XXVII Generative Art Conference - GA2024

Embodied Interaction with Algorithms

Peter Beyls, PhD
The School of Arts, University College Ghent, Belgium
www.peterbeyls.net
peter.beyls@hogent.be

Abstract

This paper primarily contextualizes the *Material Matters* (MM) research project and documents some tentative experiments. MM envelopes multiple areas of interest – (computational) aesthetics, philosophy, embodied cognition and cognitive robotics, specifically, human-robot interaction. In particular, the principle of mind-body-environment unity emerges as a first principle. MM centers on the philosophical notion of *embodied cognition*, rejecting cognition as the construction and manipulation of representations of abstract symbols. Then, creative processes as constituted and afforded through motivated bodily activity in a situated physical setting. In the context of the art studio, such inclination marks the difference between creative development through impulsive improvisational object handling and the synthesis of new ideas through pure contemplation. Starting from earlier work in gesture-based interactive composing, we progress into human-robot interaction probing the role of objects and materials in the artist's studio in relation to software-initiated initiative.

1. Introduction

This paper relates the production, experience and interpretation of generative art by humans and machines and hypotheses on hybrid, cooperative formats. However, the depth of human aesthetic experience is informed by an unknown number of mostly unconscious dimensions, including social, cultural, historical and materialist scopes, (consider the smell of oil paint). Machine experience and production follows known dimensions because implemented as explicit models in software. From this perspective, how could we possibly create a closer relationship between collective initiative by human and machine – MM suggests experiments engaging humans and machines considering notions of identity, co-operation, motivated action, adaption and freedom. A robotic painting experiment studies the dynamics of a human-machine collective through reinforcement learning and observation of exclusively physical activity by human and machine.

However, as a main focus, a rational framework is identified as a first step as documented below.

Human-machine interaction (HMI) in the musical domain, referred to as interactive composing [1], aims compelling HMI co-creation *ex tempore* – first, algorithms are developed anticipating complex interplay and second, the program performs in confrontation of human input. Conversational interaction develops, from tight instrumental control, to play-and-response interaction, to opaquely surprising feedback avoiding direct echoes of human input, to exploiting a motivation-driven strategy using real-time reinforcement learning [2]. Sound is the substance of interaction in computationally driven musical improvisation, musical fabric develops over time afforded by two apparently contrasting potentialities; human presence grounded in global cultural awareness and capacity of situated action, and the comparatively tiny algorithmic universe embedded in the program's logic. Yet, convincing procedural HMI interaction matures merging embodied presence and isolated algorithms existing only in silicon, still, a strategy of reinforcement learning allows for gradual human-machine adaptation in a real-time co-creative process [3]. Typically, HMI platforms should afford simultaneous and equally valued input from human and machines while maximizing behavioral complexity and suggesting a rewarding human experience informed by the delicate balance of meaning and mystery in the unfolding interaction.

We might attempt to chart the non-trivial intrinsic qualities and otherwise tightness of the human-machine relationship suggesting tense collaborative human-machine co-creativity to exist in affective and symbiotic emergent modalities rather than explicitly designed procedural interaction formats. Indeed, live-like systems exhibit unpredictable yet coherent behavior, not just loosely random pursuit. However, according to Gerhard Richter: "randomness does it better than me" and a life-time of intriguing work was founded on the core concept of controlled randomness by the Vera Molnar [4]. My early work conceptualized randomness as an adaptable, adjustable source of energy to activate inclusive degrees of freedom in a given algorithmic procedure, randomness is not visualized as such, it resides as a force enabling the algorithm to reveal itself by activating its implied behavioral scope [5, final chapter].

Paradoxically, we target the exposure of attention-grabbing machine-specific behavior, however avoiding explicit design, though consciously designed software is definitely still involved. In other words, we expect consistent performative autonomous behavior in software agents, not superficial reactive actions triggered from a palette of premediated options. Contrasting automatism and autonomy is key. Genuine autonomy entails development; the artificial agent acquires increasingly complex cognitive abilities by interacting within an unpredictable environment. For example, developmental robotics combines ideas of social interaction, embodied, situated and enactive development, and continuous online open-ended cumulative learning to achieve ever-more-complex skills [6].

