ABSTRACT

This paper describes the latest progress of the design platform Digital Impressionism (DI), created by staff and students in the Information Experience Design programme at the Royal College of Art in London. DI aims to bridge human creative thinking with machine computation, under the theoretical method/concept of oxymoron tectonic. Oxymoron tectonic describes the process under which hybrid materiality, that is the materiality created between the digital and the physical, takes form in human-machine creative interactions. The methodology intends to employ multimaterial 3D printers in combination with data manipulation (a process that gives data physical substance), point-clouds, and the influence of intangible environmental data (like sound and wind) to model physical forms by interfacing digital and physical making. In DI, modeling is a hybrid set of actions that take place at the boundary of the physical and digital. Through this interactive platform, design is experienced as a complex, hybrid process, which we call a digital tectonic: forms are constructed via a creative feedback loop of human engagement with nonhuman agents to form a creative network of sustainable and interactive design and fabrication. By developing a mutual understanding of design, machines and humans work together in the process of design and making.
INTRODUCTION
The making of a work of art—poiesis in Greek—is a process in which the embodied relationship between humans and objects is facilitated by machines that mould materials. The act of modeling is a set of creative actions, called design, which humans activate to give shape to physical objects. In such a process, the knowledge of material properties, fabrication techniques, and machine capabilities are pivotal; the poiesis of design is, indeed, an interwoven process, which is informed in real time by the actors that take part in it, and results in the object.

Since design began adopting computational techniques, the relationship among humans, machines, and materials has changed. The physicality of modeling gets simulated in digital space, since to model means to execute commands or manipulate graphic controls created by lines of code. The direct relationship between human creativity and materials is lost; the “informed” act of modeling, given by the material’s physical constraints, is replaced by the human’s perceived intuition or memory of material physical properties (Titmarsh 2006). The switch from physical contact to mediated manipulation, however, enables designers an extra degree of freedom. As the physical environment is simulated, CAD software does not force the human mind to think through the constraints of physical reality, as normally happens during any fabrication stage. In such a constraint-free environment, digital poiesis grants new forms, which nonetheless would be complex to design by any human brain alone (Hatzelis 2006).

It follows that computers enhance design with a new set of automated skills, like the understanding of large datasets. Computers understand large numbers in fragments of time; they can array them in lines of code. When forms are acknowledged as fields and matrices (Allen 1999), complex and nonlinear geometry enters the practice of design and architecture, which results in shapes “born digital.” The granularity of data transforms forms and materials in vectorial flows of substance directed by code; hence a new kind of material sensation that is delivered by the aesthetic quality of the represented object emerges. This code-driven tectonic has integrated new digital material qualities and feedback with design, from the language of machinic procedures. This feedback makes design a procedural set of actions that coordinate process through continuously returned values (Ferrarello, Pecirno, and Spanou 2015).

CONTEXT AND METHODOLOGY
The Materiality of the Hybrid
The emergence of digital tools in design has proceeded in phase with the digitalization of the physical realm. The ubiquitous presence of technology in the form of interfaces has helped to sync the physical with the digital world; sensors transform physical

2 Digital Materiality. Matter created in ZBrush from a 3D scanned cotton fabric.
3 Oxymoron Perceptions. The shift of materiality of a 3D scanned Bialetti metal coffee machine in the digital real.
information into digital data. The resulting granular understanding of the physical and digital is nonetheless our filter for interpreting our surroundings. If physical objects are the entities we employ to reify the physical world (Žižek 1997), data are the matter by which we reify the digital, and increasingly the physical as well.

At first, the digital world looked at physical metaphors (skeumorphisms) in order to enable human familiarity; for instance the Save icon and the Windows operating system (Gwilt, 2006). However, we are currently witnessing an inversion: we Google physical things, we hashtag topics, we photograph objects as if digital renderings. In other words, the iconography of the digital domain no longer relies on our understanding of the physical world. We live in the world of the hybrid (Ferrarello 2014); images, ubiquitous sensors, and interfaces transmit data to and from the virtual to the extent that our mind dwells in both domains considered as whole.

Digital Material Behavior
The element that most clearly distinguishes the digital from the physical is the human body, due to its capacity to acknowledge surroundings via senses that transform perceptions into tangible experiences (Karana 2015; Malafouris 2013). Although vision plays a primary role, humans use many senses simultaneously, which helps construct our physical reality by assigning unfamiliar intangible entities physical materiality. In such a process, the physical relationship the human body has with its surroundings is pivotal (Ferrarello 2016).

In the digital space of CAD software, two kinds of events happen: on one hand, our traditional understanding of the physical environment is simulated; on the other hand, there is the freedom of being out of the physical environment, where paradoxical association of physical actions can take place—Boolean operations for instance. To model in a gravity- and physics-free environment engages designers with new formal approaches, which can push creativity and imagination beyond physical possibilities.

In the digital environment, physical materials lose their physical properties. Materials become hybrids for the sake of modeling operations (Titmarsh 2006). ZBrush software, for instance, enables “painting” different materials (from wood to gold) onto the same digital mesh, retaining a hyperrealistic visual quality of the chosen material. Indeed, 3D scanned objects keep their material aesthetic quality when imported in the digital space. However, at the granular level, such materiality is lost. Objects are clouds of 3D points connected by meshes. When physical materiality is digitized, it is subject to digital rules, although resembling its physical appearance. In ZBrush, a 3D scanned apple doesn’t behave as a physical one; an apple.obj file can be modeled as if clay, while preserving the aesthetic of the physical apple.

