Shaping the form of sound through hybrid materiality

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Abstract

We describe a digital design process utilising real-time data in 3D modeling and 3D printing. Digital Impressionism is a platform explores new material possibilities, by modelling not only objects and environments but invisible forces that act upon them. Using a 3D pointcloud as a medium, we describe a project run with our students in our programme incorporating real-time audio data to manipulate 3D forms, resulting in new static and dynamic forms with what we call a hybrid materiality. We introduce the project, discuss related work, describe our methodology and results, then discuss the implications and next steps.

Introduction

For most of us, the digital is part of our everyday reality, and the architecture of the real-world environments we inhabit has, for example, been transformed by digital data. Since coding has been introduced to 3D design, physical objects are understood as matrices of points. The resulting parametric architectural forms have come under criticism for their ‘born digital’ appearance, and a critical “New Aesthetic” of digital forms invading the physical world is both celebrated and derided in art and popular culture.

Meanwhile, digital data pervades our cities, our homes, our hands and heads, and we must broaden architecture to encompass the physical and electronic [1]. ‘Smart’ objects, buildings and cities themselves become computers with and within which we have become data, and the physical has become a neighborhood within the virtual world. Thus we perceive reality as a hybrid domain of the digital and the physical, conveyed by data.

However, both physical and digital reality have a material basis, with their own physical properties. We regard data indeed as another type of building material, which takes form and substance between digital and physical reality, and the research described in this paper explores an inverse flow of information – the use of real-world environmental data to affect, and infect, digital forms.

Process is a sequence of actions, which create *tectonics*, i.e. the architecture of materiality. We aim to combine human creativity with natural entropic systems in 3D digital design processes. Digital Impressionism is a hybrid, experimental modelling platform developed by the lead author, with a responsive and interactive tectonic design process combining real-time information, such as ambient light or temperature, with the flexibility of existing 3D digital modelling. In this paper we specifically describe experiments using real-time audio as an input to shape physical forms in digital space.

Related work

In existing 3D modelling software, parameters can be adjusted through scripting or in real time via common input devices such as mouse, keyboard or stylus; in both cases the human needs to communicate in the computer's language, whether through code or a graphical interface. The artist needs first to envision an object mentally or in some other form first before encoding it in 3D software in the language of the machine. In software like Ecotect, static environmental data are used in 3D modeling for example by specifying the weather in relation to a geographical location, to create infographics that describe various environmental parameters. However, there is no real time interaction between the environment and 3D modeling.

Photogrammetry and image-based modelling techniques similarly rely on static 2D images of existing real-world objects and spaces, and these techniques have progressed to such a degree that smartphone apps can now generate 3D models of real-world objects via on-board or cloud-based processing. Meanwhile, technical advances, miniaturisation and falling costs have resulted in a variety of DIY and off-the-shelf sensors and scanners able to capture fine-grained depth data and 3D point clouds and meshes, using lasers, ultrasound and infrared.

Our programme launched in 2012 with the aim to integrate information with experience, merging static and dynamic real-world data with digital tools and processes, from a critical perspective within communication design. For example, we utilise digital data in a sculptural process to create physical artefacts, systems and experiences [2], and have used the Kinect to track people in mixed reality environments [3]. We advocate a move from the real to the surreal [4]. Maintaining a critical perspective means deconstructing and subverting computational processes by reverse-engineering them and applying them back to the real world [5].

Digital ImpressionIsm

The Digital Impressionism project began in 2015 with the aims to return the artist's hand back to 3D modeling, and to integrate the design process with a continuous flow of live data to inform the creation of form, by focusing on materials and the tectonic process of making. Investigations began with existing tools such as 123D Catch software and the Structure Sensor 3D scanner, and moved into a process of recording active data from spaces and objects, not simply capturing static properties, by adapting existing open-source hardware and software into a platform for experimentation.

Digital Impressionism allows the formation of hybrid materials, using the pointcloud as a medium and language, which can represent real or digital data. Human perception of materiality drives this process, as it conveys the perception of physical materiality to the digital realm. This approach has been described as a kind of "entropic collaboration" between human and machine [6].

The existing literature around 3D modelling and printing revolves around the concept of the voxel, a 3D pixel with its own formal and material properties, which can be combined with others into various polygonal shapes. Real-time 3D data is conceived as clouds of points in space. Digital Impressionism similarly utilises interaction and assemblage of units, but under human creative guidance. Our approach then considers materials in terms of elemental units, and regards process as an algorithm that engages human perception in the act of making. As an interface between physical and digital, a human-guided process allows the investigation of new possible territories for design, art and moving image.

