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Haptic transference: A new haptic feedback robotic control interface

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ABSTRACT: Material sculpting has evolved from the use of our bare hands to Computer Numerically Controlled (CNC) milling machines and 3D object printers. Automated machines produce a problematic mediated-materiality by distancing a makers hand from the material interactions that naturally produce tactile haptic feedback. Removing this feedback has formed a disillusioned material ethic affecting contemporary sculptors who want to utilize the machines strength, speed and accuracy while simultaneously maintaining tactile material interaction. Art-Bot is a response to this retrogression of tactual knowledge. It is an interactive robotic artwork that facilitates a hybrid haptic material interaction between artist-hand and sculpting-machine.

1 INTRODUCTION

Art-Bot is an interactive robotic co-generative kinetic art installation (Figure 1). It contains a robotic arm, built out of recycled bicycle components, which can be outfitted with tools such as a chainsaw. The robotic tools are controlled by a user to grind and chop rounds of wood, placed inside a polycarbonate protected acoustic deflection encasement. A microphone is installed next to the robotic chainsaw that records high-fidelity sounds occurring at the tools end (Figure 2). The audio signal is sent to a dynamically adaptive vibrotactile haptic arcade game controller (Figure 3). The controller is outfitted with a vibration speaker built into a large red button positioned under the users palm (Figure 3). The vibration speaker-button produces tone, pitch and frequency modulated vibrotactile undulations under the user's palm, translating into phantom material sensations. Additional force feedback is transmitted via a mechanical apparatus connecting the arm with the controls (Figure 1). The entire control panel is forced up or down depending on physical resistance encountered by the robotic arms mechanical 'kick-back'. These vibrotactile modulated force feedback mechanisms render the robotic tools actions into 'force-felt' experiences.

2 MOTIVATIONS

I am excited about technological tools that can help me sculpt beyond my body's physical capacities. I want to extend my body using enhanced cybernetic perceptual-prosthetics designed to bond my body and the machine. I want to reach out beyond the limitations of my flesh and bones into the wonderful possibilities promised to me by the mythical cyborg that made regular appearances in the books, movies and cartoons of my childhood.

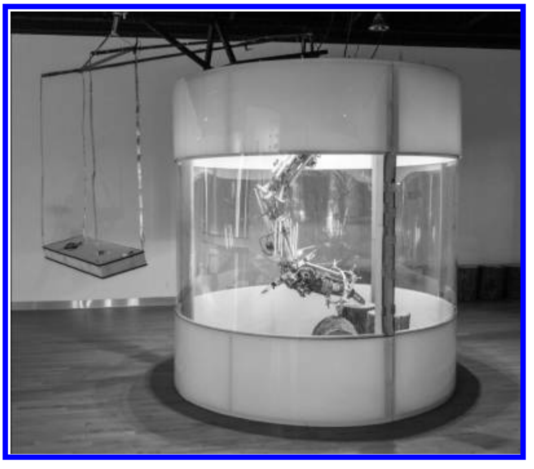

Figure 1. Art-Bot, robotic kinetic art installation, 8'X8'X12', Dec. 2012 to Feb. 2014. (© salle Alfred-Pellan de la Maison des arts de Laval. Photo: Guy L'Heureux.).

The currently available rapid prototyping tools such as 3D printers, laser cutters and CNC machines, usually work based on abstract computer generated graphically pre-represented models that are then sent to a machine that processes materials. However, these virtually-constructed computer generated models, that are output to objects, can require a great deal of iterative design work. Frequently the resulting objects fall apart, melt down and don't fit together and or simply don't work. Translating the imaginary sculptural form, of our minds eye, into an abstracted graphical representation on a computer screen, and then attempting to simply print the object out, removes the step where we tangibly interact with materials.

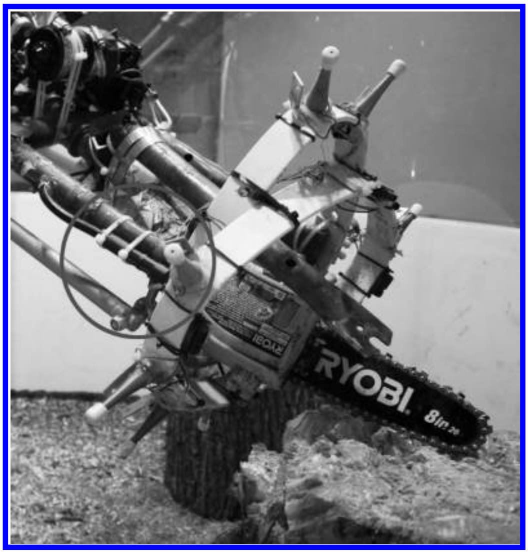

Figure 2. Detail of high-fidelity audio recording microphone (circled) for haptic vibration output of chain saw tool to controller. (© Morgan Rauscher. Photo: Morgan Rauscher.).

