# The Materiality of the Digital

Within new media literature, there appears to be considerable interest in conceiving of 'digital space' as a new realm, removed and free from the material plane. In an era of environmental, economic, and social concerns, the digital space plays host to a wide range of imagined techno-utopias. The incredible potentiality of the digital inspires and challenges engineers and theorists alike. This appeal is reinforced by its apparent simplicity – a realm of user-friendly interfaces, high level programming languages, and abstraction of complex data. Despite the explosion of popular and critical writing on the digital, there have been very few serious attempts to delve beneath the surface. Work addressing material concerns either deals with embodiment and interface, or is relegated to 'engineering'. Rarely if ever do philosophical theorists seriously attempt to unpack the digital, digging through the layers of abstraction and protocols to reveal possible connections between this digital space and the apparently more mundane materiality of our everyday existence. The aim of the present paper is to document some of the concerns that arise in such a process.

It is not the intention of this paper to discredit the idea of digital space. On the contrary, it is acknowledged that the concept is a flexible and powerful lens for critical analysis of many techno-social issues. Further, it provides a framework for scientific and industrial development. This paper intends to critique the concept of digital space as an ontological category, distinct from material reality. In stripping the digital of its ontological status, the validity of the digital as a field of study is not challenged. As a complex, interconnected region of material space, the digital remains extremely relevant as a site for social, technical and philosophical examination.

A number of key technological events have contributed to the development of the systems responsible for what we experience as digital space. Perhaps one of the first was the development of the Jacquard Loom in the early nineteenth century – a programmable weaving machine operated using primitive punch-cards (Delanda 1991, p.155). This was followed by Charles Babbage's plans for a general purpose 'Analytical Engine' (p.159), and later Alan Turing's descriptions of what has become known as the 'Universal Turing Machine' (p.129). While neither of these two devices were actually built by their inventors, they paved the way for the development of a range of programmable systems of increasing complexity.

In charting this development of technology, two significant changes are particularly apparent. Firstly, the components used to construct such machines began to shrink, due to the demands of building complex devices in limited physical space. These machines also came to rely heavily on electricity as a primary means of storing, moving and processing data. As a result, the state of individual machine components began to fall below the human perceptual threshold. Even with early valve technology, it was no longer possible to determine the state of a machine through direct observation. As Friedrich Kittler writes, data no longer existed "in perceivable time and space" (1995, para 1).

Secondly, unlike previous machinery, the descendents of Turing and Babbage's ideas shared the quality of 'programmability'. A single machine could perform multiple functions depending on the requirements of the user. What had been an accounting machine a moment ago (not unlike an abacus) was suddenly transformed into a game (similar perhaps to a chess set). Again, such changes occurred without any apparent alteration of the underlying mechanism.

These factors began to drive a wedge between the appreciation of digital systems as material technology, and the conception of them as invisible, changeable machines in a much more abstract sense. This split was exacerbated by networking technologies that physically separated the machine with which the user was engaged, from the machine where much of the processing activity actually occurred.

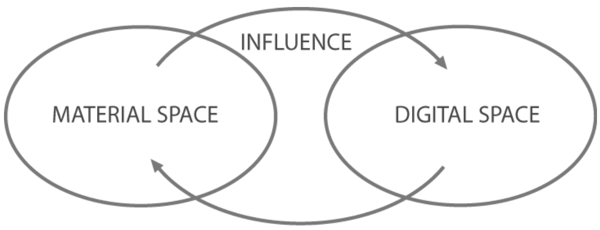
As a result of this growing schism, the notion of a 'digital space' emerged. Such a space was populated by digital data, being continually reshaped by digital processes. Interfaces acted as windows into this digital space, and through input devices users were able to shape regions of that space. As systems became increasingly complex – both in terms of integrated, multi-layered software and microscopic, flexible hardware – the digital space was further removed from the material space in which the user was situated. Beginning as a general notion most useful to software engineers, the concept of 'digital space' rapidly established itself through both academic and general usage. This acceptance was largely driven by the adoption of the Internet, hype surrounding virtual reality, and the fictionalisation of cyberspace. It is the resulting status of digital space as a discrete, immaterial region of reality that is addressed in this paper.