Digital Impressionism is thus a flexible approach allowing wide applicability, covering building or engineering simulations on the practical side, to sculptural forms on the artistic side. Our relation with humans and machines is an oxymoron, juxtaposing the contradictory processes of flattening versus depth [7]. We relate this to the world of objects through matter at a molecular or granular level, investigating how we sense our surroundings through materiality – materials are the substance of our memory and objects are the framework of our everyday dwelling.

Methodology

Initial work in the project [8] began with the use of a Microsoft Kinect depth camera to scan an existing real-world object (a vase), importing the resulting pointcloud into 3D modelling program Rhino via its algorithmic editing plug-in Grasshopper. Real-time data on ambient lighting conditions was incorporated, and models were then imported into ZBrush for further human sculpting, texturing and colouring, before 3D printing and spray painting the resulting transformed vase as a new, hybrid object.

We found that Grasshopper does not deal with real-time 3D pointcloud data very well in order to create a mesh; this is like reconstructing a puzzle from many individual pieces, and in Grasshopper required substantial manual input for mesh construction and repair. We thus switched to Processing for greater flexibility and control over using a wide range of imported and real-time data. As an initial dataset, the previously scanned vase was used. Various types of real-time data were considered, and we decided to use audio as a simple input, since Processing could easily take audio data coming a microphone; for this the Minim library was used to import the audio into Processing.

This phase of work took place over three months, involving five MA students and one MPhil student, all from different backgrounds, to experiment with the system. Using the OpenKinect library to import pointcloud data using the Kinect, Processing was used to generate 3D objects via the OpenGL graphics library, which were then exported in .OBJ format, along with a .CSV file of 3D locations, which was then imported into CloudCompare software to be turned into a mesh for 3D printing. We had help from Juan Pablo de la Vega, a recent graduate in interactive media, who helped write the code to interface Kinect data with real-time audio; the programming was then taken forward by our students.

The Kinect was initially pointed at the space of our lab, but this resulted in complex patterns; these were useful as 2D output or for more abstract representations, but for the most part, simpler shapes were desired, so most students pointed the Kinect at an object of their choice. The process was kept open as a way of thinking through making. Figure 1 shows a diagram drawn by one of our students, which represents the process.

