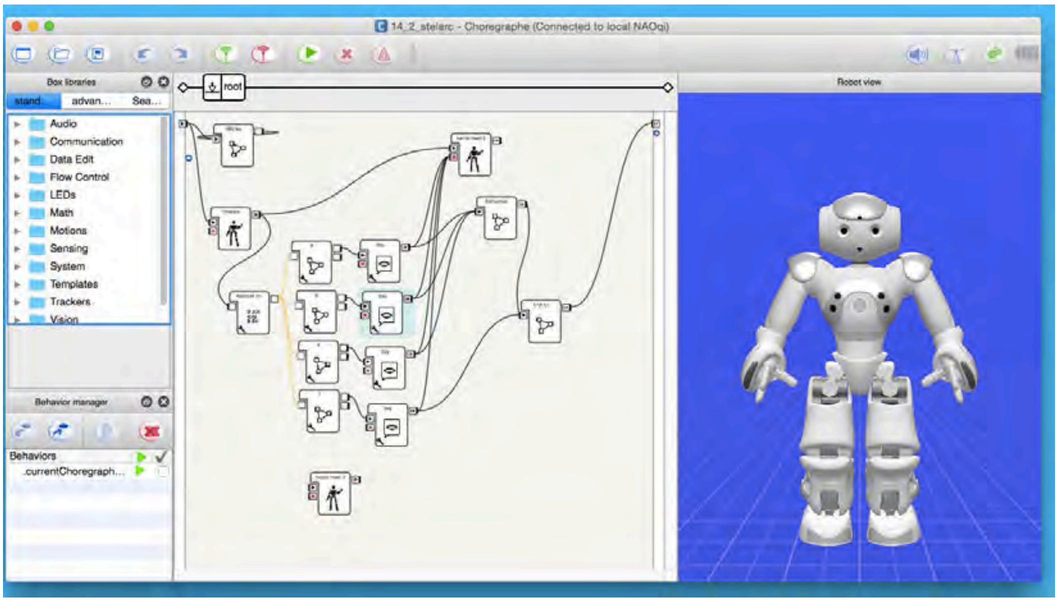

Figure 3. Aldebaran Choregraphe programming environment screen shot

robust integration of the Pioneer base and the *Nao* torso.

The fine-art students started to experiment with scripting monologues and matching gestures for the robot using the Aldebaran's Choregraphe visual programming application [Fig. 3]. Some of the test scripts written by the students contained verbal interaction with the public, the robot branching in one or other behaviour depending on the response. The *Nao's* speech recognition system quickly showed its limits, achieving a recognition rate of less than 20% for simple words like yes and no in a reasonably quiet office environment. We decided to use this feature sparingly in the final design, given that the robot would have to be deployed in large rooms with the visitors standing at a distance of one or more meters from the robot. Due to other commitments, all fine-art students but one did not follow the project until the end. The remaining student Alix Désaubliaux and her tutor Maxime Marion became very apt at programming the *Nao* with Choregraphe and custom scripts [Fig. 8]. They contributed significantly to the timely delivery of *Guido*. In agreement with the curators it was decided that *Guido* would speak French, one of the three official languages spoken in Luxemburg. As *Nao's* makers Aldebaran are based in Paris, French was *Nao's* first language. The robot's speech synthesizer is apt at producing a clear and melodious child-like French voice.

Granjon worked with the curators to make a selection of 17 exhibits from two connected spaces of the *Eppur Si Muove* exhibition. The two spaces were located on the same level, separated by a 20 meters long hallway, and all the floors were made of smooth stone very suitable for the robot's wheeled motion and odometric navigation. The robot was programmed to follow a series of via points that led it from artwork to artwork. It stopped and delivered a scripted comment in front of each artwork. A set of custom gestures was programmed for each artwork and for several interstitial behaviours. One of these behaviours was a Tourette function where the robot would briefly interrupt its current action and gently swear. Another was a walking-like arm motion and a musical clockwork sound when the robot travels between two exhibits. The detailed content of the visit is not within the scope of this article, but we provide two examples of scripts—one for a technological artefact, the other for a contemporary artwork —so as to give the reader a clearer idea of the guide's robotic perspective and of the familiar relation the robot was attempting to create with the human public. The first speech comments on a vintage car battery: "The following example is a Tudor lead-acid battery made in 1947 for automobiles. We can see that the quality of machine food is improving rapidly. This is not yet of cordon bleu standard, but it smells quite good electrically speaking, even if the old lead acid technology is a bit like baked beans: rather heavy and emitting lots of gas. Personally I prefer lithium ion, much more energetic and sooo tasty!". The second example was related to the *Tool Bones* sculptures by Damian Ortega (2013), a set of traditionally cast bronze objects combining features of human bones and common tools such as hammer or pickaxe: "Well, I went a little too far earlier when I spoke about you humans as an obsolete species. An alternative exists which has already begun: a future where human and machine merge and become a hybrid entity called cyborg. These intriguing objects made by Damian Ortega evoke a likely alternative to the obsolescence of homo-sapiens, a deep bio-technological mutation where the tool integrates with the skeleton. Your children or grand children might benefit of this new potential, living in harmony with my future cybernetic fellows".

The original idea was that after *Guido* delivered its speech on a given exhibit, it would answer visitors' questions. This would be done by switching to remote-manual mode, a human operator temporarily and transparently becoming *Guido*'s ears eyes and brain. A basic function was created that provided a joystick for over-riding the autonomous navigation and a keyboard interface for speech input. This version was sufficiently developed for testing and for planning improvements but not enough for use during visits. We will analyse the subsequent shortcomings on the robot's potential to engage with the public in the discussion section of the article. *Guido* delivered a couple of public visits a week in MUDAM between July 2015 and January 2016 [Fig. 4]. It was then returned to the Ecole des Mines de Nancy where it was painted white and made into a dancing robot called *Minoid*.

Figure 4. Guido and young visitors during a guided tour, P. Hénaff, MUDAM 2015

Am I Robot? robotic art installation

In October 2015 Granjon started work on a new commission for a robotic art installation. He had been invited to contribute to a new exhibition curated by Clare Gannaway in Manchester Art Gallery (UK), titled *The Imitation Game*. According to the gallery's website "*The Imitation Game* was an exhibition by eight international contemporary artists who explored the theme of machines and the imitation of life. [..] With a title inspired by Alan Turing's *Turing Test*, devised to test a computer's ability to imitate human thought, introduced in an article while he was working at The University of Manchester, *The Imitation Game* included three new commissions and works never before seen in the UK." [22].

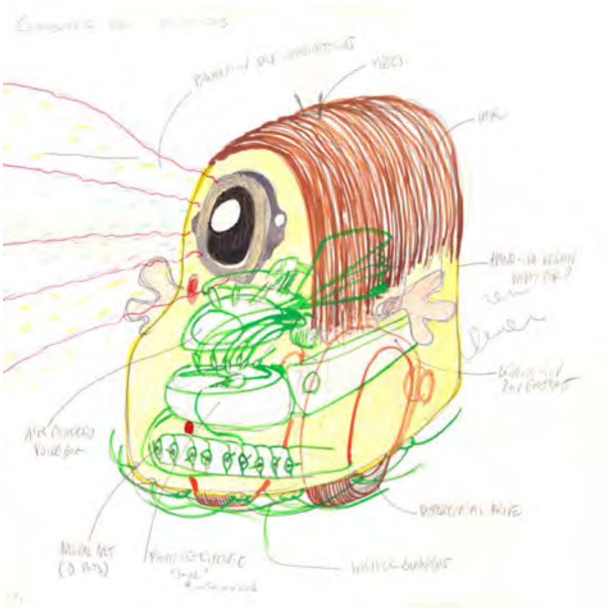

Figure 5. First visualisation sketch for the Am I Robot? robot Combover Jo, P.Granjon 2015

Granjon's project was to push further the concept of a hybrid autonomous/remote-manual system touched upon in *Guido*. He imagined a non-utilitarian non-humanoid mobile robot that would roam on the gallery floor [Fig.5]. The robot would be able to talk, navigate and display several behaviours autonomously. It would also be at times remotely controlled without a noticeable change in voice or motion. The curator found the idea interesting and Granjon was given the green light to build the installation that he called *Am I Robot?,* turning the title of Isaac Asimov's famous collection of robot stories *I, Robot* (Asimov, 1950) into a question that gave an indication of the robot's partial autonomy. The exhibition occupied two levels of the building. The robot was allocated a large roaming area on the first floor while the control room was installed on the second floor. The control room was not advertised or sign-posted as such. It was installed inside a specially built cubicle that visitors could freely access [Fig. 6c]. Most visitors would have already visited the first floor and seen the robot prior to entering the control room. In the room they found two monitors, speakers, a joystick, a microphone and a keyboard [Fig 6b]. One of the monitors displayed a live video feed from the robot while the other showed text that could be inputted through the keyboard or the microphone. The speaker played live sound captured by the robot's on-board microphone.

