

Puzzling Gestures: Prototyping a Teleoperated Interactive Artwork Using Techniques from Glass and Electronic Art

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Abstract

This paper presents the initial stages of prototyping a digital-sculptural project that mines conventionally undesirable artifacts of mass production and material residue for their expressive worth. These artifacts are used as both inspiration and raw material to transform touch and movement into reflexive structures. This is done in the form of a remote controlled 'teleoperated' interactive artwork. This artwork, called *Gesture Puzzles*, is inspired by antique glass and wood-framed dexterity puzzles that use a player's hand movements to maneuver a marble through a maze. The piece describes practical collaborative methods that use creative electronic process to exploit both desired and undesired material residues from molten pressed glass, waterjet cutting and touch screen interfaces.

Keywords

Glass, waterjet, electronics, gesture, puzzle, digital sculpture, prototype, Rapid tooling, interactivity. Teleoperation, touch screen

Introduction

Fingerprints, smudges and smears remain on touch screens as biological residue of daily use. While often unnoticeable, these marks compose a tangible reminder of physical actions that have initiated digital results.

This paper will describe the creative process behind making a sculpture in which disused processes and materials, including screen swipes, serve as a medium to prototype a teleoperated artwork. This work combines material residue in the form of wasted wood, glass and evidence of user interaction. These create the physical structure of this work, and in the rationale for their use, as a basis for conceptual frameworks in future iterations.

These objectives are supported by the following three aims. The first is to creatively utilize the tactile experience of remote control/teleoperated machines in an artwork. This artwork is influenced by antique dexterity puzzles in which a player maneuvers a marble through a maze. The second aim is to creatively integrate latent materials and performed actions. This concerns the advantages of recycling, or making creative use of discarded or overlooked resources, including how to capture hand gestures and transform them into digitally fabricated

objects through rapid manufacture. The third aim is to promote interdisciplinary collaboration between the fields of glass and electronic art. This is approached by reinterpreting, not only glass, but other analog craft processes in digital ways. This reciprocity is relevant to the field of electronic art because, with access to proper training and equipment, glass' nature as an inert, non-conductive material can be implemented expressively and structurally in digital artworks. After addressing these aims, this paper concludes by reviewing progress and suggesting future directions.

Project Description:

What is a Gesture Puzzle?

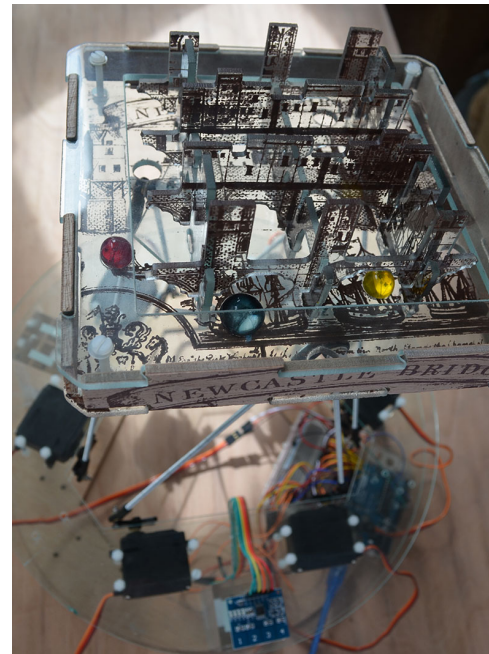


Figure 1. *Gesture Puzzle 1: Newcastle Bridge*. Glass, enamels, wood, capacitive touchpad, Arduino microcontroller, servomotors. Hursty, Bradbury. 2015.

The *Gesture Puzzles* will use a tablet or mobile phone to remotely tilt a glass and wood-framed box to maneuver a marble through a maze. The boxes are designed and cut

through CAD/CAM. When being manipulated, their pitch is controlled by servomotors, which adjust the rotation of the X and Y axes. These servos are controlled by an Arduino microcontroller and will be manipulated through a tablet touch screen interface.