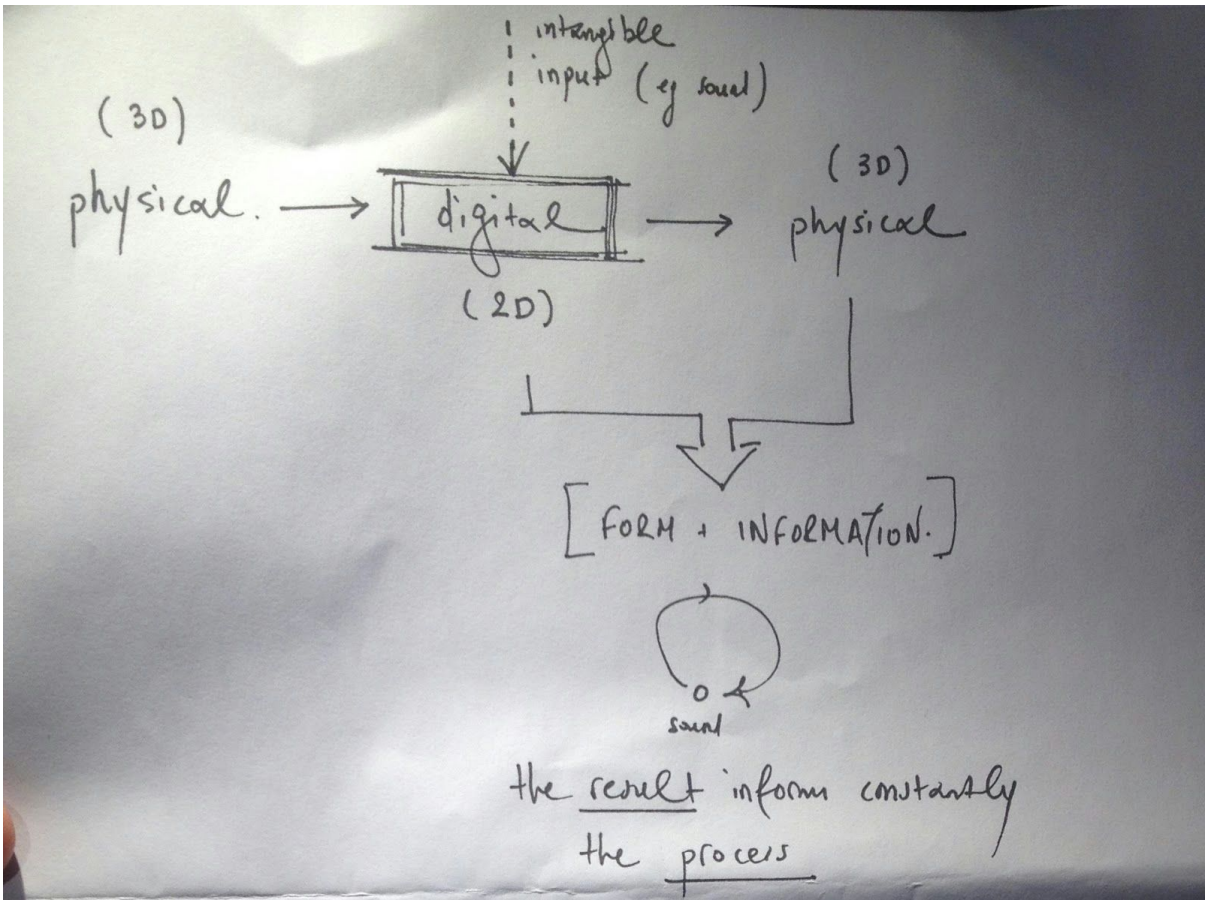

Figure 1: Diagram by first-year MA student Virna Koutla of the hybrid tectonic process in the experiments carried out.

Results

First-year MA student Danila Luppino worked only with the pointcloud data of the scanned vase. Figure 2 shows this pointcloud with individual voxels each rendered as a sphere. She then manipulated the scale and position of the spheres to re-assemble them into a new form. “I tried to build an object out of an object,” she said. She describes the hybrid form as “compact but transparent.”

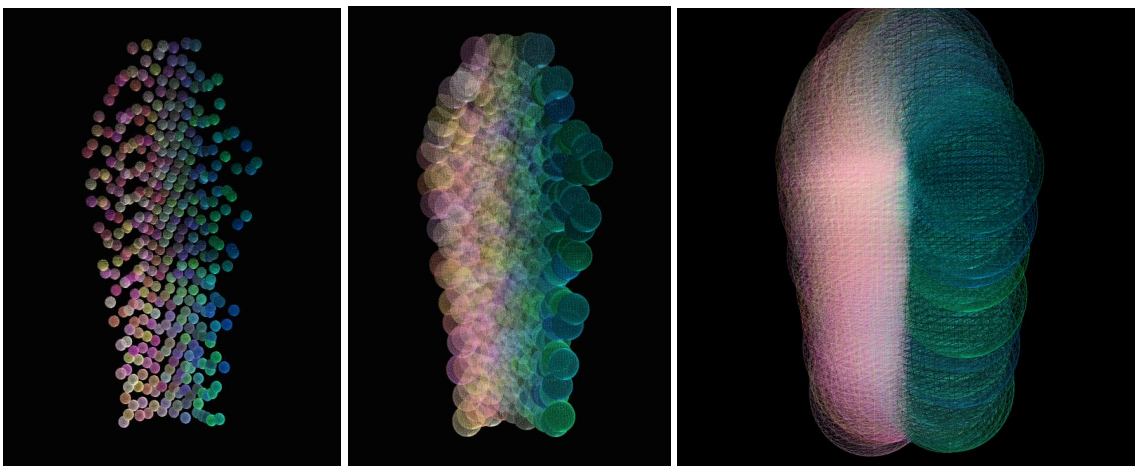

Figure 2: Manipulations of a scanned vase by Danila Luppino.

Second-year MA student Joanne Harik took the opposite approach. Beginning with the pointcloud data of the vase, she imported the sound of breaking glass into Processing and applied this to the vase. The

result was a sonic shattering of the form, mirroring the real-world phenomenon of sound waves shattering glass, but in a surreal, impossible way only possible within the digital world, in which the vase is rendered in individual triangles, intended to allude to sharp fragments of real shattered glass, yet each perfect in its own form. She displayed the result as a printed flipbook of images, shown in Figure 3.

