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Post Human Craft: A Humble Attempt to Reorient Makers to the Inevitable

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Nearing the end of the second decade of the twenty-first century many craftspeople and makers are waking up to the inevitable reality that our next human evolution may not be the same, that this time it could be different. Klaus Schwab, Founder and Executive Chairman of the World Economic Forum refers to what we are beginning to experience as the Fourth Industrial Revolution (Schwab 2017, 01). Schwab and his colleagues believe that this revolution could be much more powerful and will occur in a shorter period than the preceding industrial and digital revolutions. This revolution will cause a profound change in how we practice, labour and orient ourselves in the world. Rapidly evolving technologies will proliferate the use of robotics and personalised robots (co-bots) that can sense our presence and safely work alongside us. Digital algorithms are already becoming more reliable predictors of complex questions in medicine and economics than their human counterparts. Therefore, the gap between what a computer can learn and solve and what a robot can do will quickly close in the craft traditions.

This article will engage in the discourse of posthumanism and cybernetics and how these debates relate to craft and making. Intentionally this work is not a proud manifesto of positions, strategies, and guidelines required for greatness. Alternatively, it is a humble attempt to reorient makers to the necessary discourse required to navigate the inevitable changes they will face in their disciplines. Thus, the article seeks to transfer posthumanist literary understanding to intellectually position craft in the Fourth Industrial Revolution.

#posthuman

#digital design

#craft

#digital fabrication

#cybernetics

Introduction

Before the Industrial Revolution, artisans practised their crafts framed by preindustrial traditions. Individual and collective human agency is inseparable from craft and the philosophical and ethical tradition of Humanism. The craftsperson is the “liberal subject” in the Humanist tradition and defined by exercising critical thinking to shape material into artefacts of desire. The Industrial Revolution interrupted preindustrial craft tradition with new economic velocity prioritising efficiency and marketability. Preindustrial craft knowledge was centralised into factories and along assembly lines. However, mechanisation aligned with the humanist tradition through collective human agency. With the advent of the digital and information age, craft traditions can now return to a decentralised method of making with new digital tools that can make almost anything from a desktop computer (Gershenfeild 2005). Regardless of the social and economic changes, craft persevered as a constant human endeavour. What appears to remain through all of these upheavals is the necessity that all craft and making is an embodied human activity.

Nearing the end of the second decade of the twenty-first century many craftspeople and makers are waking up to the reality that our next human evolution has the potential to challenge human agency. Klaus Schwab, Founder and Executive Chairman of the World Economic Forum, refers to what we are beginning to experience as the Fourth Industrial Revolution. Schwab and his colleagues believe this revolution could be much more powerful and occur in a shorter period than the preceding industrial and digital revolutions (Schwab 2016, 3-10). This revolution will change how we practise, labour, and orient ourselves in the world. Rapidly evolving technologies will proliferate the use of robotics and personalised robots, so-called *co-bots*, that can sense our presence and safely work alongside us. Digital algorithms are already becoming more reliable predictors of complicated questions in medicine and economics than their human counterparts. Therefore, the gap between what a computer can learn and what a robot can do will quickly close in on the craft traditions. It is easy to see how we may begin to ask what value a human-made object has outside the sentimental imperfections. We could begin to fall further from our connection with the material world and what artefacts mean to us as a society and begin to only understand them as a code or dataset to implement for production.

The conditions that are causing change are not simple or easily understood thus creating anxiety rooted in inaccurate perceptions. The major social changes of the past that upended craft and making never questioned our embodied skill and desire. This skill was legible to us as makers because our process drove input with outcomes dependent on our skill. Regardless of the tool, we provided the sole source of knowledge and skill, and it returned a product of our making — we practised and learned, not the tool. However, this is changing; our tools can now learn from us and continue to learn independently. The cycle of making is no longer only human input with an equivalent output, but rather a posthuman cycle of making whereby the tool has now entered the discourse of learning and making. Machine learning can trigger our anxiety that craft is doomed. Indeed, tools will learn, but our anxiety regarding their place in craft is misguided, as machines neither are, nor are expected to become, sentient. The position of a craftsperson will change because the historic duality between maker and material will become a broader networked digital ecosystem. Therefore, craft will soon face the challenge of an inevitable reorientation of tools and process. This work is a humble attempt at this reorientation through a discourse of evolving technologies and social changes that craft is already encountering. A brief case study will be provided to show a simple example of how the power of Artificial intelligence

(AI) can extend the impact of a single craftsperson. Concluding, the article will take on a few of the leading conversations around this topic but through a filter of craft and making with hopes that the remaining will inform a reorientation of craft discourse.