To interact with this sculpture, the teleoperator will swipe a tablet to control the movement of the box. This movement is similar to the analog mechanism of Labyrinth, a popular sphere-in-maze, pitfall dexterity game developed by Brio, a Swedish company in 1946.



Figure 2. Brio Labyrinth game. [1]

In *Gesture Puzzles*, a program will record the direction and pressure of a participant's swipes. These recordings will be processed to display the gesture visually as 2D forms. Our current prototype (Figure 1) uses a capacitive touch pad, but we are pursuing a resistive touch screen interface as the most promising approach to registering the pressure of the screen swipes as 3D data.

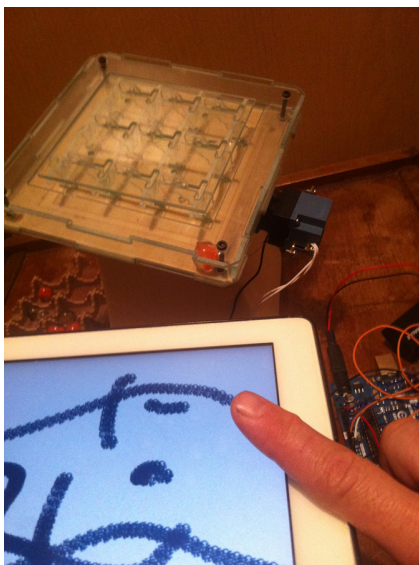


Figure 3. concept image of maneuvering a maze by swiping a tablet. Hursty, 2014

This data will be used to print 3D profiles as sculptural records of each time the puzzle is used. Depending upon the various pressures applied in each swipe, they will appear like the troughs and peaks of a sound wave. These will be incorporated into the subsequent sculpture as part of a grid structure that constitutes the navigable maze.

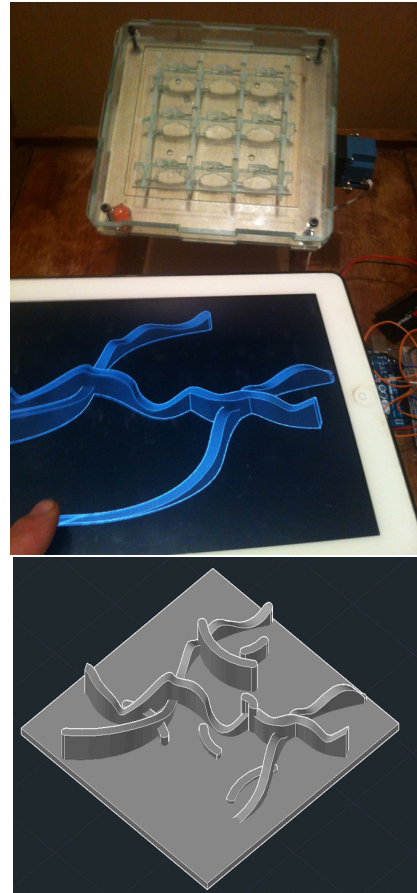


Figure 4. Concept image of capturing swipes as 3D profiles for 3D-printed maze insert. Hursty, 2014

Background: Path to Puzzle Making

Gesture Puzzles resulted from a series of projects that used press-molded glass creatively. These projects used waterjet cutting and rapid manufacture to make bespoke molds for pressing molten glass. *Muqarnas*, 2014, were the first artworks in this series. *Puzzle Boxes*, 2014, followed. The residual materials generated by these presented an opportunity to make *Gesture Puzzles*.

The choice to make glass boxes arose from applying the rising prevalence of Rapid Tooling in Rapid Manufacture to the cutting of sheet glass molds into which molten glass could be pressed. [6] The *Puzzle Boxes*, 2014, were developed to demonstrate how molten pressed glass forming, an obscure method within glass art, could be used artistically. [5] The specific premise was that by creatively reinterpreting pressed glass, which is based on elaborate

mold-making, a method could evolve in which the mold permanently encompasses the finished artwork.