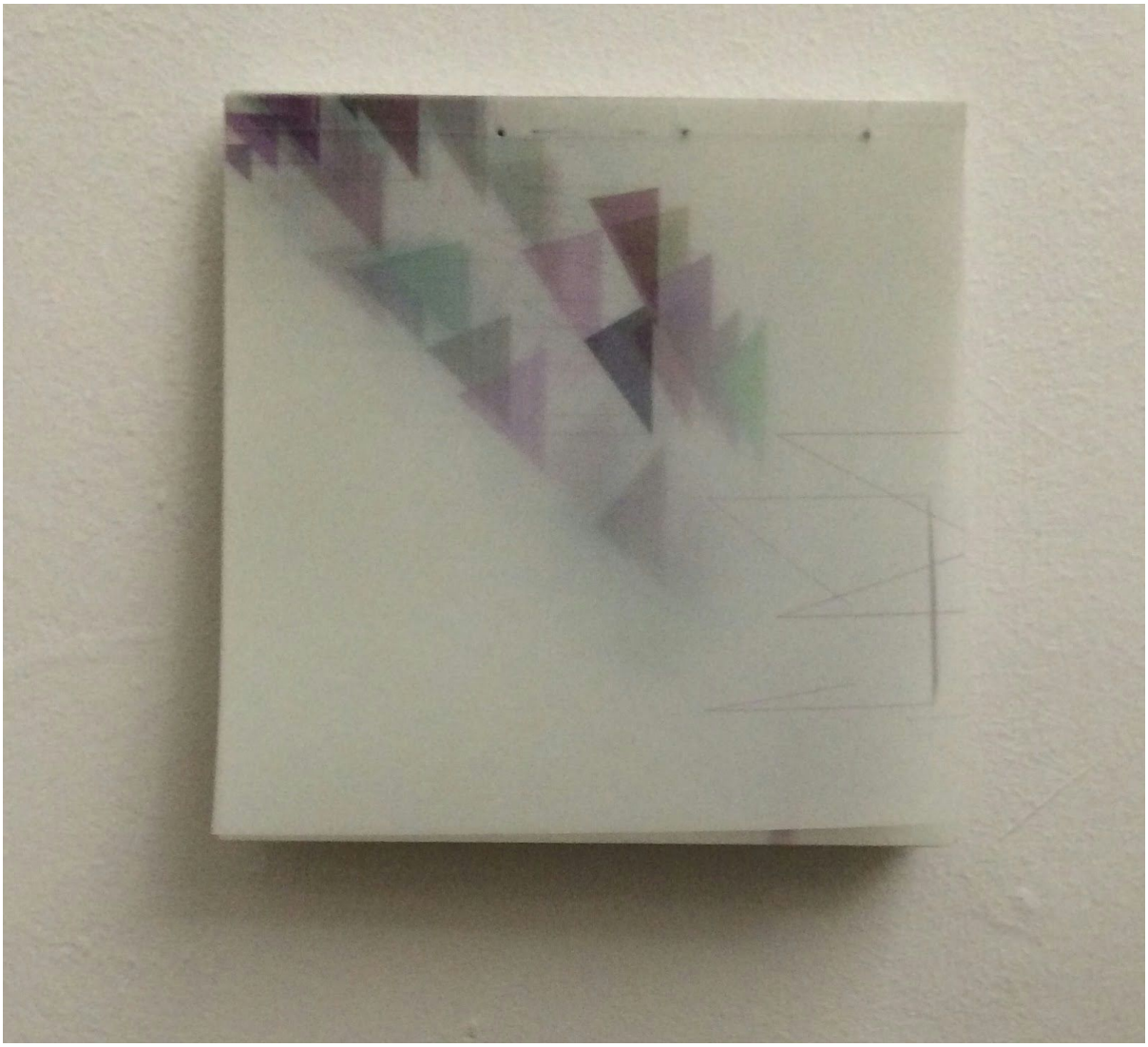

Figure 3: Flipbook showing the sonic shattering of a vase by Joanne Harik.

First-year MA student Virna Koutla began with the pointcloud of the scanned vase, but quickly shifted to working with sound input only, experimenting with staccato, percussive sounds versus sustained vocal sounds, then manipulating the resulting waveforms, shown in Figure 4. She became interested in the lag time between the sound input and the visual rendering on the screen; exported still images became fragments of time. “You cannot always perceive the world like a mirror,” she said, “capturing every detail at the speed of human motion.” Assembled into a simple GIF animation, the fragments then become not moving image but images of moving sound. (The animation can be seen at http://bit.ly/1ZF5XUc.)

