Digital deviation: cross-wiring tactile art-making with CG tools and manual extrusion.

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Abstract

This paper describes an investigation of tactile artmaking in digital and physical space. The tools employed are 3D printing, 3D animation, photogrammetry, and ceramic sculpture. Through art practice, the research connects the structures of these tools through a "cross-wiring" approach, addressing the question, "How can medium-specific structures enable the translation of tactility between computer graphics (CG) and physical artmaking?".

The research uses breakage and failure to expose medium-specific structures. For instance, 3D printing extrudes material in stacked layers to create a form. These structures suggest pathways for translation between media, such as the controlled extrusion of printing filament and the free extrusion of other sculptural materials. Likewise, the stacked 2D layers of the print and the sequential 2D images of animation. This structural "cross-wiring" provides a scaffold for an artist to navigate the digital-physical continuum, generating outputs which draw on the tactile affordances of both computer-based and physical art-making.

The research is situated within a field of artists who, in different ways juxtapose the corporeal and the digital experience. It is distinguished by its particular focus on the translation of tactility and by doing so in an open-ended iterative workflow which yields both physical and digital outcomes.

The paper will demonstrate this approach through a series of sculptures and an animated 3D object made by the paper author. The practice outcomes invite reflection on the experience of tactility along a digital-physical continuum.

Keywords

Translation, Virtual, Physical, Artmaking, 3D-Printing, Ceramics, Tactility, Glitch, Sculpture, Animation

Introduction

Digital artmaking offers ways to simulate and replace tactile physical processes. 3D printing allows the construction of a physical object without the artist needing to even touch its surface. 3D dynamics simulation can photo-realistically represent messy, sticky, tactile materials without the artist getting their hands dirty. Other tools such as digital painting and sculpting, immersive environments and haptic interfaces offer further ways to simulate tactile processes. However, there is an opportunity for a more process-based interrogation of tactile artmaking through open-ended translation and cross-connection of structures between media.

The research takes the approach of processing sculptural forms through different media, allowing medium-specific imperfection and breakage to contribute to its transformation. It draws on existing studies of glitch, imperfection and breakage as a way to generate an aesthetic as well as bring the physicality of digital processes to the fore. Specifically, this research advances the idea of the physicality of digital media, as described by Jussi Parikka and James Allen-Robertson among others.

The research takes place across a digital-physical continuum which describes a sliding scale between two extremes of entirely computer-generated imagery and purely hand-made physical sculpture. The connecting space includes hybrid objects such as a 3D printed ceramics or a photogrammetry-capture of a hand-made object[1].

Across this continuum, there are connections. The output from one medium can be used as the input for another, in an iterative, open-ended workflow. This practice will be referred to as "cross-wiring" and will be described further in *Methodology.*

This paper will detail two practice-based examples which address this question.

[1] Photogrammetry is a technique used to create a digital replica of a physical object through the synthesis of multiple photographs.

Methodology/Approach

This research uses an approach of foregrounding the breakage of tools to expose their component structures. In the case of 3D ceramic printing, the breakage can entail the failure of the clay to follow the path of the extruder nozzle, failure of inter-layer adhesion and failure of the clay object to withstand the force of gravity.
In the words of experimental composer and theorist Kim Cascone,

> *"Failure" has become a prominent aesthetic in many of the arts in the late 20th century, reminding us that our control of technology is an illusion, and revealing digital tools to be only as perfect, precise, and efficient as the humans who build them.* [1]

In response to the common conception of digital space as an immaterial creative utopia, artists have used glitch and rupture to expose and foreground the process of mediation. Allen-Robertson notes that with the digital age, the physical substrate of media has become obscured within the "black box" of the computer [2]. Pre-digital media were defined by their unique physical substrates, (such as vinyl record, cassette tape or cel[2] animation). Digital media, by contrast, although encompassing many artforms and tools, are united by their lowest level component structures: bits[3] on a hard disk. This root functionality is so far removed from the experience of the digital artist that is tends to be forgotten.