## Digital Space

In describing the emergence of digital space, many writers have seen it as “a new domain, a new space that simply did not exist before.” (Wertheim 1999, p.223). One of the most important features attributed to this new space is its immaterial nature. Michael Benedikt pictures the digital breaking away from “the ballast of materiality” (2000, p.31), creating a space that Benjamin Wooley populates with “purely abstract entities … independent of any particular physical embodiment, but real nonetheless” (1992, p.69). Similarly, Margaret Wertheim suggests that this digital space “is not made up of physical particles and forces, but of *bits* and *bytes*. These packets of data are the ontological foundation of cyberspace, the seeds from which the global phenomena ‘emerges’.” (1999, p.228, emphasis on original) In such an ontologically distinct space, it makes sense that “neither mechanistic, or relativistic, or quantum laws apply” (p.228). In this way, reality is divided into “a material realm described by science, and an immaterial realm that operates as a different plane of the real.” (p.229). Through this manoeuvre, science loses all claim to explaining the functioning of this digital space.

Such independence from the material is asserted politically by Perry Barlow on behalf of all inhabitants of this new digital space, when he declares the digital “naturally independent of the tyrannies [the Governments of the Industrial World] seek to impose” (1996, p.272). He goes further, claiming that these material institutions do not “possess any methods of enforcement we have true reason to fear” (p.272), partly because “the global conveyance of thought no longer requires [material governments’] factories to accomplish” (p.273). This may be news to those working on the assembly lines of IBM or Cisco Systems, or indeed in the cube-farms of Microsoft.

While other politically enmeshed writers disagree with this absolute removal from the influence of the material, many still see the digital as ontologically distinct. Paul Virilio describes digital space as “a ‘fractional’ dimension alongside the ‘whole’ dimensions of our customary milieu.” (1995, p.138) To support the creation of this external dimension, he extends the definition of reality, suggesting that ‘matter’, which previous to the advent of the digital was “considered in terms of mass and energy, [be] rounded off by the addition of the notion of information” (p.138). Constructed purely of information, the digital forms “a fractal dimension, not of space now, but of time” (p.145).




In positing two distinct spaces of reality – the material and the digital, it becomes necessary to understand the means by which these spaces interact and influence one another. Many of these researchers describe such interactions in only the broadest terms, acknowledging that “there are connections and resonances between these two spaces” (Wertheim 1999, p.229), or expressing concern over the “eroding boundaries between the real and the virtual” (Turkle 1996, p.10). Most theorising of the actual mechanisms of interaction has occurred within studies of digital aesthetics and interface design, rarely touching on ontological concerns.

A number of theorists have gone further, to acknowledge that there may not be such a defined division between the material and the digital. Despite asserting their separation, Wooley admits that "the hardware/software distinction does not work all that well when applied with any theoretical rigour." (1992, p.68)

William Mitchell integrates the two spaces further, announcing that the "trial separation of bits and atoms is now over. … the boundary between them is dissolving" (2003, p.3). In such a dissolution, "physical space and cyberspace [have] become locked in an intricate, mutually transforming embrace" (p.129).

Along somewhat similar lines, Kittler sees the digital as a growing network of material relations. As a result of technological change, "invisible, intangible, electromagnetically encoded information establishes new types of relationships among *physical* objects occurring in *physical* places" (1995, p.4, emphasis in original). As a consequence, data should be thought of as "something concrete, with definite spatial and temporal coordinates" (p.4).

Within the practice of software development, the relevance of the material is reinforced by suggestions that programmers "must be familiar with the physical tools for implementation – memories, processors and techniques for recording structure" (Stubbs & Webre 1987, p.37).

Even Wethheim softens her dualist stance, suggesting that the digital "is a technological by-product of physics", a space that "emerges from the interaction of its myriad interconnected components" (1999, p.229). However, even given this, she reinforces her belief that the digital is "not reducible to the physical laws that govern the chips and fibres from which it indubitably springs." (p.229)

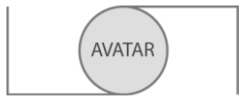
For Wertheim, the complexities of emergent behaviour form an impenetrable boundary between the material and the physical. Contrary to this, Manuel Delanda sees this space of emergent complexity as a vital site for study. Ontologically, Delanda proposes a material reality composed of a single 'matter-energy' (1997, p.21). The suggestion that the digital is based on the same fundamental substance as the material makes a strong case for a single spatiality. As Lefebvre asserts, the basis for invoking space is specifying what is deployed within that space; space is an "empty abstraction" without being grounded by constituent substance (1991, p.12). Within Delanda's worldview of a single ontological substance, by creating an apparent digital space, "computers have simply intensified the flow of knowledge, a flow which, like any other catalyst, still needs matter and energy flows to be effective." (1997, p.21).