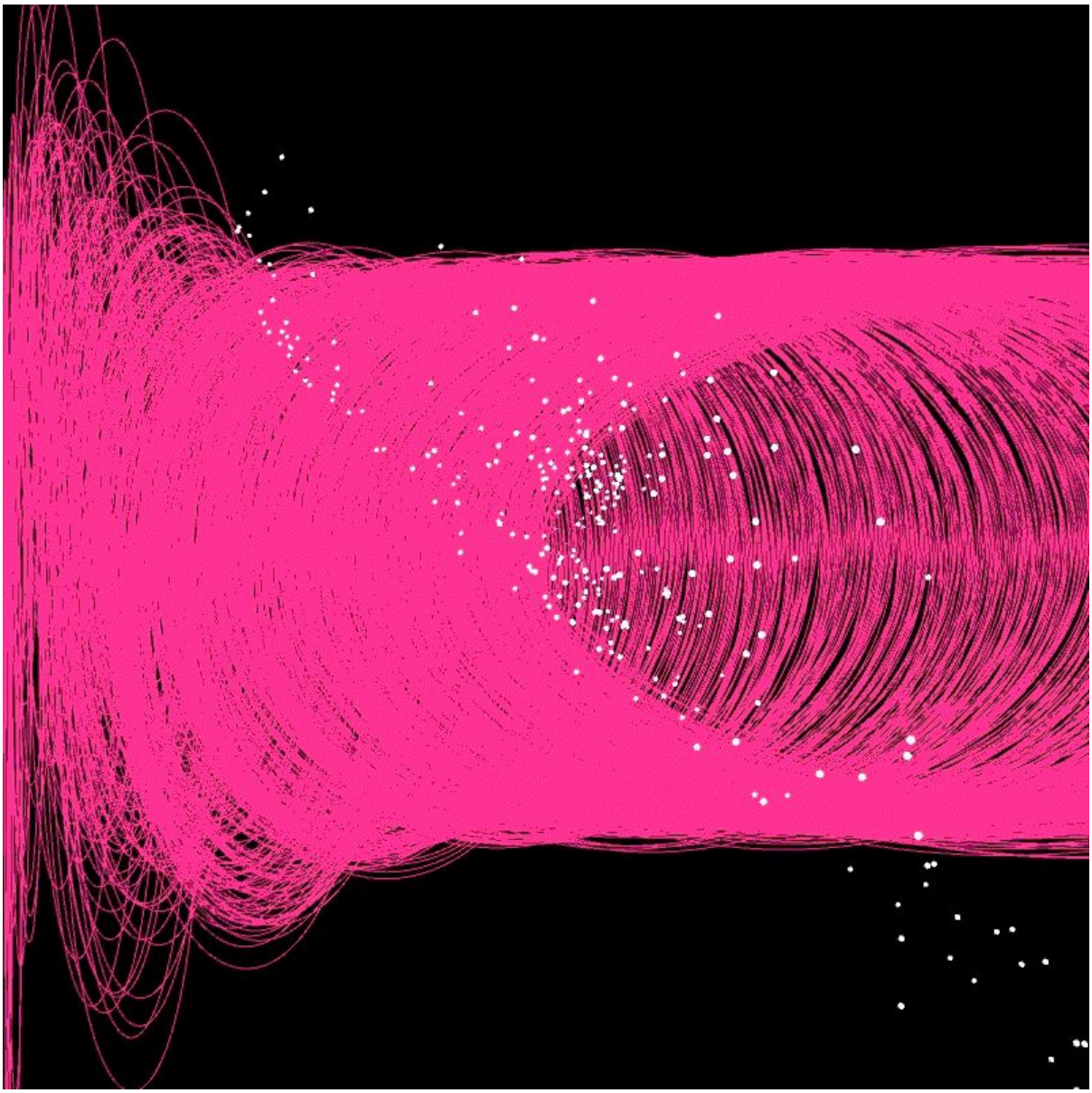

Figure 4: Animation of audio waveform images by Virna Koutla.

First-year MA student Francisco Norris first worked with the scanned vase data; Figure 5 shows the vase exploded into a series of polygonal voxels. For simplicity he used a single frequency generated by a simple oscillator – the pink lines in Figure 5 represent the audio waveform.

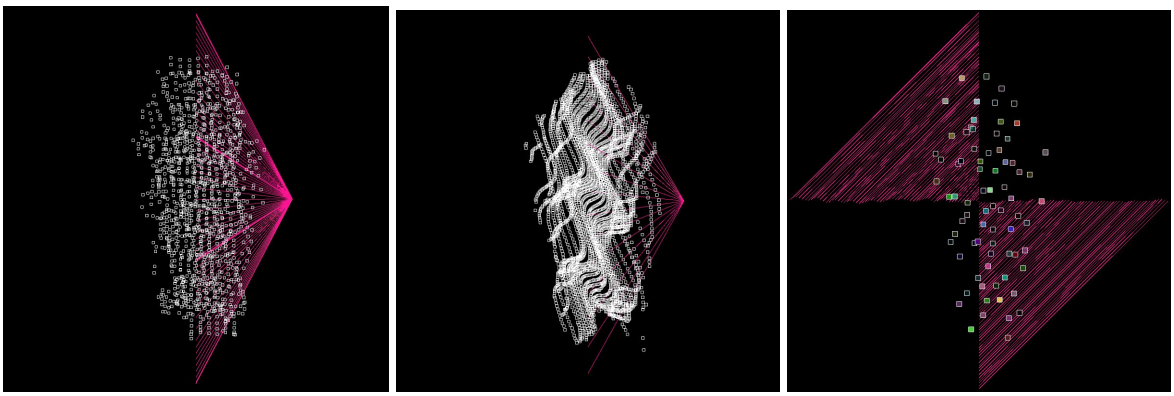

Figure 5: Vase manipulations using single-frequency audio input, by Francisco Norris.