Situating Craft

Craft is typically defined as a skill practised to achieve consistent outcomes. One might think of a potter at the wheel consistently creating the same vessel to near perfection or a welder fusing steel that can achieve an expected shear load. Most agree that craft is achieved by practice and that it provides consistent, exceptional outcomes. The Encyclopaedia of Diderot & d'Alembert described craft as the;

> *name given to any profession that requires the use of the hands and is limited to a certain number of mechanical operations to produce the same piece of work, made over and over again* (Gendzier 2009).

Preceding organised industry, ancient peoples used utilitarian objects solely created by artisans. In the absence of industry, craftspeople played a defined role within society tending to a body of knowledge handed down through generations of masters, journeymen, and apprentices. The Industrial Revolution interrupted the relative stability of craft through mass-production machines and the division of labour. The cultural response was to preserve and protect the handcrafts, and this manifested in the political writings of Karl Marx, and the critical writings of John Ruskin and the Arts and Crafts movement (Ruskin 1867). These reactions were rooted in an appreciation for craft that differentiated it from industry. The duality of industry and craft set up opposing views of material culture. On one end, the view of craft was nostalgic and sought material links to a pre-industrial past; on the other was the view of modern efficiency defined by speed and egalitarian distribution of a product. It is true that many of the craft processes and artefacts share lineage with their pre-industrial precedents, but it is essential to understand that modern craft is not a result of the past. Modern craft is a manifestation of industrialisation itself, developing alongside industry, both benefiting from the other (Adamson 2013, xiii-xv). The opposition between viewpoints only reinforced the importance of both.

David Pye clarified the distinctions between craft and industry by identifying the craftsmanship of risk and the craftsmanship of certainty. The craftsmanship of risk is a process where the quality of the result is frequently at risk during the process of making and is dependent on the judgment and care exercised by the maker. The craftsmanship of certainty requires comprehensive planning of the process before manipulation of the materials with all variables predetermined and pre-tested to the greatest extent possible (Pye 1968, 20). These definitions still hold today in that they define the primary differences between industry and craft by highlighting industries' aversion to - and craft's requirement for – risk. Both the single craftsperson and the collective industrial process embodied human desire, exceptional skill, and knowledge.

Situating Digital Craft

The use of digital tools for communication, design, and fabrication to produce craft objects has profoundly influenced material culture. The most apparent influence is in the limitless possibilities for generating complex forms. The computer allows for unlimited possibilities and complexity not dependent on the material world. Digital modelling tools such as Rhinoceros and Grasshopper are acting in response to the demands of digital practice. Perhaps the most profound influence is the streamlining between digital design tools and digital fabrication tools. What is designed can now be readily and directly fabricated using digital technology. Practising digitally has created a process-based change to craft disciplines.

The Digital Revolution brought numerous remarkable and productive virtues, but it has also introduced some potentially inhibiting deficiencies. Most profound is the increased abstraction and tendency toward loss of human touch introduced with digital tools. Because electronic digital tools are ultimately based on numeric control, they require specialised knowledge of an abstract set of commands and symbols. Digital tools do not yet emphasise intuitive and physical interaction and response. They require constant precision and inhibit most rough estimation. Digital tools can create a world unto themselves, with a tendency for an operator to lose themselves in a self-referential world of simulation and required procedures divorced from representing reality or intuitive process. These tools tend to guide the craftsman, rather than the craftsman guiding the tools. Outcomes often resemble abstract mathematical models more than haptic experiences defined by a craftsman through real material and specific historical lineage and context (Stevens 2015, 9).

Although the premise is debated in academia and popular culture, this article identifies digital craft as the use of the digital and the hand in a productive negotiation, viewing craft as a process or activity rather than a category (Adamson 2013, xxiii). When viewing craft through the lens of processes, rather than categories such as pottery, weaving, and metalsmithing, the processes become complex with the loss of the binding traditions embedded in such disciplines. As early as the nineteenth century, craft was most commonly viewed through its material and disciplinary category. The material artefacts produced were guided by "conservative" links to a "traditional" past (Adamson 2013, xvii). This view of craft, fair or not, did provide the craftspeople a set of longstanding and generational knowledge, and more importantly, principles and limits to guide their work.