Taking this 'monist' position, Delanda is drawing on Gilles Deleuze and Felix Guattari who describe a single "plane of consistency … abstract yet real" (1987, p.254). In such a space, complex regions like the digital "represent the different ways in which this single matter-energy expresses itself." (Delanda 1997, p.21). Given this grounding of digital activity in the material, the study of the digital becomes a study of the structuring of materiality, and the process by which this structuring occurs. Delanda suggests that it is important for such an examination of the genesis of structure to be conducted from the bottom up, beginning with simple underlying components (p.270).

Drawing on the same philosophical heritage as Delanda, Brian Massumi suggests that "there is only one world, one nature, and – below the quantum level of matter and beyond the synapses of our brains – one unified field" (1992, p.21). The structuring of this field is then a ceaseless division into a "multiplicity of singular events and composite materials" (p.21). Within such a framework, the relations between these events – some of which we perceive as digital, some as material – form the focus of research into digital space.

## The Avatar

To problematise the delineation between the material and the digital, it is useful to consider a process that crosses the material/digital threshold. The instance analysed here is the act of engaging with a digital avatar.

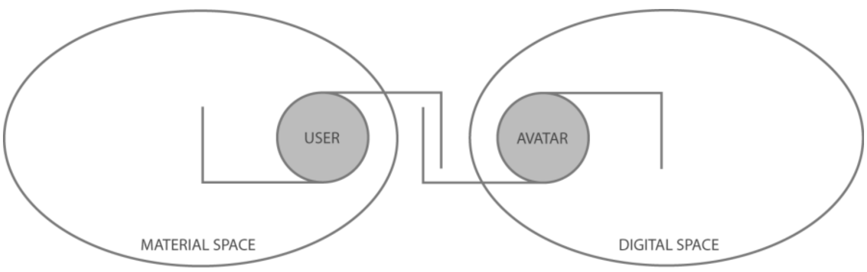



Existing in a range of digital environments, the avatar is “a prosthesis through which the master feels his or her way through a world he or she cannot physically enter” (Egginton 2003, p.11). The avatar is an embodiment in digital space that mediates the activity of the user in that space.

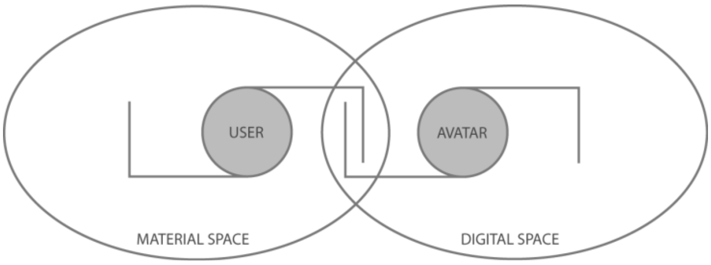
In unpacking the relations that we enter into with avatars, it is useful to employ the Deleuzian notion of ‘machines’. Any system of interacting components can be considered machinic, whether material or digital (Massumi 1992, p.192). The user of a computer is a machine, a ‘user machine’ – a complex biological system situated in material space. The ‘avatar machine’ is a digital machine, composed of data and processes.

While they have some degree of autonomous functionality, each machine also relies on other machines exterior to itself (Guattari, 1995, p.37), coupling with them and consequently entering into relations of flow and interruption (Deleuze & Guattari 1972, p.36).


Through these couplings and uncouplings, machines come to form articulated collections or ‘assemblages’. In this instance, the user engages with the avatar, and the ‘user/avatar assemblage’ is formed. Such an assemblage does not necessarily imply any direct bonding or interaction – many assemblages are constituted through the relation of fields of potential. (Guattari 1995, p.35)