Tactile material interaction is critical to understanding material properties. In traditional methods of subtractive sculpture making, I pound on stone and carve out wood with a hammer and chisel, and I am given clues as to how to interact with the materials. I am forced to negotiate the naturally occurring material properties encoded into the materials themselves. When I sculpt something by hand, I am deeply immersed in an interwoven cycle of reflexive-interactive-iteration. I am commanding and being commanded by the materials I sculpt. I negotiate my imaginary into a material reality, and the iterations are manifested in a live event. This process allows me to dynamically change, adapt and ethically collaborate with the material properties of the stone, wood, ice, clay or metals I compose.

Cultural production is unfolding into a world of technological collaboration. Art-Bot contributes to the advancement of contemporary technologically aided sculpture making by producing a research creation artifact and platform for machine assisted iterative material engagement. My creative inquiry is therefore situated to inform this moment in cultural production history as it contributes to the evolution of technologically aided sculptural practice and live material enactment of sculpture using robotic machines.

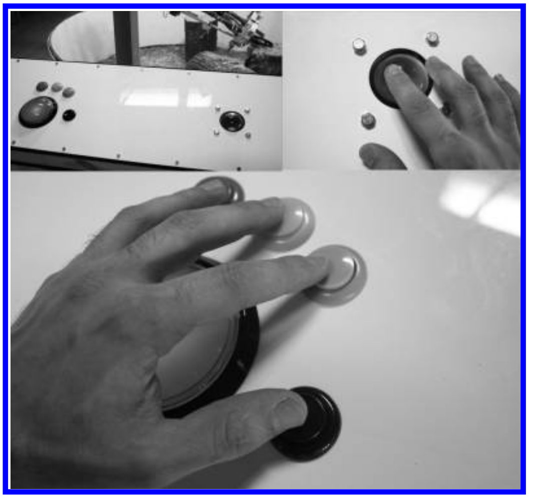

Figure 3. A dynamically adaptive vibrotactile haptic arcade game controller. (© Morgan Rauscher. Photo: Morgan Rauscher.).

3 FOUNDATIONS

Art-Bot is a research creation project, which uses sculpture to address a knowledge deficit in tactile material object modeling, in the field of interactive and generative-kinetic robotic art. This project also has a connection to the lineage of tool and technology developments made by and for craftsman, artists and designers who work with tangible materials.

Relevant cross-disciplinary philosophical explorations covering tacit knowledge have been explored by Polanyi (Polanyi 2009). Sennett's "The Craftsman" covers historical developments of the hand-craft (Sennett 2008). The influence of technology on performance is another related consideration that is explored by Salter in "Entangled: technology and the transformation of performance" (Salter 2010). In almost every instance of investigation where technological tools are used to enact expressive intent; both the body and technology are presented as critically interwoven elements combined to co-create an expressive communication. Art-Bot builds on these foundations to form a platform for the enactment of expression through creative performativity.

I do not separate sculpture from any other artistic performance. Sculptural action is manifested into physical formations. Traditionally, the gestural movements of a sculptor would have produced visual clues that act as ciphers for the enlightened viewer who would be able to follow a sculptor's actions as they inspected the sculptures material narrative. Art-Bot presents the possibility of expanding this tradition by literally recording and codifying a sculptor's movements and corresponding material interactions, which could potentially be 'sensed' by a viewer or sculpture student at some future date.

4 A BRIEF HAPTIC PRECEDENT

The medical community has been developing teleoperated haptic feedback "robot-assisted surgery" for over a decade (Okamura 2004). Haptic simulation has been widely used in a broad range of computer generated algorithmic feedback representations of force, and incorporated into technologies such as "Haptic Holography" (Page 2013). Roboticists have even gone as far as working with atomic scale force feedback using "tele-nanorobotic manipulation" (Hollis et al. 1990).

In contrast, the rapid prototyping and materials fabrication technology that has been developing has moved away from tactile material interaction. The good news is that haptic-feedback technology is widely available and could easily be intersected with rapid prototyping and machine milling to exploit the possibilities of robotically assisted material sculpting proposed by Art-Bot.

I would also like to note that, although we have engineer-centric material data sheets that can tell us everything from tensile strength to electrical conductivity, the craftsman and sculpting artist needs more than can be codified by words and diagrams in order to bond with a sculpture on the level of intuitive tacit knowledge. I look forward to a future where material datasheets become expanded to include material tactility, codified and retransmitted in the form of felt sensations.

5 FUTURE DIRECTIONS

I am working with interdisciplinary research methodologies including: interviewing and observing sculptors at work with hand tools (hammers, chisels, rasps and files), interviewing and observing contemporary rapid prototyping settings (3D printers, laser cutters and CNC machines), comparing functional outcomes between 'human-made' and 'machine-made' sculptural objects, and cross referencing all of these results with artist interviews. I am also observing and interviewing Art-Bot users to determine if the device facilitates a heuristic tacit-sculptural material interaction towards my long term goal of producing tacit transference in sculptural pedagogy.

Art-Bot is a project in its infancy. It is a prototype case study that achieves my first goal of building a telemanipulation haptic-robotic application for sculptors. However, I also plan to incorporate industrial robotics, modular tool sets, heads-up augmented interactive visual displays, dynamic lighting, tele-macro operation, record and replay (reproduction modes), and a powerful modular software application programing interface (API) that will make the entire platform accessible for constant improvement.

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