Further to this, in the last two decades there has been a shift towards a materialist approach to media theory, which places importance not just on the material infrastructure of media transmission, but the meaning taken from the way a medium operates, rather than its content [3]. Jussi Parikka establishes a geology-based framework for understanding the evolution and function of digital media, bringing awareness to the entanglement of digital processes on physical Earth-sourced materials [4]. Not only are the components of digital devices enabled by minerals mined from the Earth having developed over millions of years, but they return to Earth as e-waste after their functional life is over. Thus, Parikka sees digital media as a layer of geological history. The physicality and slowness of the production of its materials at odds with the compressed time associated with technology.

This thinking in the field of glitch art and materialist media demonstrates some of the slippage and connection between digital and physical space which this practice-based research addresses.

Context

This research is situated amid a group of artists who employ unconventional and experimental workflows between 3D ceramics printing, computer graphics and photogrammetry to disrupt the predictability of CG tools and reinsert an element of human touch. Rachel Rossin creates both physical and digital outputs, distorting and connecting imagery in techniques and breakages specific to her media. For instance, In *Mirror Milk* [5], Rossin scanned her own childhood drawing of a cat into digital space where she applied dynamic simulation to the surface, causing it to drape and fold like cloth, distorting the image. She then rendered the result as a physical oil painting. The interplay between the digitally simulated physicality, the visible materiality of the oil paint creates a surreal aesthetic which speaks of both digital and physical materiality. In another series of work, *I'm my loving memory* [6] Rossin printed virtual imagery on clear plexiglass sheets. She then heated and shaped them with her own body. The pieces are displayed with light shining through their transparent surface, casting the imagery onto their environment. These sculptures offer a physical counterpart to digital projection and the visual distortion it can cause[4]. Though the imagery is derived from the virtual, Rossin connects it to her own body as she physically pushes and pulls the constraints of the plexiglass medium.
Rossin's practice demonstrates the "cross-wired" approach of this research. However, the distinction is that Rossin's work focusses on the translation of visual rather than tactile methods of making. Her image palette includes childhood drawings and videos, images and 3D models from contemporary internet culture and gaming. These images carry their own significance which contributes to the meaning of visual distortions that Rossin enacts.

Artists such as Anya Gallaccio and Oliver van Herpt explore the implications of digital tools on tactility in art-making. In her work *Beautiful Minds* [7]. Gallaccio collides the consistency of digital 3D printing with the unpredictable agency of clay. The installation is a room-sized clay-extruder robot arm, printing a digital model of the US mountain, "Devil's Tower". As the robot builds the structure, the clay sags and ruptures, contributing its own material presence to the sculpture.
A connection is apparent between the layered structure of the 3D print and the much slower formation of the geological layers in the actual *Devil's Tower*. Another connection exists between the Earth-based medium of clay, and the Earth-based form it depicts. These are the kinds of

[2] Cel animation was named after the transparent celluloid film animators drew on in order to layer a scene together.
[3] Bit is short for "binary digit", the smallest unit of data a computer can store.

[4] Digital projection is the process of casting a 2D image or texture onto a 3D object. Any part of the image that is not projected perpendicular to the surface becomes stretched and warped along the object surface.

"cross-wired" connections employed in this research project.

Adjacent to Gallaccio in the field of 3D printing, Olivier Van Herpt has experimented with the interference of material in his wax 3D printing device. Resisting the removal of the artist's presence that can occur in 3D printing, he actively builds his own custom printers, experimenting with different effects, essentially "making the process" rather than "making the objects" themselves [8]. For instance, he has adapted a 3D printer which drips wax rather than extruding clay. The result takes on a highly irregular surface, covered in dribbles and drips.

As described above, tactility in digital and physical practice as currently addressed by artists differs from the practice of the author in that it either applies the cross-wired approach to visual imagery, or it addresses tactility and the making process itself in a closed workflow with only one instance of translation.

Practice - Breakage: Experimentation

Physical extrusion of malleable materials is the starting point for this practice-based investigation. Materials such as silicone and clay were pushed through rigid perforated surfaces as well as flexible mesh. Materially, it is a way of exploring how a substance behaves under pressure and gravity. The separation of the material into smaller modular worm-like structures exposes the extent to which it droops and resists. The material's shear factor affects the blending between one batch of material and the next. Conceptually, extrusion embodies a process of becoming. As formless material passes through a filter, structure is imposed, form is taken, and the material exposes its own capacities and limitations.

Artwork 1 *Brain vase* (2023). Earthenware and glaze.