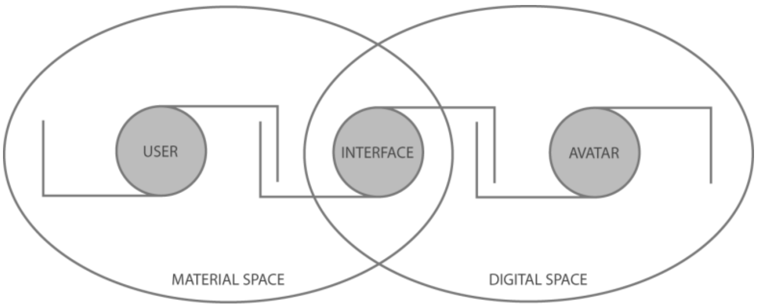



Importantly, these machines reside in separate “Universes of reference” (Guattari 1995, p.36); the user in the material, the avatar in the digital. And yet, an assemblage is formed. Relations are entered into. One means of explaining this connection is through ‘abstract machines’. Abstract machines are composed of pure structure, unlike the more ‘concrete’ machines discussed previously. Such abstract machines can be situated ‘transversally’ to the material and digital spaces of machinic existence. So placed, these abstract machines are “capable of relating all the heterogenous levels that they traverse.” (p.35)




While such a solution maintains a degree of discreteness to the material and digital spaces, it relies on a set of ‘abstract’ machines that can only be described in non-specific terms. An alternative way of understanding the relation between the user and avatar is to acknowledge the permeability of both spaces, and posit the existence of some form of ‘liminal’ space at the material/digital threshold.

Machines and assemblages operate at various levels of abstraction. What may appear to be a machine at one scale (such as the user) may become an assemblage when examined in more detail – an articulated network of bodily organs.

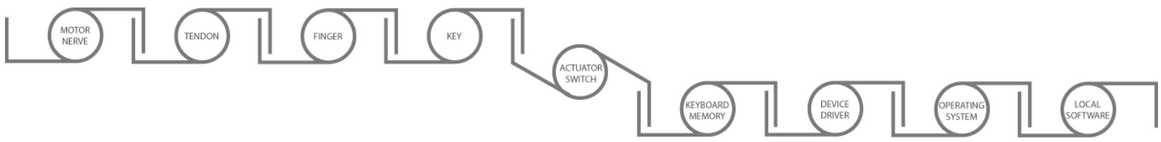



In this way, the user/avatar assemblage can be decomposed to consist of a larger number of lower level machines. As a first instance, a component may be isolated – the interface – which exists within the hybrid space that lies at the material/digital threshold.

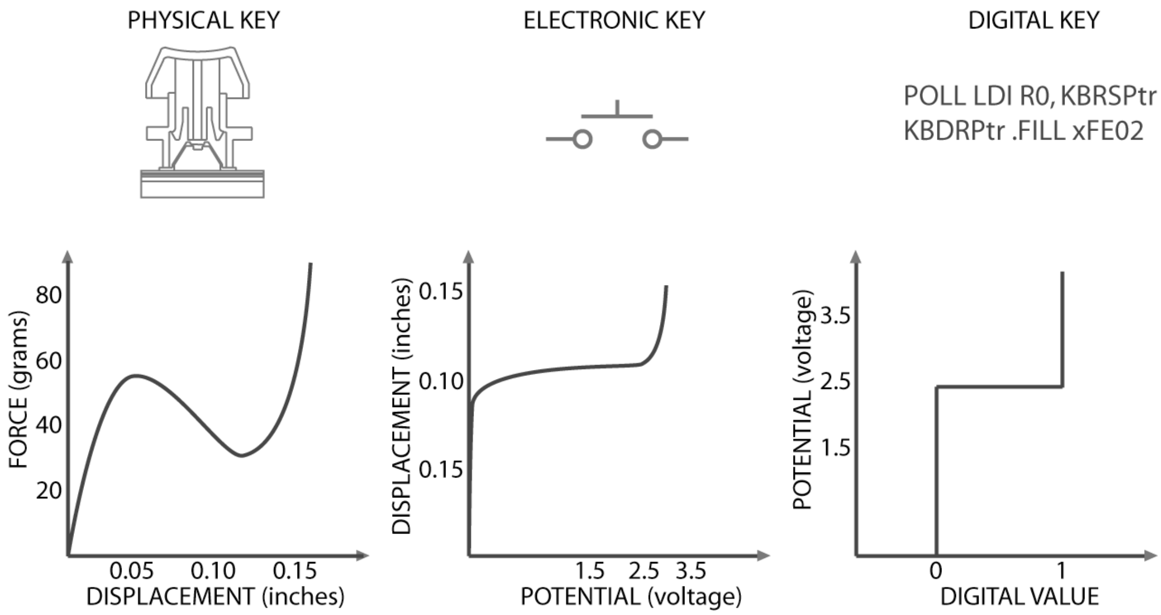

This is only the first step in the process of unfolding the user/avatar assemblage. Between the two terminal entities lies a chain of mediating machines. Each is connected to the next in a series of interlocking couplings. It is important to note that this simplistic linearity is an artefact of the selection of specific machines for the purposes of this discussion. In reality, the assemblage would be a complex mesh of multiple connections. The user relates to the environment around them, the chair they sit on, the music they are listening to. The local software is related to operating systems, other software, an internal system clock. When considered in depth, the assemblage is a rhizomatic web of dependence and effect, “ceaselessly establishing connections” (Deleuze & Guattari 1987, p.7).