The word "craft" has evolved along with these changes. Now, disciplinary activities ranging from surgical procedures to brewing beer are self-categorising as craft. Richard Sennett describes Linux system programmers as "a community of craftsmen focused on achieving quality and doing good work" (Sennett 2009, 29). Preceding Sennett, Malcolm McCullough explored the idea of virtual and dematerialised craft asserting that "digital practices seem more akin to the traditional handicrafts, where a master continuously coaxes a material. This new work is increasingly continuous, visual, and productive of singular form, yet it has no material" (McCullough 1996, x). The pre-digital tactile shaping of material was viewed to have a parallel digital equal in computer clicks and bits. McCullough maintains that the act of craft can occur entirely virtually regardless of whether the work results in a physical artefact.

Craft evolved through incremental improvements while maintaining a connection to the past. However, the social, economic, and global change that upended many handcrafts occurred so quickly that we are recently beginning to understand the immense complexity and opportunities provided to a craftsperson engaged in the use of digital technology. Scott Marble observed that digital processes in design evolved into three distinct systems. The first is the replacement of formal geometry with mathematical algorithms. Prior to the virtualisation of geometry, craftspeople shaped material by hand. These shapes can now be mathematically defined, controlled and generated in unlimited quantities. Second, the designer has new control over organisational complexity allowing designs to have embedded data ranging from cost to weight, thereby extending the craftsperson's control over production. The third, and most significant for this study, is the development of digital fabrication (Deamer and Bernstein 2010, 39-43). This development now provides the link between McCullough's dematerialised craft, allowing for materialisation of digital media. Most significantly, this materialisation is controlled by the direct actions of the craftsperson. Marble, however, does not wade into the coming age of robotics and AI, likely to add additional making systems not imagined or understood. All the systems outlined have a clear demarcation between the human and tool and are positioned in the historised Humanist tradition. It is clear that these new systems will take the ideas of dematerialised craft and direct digital making for granted as a standard process of craft and will challenge the duality between human and machine.

Situating Humanism and Posthumanism

Since the inception of Humanism in the Renaissance, the philosophical perspective has evolved and bifurcated to include multiple realms of understanding. Humanism shaped civic life through liberal democratic principles and framed a path to a more reasoned life as an alternative to mystical and religious positions (Keeling and Lehman 2018). Architects in the post-war era began to revisit Humanist architecture that not only considered human proportions as paramount but situated the human as the primary receiver of the built environment. It is when humanism is framed as a body of literature and discourse that it provides insights into craft and making through its assignment of agency and autonomy to the human. The human action of craft and the embodied actions required in making align with the humanist literary discourse by attributing the conscious and intentional human subject as the dominant source of the agency most worthy of scholarly attention. Diane Keeling and Marguerite Lehman summarise literary humanisms' values to constitute a human being as follows:

1. Autonomous from nature given the intellectual facilities of the mind that control the body,
2. Uniquely capable of and motivated by speech and reason, and
3. An exceptional animal that is superior to other creatures.

Keeling and Lehman (2018) continue by reaffirming that humanist principles are infused in all Western philosophy and reinforce a nature and culture dualism where human culture is distinct from nature, a dualism that is also apparent in the act of craft. It is this duality that is in question in posthumanism discourse. The humanist assumption that we are liberal subjects of autonomy is rejected for the view that agency is distributed through an environment or network that the human participates in but does not intend to control. To illustrate, Keeling and Lehman summarise their contrasting points for what constitutes posthuman thought. Posthuman cognitive systems are:

1. Physically, chemically, and biologically enmeshed and dependent on the environment;
2. Moved to action through interactions that generate effects, habits, and reason; and,
3. In possession of no attribute that is uniquely human but is instead made up of a larger evolving ecosystem.

An environment and ecosystem defined in this discourse is related to a complex network or interconnected network, therefore not necessarily excluding an architectural environment or the ecosystems of the physical environment. As humans developed sophisticated systems of architecture to separate themselves from the physical environment and intellectual structures to stand apart from other terrestrials, humanist values reinforced what we observed in ourselves as superior enlightened beings. This historicised certainty was challenged however with new networks and new cybernetic environments of our own making.