The present paper extends HMI into an object-based and material-oriented studio practice, proposing a critical consideration of the discrepancy between the discreteness of the digital medium and the continuous nature of human perception and cultural engagement. Then, how could software-initiated activity and spontaneous bodily action merge into a new medium affording innovative human-machine co-creation? The MM research project aims to study and analyze the complexity of hands-on material and object centered studio practice within a digital context. For example (1) how to integrate affective gesture and algorithmic decision making, and (2) how to extract underpinning procedural patterns from engaging with physical materials. Our objectives are addressed through experiments in human-machine co-creation, affording creative action from and within both partners, with both entities being grounded in a shared physical environment. If, in the light of computational creativity, we acknowledge the hypothesis that art is fundamentally a social phenomenon [7, p. 9] and art as communication and sharing between people and art-making as an adaptive product of our biological evolution – "we do expect that the AI has to say something socially, something that suggests an inner consciousness and feeling" [8, p. 141], as such, software is still a long way from being considered art.

However, ideas and abstractions of human psychology can indeed function as design principles for artificial agents-based systems spawning complex emergent behavior from the specification of mutual social affinities, for example, user-supplied gestures viewed as virtual creatures developing complex behavior while adaptive and sensitive to neighbor creatures [Figure 1] to a self-organizing agency driving digital sound synthesis. Our present research aims to grow a similar distributed platform for social negotiation as instantiated in human and materialist non-human participants.

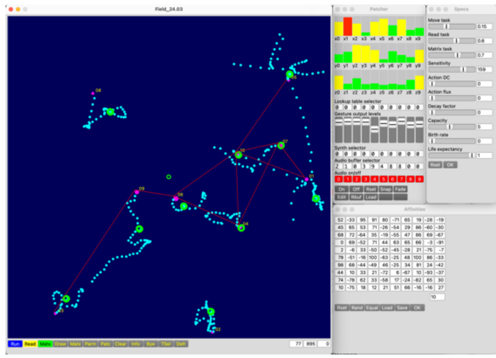

Figure 1: Living gestures audio interface

2. Contextualization

Renowned neuroscientist Antonio Damasio observes "The universe of affect – the feeling experiences derived from drives, motivations, homeostatic adjustments and emotions – was a *prior historical manifestation of intelligence*, highly adaptive and efficient, and was a key to the appearance of growth and creativity" [9, p. 181]. The author challenges the traditional Cartesian separation of mind and body, highlighting the crucial role of emotions in decision-making and rational thinking. Damasio advocates for a holistic understanding of the mind and body, emphasizing the interconnectedness of emotional and cognitive processes.

MM aims to close the mind/body gap through the development of (1) an extended contextual framework to address notions of materiality and object-centered activity relating to digital culture and (2) implement skin-tight innovative partnership formats in human-machine interaction (HMI) as to foster co-creation in a common physical ecosystem. The problem of human-machine interaction is explored in the context of the artists' studio taking a unified approach in the sense that human bodies, machine hardware, a widely diverse range of production tools, objects and materials all contribute to a materialist environment in continuous flux. All components contribute to the emergence of affordances allowing tangible creative exploration. When discarding any mind-body, software-hardware and analog-digital dualities, a key question arises: how do generative algorithms relate to this setting?

A plethora of tools has entered the studio, some situated at extreme opposites of the complexity spectrum; consider a worn-out pencil as contrasting to computer animation using a quantum computing [10]. However, media value and complexity should be considered in relation to its impact on the creative process – a pencil typically drives rather than implements a cognitive process – Richard Feynman insisted "I actually did the work on the paper (…) it's not a record, not really, it's working. You have to work on paper and this is the paper" [11, p. 256]. On the other hand, random ideas generally instantiate unconditioned by the pressure and technological burden of complicated media. The point I am trying to make is to stress that "ideas" are not machine-generated but unconsciously instantiate, typically from exposure to open-ended, undefined environments (consider, for example, a walk in the park) addressed without prejudice or unambiguous goals. Then, bodily experiences suggest procedural action implemented as algorithms: aspects of a macro universe reflect in the stylized (logical) micro universe of a computer program.