Francisco then scanned a banana as an additional object dataset, as it had a simple shape and flat colour. He then printed a version of the banana distorted by the audio data, shown in Figure 6.

Figure 6: 3D printed banana distorted by sound waves, by Francisco Norris.

First-year MA student Ker Siang Yeo took a more narrative approach. “For me the tools were already there and thus the input (idea) is the most crucial aspect,” he said. Considering the vase as a vessel, and referring to nature, he thought of nests and birds, landing on the idea of a hummingbird, and thinking specifically of the sound it makes. He located the sound of a hummingbird building a nest and applied it to the vase pointcloud. “The wings’ lightness and movement, while nest-building,” he said, “is utilised as an implement to sculpt a virtual vase, facilitating making in our nature to encompass towards making in the virtual.” The low-frequency soundwaves can be seen in pink in Figure 7, distorting the form of the vase which is rendered as a series of spheres in 3D space.

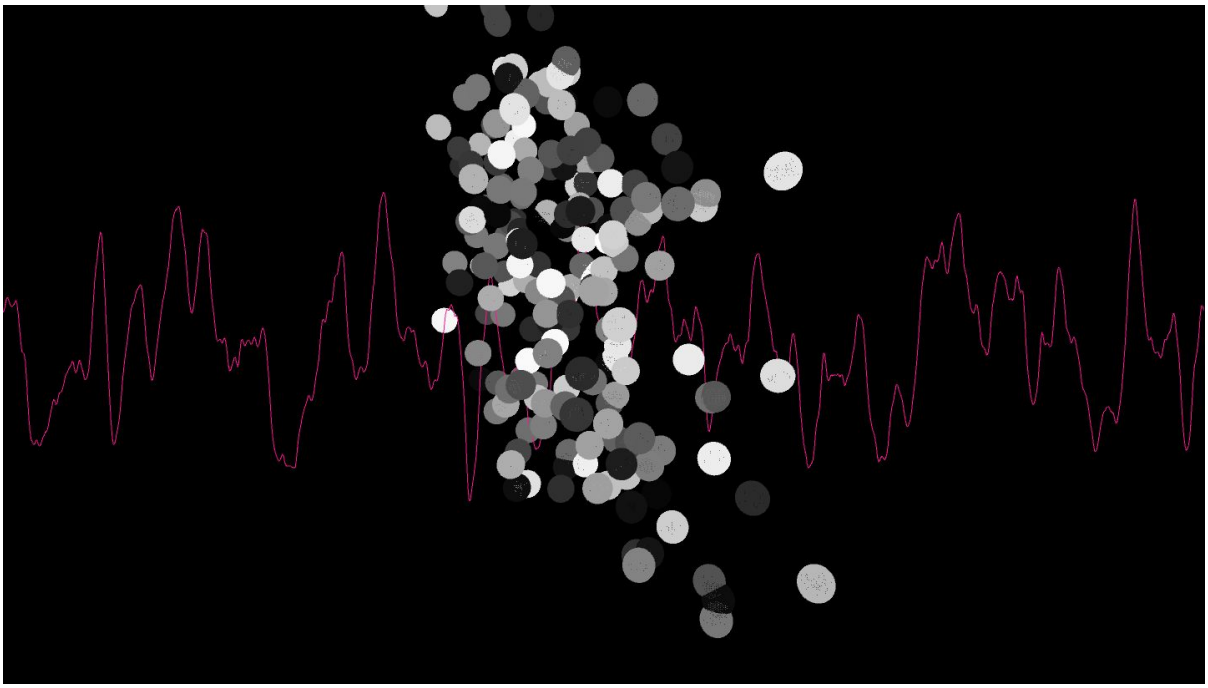

Figure 7: Vase distorted by the sound of a hummingbird by Ker Siang Yeo.

MPhil student Caroline Yan Zheng is researching tangibility and interactivity in relation to human emotions, coming from a background in fashion. In this project she experimented with giving perceivable qualities to emotions. She first set the Kinect to record the position and movements of her own body, then introduced recorded sounds of human emotions – laughing, hailing, quarreling, whispering and crying – to observe how the various frequencies of each sound shifted the points representing her body in different directions. A screenshot is shown in Figure 8.