Figure 1. *Brain Vase*. 2023. (Potterbot) © Sarah Eddowes.

This ceramic sculpture has an irregular surface resembling looped yarn. The topology of the surface is accented by darker pink on the outer contours of the surface. The technique used to create this work emerged from a response to the failure of the ceramic 3D printer, the *Potterbot*[5]. The artist initially was aiming to print a 3D model of digital extruded noodles digitally wrapped in plastic (Figure. 2). However, during the printing process, the stream of extruded clay frequently broke apart due to the frequent on and off action of the extruder[6]. Leaning into this material failure, the extruder was switched to a continuous stream and the base platform holding the extruded sculpture was manipulated by hand, building up the exterior wall of the object layer by layer. The object was then fired and glazed in keeping with traditional ceramics practice. Coloured gloss glaze was applied to the outer surfaces of the object, to highlight the nodular surface. The manual manipulation was no match for the computer's consistency. However, by interrupting the consistent action and extrusion of the printer with the intuitive and irregular movement of the artist's own body, an artefact was created which connects these two approaches to art-making.

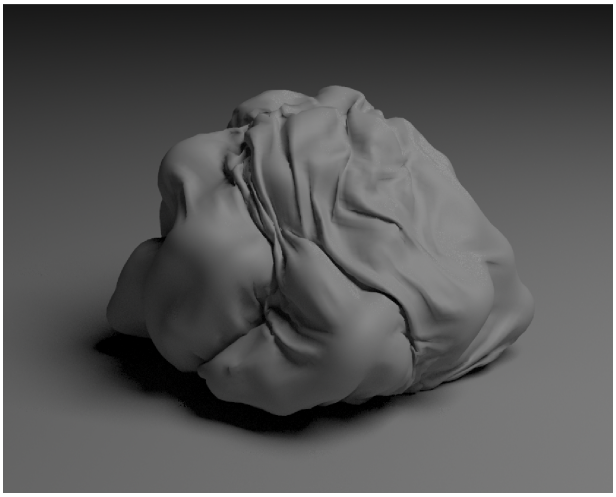

Figure 2. *Noodlepile plastic wrap*. Houdini render © Sarah Eddowes.

[5] *Potterbot* is a licensed clay 3D printing machine. A cylindrical cartridge is filled with clay and is extruded through a nozzle while the motorised platform below moves on castor wheels according to the map of a programmed digital 3D model.

[6] The printer turns the extruder motor on and off according to the mapped path of the nozzle.

Figure 3. Breakage in Potterbot clay 3D print of *Noodlewrap II.* © Sarah Eddowes.

Artwork 2 *Dancing mountain* (2023).
Earthenware and glaze.
(Clay through electric extrusion gun)

Figure 4. *Dancing mountain*. 2023. © Sarah Eddowes.

Manually moving the platform under the *Potterbot* (as described in *Artwork 1)* was limited to the height of the printer and the weight of the clay, which became unsustainable to hold for larger pieces. The technique was adjusted to use a stationary platform with the manual movement of an electric extruder gun. This technique produced the same irregular surface as the *Potterbot* pieces, with the capacity for larger scale pieces and a more physically feasible action for the artist. The transition away from the *Potterbot* altogether was sliding toward the physical hand-made on the digital-physical continuum while retaining the technical approach of the computerised 3D printer. This development, along with the use of clay, recalls the traditional technique of coil-building in ceramics. As ceramicist Jonathan Keep points out, 3D printing allows the freedom of form afforded by coil-building, unlike the pottery wheel which is bound to symmetrical forms [9]. This acknowledgement creates a cross-wired connection between the cutting-edge digital technology of photogrammetry and 3D printing back to traditional ceramic hand-building. The object inherits aesthetic elements from both its mechanical and hand-made construction.