Developing this method resulted in a series of works entitled *Puzzle Boxes*. These are box-shaped mold artworks inspired by Chinese puzzle boxes. The Qing dynasty (1644 – 1911) boxes were carved from ivory, wood or jade. They opened in elaborate or hidden ways and were prized curiosities exported along maritime trade routes to the West. The term 'puzzle box' also refers to boxes containing sets of intricate carved ivory puzzles during this same period. [2]



Figure 5. Chinese export puzzle set, 19th century. Copyright 2014, Discovery Museum, Newcastle

Hursty's *Puzzle Boxes*, 2014, were made out of bespoke sheet glass produced for the field of artistic fusing. These could be heated to a high temperature and then poured into with ladles of hot glass. The project was conceived for two reasons. First, as transparent shells for witnessing the normally opaque process of pressing molten glass into a metal mold's crevices. Also to fuse designs of varied glass colors, including the mold itself, together, like glass marquetry.

Fusing glass molds like this is a new technique for mold-pressed and cast glass that can expand the creative possibilities for glass casting. This development also inspired performative work that focused on the spectacle of the flowing molten glass (Figure 6). Importantly, this technique substituted glass for making molds instead of metal, the most favored material used for press forming. Pouring into transparent molds in this way makes the opaque process of pressed glass visible.

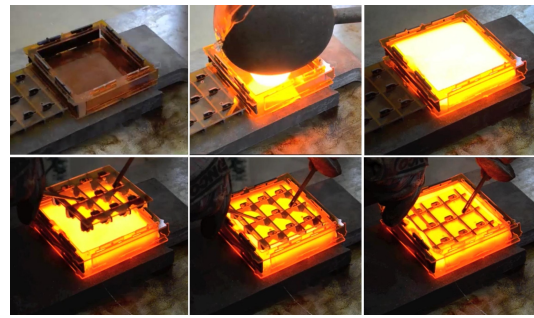


Figure 6. Montage of pressing molten glass into a sheet glass *Puzzle Box*. Hursty, 2014.

The glass boxes that resulted, as well as the discarded wood that was sacrificed in the process of making them, evolved into the *Gesture Puzzles* described in this paper. This happened by recycling the disposable byproducts of the design and making process, the scrap glass and wood components, to make experimental boxes that could never be fused together. Instead, they are being developed as interactive dexterity puzzles inspired by the movement and flow of hot glass.

The ebb and flow of process that influenced the final *Gesture Puzzles* also involved electronic methods. First, it influenced the CAD/CAM that was required to make the components. Second, it became an inspiration to develop an interface to manipulate the boxes through touch-screen teleoperation.

Using Residue as a Creative Resource

The raw materials, the glass and wood used to make *Gesture Puzzles* emerge from the residue of rapid manufacture and digital process. The residual glass came from experiments with disposable window glass rather than expensive fusing glass. This provided an inexpensive way to test that the tolerances of the joining nodes could be fit by hand and that they could be cut reliably using the waterjet machine.

Waterjet cutting is a computerized numerical control (CNC) process that uses extremely high pressures to allow a .75 millimeter stream of water infused with garnet abrasive powder to cut glass (and most other materials). When cutting sheet glass with high water pressure, a backing board is required to avoid breaking delicate pieces. This underlayment is usually made of wood, though other materials are possible. This incidental support is cut as a twin, in the exact pattern as the overlain glass material. It is usually disposed of as it is considered scrap. In *Gesture Puzzles*, both the wood and inexpensive non-fusing glass are kept and assembled to make up the platform and boxes. Using these materials in this way allows for different assemblages and aesthetic permutations to result across the series.