Many of my generative systems explored randomness as catalyst, it does not get visualized, it is not perceived as such though it affords the excitation of a maximum degrees of freedom implied in a supporting associated algorithm. However, "to come up with new and radical strategies, we need radical diversity of representation and ability" [12, p. 246]. Then, randomness is not perceived as the opposite of informed decision-making but underpins the *maximization of diversity* as a primary working principle.

3. Embodied Cognition

From a much wider perspective - from philosophy to Artificial Intelligence - the role of situated activity versus formal operations in human cognition is being considered thoroughly, how do motivated human bodies and programmed machines interact by virtue of sharing a common physical habitat? Answers are found in the concept of Embodied-Cognition (EC), and rejecting cognition as based on representations of abstract symbols. EC considers thinking processes as constituted and afforded through motivated bodily activity in a situated physical setting. In the context of the art studio, such inclination marks the distinction between creative development through impulsive improvisational object handling and the synthesis of new ideas through pure contemplation. MM discards the mind-body, software-hardware and analog-digital dichotomies, MM looks for materials/machines to respond and behave not by explicit programming but by the nature of their physical structure.

"Philosophy in the Flesh: The Embodied Mind and Its Challenge to Western Thought" by Lakoff and Johnson [13] explores this relationship between human cognition and the body, challenging traditional Western philosophical views: human thought is fundamentally shaped by the body's sensory motor experiences and deeply rooted in the way our bodies interact with the environment. Lakoff and Johnson also introduce the concept of *embodied realism* suggesting that abstract concepts and metaphors are grounded in our bodily experiences, cognitive processes such as image-schemas illustrate how our bodily interactions shape our conceptual systems.

From another angle, a highly relevant philosophical theory is *speculative realism* which seeks to move beyond anthropocentrism and explores the reality of entities independently of human perception. As part of Object-Oriented Ontology (OOO), asserts that objects are the primary focus of ontology [14]. Objects can include not only physical entities canvas and paint but also non-physical entities such as aesthetic concepts. OOO promotes a *flat ontology*, meaning all objects, whether human or non-human, are considered equal in terms of ontological status; it challenges hierarchical views that prioritize certain entities (humans) over others. Again, this fits my first principles of maximization of diversity and bootstrapping from scratch, object and subject are treated as equal partners, "what are normally called subject and object are simply *aesthetic* properties that are shared between objects … in the OOO universe, aesthetic experience is real and tangible yet unspeakable" (15, p. 63). Then, if machines are on equal (creative) authority with humans, could they address the environment consciously – since "nothing can be known in the absence of consciousness" [16, p. 114]. Accordingly, nascent feeling machines' experiences are derived from motivations and homeostatic adjustments, meaning intelligence through affective adaptation. Consequently, feeling robots should exist as physical bodies requiring regulations and adjustments to persist with sensors reporting internal and external states, leading to optimized global behavior from the network of competing processes in the body and the environment. Therefore, the critical idea of machine autonomy is addressed, in particular, how it might contribute to innovative and unconventional human-machine co-creation.

Autonomy closely relates to the notions of *autopoiesis, co-evolution* and *enactment*: with humans in the loop [17], humans and artificial systems coalesce, interact and make sense of their common environment (the art studio) – the process of enactment takes place. Seminal work by Maturana and Varela [18] defines enaction and autopoiesis (self-creation) as key to life itself; living organisms constantly regenerate and maintain their own components, enaction describes the active role of the organism to create its own reality, and cognition is not a representation of an external reality but an ongoing, dynamic process that emerges from the interactions of an organism with its environment. Then, enaction supports participative AI, mediated creation of meaning from human-environment interaction, therefore, it is deeply rooted in radical empiricism [19].

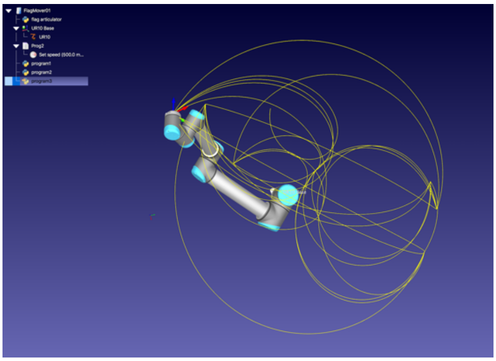

Figure 2: Finite State Machine robot action

In addition to participative AI, thinkers in art philosophy wonder how to be complicit with materials, [20, p. 12], media design [21], aesthetic theory [22] and social psychology [23] are asking a fundamental question: how to build media supporting qualitative coexistence of human and non-human participants, media balancing material diversification and expanding the human experience into a wider shared ecology.