Figure 8: Pointcloud model of Caroline Yan Zheng captured by Kinect and distorted by the sound of sighing.

While this resulted in an interesting doubling of her bodily form in the pointcloud captured by the Kinect, the different emotional sounds did not exhibit sufficient variation, and the captured image was too complex in this initial setting, containing irrelevant environmental details. She thus decided to focus on a simple form – a balloon, a common representation of human happiness. She then sang into the microphone a simple vocal scale, resulting in a clearer pattern of distortion of the form. She selected one of these for 3D printing, the model being shown in Figure 9.

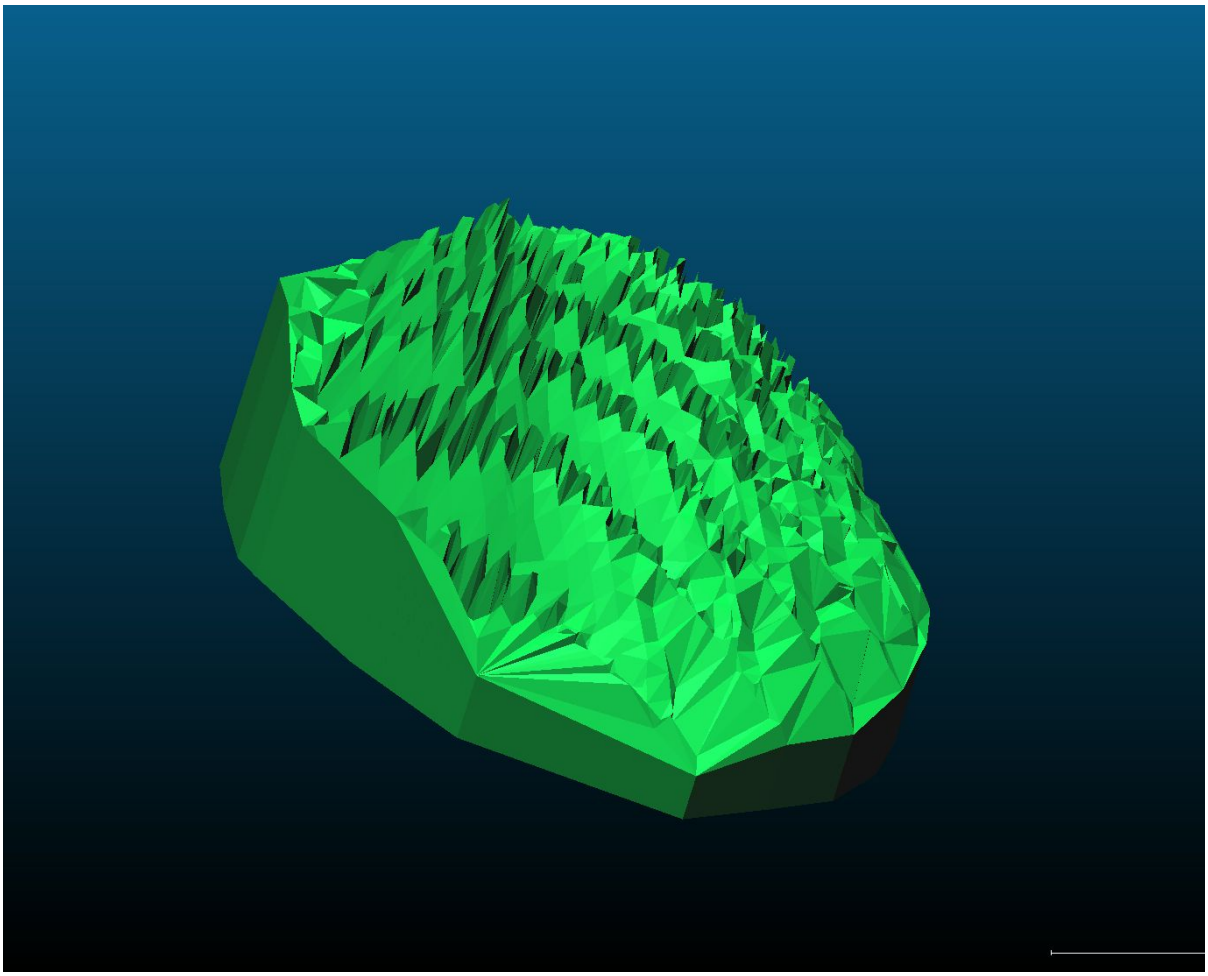

Figure 9: 3D model of a portion of a balloon distorted by singing, by Caroline Yan Zheng.