Figure 7, *left*. Waterjet cutting glass with disposable wooden backing board underneath. Hursty, 2014

Figure 6, *right*. Discarded waterjet cut wood underlayment. Hursty, 2014

Another source of residue for the boxes comes from mark-making. The concept of *Gesture Puzzles* is for them to function like a drawing tool by making creative use of tactility. The movements of playing are simultaneously transformed into mark-making that is both immediate and mediated. The marks imply meaning as both a record of the teleoperator's intent to get a ball through a maze and as an artistic record. This represents the path taken through the maze and the biological residue in the form of fingerprints and smears that are left behind. These gestures reflect not only the daily performativity that occurs between tablet users and screens, but as an interface between manual touch and digital results.

Design Researcher Tavs Jorgensen explores the possibilities of digital products whose physical forms bear the traces of manual shaping. One such product was a set of tea towels on which motion capture imagery of a hand using a tea towel was printed. [6] In that application

Jorgensen utilized a 3D motion capture glove for its 2D expressivity. The goal of the *Gesture Puzzles* is not only to register screen swipes as X and Y axes for 2D profiles but also to capture the pressure of the swipes as a Z axis in order to transform the movements of a user's movements of 3D profiles for digital manufacture.



Figure 8. Tablet screen with subtle fingerprints and swipe marks visible.

Screen swipes have been used by artist Evan Roth in his *Multitouch Paintings*, which were "created by performing

routine tasks on multi-touch hand held computing devices." [7] In this series, the fingerprinted gestures of playing a game, using an app, or engaging with social media are displayed in a grid (Figure 9). This flattens, concretizes, and equalizes the time and effort that has gone into these otherwise fleeting acts. Whereas Roth employs the 2D nature of multi-touch through painting, *Gesture Puzzles* seeks to capture the depth of such mark making to make them into tangible objects.



Figure 9. *Angry Birds All Levels*. Ink on tracing paper. Evan Roth, 2012. [7]

Judith Donath expresses the significance of mediated touch in communication channels that depend upon screen-based devices.

"As human beings, we interact with one another through many modalities: gaze, touch, gesture, and speech. In our daily experience with laptops and desktops—e-mail checking, Web surfing, and game playing—touch and text are our main communication channels." [4]

As we use mobile devices to access information online, play games, and to interact socially, our physical gestures disappear with only the slight residue of fingerprints remaining. *Gesture Puzzles* would freeze these gestures in time, reinterpreting and reconstituting them as components for new boxes. They would then serve as physical reminders, ghosts of movements that would otherwise disappear.

Technique: Making the boxes

When the boxes were first assembled, they drew comparisons to mass produced antique puzzles. Belying this simplicity was an iterative and complex process, which is described here.

The sides of the boxes are cut in uniform patterns from 3mm thick sheets of wood and glass. These create flat interlocking sections that are possible because the patterns contain complementary dovetail joints, allowing the various segments to fit together. The profiles are drawn using CAD in multiple versions. After being cut, in order to be fit together, they are heated to 575 degrees centigrade, and then poured into by molten glass at 1260 degrees centigrade. Once experimentation with fusing glass began, further versions had to be made to improve annealing of the boxes (slowly cooling them to relieve destructive tensions within the glass) and to accommodate new designs. This experimentation generated the substantial amount of disposable wood and glass components mentioned earlier.

The original *Puzzle Boxes* had annealing problems. These arose because the height of the protruding glass tabs was too extreme; the overlapping tabs would not anneal properly or would crack. To minimize this problem, dovetail joints, common in woodworking, were applied to glass cutting. By doing this, overlapping joints became practically flush with each other. This improved their annealing prospects.