Cybernetics and the Discourse of Posthumanism

At the close of the twentieth century, Katherine Hayles published *How We Became Posthuman (1999)*. Her publication searches for answers to the boundaries between human and machine and how we are evolving or devolving with technology. It probes the question of what makes us "human," and if we will continue to value the "liberal subject" or alienate it (ibid). The inclusion of this text is an epistemological transfer of domain that could be seen as invalid. Therefore, the validity for craft must expand to include the primary characteristics of inscription and incorporated knowledge. Indeed, the discourse of posthumanism preceding and following this publication is robust and divided into valuable philosophical positions. However, an account of these positions and their place within this discourse are outside the scope of this work. Therefore, the boundary provided by Hayles is just one of many possible frameworks to speculate on a multitude of scenarios whereby technology and the human are intertwined. This framework allows for discourse around what is essential to humanness and what is not. It allows this article to ask the question: *are we extending our abilities or are we devolving into information?*

Provided is an outline of a discursive understanding of cybernetics, or the science of communication and automatic control systems. These critical moments of understanding resulted from what is known as the Macy Conferences held between 1945 and 1954 and helped define the epistemological foundation of cybernetics. Hayles explains this in three plateaus of understanding:

The first model of cybernetics grew out of an understanding of the biological systems of homeostasis. The concept is founded on the idea that living organisms have the ability to maintain steady states regardless of environmental changes. Therefore, information was seen as a quantifiable choice in a feedback loop with the organism regardless of environmental conditions. The programmer feeds input data and the machine returns output in a binary loop.

Secondly, from dialogue and debate of the first model of thought came the understanding that cybernetics may also emulate the biological system of autopoiesis, or a self-encoded system that develops not by what it observes but how it is encoded to respond to its unique needs. The ideas presented the possibility that systems construct reality rather than observe it and that system components could work together to replicate themselves. By removing the observer, cybernetic information could be defined as an entity separate from material instantiation and could be "calculated as the same value regardless of the contexts in which it was embedded, which is to say, they divorced it from meaning" (ibid, 53-54). This isolation of information is in her view how information lost its body.

Thirdly, autopoiesis leads to a larger understanding of emergence. This is to say that the system has the ability to evolve on its own. This is seen in contemporary systems of augmented reality (AR), virtual reality (AR), and Artificial Intelligence (AI). Emergence uses the feedback loop of information understood by homeostasis but adds both an input and output of information, thus collecting, processing, and evolving independently (ibid, 10-11).

Hayles provides the following "suggestive," rather than a prescriptive list, of what the posthuman view is (Hayles 1999, 3):

1. The posthuman view privileges informational patterns over material instantiation, so that embodiment in a biological substrate is seen as an accident of history rather than an inevitability of life.
2. The posthuman view considers consciousness, regarded as the seat of human identity in the Western tradition long before Descartes thought he was a mind thinking, as an epiphenomenon, as an evolutionary upstart trying to claim that it is the whole show when actuality it is only a minor sideshow.
3. The posthuman view thinks of the body as the original prosthesis we all learn to manipulate so that extending or replacing the body with other prostheses becomes a continuation of the process that began before we were born.
4. The posthuman view configures the human being so that it can be seamlessly articulated with intelligent machines. In the posthuman, there are no essential differences or absolute demarcations between bodily existence and computer simulation, cybernetic mechanism and biosocial organism, robot technology and human goals.

Hayles divides human practice and knowledge into two dualities: first, an incorporating practice that is encoded into bodily memory by repeated performances until it is habitual. Opposed is inscribing practices that can be cognitively mapped and encoded (ibid, 199). Hayles continues by providing five distinguishing characteristics of knowledge gained through incorporative practices (ibid, 205):

1. Incorporated knowledge retains improvisational elements that make it contextual rather than abstract, and that keep it tied to the circumstances of its instantiation.
2. It is deeply sedimented into the body and is highly resistant to change.
3. It is incorporated knowledge that is partly screened from conscious view because it is habitual.
4. Because it is contextual, it is resistant to change and obscure to the cogitating mind. It has the power to define the boundaries within which conscious thought takes place.
5. When changes in incorporation practices take place, they are often linked with new technologies that affect how people use their bodies, and experience space and time.