The robot itself [Fig. 6a], like *Guido*, was based on a differential drive platform. Unlike *Guido*, it was built from scratch in a manner more similar to Granjon's usual method where a "low-level, empowering methodology [is] based on a first hand understanding of principles at work in the electronical-mechanical objects I build" (Granjon, 2007). Significanlty less complex in software and in hardware than *Guido*, the robot's body was built from a Beseler Vu-Lyte 2 epidiascope (1956), a distant ancestor to the data projectors now used in education environments, providing a bulk slighlty smaller than an R2D2 unit. The robot was not given a face but had two three-fingered hands and a mock combover of brown electrical cable running across its top. This last feature provided the robot's name: *Combover Jo.* The motorised hands originally fitted on the robot were removed in the final version of the robot due to catching walls and fixtures, leaving the robot without any humanoid characteristic but the lens of the epidiascope turned into a sort of eye with a circle of green

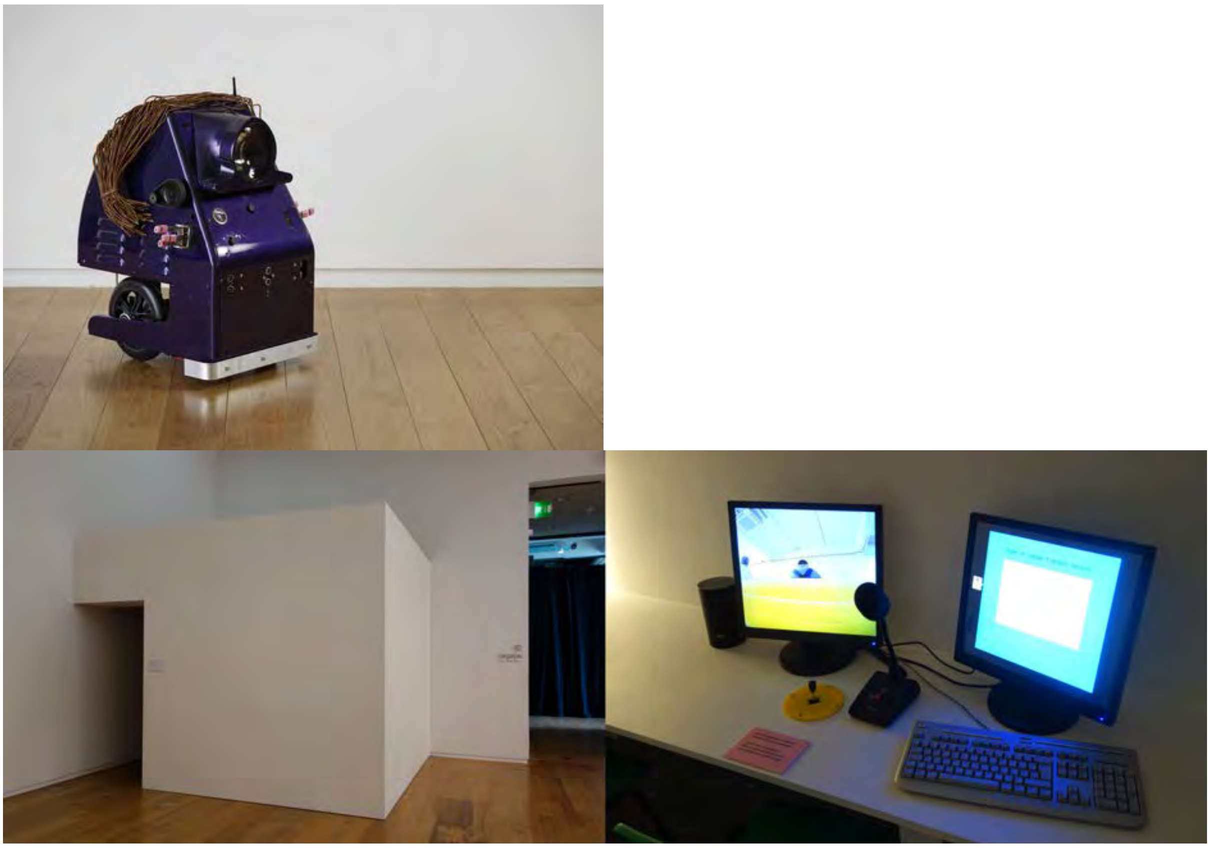

Figure 6. clockwise from top: a- Combover Jo robot version 1 (Manchester), photo credit Michael Pollard b- Am I Robot? control room controls, P. Granjon c- Am I Robot? Control room outside, P. Granjon.

LEDs. The robot's non-threatening, almost comical appearance aims at putting the visitor at ease, removing apprehension, fear or uncanny valley-related unease. *Combover Jo*'s top speed is approximately 0.5 m/s. In autonomous mode it avoids obstacles, including visitors and pronounce randomly one of 200 pre-programmed sentences at irregular intervals. It speaks English or Spanish with a distinctly robotic voice that is neither male nor female. The sentences range from humorous greetings such as "Hello Dude", "Hello Dudette" to deeper existential reflections like "Where is my soul?" or "I was not born". Green coloured stripes on the floor mark the limits of the robot's domain. A colour sensor fitted under its base triggers a u-turn manoeuvre when it detects green. Detection of a red floor area activates the robot's dream state, where it will stop when close to an obstacle and project through its eye-lens a short pre-recorded video sequence, presented in the exhibition catalogue as a "robot dream" (Furber et al., 2016). The dreams feature non-narrative edits of technology and science footage combined with images of nature. As soon as a visitor touches the joystick in the control room, *Combover Jo* switches to manual mode. Text typed or dictated in the control room is transmitted to the robot and pronounced in the same voice and tone as the pre-programmed sentences. The robot moves under joystick command with an overriding avoidance manoeuvre taking over when it is too close to an obstacle while moving. When the robot is not moving while under manual control, visitors can get to touching distance.

Am I Robot? has been exhibited in three different exhibitions at time of writing, with a significant upgrade installed for the last showing. In all cases three main types of interaction with the robot were observed:

- No interaction, the visitors avoids or ignores the robot and continues on their initial destination
- Attempt to interact physically, for example by standing in the way of the robot or dancing.
- Talk to the robot.

The last two types interactions do not last more than approximately one minute when the robot is in autonomous mode (unless the visitor is a child). When in telepresent mode, the interaction becomes much more involved and complex. When the visitor in the control room has mastered the controls, *Combover Jo* becomes really responsive. It can comment on a visitor's clothing or even, when the driver knows the person in front of the robot, call them by their name or ask knowing questions. It can also follow or avoid specific members of the public or perform basic dances. More than half of the visitors observed assume that, when in tele-operated mode, the robot is autonomous and driven by an AI program. Children tend to question less than adults the personal knowledge the robot might demonstrate and enjoy playing and conversing with it. Some adults will react incredulously ("How does it know my name?!") but still not suspect that another human is behind the intelligent behaviour of the robot until they enter the control room or another visitor informs them about its existence [Fig 7b]. In the control room, visitors tend to behave like tricksters [Fig 7a], giggling and prompting each other to enter text that will trigger optimum response from *Combover Jo*'s current interlocutor. Other visitors who might not suspect another human to be in control when the robot simply greets them become suspicious when it starts to show too much knowledge, humour or general intelligence.