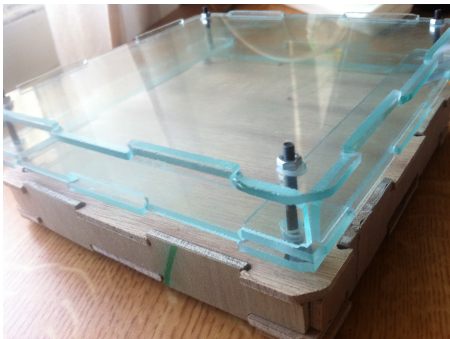


Figure 10. Waterjet cut dovetail joints in glass and wood. Hursty, 2014.

From a tooling perspective, cutting dovetails at the perimeter of the glass was a quicker and less fragile technique than poking holes, which had been done in previous versions. The reason these design decisions led to the *Gesture Puzzles* was that with so much material being cut to develop an ideal shape, their underlying sheets of backing plywood and scrap glass result in an equal amount of matching components. Because the sheets of wood and glass are the same size, they are interchangeable and can be swapped to make hybrid glass and wood boxes. These boxes resembled sphere and maze games such as *Labrynth* and *The Busy Bee*.

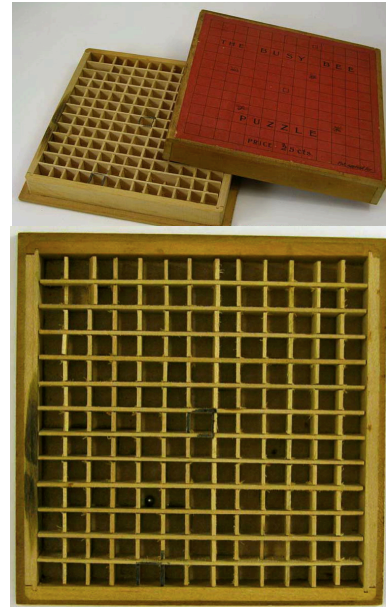


Figure 11. *The Busy Bee*, sphere in maze route finding puzzle, late 19th century. The Puzzle Museum. [2]

Wooden games traditionally would have been cut by hand, band saw, or router. Due to the fact that glass can only be cut in certain ways without shattering, the glass and wood shapes used in *Gesture Puzzles* are cut with high-pressure waterjet. This type of cutting, in terms of detail, provides results similar to laser cutting. This level of detail, from an ancient technological perspective was achieved by Chinese jade carvers who used abrasive powder on thin bronze wire bow saws to carve intricate patterns.

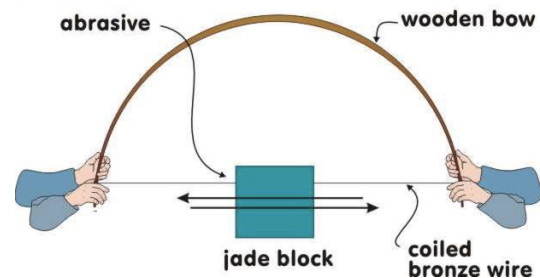


Figure 12. Chinese bow saw used for ornamental jade cutting.

Though the glass boxes were originally intended as one-time use molds for pressing molten glass, they have been used in different ways throughout the series.

A Duel in the Air: teleoperation

Maneuvering the puzzle boxes as a gestural fluid motion game also took inspiration from glass's molten properties. Hot glass practitioners must constantly maneuver glass to balance it "on-center" like a gyroscope. This maneuvering can be compared to dexterity puzzles like *Sky Pirates*,

where a biplane pilot, or his marble proxy, must avoid falling into holes fired by a piratic dirigible.