In addition to this complexity, a number of the machines discussed here have been problematised by recent critical theory examining the nature of subjectivity. For the present analysis, issues regarding the nature of the user’s subjectivity and agency will be bracketed for the sake of simplicity. Obviously, any full exposition would require acknowledgement of these complexities.


The machines involved in the assemblage between user and avatar can be further isolated. The user controls the avatar through a sequence of keystrokes. Each keystroke is a flow through the assemblage, mediated by the various machines. The nature of this flow changes as it is passed from one machine to the next. The motor nerve in the user triggers the tightening of a tendon in the forearm. This results in movement of the finger and a key is depressed. A switch is actuated as a result, from which it follows that values in the keyboard memory buffer of the built in operating system (BIOS) are altered. A specialised piece of software (the device driver) interprets these changes and passes this information to the operating system. The local software then polls the operating system to detect incoming keyboard input. Guattari describes these machinic relations as a form of “syntagmatic linkage” (1995, p.42), where the fitting together of individual machines to form an assemblage requires “a formal serialisation and a certain perdition of singularity” (p. 35).




It is readily apparent that certain machines reside in the material space – the tendons of the arm, the finger – while others, such as the BIOS and the operating system appear to be fundamentally digital. Situated between these poles, in the hybrid space of the material/digital threshold, is the actuator switch – a small electronic component triggered by pressure on the key.




Such ‘threshold machines’ are important in that they map in a straightforward fashion from material into the digital space. This can be seen by looking at state diagrams of the actuator switch. As the physical key is depressed, force is mapped to the vertical displacement of the key, as a simple function. This displacement can then be mapped fairly trivially to a potential voltage across the contacts of the actuator switch. Finally, this voltage can be mapped to a digital state for the key. From force (a purely material entity) to a binary value (a purely digital entity) the actuator switch allows transparent mapping to occur.

Many older technologies show this blurring between material and digital. Before the advent of solid-state electronics, digital computer memory was often stored using ‘magnetic cores’. Each bit was mapped to a ferrite torus through which copper wires ran. When sufficient current was passed through the wires, the magnetic polarity of the ferrite torus could be manipulated. This polarity would remain stable without further current, ‘locking’ the core and hence holding the data. Programmers found that oscillating two neighbouring bits of data rapidly would result in unanticipated interaction between the physically proximate magnetic fields being created and destroyed. As a result, the cores would vibrate and heat to the point of failure. In this way, the material and the digital were shown to be intimately interconnected.

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This paper focuses exclusively on the digital as a form of apparently immaterial space. Through examination of basic digital machines, and consideration of building complexity through layers of iterative structure, it is suggested that the digital is simply a mapping of material objects, perceived as a distinct space.

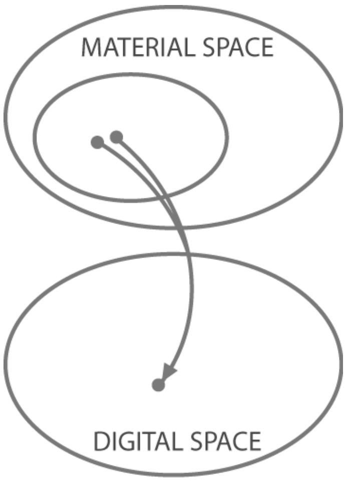
While such conclusions are limited here to the digital, they can be equally applied to other realms of immateriality such as social and mental spaces. The space of social objects (Lefebvre, 1991; Merleau-Ponty cited in deCerteau 1984, p.117) and the space of mental objects (Lacan cited in Wertheim 1999, p.231) have both been proposed as realms distinct from the material. Just as it is suggested that any understanding of the digital must incorporate an appreciation for the material basis of digital objects, the same is true of the social and mental. Though it is beyond the scope of the present paper, there is a significant opportunity to deepen our understanding of these spaces by exploring the material components from which they are constituted, and the complex relationships between those components that create the structures we perceive as discrete spatiality.