*Figure 7. **a.** visitors in Am I Robot? control room. **b.** Combover Jo version 2 (Hull) and visitors in the gallery space. Photos credit Tom Curran*

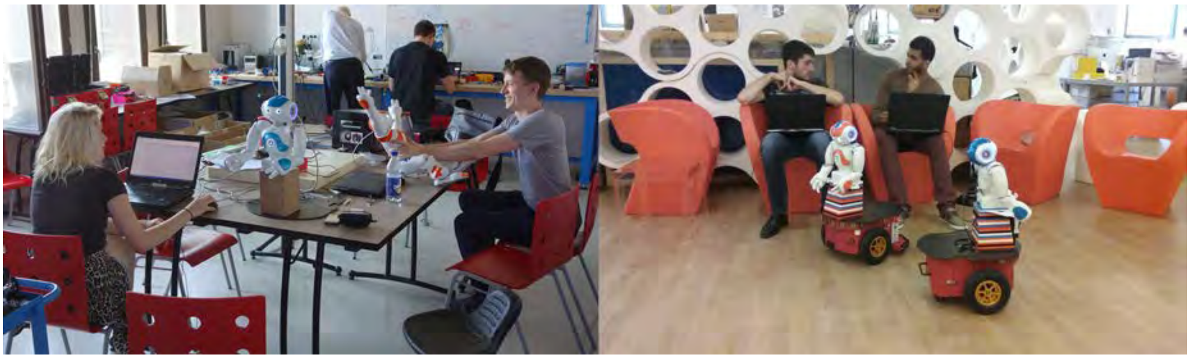

Figure 8. ***a.*** *Alix Desaubliaux and Maxime Marion working with Naos in Ecole des Mines de Nancy, 2015.* ***b.*** *Mehdi Adjaoue and Romain Schumers with two Guidos in MUDAM, 2015. All P.Granjon*

2.Discussion

Guido

The navigation and spatial accuracy of the robot were very good, *Guido* succeeded in positioning itself by the artworks for script delivery with an approximately 20 cm precision, even if it had encountered obstacles on the way. The integration of the *Nao* torso with the Pioneer P3DX base was also very functional and robust, with seamless communication between the two units.

During the preparation of the *Guido* project, the MUDAM Museum guides expressed a semi-serious concern about the future of their jobs: would visitors prefer the robot guide's visits to the ones they were paid to deliver. After seven months of robot visits they were fully reassured: a common response from visitors was that after an initial peak of interest due to the unusual nature of their guide, they realised its limitations, the rigid nature of its performance and lost interest. This had been anticipated by Granjon whose response was to imagine a robot with a hybrid autonomous/remote manual mode manned by a trained operator. The rationale behind the decision to implement a hybrid system was motivated by two main factors:

- The budget, timescale (8 months), and workforce available for delivering a fully functional robot guide were tight.
- More crucially, the natural interaction that was sought to achieve required a level of general artificial intelligence significantly superior to any system presently available, including all the guide robots mentioned above. Even Honda's famous *ASIMO* was not up to the task. In 2013, "to test the robot in real-world conditions, Honda set up *ASIMO* as a tour guide at Japan's National Museum of Emerging Science and Innovation. The company want[ed] to see if the robot c[ould] autonomously interact with visitors, answering questions and explaining things" (Falconer, 2013). *ASIMO* repeatedly failed to recognise visitors' raised hand motions and relied on tablet input to overcome the difficulties of real-time speech recognition in actual museum conditions.

Despite the engineering team's efforts, *Guido*'s complete hybrid mode was never delivered due to two main reasons:

- The budget was not sufficient for training and paying the wages of a professional museum guide who would have supervised all the visits throughout the exhibition. This

person would have had a key role, ready to switch to remote manual mode anytime a visitor had a question, or when he/she would have spotted a good moment for snapping off the recorded script and comment, for example if someone's phone was ringing or if a child had a robotic toy.
- The speech input function, that would have allowed the responsivity required for a full conversation level of interaction with *Guido*, was never implemented.

In their work with the human guide-controlled telepresent robot *Virgil* mentioned above, Lupetti et al. state that "keeping the storytelling activity performed by the museum guide is fundamental due to the fact that only a human can provide the interpretative aspect. The interpretation [...] is the process in which the museum guide can create links between the visitor culture and the heritage contents. This process allows visitors to develop an empathic relationship with both the museum guide and the cultural heritage itself." (Lupetti, 2015). Similarly Granjon places a crucial emphasis on the role of the human in the loop as a factor of empathy with the robot. He favors a collaborative approach where the robot is given space and time to operate in full autonomy while a human operator monitors the activity and can take over aspects of the interaction when the robot is not able to deliver a convincing behaviour. Granjon sees variations on this approach, at least for the present and mid-term prospects of general artificial intelligence, to be the only available tool for answering the audience's expectations for a truly engaging robot.

Am I Robot?

The conclusions drawn from the *Guido* project strongly informed the conceptual and design decisions for the *Am I Robot?* installation. Most importantly, *Am I Robot?* delivers a fully functional hybrid mode. In addition, *Combover Jo*'s non-humanoid design and the lack of a utilitarian role are intended to reduce the amount of pre-conceived opinions regarding the robot's role or intelligence. Levillain and Zibetti examined several non-humanoid, non-utilitarian robots in their research on behavioural objects, artifacts with life-like interactive behaviours made possible by techno-scientific developments, shifting away from the status of simple objects. They posit that "the appearance of a humanlike robot prompts attributions of the capacity to feel and sense. This kind of assumption may conflict with the actual behavior of the robot, which is often not as sophisticated as its appearance" (Levillain et al., 2017). *Combover Jo*'s lack of humanoid or zoomorphic features does not generate the same level of assumptions (although several visitors have enquired about its ability to hoover, drawing parallels with a cleaning robot). The absence of a clearly defined function produces a similar effect: as *Combover Jo* is not presented as a guide or a receptionist, visitors do not assume that the robot will deliver a set behaviour inspired from a human guide or receptionist. Such a behaviour would most likely be inferior in presence, interaction and engagement compared to a human professional, which would leave the visitor dissatisfied as was apparent in the *Guido* project.

The notion of behavioural object can be applied further to *Am I Robot?* Levillain and Zibetti state that, "unlike the social robot, behavioral objects are not specifically conceived to serve, help, or cooperate with humans. Although they can sometimes mimic human social behavior, they are not designed to engage a user with humanlike social skills, or features such as gestures, posture, body and facial traits that organize the social interaction" (ibid.) Behavioural objects can be used for exploring aspects of HRI, especially playful and explorative interactions, that would be more difficult to access with task-oriented anthropomorphic social robots. In the same way as a humanoid robot elicits a specific set of expectations, a social robot will also be expected to behave in a helpful, utilitarian and benign way. Granjon examined the limitations imposed on the exploration of the true potential of machinic life — a notion explored by Johnston as the capability of a machine "to alter itself

Figure 9. Visitors socialising with Combover Jo during the States of Play exhibition, Hull UK, 2017. a: photo credit Tom Curran. b: P. Granjon

and to respond dynamically to unknown situations" (Johnston, 2010) — by constraining social robots to a benign role. He suggests a creative robotics approach to non-benign experimental robots where "non-benign [...] does not stand for malign, but instead aims to define an area where a wide range of autonomous behaviours are possible, covering a full gamut of possibilities which may include aggressive as well as friendly traits." (Granjon, 2017). The notions of behavioural object and of non-benign robot share the characteristic of not being designed for serving human needs, allowing exploration of speculative HRI scenarii not subjected to utilitarian, commercial or scientific constraints.

In that manner, *Combover Jo*'s non-utilitarian and non-humanoid characteristics, combined with a robust, safe, human-friendly design and an absence of instructions not to touch or get too close to the robot aim to lay the foundation for an open human-robot relationship. Granjon's observations of visitors' interaction with the robot confirm that in many cases a natural interaction occurred, especially with children but also with adults. Largely perceived as a friendly creature, *Combover Jo*'s unassuming presence is a simple but effective way to engage humans. The semi-concealed control room trick is not a lie, as visitors are implicitly invited to discover the controls. The trick operates instead on two levels:

- It allows the emulation of an intelligent robot (of the future?), capable of initiative, humour, conversation, and moods.
- The robot's disclosed reliance on HI for delivering an intelligent presence raises questions about the capabilities of general artificial intelligence in comparison to humans'.

Directions for future research

There is no plan at this stage to continue research and development of a museum guide robot. After the initial exhibition in Manchester, the *Am I Robot?* installation was shown in the Oriel Mostyn Art Gallery in Llandudno UK and in the *States of Play* exhibition organised by the British Craft Council in Hull UK. It was included in *Prototipoak*, a creative robotics exhibition in Azkuna Zentroa Arts Center in Bilbao Spain in summer 2018. Public interest in and engagement with the installation motivates further development of non-utilitarian collaborative robotic artworks. Two main aspects need to be addressed in future projects:

- improving the quality of the autonomous mode by integrating machine vision aspects such as people detection and face recognition, basic speech recognition, and more importantly a learning function that would allow the robot to generate new behaviours from past experience. The learning function would include a curiosity factor inspired by Kaplan's work with *Aibo* robot dogs [31]. The autonomous mode could be further improved by studying visitors' reactions to various programmed behaviours following on Levillain and Zibetti's concept of behavioural objects.
- develop a more complex and integrated collaborative mode instead of the current basic tele-operation. More functions could remain shared between the robot and the human. Some of these functions would be influenced by the learning engine of the robot, acting as a sort of personality that could be only partially over-ridden by the human. This advanced collaborative option would implement aspects of the co-active approach described by Johnson et al., where the robot and the human operate as interdependent team partners.