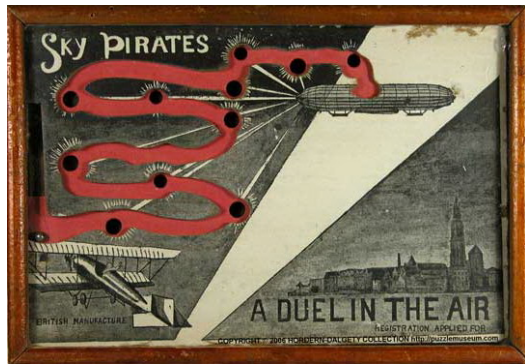


Figure 13. *Sky Pirates*, sphere in pitfall maze dexterity puzzle, 1910-1918. The Puzzle Museum. [2]

Hot glass has a time limit and can only be worked for short periods. In the course of playing *Sky Pirates*, a mistake can be reset. With one-time use glass molds, however, once a mistake is made and the glass fuses together, the process is irreversible. To reflect the reality that hot glass cannot be directly manipulated by hand, but rather through intermediate tools, it was decided that the boxes should be toggled remotely through electronics. The *Sky Pirates* slogan, *A DUEL IN THE AIR*, resonates with teleoperation, which uses invisible communication to maneuver something from across a room or removed to a different location entirely.

The feedback loop between human and machine sought by *Gesture Puzzles* points to a cyclical conversation of touch and materiality. This is reflected in an analog sense in dexterity puzzles such as *The Busy Bee* game (Figure 13), in which a player was tasked to move a ball around a maze, the route and pathways of which they could not clearly see. This draws a comparison to the underlying, hidden nature of programming code that directs and manages our interactions with electronic devices. Sitting beneath the surface of our gestures and communications sits a labyrinth, an obfuscated language that controls us in ways of which we are only superficially aware.

Conclusion

This paper describes the creative development of the first *Gesture Puzzles* prototype. Process and content have been linked from the original objective of making an artwork from press-molded glass to incorporating that project's residue into the *Gesture Puzzles*. This ethos of reuse inspired the current work's content without losing the series' original pressed glass focus.

Though the assembled boxes were no longer used for pressing glass, a metaphor for molten glass evolved that used the trope of antique maze games. This was intended to elicit a comparison to the formal theme of the work; abstracting touch and movement into reflexive structures.

This research brings little-known glassworking processes in line with electronic art. Waterjet cutting and rapid manufacturing techniques resonate with electronic arts practice, which is versed in rapid prototyping and laser cutting, but less so with cutting and melting glass. One benefit of an exchange between glass and electronic art is that the same CAD files can be used in both laser cutting and in the comparatively obscure practice of waterjet cut glass.

While it is understood that analog materials have physical limitations, digital formats are expected to have unlimited potential to do what we ask of them. Analog limitations of glass include specific ways of how, and at what temperatures it can be fit together. Limits of digital interfaces include the requirements of programming code to perform pre-determined actions in precise ways. Comparing analog and digital materiality through this interdisciplinary artwork problematizes the expectation of ultimate efficiency in digital formats with questions of interface and intuition.

This crossover was seen in *Gesture Puzzles* in the following examples. Teleoperation parallels the enforced distance and intermediate tools that must be used when working with glass. It also removes the hand of a player from obscuring the glass box, allowing light to be projected through the object. *Gesture Puzzles* offers an open-ended maze, with numerous exit doors, that are not intended to restrain, but to open a framework for digitally transforming physical gestures into tangible glass objects. While glassworking is an ancient technique, its use here demonstrates to the field of electronic art that new, potentially relevant glass techniques are still being discovered for creative use. This relevance also applies to how glass, with its properties of clarity, light and many other qualities, can be employed as a source of content by electronic artists.

For future *Gesture Puzzles* iterations, further comparison will be forged between teleoperating a machine and mediated social relationships. Transforming actions between digital and physical, sometimes over long distances, could be compared to interacting with other people, both on and offline. These different social modes can be evaluated as they are communicated through touch and iterative object.

The shape of the box forms could also evolve to a point in which the functionality of the maze breaks down completely as visual and physical complexity grows. Instead of composing a maze, the components can be used to build other sculptural forms. Whatever new forms result with this platform, the focus on remote control and the absence of tactile and vestibular (balance) feedback remain relevant for continued development. As teleoperation allows more tasks to be performed remotely, an emphasis on preserving a sense of tactility and sculptural resonance will remain.

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