## Mappings

Threshold machines such as the key described above suggest that what we perceive as the digital is purely a conceptual remapping of the material. While this is trivial at a basic level, the complexity of the mapping at higher levels makes tracing the relations between the two realms more difficult. A single keystroke can be readily understood in material terms. The material implementation of an integrated circuit diagram over sixty-four square meters of blueprint (Kittler 1995, para.1) defies comprehension at that level.

Unable to cognitively manage the inherent complexity of these material structures due to human limitations, we ignore inessential details of these complex systems, “dealing instead with a generalized, idealized model[s] of the object[s]” (Shaw 1980, cited in Stubbs & Webre 1987, p.51). This abstraction is reinforced by graphic interfaces, the aim of which is to “hide a whole machine from its users.” (Kittler 1995, para.12).

To understand how this complexity arises, and how it is structured, it is useful to employ the mathematical tools used to analyse ‘functions’. A function describes a system where one variable is dependent on another (Epp, 1990, p.379). It is suggested that, in an analogous way, digital space is a function of material space.



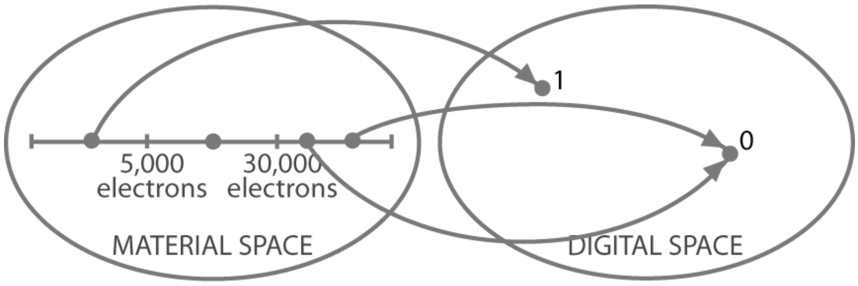

Speaking mathematically, this implies that digital space is the ‘image’ of part of material space under a digital transformation or ‘function’. This function maps a set of elements of material space (the ‘domain’ of the digital function) to the digital space. (Epp 1990, p.380)

This definition has a number of corollaries. Importantly, the mapping is partial (or ‘non-injective’) as there are many elements of the material world that are not part of the abstraction we experience as the digital (Epp 1990, p.411). Conversely, every ‘bit’ of the digital can be tracked back to a material source, hence the function is ‘surjective’ (p.416).

Finally, two different material elements or states may map to the same digital element. Moving the location at which a website is hosted, for example, will change little in a digital sense despite significant change in material space. As a consequence, the digital function is described as ‘one-way’ – which means that while it is possible to calculate the digital from the material, it is not possible to generate the state of the material world from digital data. This has important consequences for digital operations.

To illustrate these aspects of the material/digital mapping, another simplified instance will be reviewed. In this case, the machine examined is the memory cell of the Intel Flash memory chip (Fazio, Keeney & Lai 2002). Flash memory is a technology allowing systems to store data in re-programmable, non-volatile solid-state integrated circuits. These circuits are made up of a large number of individual cells. Each cell stores a single bit of data, depending on the charge of a small area within the circuit, known as the ‘floating gate’. The example discussed here is the eight generation of Flash memory produced by Intel, where each memory cell is approximately 0.13μm in width. The parameters of the cell’s charge are described as follows;

> “For single-bit-per-cell devices, the transistor either has little charge (<5,000 electrons) on the floating gate and thus stores a ‘1’, or it has a lot of charge (>30,000 electrons) on the floating gate and thus stores a ‘0’.” (Fazio, Keeney and Lai 2002, p.27)




Examining the digital mapping of a number of possible material states reinforces the specifics of the digital mapping function described above. Firstly, multiple points in the material may map to the same digital point. Regardless of whether there are 32,000 electrons or 35,000 electrons (and regardless of the arrangement of these electrons), the digital value of the memory will be ‘0’. Secondly, there are points in material space that do not map into the digital. A cell with 15,000 electrons falls between the threshold limits. As such, that cell is inherently undefined digitally – it cannot be mapped from the material space into the digital.