Hayles continues to summarise by stating:

> *Formed by technology at the same time that it creates technology, embodiment mediates between technology and discourse by creating new experiential frameworks that serve as boundary markers for the creation of corresponding discursive systems. In the feedback loop between technological innovations and discursive practices, incorporation is a critical link (ibid).*

Testing Posthuman and AI Craft

To test how incorporated and inscribing knowledge can be engaged in posthuman craft, researchers conducted an experiment using a ceramic 3D printer modified to allow for digital (inscribed) and manual (incorporative) control (*Fig.*

1). The principle that guided the tool's design was to have distinct tasks relegated to the computer and the human hand to produce artefacts that an Artificial Intelligence (AI) database can learn and analyse. The choreography allows for consistent digital control of the x, y, and z-axis while also allowing for manual interruptions. An artefact created in this way differs from the digital model that generated the g-code that directs the movements of the printer (*Fig. 2*). By allowing improvisations, the research team was able to produce a multitude of artefacts from the source shape, a cylinder that served as the control object made without alterations by the operator (*Fig. 3*).

In describing the unique work of a craftsperson, historians and artisans relied on comparing unique artefacts to each other to define styles and traditions and more specifically a collection or a work by an artisan that occurs over a designated period. The research team completed a broad set of unique improvised prints that defined a collection for the AI to learn (*Fig. 4*). All improvised prints in the collection are unique hybridised digital and handmade artefacts that have a geometric relationship to the control cylinder. To measure these modifications, all of the artefacts printed and improvised by the operator were 3D scanned (*Fig. 5*). The re-digitisation of the prints provided a digital 3D model to scale that was compared to the control cylinder. The AI database then understood common deviations that were analysed. These improvised deviations built a morphological dataset that is unique to the operator who made the modifications and the output collection. The AI returned to the research team a large quantity of data that were used to reconstitute AI-improvised one-of-a-kind artefacts (*Fig. 6*). The new AI artefacts were then printed using a standard 3D printer. Thus, the craftsperson's tacit knowledge and tool dexterity was not degraded by AI but extended by a cybernetic ecosystem.

There is potential for artisans to teach AI the formal and morphological properties of a given collection. This then can be learned and replicated by the AI, allowing the craftsperson the freedom to move to the development of new and inventive collections that the AI can later be trained to produce. This new division of labour removes replication by the human hand and makes paramount the conscious mind required to create a new artefact. This case study demonstrates that AI was capable of learning how one human operator could improvise digitally fabricated objects and teach AI how to emulate their sensibilities. Most significantly, the objects created with AI are an extension of the human who originally made them. They are direct products of the craftsperson's hands and thus extend the productivity and economic impact of fluid improvisational making. AI allows higher productivity, but the human maker is essential in training. If done in partnership, this workflow allows the human craftsperson to extend their influence and impact while still maintaining the necessity of handmade artefacts in the age of AI.

A New Discourse for Craft

The duality set up by the inscriptive and incorporated knowledge is not seen as a path that must be selected but as a place for humans to fluidly reside. In a statement striking to any craftsperson, Hayles states:

> *The recursivities that entangle inscription with incorporation, the body with embodiment, invite us to see these polarities not as static concepts but as mutating surfaces that transform one another, much like the Mobius strip…. Starting from a model emphasising polarities, then, we have moved toward a vision of interactions both pleasurable and dangerous, creatively dynamic and explosively transformative.*
> (Hayles 1999, 220).

When discussing the future Hayles attempts to privilege materiality over information in the discussion of cybernetics by stating:

> *If my nightmare is a culture inhabited by posthumans who regard their bodies as fashion accessories rather than the ground of being, my dream is a version of the posthuman that embraces the possibilities of information technologies without being seduced by fantasies of unlimited power and disembodied immortality, that recognises and celebrates finitude as a condition of human being, and that understands human life is embedded in a material world of great complexity, one on which we depend for our continued survival* (Hayles 1999, 5).