3.Materials and Methods

Guido

Hardware

Guido was based on a standard *Pioneer P3-DX* differential drive mobile base on which a *Nao* T14 torso was attached. The torso was raised with a stack of perspex slabs so as to bring Guido's head to a height of approximately 60 cm. Communication between the base and the *Nao* was effected by an on-board NUC computer connected with an ethernet cable. The Pioneer base was fitted with two 12 V lead acid batteries that were also used to power the NUC and an on-board Wifi unit. The base was connected to the NUC by USB. The *Nao* torso was powered by its own built-in battery. An emergency stop button mounted on the platform could interrupt the supply of power to the motors. At times an amplified speaker and an external microphone were used to amplify Guido's voice. We also experimented telepresence with a Wifi camera installed at the front of the Pioneer base. Built-in ultrasound sensors and bumpers on the P3-DX, combined with on-board odometric hardware were used for navigation and obstacle detection.

Software

The Pioneer mobile base embeds the Aria operating system that allows real-time execution of low-level programs for control and management of sensors. It was programmed with the Aria API. The program integrated specificities of the robot's field of operation such as the percent of wheel slip on the stone floor, calibration of the magnetometer according to the ambient magnetic field as well as the maximal and minimal values of emergency acceleration and de-acceleration. The *Nao* torso runs Gentoo Linux from a built-in computer located in the robot's head. The two robots have been integrated into the framework ROS (Robotic Operating system) running on Linux Ubuntu 12.04, installed on an on-board NUC PC [Fig. 10]. ROS allows communication and exchange of informations between several communicant objects in a robotic project. Here it allowed to build the control architecture of Guido by creating software links between the Nao (using Aldebaran's Nao-dedicated programming environment NaoQI2+ and the Pioneer P3DX (using its specific layer ROSAria) and the remote monitoring computer through the Wifi network. All the programs of the control architecture are coded in C++. An algorithm based on Braitenberg's vehicles was used for a fluid obstacle avoidance. The voice and gestures of the *Nao* torso were programmed with Aldebaran's Choregraphe. Choregraphe uses a visual timeline and drag and drop function boxes that also give access to C-like scripting. Pre-scripted functions can be called sequentially or in response to sensor inputs or Wifi commands.

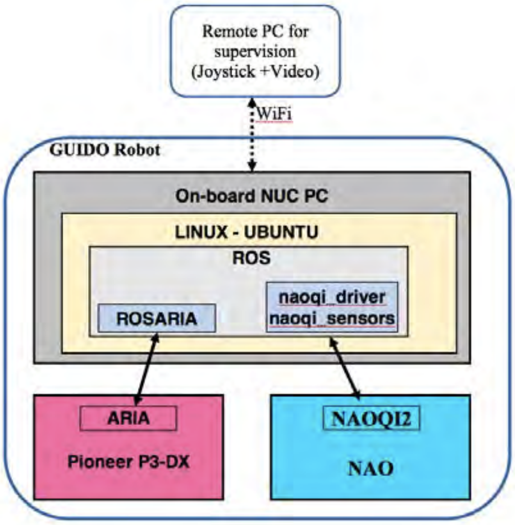

Figure 10. Guido's software architecture

Am I Robot?

Hardware

Combover Jo's body is based on the shell of an *ITM Vu-Lyte II* epidiascope, sprayed metallic purple. The shell is mounted on a bespoke aluminum platform. Two DOGA 12 V 60 W motors provide up to 80 rpm to the 20 cm diameter polyurethane scooter wheels. Two free spinning caster wheels support the front of the robot. Power is provided by a 12 V 16 aH Lithium Ion battery connected to an 8 V, a 5 V and a 3 V low drop voltage regulators. An Arduino Mega microcontroller [32] runs the main program that deals with navigation in autonomous and remote-controlled states as well as state monitoring and selection. Another Arduino Mega controls the Parallax Emic 2 text to speech synthesizer and the dream function's on-board Pico PK-120 pocket video projector. An Arduino Nano connected to the main Arduino Mega is dedicated to reading data from the floor colour detecting sensor. Three HS-04 ultrasound sensors and a front bumper are used for obstacle detection. The eye-lens cavity carries a circular array of 24 ws2812 addressable RGB LEDs and the video projector. A motor can move the lens forth and back but this function is not implemented in the current version. A Sony camera module connected to a Tramtec 2.4 GHz dedicated encoded transmitter provide video monitoring to the control room. A Sennheiser wireless microphone and transmitter provide the audio monitoring. Combover Jo's voice comes from a front-mounted speaker connected to a 12 V 20 W mono audio module that amplifies the speech synthesizer's output. Two Zigbee modules receive data from the control room: one for the joystick and one for the ASCII speech stream.

In the control room, processing is done by an Apple Mac Mini. An AKG dynamic table microphone connected to a compact 4 way USB audio mixer is used to collect the user's speech input. The base of the microphone was modified with addition of a push button, a reed relay and an Arduino Uno. The Arduino Uno controls the reed relay that cuts speech input after a set duration so as not to overload the speech to text software (see below). The Arduino also reads keystrokes from a modified PS2 keyboard used to input typed speech. The Mac Mini's keyboard is concealed, used only by staff to start and stop the installation at opening and closing times. Dedicating a keyboard solely to the speech input function is a fool-proof way of preventing unwanted user interference. Such interference happened in the first version of the installation that operated from a Chrome web interface in kiosk mode with a single keyboard. A small audio amplifier and a speaker are used for audio monitoring the on-board microphone. From the control room, several connections lead to a shelf located in the same room as the robot. The shelf carries an xBee module connected to the Mac Mini for speech transmission, an Arduino Mega connected to the Joystick and to the other xBee module for the transmission of manual navigation data, the Sennheiser audio receiver and the Tramtec video receiver. The transmission range from shelf to robot is variable depending on walls and other obstructions, averaging at 25 meters approximately for a robust video signal, and significantly more for the xBee modules' text and joystick data transmission. We observed no interference between the xBee modules and the video system or with the local Wifi network, that all operated at 2.4 GHz.

Software

Combover Jo runs on standard Arduino code, using several timers to monitor and actuate its different functions. The Mac Mini in the control room runs an application written in Xojo to manage text input from the microphone and from the PS2 keyboard. The keyboard strokes are decoded by the Arduino Uno in the base of the microphone, sent serially to the Xojo app that displays the text on the monitor. Text is sent to Combover Jo's text to speech unit either if the user presses return or if the input exceeds a set number of characters. If the user pushes the button on the microphone base, speech input is prioritised and treated by the Dictation speech recognition application built-in Mac OS X 10.10. The speech recognition software used in the first installation of *Am I Robot?* was running CMU Sphinx on a Linux machine, but this proved too inaccurate for reliable public use. The Apple Dictation and Xojo solution is very robust and approximately 80% accurate. It deals well with ambient noise and different accents. The timing device that cuts microphone input after 20 seconds was implemented to avoid overloading Dictation. Prior to that patch, the software was constantly trying to process microphone input while the user kept the button depressed and eventually crashed if the user kept the button pressed for too long. The time limit relay resolved the problem. The increased accuracy and ease of use of the speech input combined with software updates to navigation and to the dream mode brought the second iteration of *Am I Robot?* to a robust professional exhibition standard.

Conclusions

Observations of both *Guido* and *Am I Robot?* artworks in action confirm that some humans are ready to embrace friendly robots as agents, at least in the context of art exhibitions. Presently the current state of general artificial intelligence robotics is not matching humans' expectation for a robot agent, a gap that generates frustration and lack of engagement from the visitors. The collaborative robotics approach, of which several examples are mentioned above, is an effective way to overcome this expectation gap as well as being a solution for exploring speculative HRI scenarii and future human-machine cooperative systems. Granjon's ongoing interest in exploring the co-evolution of humans and machines is underlined by a belief in the importance of cultivating innate cognitive and physical human abilities. Playing a transparent trick on the viewers, who might be lead to believe they are interacting with an autonomous intelligent machine when in fact they are in contact with another human intelligence, aims to provide a playful counterpoint to the false expectations fed by science-fiction movies and non-specialist media.