4. Art/Science context

From art historian Clement Greenberg's definition of art materials as autonomous with distinct properties to physicist Karen Barrad's notion of *material complicity* – viewing material agency as a network of relationships rather than a property of things, discussions of materiality in art persist [24, 25]. Concept art introduced a shift from object-based art to more conceptually driven process-oriented practice. However, installations, performance/body art, and interventions in specific locations became prominent during this time, materiality was re-invented rather than abandoned. Consider Duchamp's ready-mades, the physical incarnation of a large number of symbolic elements (*la machine célibataire*) as a large glass sculpture and, most prominently, *Étant Données* (1946-1969) built from wood, nails, bricks, brass, aluminum sheet, steel binder clips, velvet, leaves, twigs, a female form made of parchment, human hair, glass, plastic clothespins, oil paint, linoleum, an assortment of lights, a landscape composed of hand-painted and photographed elements and an electric motor housed in a cookie tin which rotates a perforated disc [26]. Afterall, Duchamp proves objects are not reducible to the materials, objects afford multiplicity of thinking, subsequently "the idea has to be awfully good to compete with the object" [24, p. 31]. According to Sherry Turkle, "We think with the objects we love; we love the objects we think with" [23] – *evocative objects* are objects that express a meaning beyond their purely instrumental functionality, they act as emotional companions, relate to one's memories, support a relational attitude and trigger the imagination.

Then, how could specific *evocative objects* contribute to the experience of a corporeal aesthetics-oriented human-machine playground? Experience-centered aesthetics as total engagement was recognized early on by American philosopher John Dewey; *art as experience* emphasizes materialist interaction, the integration of art into the fabric of daily life thereby suggesting a holistic, inclusive approach to understanding and appreciating art [27]. Then, human-machine co-creation could be viewed as a hybrid network linking art-historical awareness, cognitive abilities in machines, objects and humans configured as a complex dynamical system, pushing the system in various behavioral orbits through internal and external activation might reveal an unexpected yet compelling experience. Obviously, a fascination with unscripted machine-initiated action persists, however, idiosyncratic machine behavior is oxymoron with scripted instruction, what could a blend of bits and atoms in an analog/digital amalgam bring to the discussion? We might be able to describe how machines work, but what do they experience, what is their proper phenomenology? [28 p. 10]. Flat ontology suggests things can be many and various, specific and concrete, while their *being* remains identical – material objects and abstractions co-exist on equal levels of authority, another fundamental holistic vision.

While the idea of computation is unavoidably connected to human understanding and awareness, typically, engineering concerns over optimization prevail rather than efforts of considerate understanding of the machine by itself. Post-humanism rejects the notion of human-world (man-machine) correlate, humans are entangled and implicated in other beings. Flat ontology synthesizes the human and non-human into a common collective [29, p. 33], then, biological and synthetic/artificial agents might articulately co-exist on a common existential stratum. As objects are to be understood as both concreate and abstract, how could such intimate symbiosis be implemented to anticipate emergent creative action?

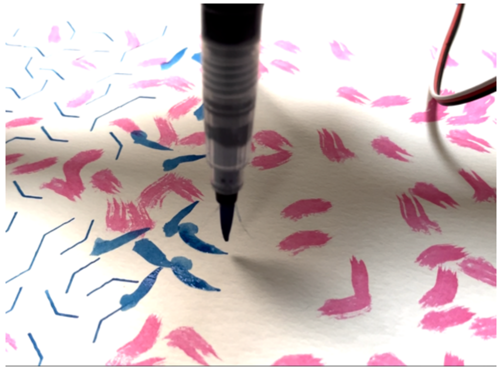

Figure 3: CNC machine with brush

Ian Bogost recommends a similar speculative question – while rejecting a selfishly anthropocentric view – how can we nevertheless deal with complex structures crafted by humans? Relevant to our hands-on approach, a pragmatic speculative realism of object-oriented engineering to physics ontology is put forward: “as philosophers (…) our job is to amplify the black noise of objects and to make the resonant frequencies of the stuffs inside them hum in credible satisfying ways” [28 p. 34]. Then, objects are not reducible to material substance but open to function as speculative triggers; this is why “the artwork is a prime example of the object’s capacity to evade the knowing grasp” [28, p. 14].