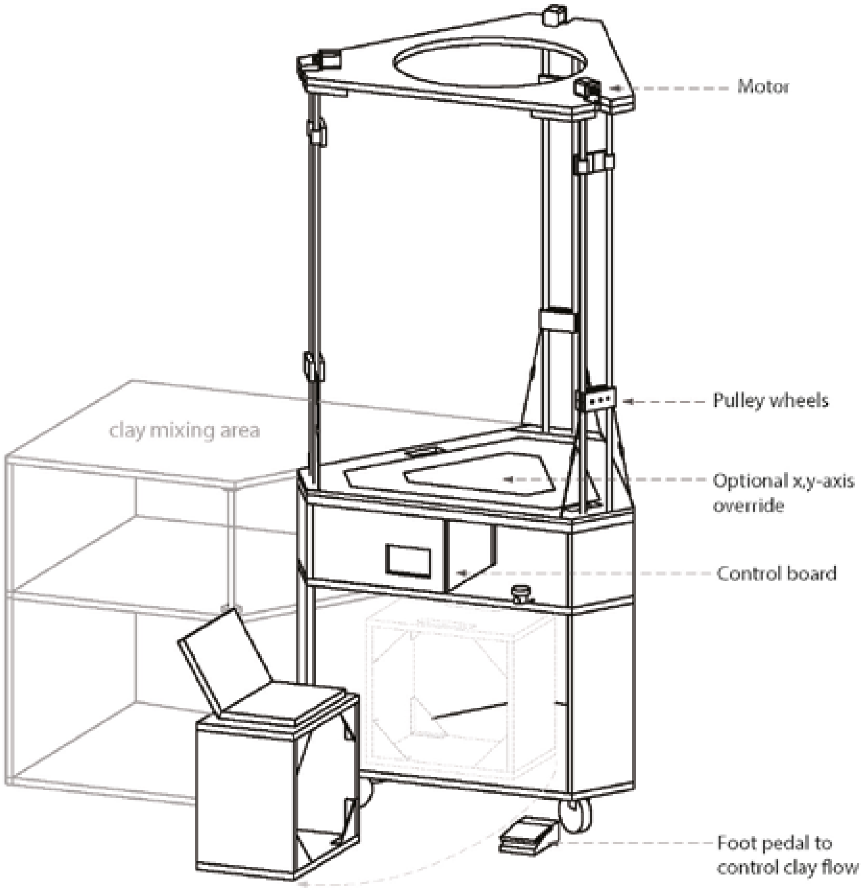
Hayles' contribution rests in the area of cybernetics and literature. However, her definitions and defining characteristics of inscription and incorporation practices fall within the epitome of craft reconciling the encoded variable alongside the improvisational human. The discourse surrounding the posthuman is still evolving since the publication of this text in 1999. Although engineers are no closer to developing a truly sentient machine the debate continues around what posthuman means and if it is a positive evolution or negative devolution. Questions about the validity of embodiment and materiality, as human form and action, are necessary for being human or whether intellect, knowledge, and experience can be fully *downloaded* to a machine, from cells to bits. Despite these intellectual debates, how these technologies will impact the economy, society, and craft, is still not understood. Given the rapid pace of their development, understanding may arrive only in hindsight.

The contemporary craftsperson must be aware of how new technological developments will impact social and economic systems. With the rise of AI and other disruptive technologies, both manufacturing and the service industry may no longer exist and therefore will not be outsourced to populations with low wage bases. Some reports indicate that up to 40% of current jobs may be eliminated over the next 30 years (Schwab 2016). As with many of the past economic and social upheavals these jobs will be replaced with new, but fewer high-skilled jobs. Of course, these are only economic speculations, but they carry with them an undeniable warning: our policymakers must engage in and understand technology so that they can lead their nations to a sustainable future. Developed economies like the United States and China are far from insulated from these changes. Many argue that given the significant infrastructural obligations of these nations their stability could unravel given the disruptive potential that AI and robotic automation may have.

What these questions provoke is a possible third path, one that is not purely a technological utopia of digital making that excludes the human and minimises labour, but one that uses technology to extend human creativity and human potential. It is the nature of capitalism and liberal democracy to maximise profits and minimise labour obligations so such a third proposal may seem idealistic and naïve. However, the leaders of our nations in the future may once again become vexed by even further social inequality. Marx identified the conditions of mass inequality in capitalism and predicted a revolution in industrialised nations where manufacturing degraded the worker and built wealth for the industrialists (Marx 2009, 7). Although his predictions did not come to pass, the principles identified in his concerns were the impetus for the rise of the Communist Party and the Soviet Union that had their origins in protecting the worker from mechanisation. Current populist movements in Western capitalist societies such as Brexit may be the first rumbles of the repercussions of the Fourth Industrial Revolution.