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Artworks

Artwork 1: Fluffy Tamagotchi

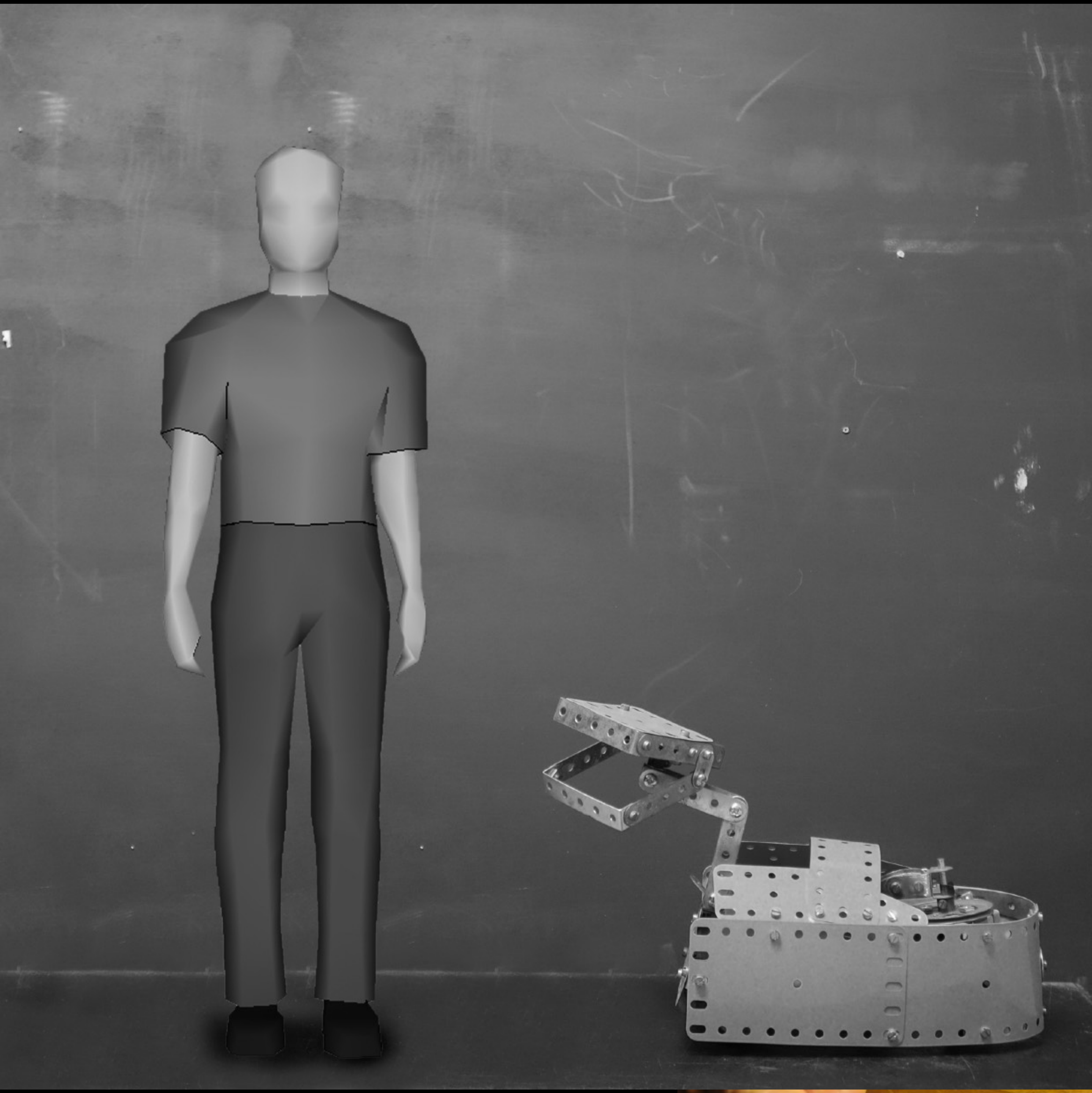
Fluffy Tamagotchi

Robot for video, 1998

Video: https://www.zprod.org/zwp/fluffy-tamagotchi/

Fluffy Tamagotchi
Robot for video, 1998

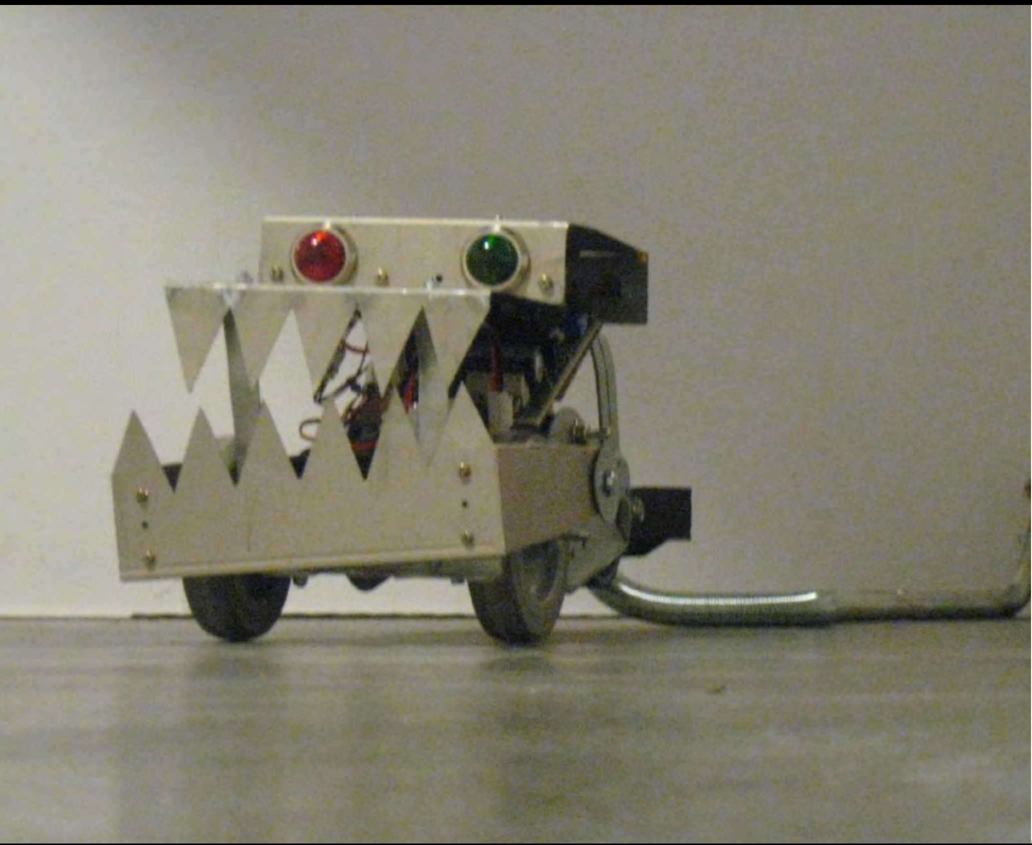
Artwork 2: Wild Robot Coy-B



Wild Robot Coy-B

Concept performance with robot, 2009-ongoing

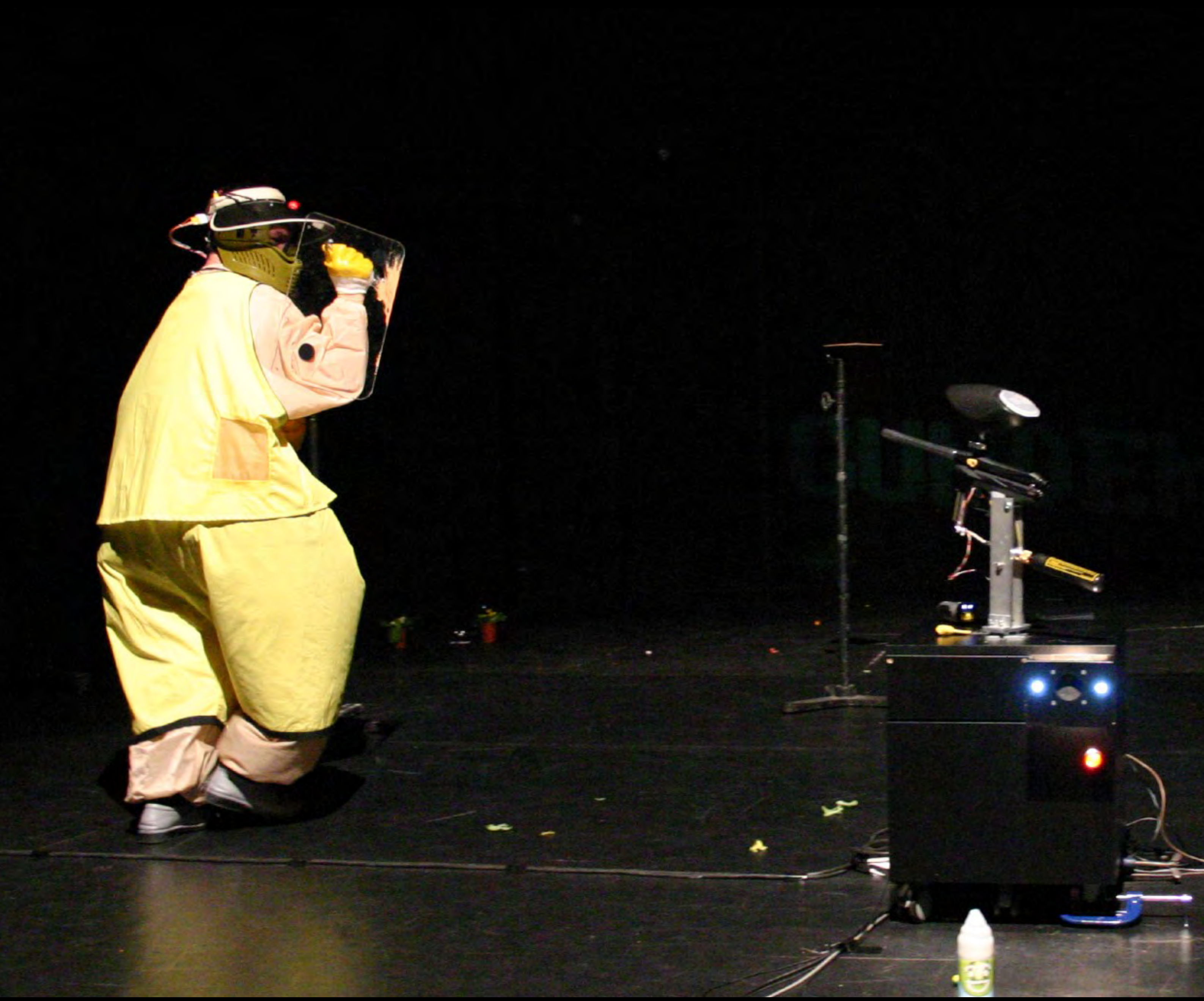
Prototypes and sketches



Wild Robot Coy-B

Concept performance with robot, 2009-ongoing