5. Experiments

Over the years, I have often contemplated on emotive relationships with machines, in particular computers, in the sense of how the physicality of the programmer (human body) relates to the materiality of the medium (computer hardware). For example, a patch on an analog computer is a physical reflection of an idea, itself a hypothetical imaginary procedure yet implemented as corporeal object. Handling DEC tapes on a PDP15 mainframe computer producing both intensive heat and excessive noise strongly impacts the programmer, intellectually and emotionally in an intimate attachment: the machine manifestation embodies the programmer. Programming in assembly language, counting processor action in nanoseconds versus using high-level symbolic languages such as LISP entails distinctive degrees of authority and reciprocal action. Today, computing impacts society on a larger scale, consider distributed laptop performance geologically extending situated/embodied cognition into sociocultural space in global networks. All instances prove human imagination to be affected and motivated by materiality, tangibility and overall physicality of the digital medium. As mentioned before, research in Digital Aesthetics views itself in bottleneck by accounting for the ontological discrepancy between the continuity of human perception and cultural engagement and the discreteness of digital technology. In addressing this problem Simon Penny suggests an aesthetics of behavior - cultural action emerging from a "reconceptualization of cognition as embodied, enactive, and integrated with the material and cultural world" [30 p. 213], and in a wider scope, viewing intelligence as residing at the intersection of the body and the world, viewing sensing and action as indivisible, and (following Varela) identifying action as a structural coupling between body and world.

Figure 4: UR10 robot setup

Figure 5: UR10 robot watercolor

A wide range of robotic infrastructure is being investigated in recent machine art, from musical robotics, social robots as creativity eliciting agents and embodied performance with robotic actors [31]. My early robotic work explored the machine's behavioral scope based on a probabilistic Finite State Machine algorithm [Figure 2].

Two approaches to machine drawing and painting within MM are briefly documented here: CNC machine and UR10 robot arm. CNC explores structural painting using brushes equipped with containers holding colored ink [Figure 3]. Initially, UR10 explored watercolor painting based on earlier software driving a pen plotter. A Python program runs inside the scripting engine of RoboDK [32]: take water and paint using a timing algorithm adapting to the materiality of the painting process itself [Figures 4, 5]. The current UR10 implementation takes the human in the loop, human and machine painting on a common surface, the robot using computer-vision to interpret input by both parties. Human and machine (H/M) take turns in a conversational process of action (select a color, decide how, what and where to paint and act) and perception (analyze the current contents of the painting surface and create a list of features). Our goal is to speculate on developing prolific emergent dynamics of social H/M interaction avoiding explicit instruction altogether. Questions arise: can we bootstrap interesting behavior from scratch, how to guarantee equal authorship of human and machine and how to maximize diversity without resorting to blind uncertainty. In addition, given a materialist platform, how to sense and make sense of tendencies in corporal human and machine activity? UR10 balances two competing motivations: H/M both aim to express a personal character while also intent to integrate into a larger social whole. A measure for social H/M proximity is related to (1) the physical distance, (2) the painting amount/surface and (3) color similarity between consecutive human and machine inputs. Intervals in proximity reflect intentions: for example, H painting nearby in space and with comparable colors mirrors H wishing to temporarily connect to M. H and M gradually learn about each other's aesthetic orientation. M uses various computer-vision tools (OpenCV) to discriminate between successive H actions and capture amount and complexity of H input. M holds a collection of speculative motivations, represented as arrays of types of possible actions and their respective efficiency which, itself, is updated according to intervals in social proximity – smaller intervals imply increased efficiency i.e., H and M integrating. A second adaptive process considers eventual M expression: machine motivations are adjusted using specific relationships (implemented as non-linear functions) between a list of features derived from human input and the motivation arrays. Then, a strong connection is being appreciated in the H/M abstract dialog, mutual activity seems coherent yet unpredictable. The software is being finalized right now; comprehensive results will be published in a subsequent paper.