Artwork 3 *Noodlepile I. (2022).* Looped animation

Figure 5. *Noodlepile I*. Looped animation. 2023. © Sarah Eddowes. VIDEO LINK

This animated work shows a translucent pink noodle-like pile bouncing and wobbling. The work was made initially by the manual extrusion of clay. This object was then translated to digital space with photogrammetry. Once digitised as a 3D object, in *SideFX Houdini*[7], the colour, reflection and subsurface scattering[8] of the surface were

[7] SideFX Houdini is a procedural software used for animation, modelling, simulation and rendering.
[8] Sub surface scattering is a technique in computer graphics which simulates light penetrating the surface of a model and bouncing around before exiting. It is used to depict semi-translucent materials such as skin, marble and wax.

manipulated, giving a flesh-like appearance. A *vellum*[9] dynamic simulation was then applied to simulate a soft, elastic jelly material. The animated output connects the wet, plastic tactile experience of the physical clay with the versatility of CG rendering and material simulation. The object is both clay and simulated digital jelly, which offers a layered expression of tactility. The manipulation of the surface material of the CG object echoes the glazing process employed with the physical ceramic pieces described above in *Artwork 1* and *II*. In both the ceramics and CGI workflows, the object surface was assigned reflection, translucence and colour. This "cross-wiring" emerged from simultaneously working across the tools in an experimental, open-ended approach.

Outcome Reflections

Through this process of experimentation, different elements of tactility are explored across digital and physical space. The aesthetic resonates with both the hand-made and systematic mechanical construction. By translating forms between the tools of photogrammetry, 3D animation, 3D printing and ceramic sculpture, structural connections emerge, creating an interconnected dialogic workflow. What is more, the limitations and structures of these tools reveal their inherent function and materiality. Just as physical clay has its own agency through its weight, smoothness and stickiness, digital tools have their own tendencies and breakages. Digital tools also have a capacity to express tactility through simulation of physical materials, which invites both amplification and alteration of material behaviour. Going forward, the manual 3D printing technique invites further experimentation through CG simulation of other materials such as fluids, brittle matter and pyrotechnics. Continuing to engage with physical parallels or emulations of these processes will illuminate further connections between tools and materials.

References

[1] Kim Cascone. "The Aesthetics of Failure: Post-Digital Tendencies in Contemporary Computer Music." *Computer Music Journal* 24, no. 4 (Winter 2000).
[2] James Allen-Robertson. "The Materiality of Digital Media: The Hard Disk Drive, Phonograph, Magnetic Tape and Optical Emdia in Technical Close-Up." *New Media & Society* 19, no. 3 (2017).
[3] Grant Bollmer. *Materialist Media: An Introduction*. New York: Bloomsbury, 2019.
[4] Jussi Parikka. *Geology of Media*. 1st ed. Vol. 46. Electronic Mediations Series. University of Minnesota Press, 2015.
[5] Rachel Rossin. *Mirror Milk.* 2015. Oil on canvas
[6] Rachel Rossin. *I'm My Loving Memory*. 2020. Plexiglass, various.
[7] Anya Gallacio. *Beautiful Minds*. First exhibited Thomas Dane Gallery, London 2015. Clay printer installation, room scale.
[8] Justin Zhuang. "Oliver Van Herpt. About," 2015. https://oliviervanherpt.com/about/.
[9] Jonathan Keep. "Potting in a Digital Age." *Studio Potter* 47, no. 1 (2019): 17.

Bibliography

Allen-Robertson, James. "The Materiality of Digital Media: The Hard Disk Drive, Phonograph, Magnetic Tape and Optical Emdia in Technical Close-Up." *New Media & Society* 19, no. 3 (2017).

Bollmer, Grant. *Materialist Media: An Introduction*. New York: Bloomsbury, 2019.

Cascone, Kim. "The Aesthetics of Failure: Post-Digital Tendencies in Contemporary Computer Music." *Computer Music Journal* 24, no. 4 (Winter 2000).

Gallacio, Anya. *Beautiful Minds*. First exhibited Thomas Dane Gallery, London 2015. Clay printer installation, room scale.

Keep, Jonathan. "Potting in a Digital Age." *Studio Potter* 47, no. 1 (2019): 17.

Parikka, Jussi. *Geology of Media*. 1st ed. Vol. 46. Electronic Mediations Series. University of Minnesota Press, 2015.

Rossin, Rachel. *I'm My Loving Memory*. 2020. Plexiglass, various.

Zhuang, Justin. "Oliver Van Herpt. About," 2015. https://oliviervanherpt.com/about/.

[9] "Tetrahedral softbody" is an operation within *Houdini* which maps the movement of a low resolution mesh to the original mesh. It is suited to simulating collapsible soft rubber or jelly-like materials.