These possible reactions are occurring even before capitalism has been tested by the possibility that AI and robotic automation could supplant many workers into a new useless class (Harari 2017, 322).

This discourse is not nihilistic, nor does it dictate a bleak view of the future. In contrast, the debate probes ideas of what makes us human, more specifically, what makes us humans that are compelled to craft and make. Those engaged in studio-based practices that depend on traditional craft must be mindful of the inevitable disruptive technologies that this work recognises. The contemporary craftsperson must acknowledge what is to come and begin to understand how to position craft into a new networked system not entirely under their control. The example given in this article only shows one of an infinite number of possibilities of how craft can productively enter the Fourth Industrial Revolution without sacrificing human agency. The contemporary craftsperson now has the opportunity to choreograph human and machine to achieve artefacts not yet imagined.


Motor
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clay mixing area
Optional x,y-axis override
Control board
Foot pedal to control clay flow

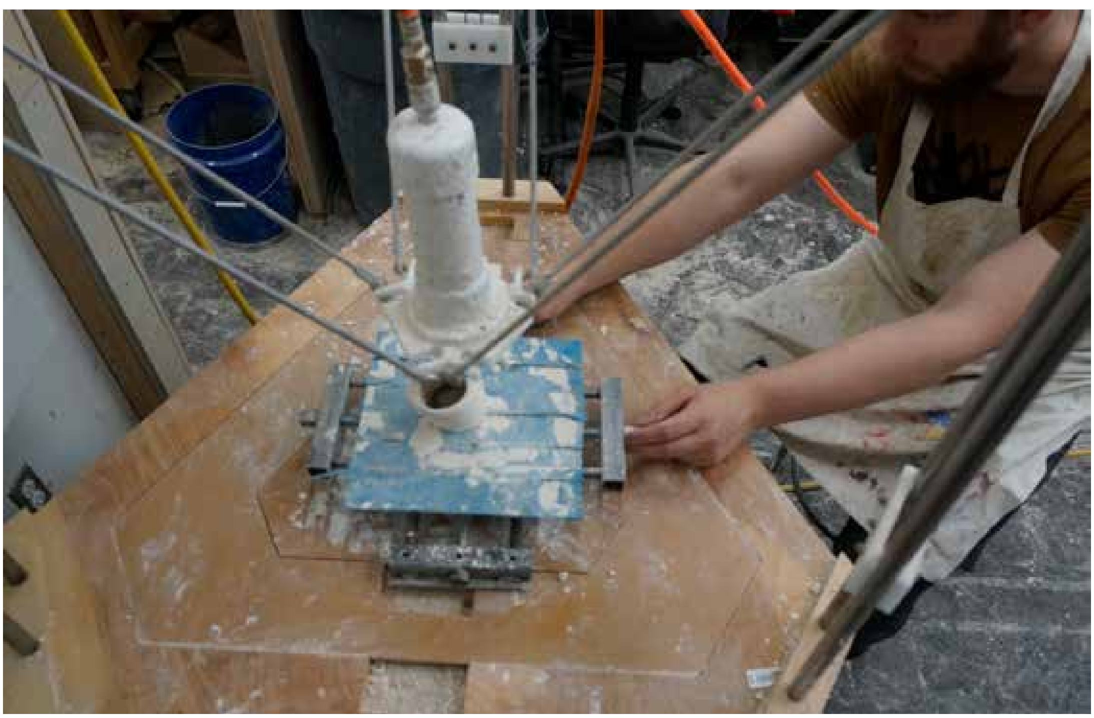

Figure 1 (top, opposite page): Custom 3D printer designed for craftsperson improvisations. Source: *author.*

Figure 2 (bottom, opposite page): Craftsperson using manual x, y-axis controls to improvise ceramic form. Source: *author.*

Figure 3 (top): Control artefact (left) compared to improved artefact (right). Source: *author.*

Figure 4 (bottom): Portion of the improvised collection of artefacts. Source: *author.*