Acknowledgements

I am indebted to my colleagues Elias Heunink and Thomas Janssens for technical and logistic support. The MM research project is financed by the Flemish Government of Belgium.

References

[1] Chadabe, J (1989) Interactive Composing, an overview, the Music Machine, C Roads (ed.), MIT Press, Cambridge, pp.143-148

[2] Beyls, P (2019) Art as a Living Interface, *Springer Lecture Notes in Computer Science*, HCII, Orlando, FL

[3] Beyls, P (2018) Motivated Learning in Human Machine Improvisation, *NIME2018 Conference Proceedings*, Virginia Polytechnic Institute and State University, Blacksburg VI

[4] Molnar, V and Baby, V (2022) *Vera Molnar: Interview with Vincent Baby*, Manuella Editions, Paris, France

[5] Beyls, P (2015) *Simple Thoughts*, MER Publishing, Belgium

[6] Cangelosi, A and Asada, M (2022) *Cognitive Robotics*, MIT Press, Cambridge, MA

[7] Bown, O (2021) *Beyond the Creative Species*, MIT Press, Cambridge, MA

[8] Hertzmann, A (2018) Can Computers Create Art? *Arts*, 7, 18

[9] Damasio, A (2005) *Descartes' Error: Emotion, Reason, and the Human Brain*, Penguin Books

[10] Lioret, A (2021), Proceedings Generative Art Conference, Rome, Italy

[11] Clark, A (2013). Gesture as Thought? *The Hand, an Organ of the Mind; What the Manual Tells the Mental* (pp. 255-268). MIT Press, Cambridge, MA

[12] Bridle, J (2023) *Ways of Being, Animals, Plants, Machines: The Search for a Planetary Intelligence*, Pinguin Random House, UK

[13] Lakoff, G and Johnson, M (1999) *Philosophy in the Flesh The embodied Mind and its Challenge to Western Thought*, Basic Books

[14] Harman, G (2010) Object-oriented Philosophy, *Towards Speculative Realism: Essays and Lectures*, Zero Books

[15] Morton, T (2013) *Realist Magic. Objects, Ontology, Magic* Open Humanities Press

[16] Damasio, A (2021) *Feeling and Knowing: Making Minds Conscious,* Pantheon

[17] De Loor, P, Manach, K and Tisseu, J (2009) Enaction-Based Artificial Intelligence: Towards Co-evolution with Humans in the Loop, *Minds and Machine*, 19, pp. 319-343, Springer

[18] Maturana, H and Varela, F (1992) *The Tree of Knowledge*, Shambala

[19] *Cosby, D (2013) The Philosophy of William James: Radical Empiricism and Radical Materialism* Rowman & Littlefield Publishers

[20] Lange-Berndt (2015) How to be complicit with materials, *Materiality*, Whitechapel Gallery/MIT Press

[21] Nitsche, M (2022) *Vital Media: Making, Design and Expression for Humans and Other Materials*, MIT Press, Cambridge, MA

[22] Fazi, B (2019) Digital Aesthetics: The Discrete and the Continuous, *Theory, Culture and Society,* Vol 36(1) 3 - 26

[23] Turkle, S (2007) *Evocative Objects: Things We Think With*, The MIT Press, Cambridge, MA

[24] Lippard and Chandler, 1968 The Dematerialization of Art, *Art International*, Vol. XII, nr. 2

[25] Hudek, A (2014) *Object*, Documents of Contemporary Art, Whitechapel Gallery/MIT Press

[26] Belting, H (2010) *Looking Through Duchamp's Door*, Walther König, Köln

[27] Dewey, J (1934) *Art as Experience*, Minton, Balch, University of Michigan

[28] Bogost, I (2012) *Alien Phenomenology, or What It's to Be Like a Thing*, University of Minnesota Press, Minneapolis, MI

[29] Bryant, LR (2011) *The Democracy of Objects*, Open Humanities Press

[30] Penny, S (2018) *Making Sense*, The MIT Press, Cambridge, MA

[31] Creativity and Robotics, 2020 *Frontiers in Robotics and AI Journal*, ICSR 2020

[32] RoboDK, https://robodk.com/