Discussion

This was a brief, initial investigation into hybrid digital-physical forms, with several limitations. Processing is not a comprehensive 3D modelling program, on its own capable only of displaying simple 3D primitives and pointclouds without extensive coding – something we wanted to avoid in this project. The open-source Kinect and audio libraries were helpful in this regard, but while Processing enabled flexibility of data streams and output types, any models to be 3D printed still needed to be turned into meshes and cleaned up in another program.

The Kinect, with a pair of low-resolution infrared depth cameras, also results in messy pointcloud data; this can be controlled for to a certain degree by capturing in a minimal environment away from walls and other objects. We controlled for the complexity of captured pointclouds by switching from scanning whole spaces to simple objects in order to evaluate visible results from isolated parameters.

Similarly, audio data can be complex. Minim and other software libraries can separate incoming audio into discrete frequencies, but again in order to obtain usable results, we found it easiest to resort to simple frequencies such as the hum of a hummingbird's wings or the singing human voice. When linked to narrative or emotional content, these pointed to interesting directions for further research, going beyond simple experiments with form and abstract audio. In particular, linking emotion to tangibility highlights identity and subjectivity, reminding us that how we relate to objects informs how we make meanings in personal, social and physical contexts [9]. This also reminds us that human qualities such as emotions are tracked by large corporations who use treat us as sources of data input and experimental subjects.

Looking at other possible inputs, we have also experimented with tangible forms, using sensors embedded in clay [6], building on work done in MIT's Tangible Media Group [10]. We have also experimented with inflated-air actuators, in collaboration with the Tangible Media Group and linked to Ishii et al's [11] concept of 'radical atoms' (see http://www.inflating-curiosity.com).

Next steps

The project has ample scope for expansion in many different directions. Purely in relation to form, for example, Francisco, one of the MA students with a background in sound, said, "There's a lot of room for maybe getting to a physical representation of objects in space – for example re-creating the shattering of the vase, then printing that." This was explored by Joanne, another student, and further by William Fairbrother, a recent graduate of our programme (http://www.williamfairbrother.co.uk/Le-Vase-Fragmente).

Danila, with a cinematography background, would like to make a sound sculpture: "It would be digital, but sound would create the physical part," she said. She would like to create a form that then generates its own sound. "It would be moving image but without narrative, coming alive through sound." Similarly, Ker Siang imagines a live feed of a hummingbird making its nest: "Over time, a collection of hummingbird vases can grow and have many variations. Therefore the impression of vase will be a result of not just sound, but also time, space and community." Such a project could extend to other natural phenomena. Coming back to the human, Caroline, the MPhil student in this project, envisions tracking emotion over time and then reflecting or embodying them in jewellery or fashion.

The outputs of this project indeed need not remain static. We envision the processes described herein to create not objects but tools. Maintaining focus on moving image, we have discussed 3D modeling a camera, evoking the disappearing desire to understand how things work and how to make one's own tools. We draw inspiration from the early Silicon Valley spirit of hacking, deconstructing and constructing our own machines; the difference now is that we can now draw on and collaborate with existing digital tools and artificial intelligence. We are thus looking at new multi-material 3D printers and 3D bio-printers. With its own physical and material properties, the voxel can be assembled with others to create forms, and can also be composite in terms of intelligent behaviour; their physical manifestations might include sensors or be made of smart materials. The new horizon opened by multi-material 3D printers leads to a true hybrid materiality, as physical and digital properties can meet in the form of composites.

Summary

By understanding materials (both digital and physical) at their molecular level, we aim to create a platform that allows infinite variations and applications. But we are artists and designers, not engineers or scientists. Digital Impressionism is not intended to be an app, designed to make 3D modelling easy. It incorporates traditional artistic methods with a critical perspective, hacking current machines, algorithms and data in order to improve our collective knowledge, in the spirit of early hackers [12][13]. A key aspect of what makes us human is the ability to make. Our reality, and our perception of reality, is becoming flattened by the glass of the screen; like a brick thrown through a window, the human re-introduction of depth and form could wake us up to the possibilities that lie beyond the screen. The process we have described in this paper thus moves from physical to digital to physical.

Digital Impressionism takes its name and inspiration from artists from more than a century ago. Claude Monet, for example, pushed the traditional boundary of the representation of the real by means of a new technique. J.M.W. Turner after him pushed the threshold even further, combining environment (landscape, seascape, sky) and emotion into visual narratives. The look, the sound, the feeling of a stormy sea, for example, was rendered into something physical and static yet dynamic and evocative. With new and ever-evolving tools, we hope to carry on this spirit in a performative exchange between human, machine, environment and object.

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