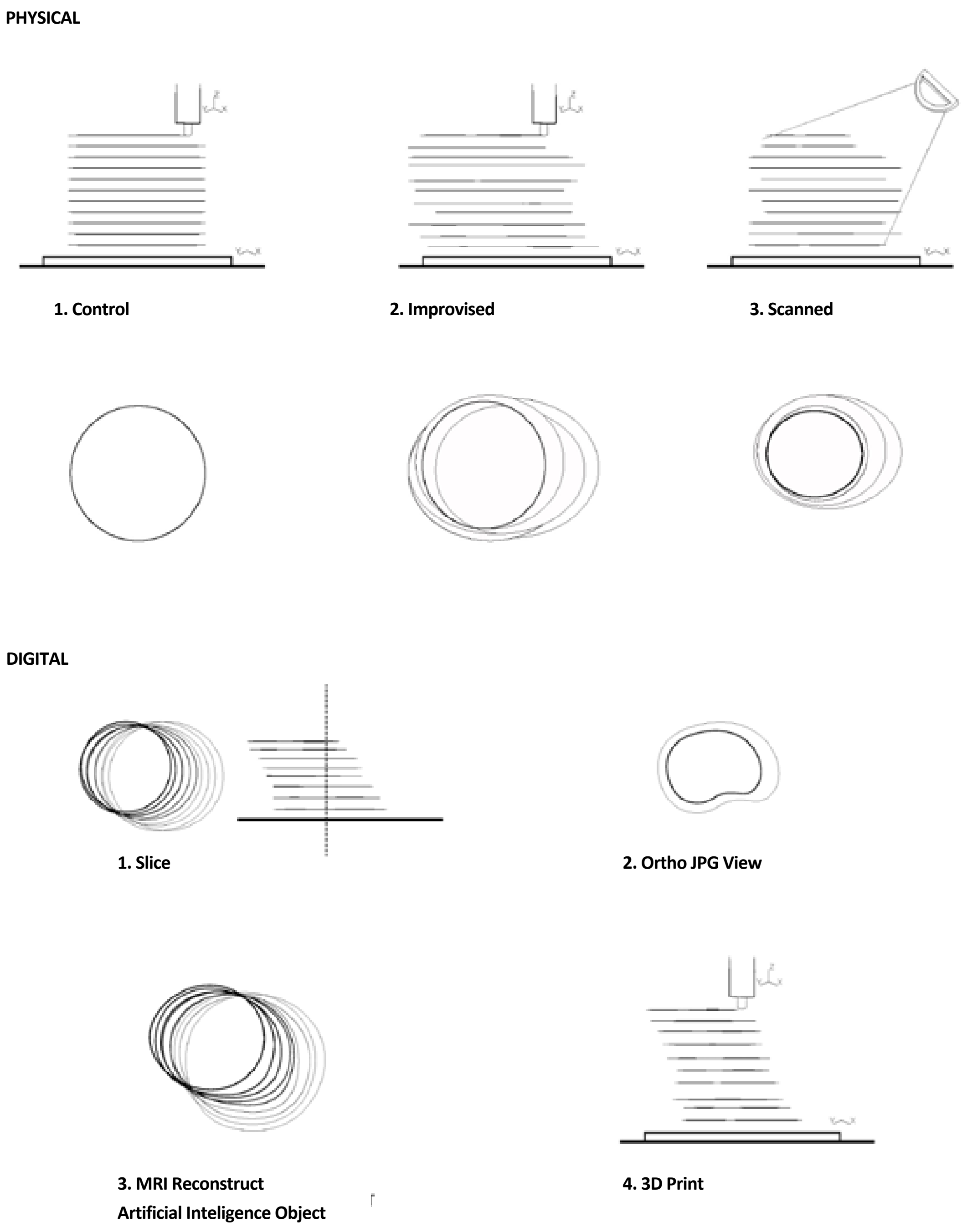

Figure 5 (page 162–163): 3D Scan in progress of improvised artefact. The pixelated image was captured during the scanning process. Though not in high visual resolution, the scan image includes the topological information vital to digitising a one of a kind, hybrid artefact. Source: *author.*

Figure 6 (top): Primary steps in the process to create AI artefacts. Source: *author.*

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Bio

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