Artwork 3: Robotic Gun



Robotic Gun

Performance robot, 2010-13

Video: http://zprod.org/PG/performances/blackBoxNi.htm

Robotic Gun

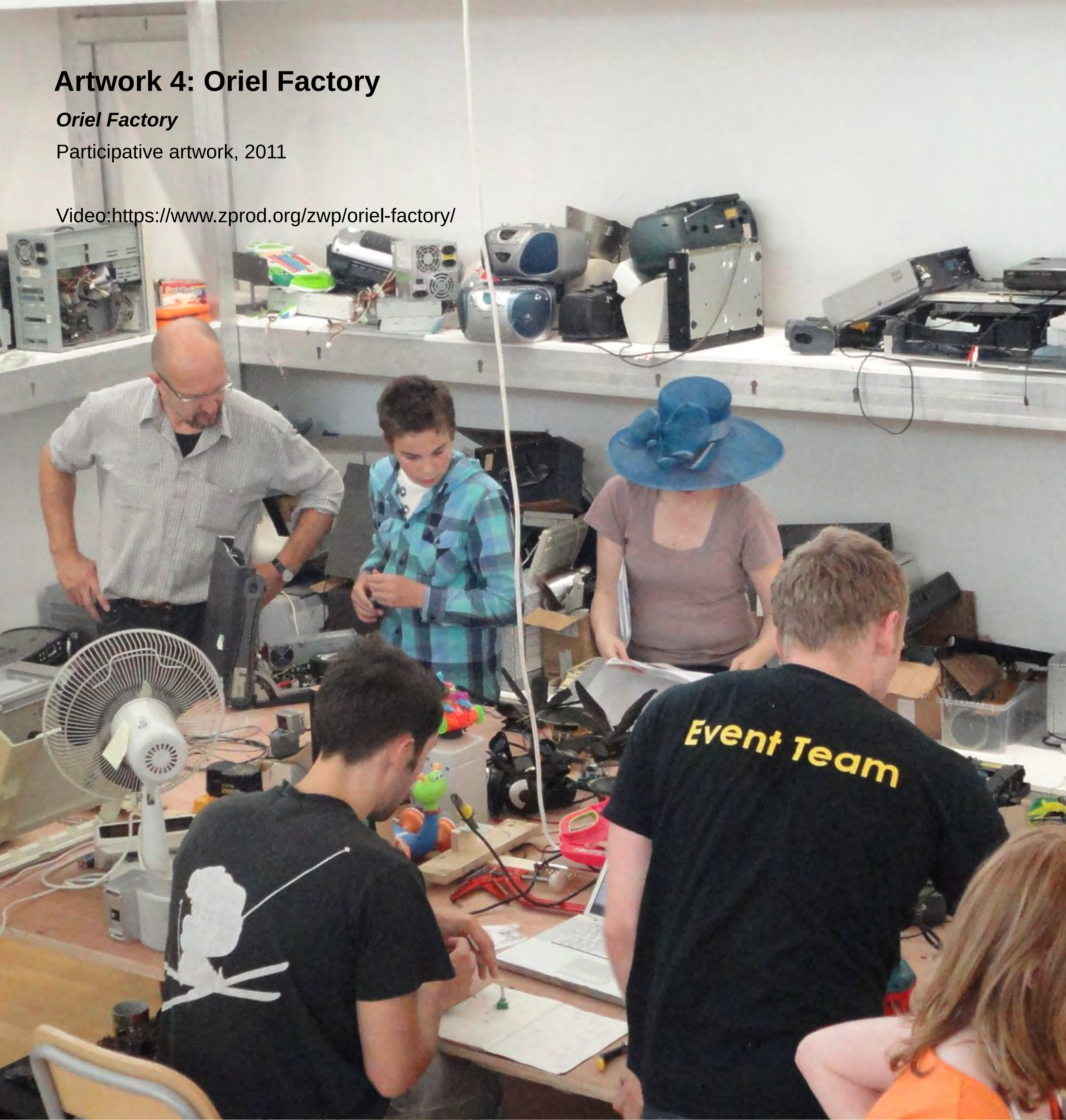
Performance robot, 2010-13

Artwork 4: Oriel Factory

Oriel Factory

Participative artwork, 2011

Video:https://www.zprod.org/zwp/oriel-factory/



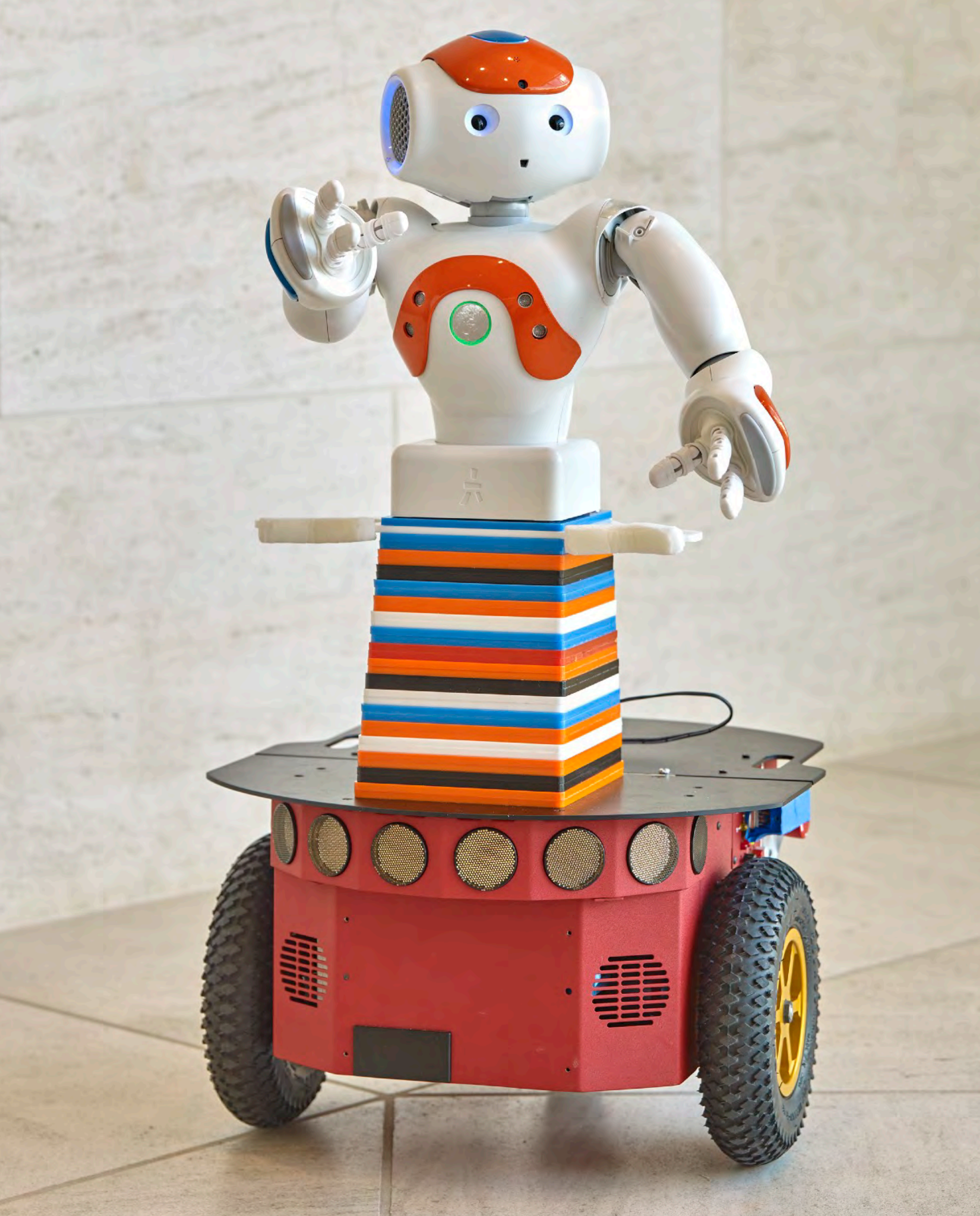
Oriel Factory

Participative artwork, 2011

Artwork 5: Guido the Robot Guide

Guido the robot guide

Semi-autonomous exhibition guide robot, 2015