But more recently, the freedom of digital modeling has been challenged with digital fabrication machines, like 3D printers, that demand specific rules in order to assign digital objects to physical matter. Such rules direct the modeling process, but do not act as feedback, in which return values become part of the design.
There is not yet a mutual and interactive communication in terms of design thinking and design process.

The Oxymoron as Methodology
DI follows the concept of the oxymoron as methodology. In literature, the oxymoron is a paradox resulting from the juxtaposition of two elements that appear to be in contradiction. Here, a 3D scanned apple that becomes smooth as clay through the process of digital modeling generates an oxymoron materiality, which is a hybrid composite constructed from the interaction of the digital and physical (Ferrarello 2016). The oxymoron re-establishes communication between humans and materials via the interactive collaboration between human and machines. The oxymoron enables the assemblage of physical paradoxes to generate forms. This oxymoron materiality juxtaposes paradoxical physical properties—read as voxels (3D pixels) in digital computation to create composites. The oxymoron emerges from the understanding machines have of materials, juxtaposed with the human sensory expectation of it. Humans understand an apple because of the physical memory of touching it, while computers read it as a meshed cloud of 3D points with texture mapped onto it.

RESULTS
Under the guide of the oxymoron, DI has been tested through various investigations undertaken by IED students.

Interactive Clay
With William Fairbrother, we investigated the concept of hybrid materiality using a pressure sensor, embedded in a piece of clay, connected to Blender 3D software via an Arduino microcontroller. When the human hand moulds the clay, a digital cube displayed in Blender reacts accordingly. The human input is then stored as Python variables in Blender, with the intention of transmitting it back to the physical clay as vertical force via an actuator. The intention is to explore the computer’s understanding of human touch by using physical modeling materials as interface (Ferrarello and Fairbrother 2015). The problem faced in this experiment is how to translate the physical behavior of clay to the digital one.

Designing with the Instagram API and “Booleaning” Pointclouds
Ker Siang Yeo used the Instagram API to model shapes using RGB colors. Through a hashtag, he collected Instagram posts of Battersea Park in London. He then created a pointcloud from the RGB data extracted from the images through GMic software, which use RGB as xyz coordinates. The pointcloud was then imported into MeshLab to create a mesh. This experiment uses a pointcloud as “sharable” tool for digital modeling. The problem we are facing next is how to control the projection of the RGB data to extract a clean pointcloud.

Ker Siang used a similar methodology to model an apple from image-based models and 3D scanned objects. Using Boolean difference, the pointcloud extracted from the RGB and a 3D scanned apple. This experiment focused on the quality of digital
mater (Ferrarello 2014) as modeling information. This case shows a better way to use the RBG pointcloud for modeling purposes.

**Modeling with Voxels**

Suramya Kedia experiments with modeling processes that employ voxels as material placeholders. She uses the variation of sound to time to aggregate forms. Her intention is to understand how properties can pass from material to material via boundaries. By employing VSpace software, she creates an abstract environment based on material properties interactions (boundaries), which confront behavior that triggers formal aggregation out of the input information. In her experiment, Kedia used sound and time as starting information. She modulated the concentration of sound in relation to time, which created different kinds of formal aggregation. By reversing the design approach, which seeks forms before material performance, she uses data flow as a medium of formal material aggregation that shapes a new kind of physical/digital tectonic.

**CONCLUSION**

Creativity is the human faculty that drives innovation for its capability to adapt, reroute, and challenge surrounding conditions. Digital fabrication machines have helped to bridge digital design with the physical world. Under the guide of the oxymoron, DI intends to constitute an ecosystem in which humans and machines equally participate in a dialectic creative design cycle. By bringing together the procedure of digital design—i.e., variables and nested arrays—and the constraints of physical material properties, this paper described a series of examples that tackle the topic through different aspects.

The challenge this paper proposes goes beyond the mere use of machines. The paper draws a possible route for the profession of the architect/designer; as artificial intelligence improves the capacity to learn, DI proposes to construct a common territory where both can operate by challenging each other’s skills. The result is a design language that enables creative dialogue, communication, and interaction between humans and machines. DI pursues a system where collaboration between humans-machines-humans triggers innovation (Geels 2005). Data help to create a loop in this collaboration by linking the physical to the digital environment. The next step is to make complexity—data, pointcloud, voxels, multimaterial 3D printers—a looping information that fosters sustainability in design and manufacturing.

By treating data as matter, DI augments human senses in data modeling techniques; data are no longer stored in databases but treated as the matter of the everyday. DI is a platform that sees design as a body/mind experience of our surroundings, and that leverages human senses and machinic processes to construct forms through an oxymoron tectonic. The process of digital modeling and fabrication becomes a looping sequence of dynamic actions where designers and machines remodel the environment by taking into account the complexity of digital and physical information.
ACKNOWLEDGEMENTS

Thanks to Information Experience Design (IED) and Kevin Walker for giving the project the space to operate. Thanks to William Fairbrother for the help with the Interactive Clay experiment. Thanks to IED students Ker Siang Yao (Designing with Instagram and Booleaning with Pointclouds) and Suramya Kedia (Modeling with Voxel).

REFERENCES


IMAGE CREDITS

Figures 1, 3–4: © Ferrarello, 2016
Figure 2: © Ferrarello, 2013
Figures 5–7: © Ferrarello, 2015
Figures 8, 12: © Yeo, 2016
Figures 9–10: © Kedia, 2016

Laura Ferrarello is an architect, designer and researcher. She currently teaches at the Royal College of Art in London and looks at the interaction between digital/physical reality through design processes capable of enhancing human senses through machine interaction. Laura received a PhD in Architectural Design at IUAV University of Venice (2010).