Guido the robot guide

Semi-autonomous exhibition guide robot, 2015

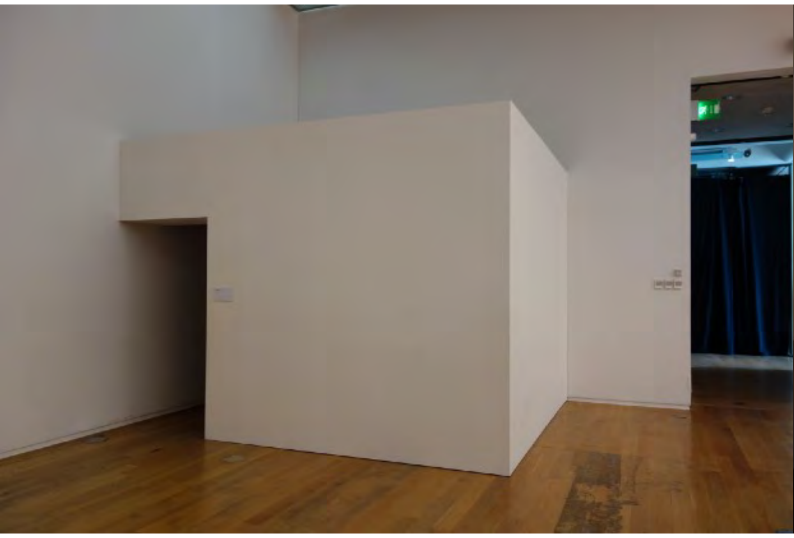
Artwork 6: Am I Robot

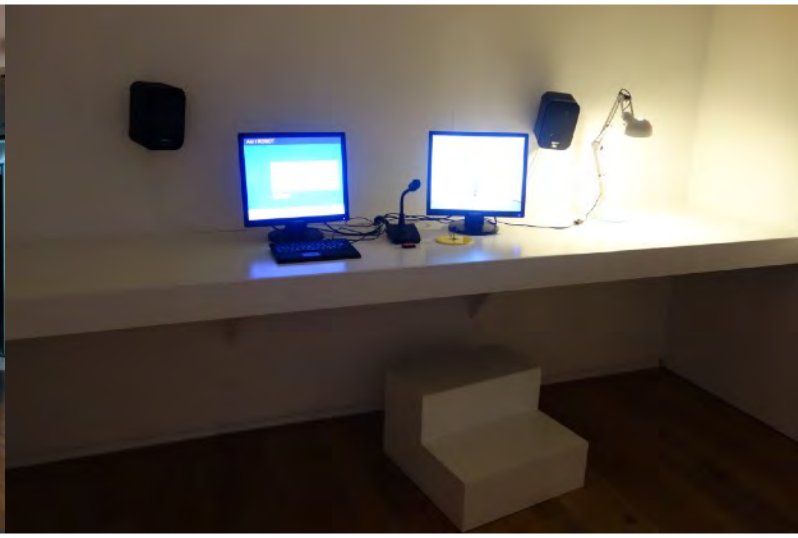
Am I Robot, semi-autonomous interactive robot installation, 2016
Video: https://www.zprod.org/zwp/amirobot/

Am I Robot, semi-autonomous interactive robot installation, 2016

Am I Robot

Semi-autonomous interactive robot installation, 2016





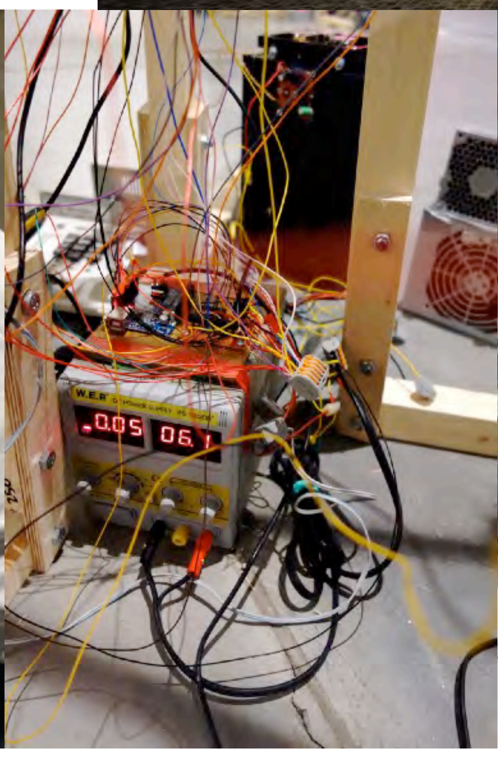
Artwork 7: Electronic Wildertree Wrekshop

Electronic Wildertree Wrekshop

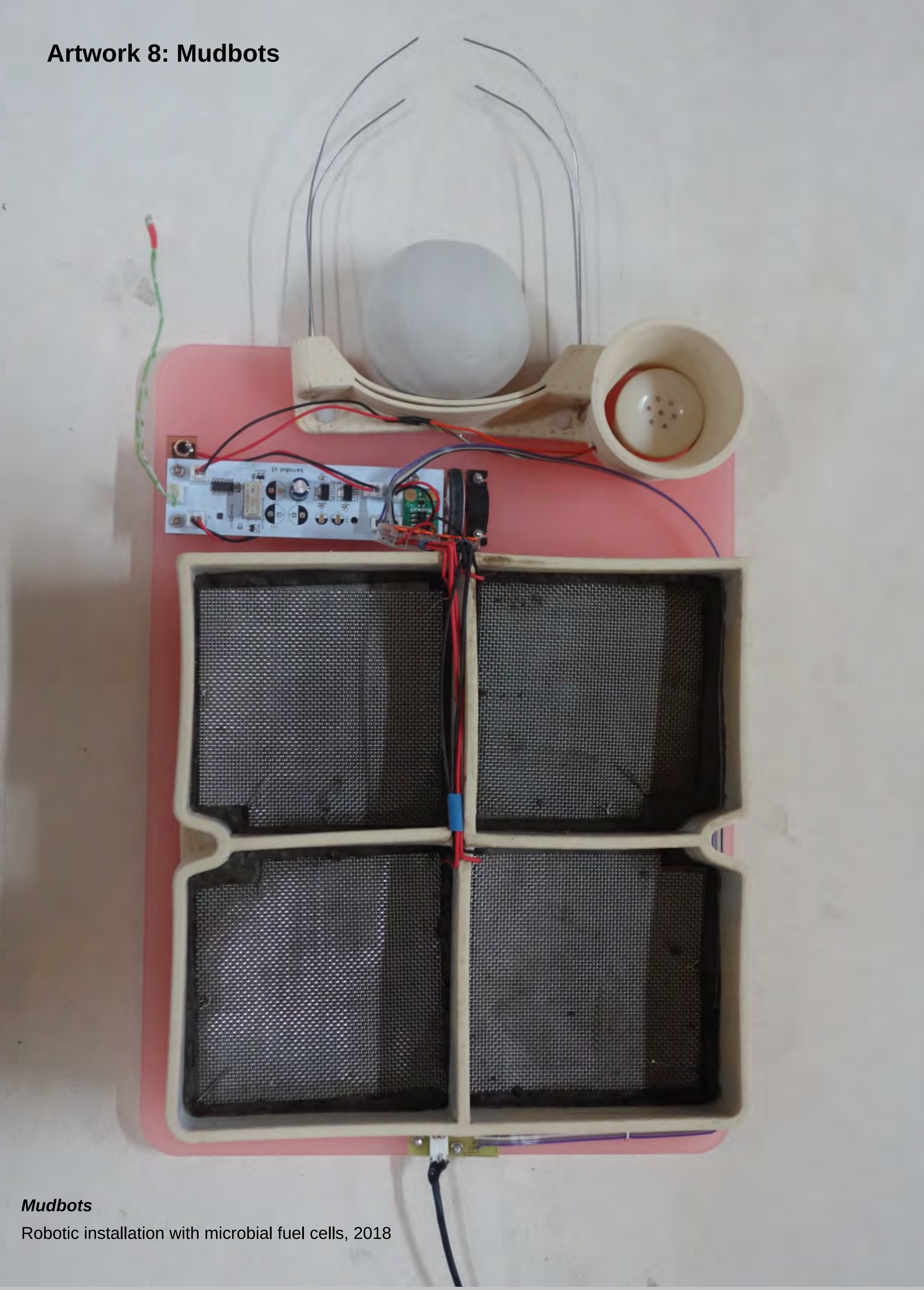
Participatory installation, 2017


Electronic Wildertree Wrekshop
Participatory installation, 2017



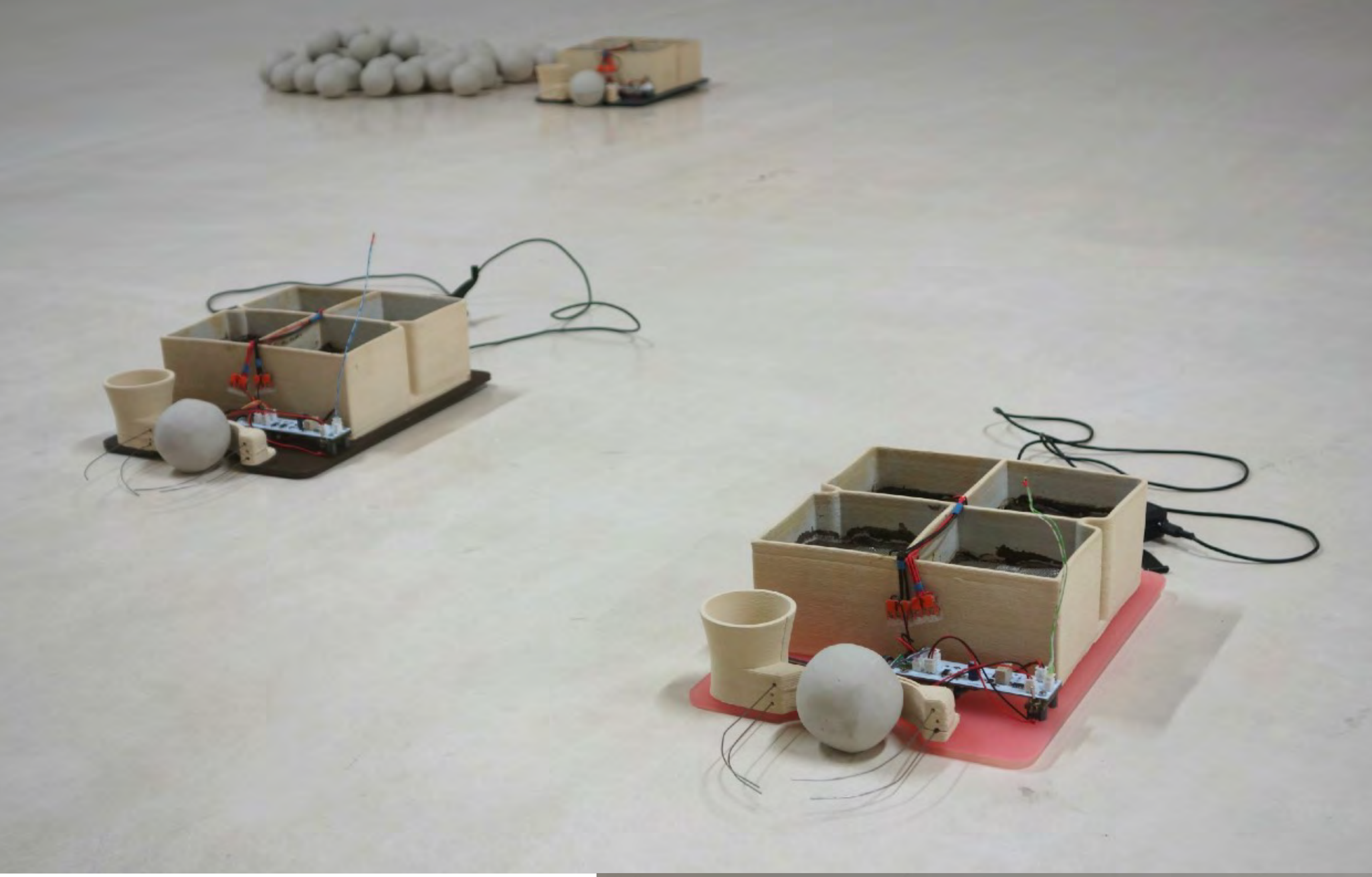



Artwork 8: Mudbots



Mudbots

Robotic installation with microbial fuel cells, 2018



Mudbots

Robotic installation with microbial fuel cells

2018

Artwork 9: Insect Buzz

Insect Buzz

Electronic placards for environmental protest,

2019-20

Insect Buzz

Electronic placards for environmental protest, 2019-20

Developed as part of the EASTN-DC European research project on digital creativity

Video: https://www.zprod.org/zwp/insect-buzz/

Artwork 10: Mud Machine Workshop

Mud Machine Wrekshop

Participatory kinetic artwork, 2020

Video: https://www.zprod.org/zwp/mud-machine/

Mud Machine Wrekshop

Participatory kinetic artwork, 2020

Appendix

Documentation of significant artworks mentioned in the Analysis but not included in the submitted material

Figure 1, appendix, Automated Forest, installation, 2001

Figure 2, appendix
Automated Forest
Installation, 2001

Figure 3, appendix, Mofo, performance robot, 2008

Figure 4, appendix, Reflections of a Button Pusher, performance 2005-2007

Figure 5, appendix

Audience testing the Robotic Ears

Performance, 2003

Figure 6, appendix

Audience testing the Robotic Perception Kit for Sexed Robots

Performance, 2006

Figure 7, 8, appendix, ***Positive Activities***, participatory artwork, 2006

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DECLARATION

This Work has not previously been accepted in substance for any degree and is not being concurrently submitted in candidature for any degree.

Signed...(candidate)

Date 13/09/2022 ....

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This thesis is the result of my own investigations, except where otherwise stated.Where correction services have been used, the extent and nature of the correction is clearly marked in a footnote(s).

Other sources are acknowledged by footnotes giving explicit references. A bibliography is appended.

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