The ability to map several material points to a single digital point (the non-injective nature of digital mapping) has an important consequence. Any process occurring within material space can be described as a function mapping the material space onto itself. From a specific point in the material, an action is performed, the result being another point in the material. Assuming that both these points exist within the region of the material mapping to the digital (the digital ‘domain’), the function also has a corresponding digital effect. For instance, toggling a switch has a clear material effect – if the switch is part of a digital system, it also has a digital effect. This is because the initial material state maps to a one digital state, while the final material state maps to a different digital state.

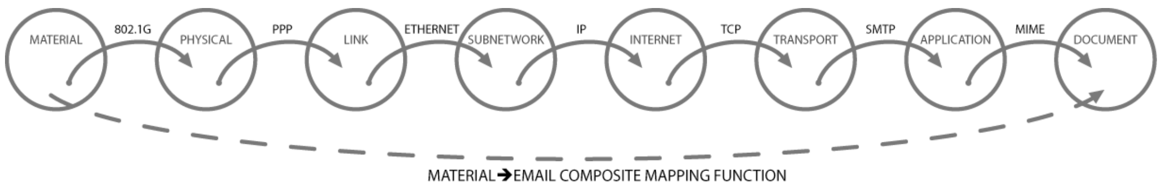
Conversely, purely digital processes cannot exist. Just as the material process described above has an impact on the digital, it would be necessary for a digital process to have an impact on the material. A digital process would move a digital system from an initial to a final state. This would mean that the related material structures would have to be moved to a corresponding final state. However, that state may be indeterminate, as many different material points may map to the same final digital state.

As an example, the setting of a Flash memory cell may be seen as a material or digital process. If it is seen as a material process, it involves a number of electrons moving into or out of a defined space (the floating gate). When this movement has occurred, the digital state of the system can be derived from the new material state. However, if seen as a digital process, the reverse is not true. Given a Flash cell set to ‘1’ (with perhaps 2,000 electrons present in the cell), an hypothetical digital process could set that memory bit to ‘0’. As a consequence of this, the material state of that cell would be required to change. Unfortunately, the digital state of ‘0’ does not indicate how many electrons will be present – only that there will be more than 30,000. In this way, a digital function fails to adequately map the detail of material space. It would be like the independent movement of one’s shadow having a corresponding effect on one’s behaviour.

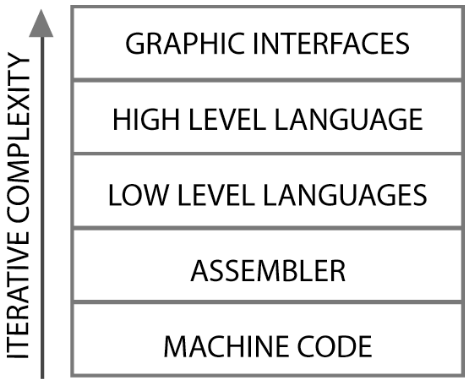
As a consequence of this, it is important to realise that all processes (including apparently digital processes) are actually material. The apparently simple digital actions described by programming languages in fact reflect extremely complex material interactions, abstracting almost all of the low-level detail.

While such an example illustrates basic mapping, it could be argued that it fails to adequately account for the complexity of the digital and its apparent independence from the material. To explore this, it is necessary to realise that the digital is not one discrete realm, but can be seen as many partial, overlapping regions. The ‘world wide web’ is distinct from the world of Everquest; the programming space of Pascal is distinct from the editing space of Microsoft Word. Each form of interpretation of digital data forms its own ‘Universe’. Similarly, there is not a single digital mapping for each data point. Most digital content is mapped through a series of functions, wrapped inside one another.

These iterative layerings of functions are referred to as ‘composite functions’ (Epp 1990, p.445). An instance of this is the encapsulation of Internet protocols. A simple view would suggest that any email a user receives is merely the perception of a mapping of many various objects in material space. Such a one-step mapping (while technically possible) is impractically complex. Examining the structure of systems, there are numerous functions that operate on one another to produce any given email.




If a wireless network were used to transmit the email, a set of electromagnetic waves could then be mapped through a function embodied by the 802.1b wireless data standards. The result would be a bit-stream that is mapped using point-to-point protocol (PPP) to produce small packets of data. These packets can be mapped through Ethernet specifications resulting in IP packets that are, in turn, then mapped to larger whole messages through the TCP function. The SMTP function maps these messages into the email space before finally they are interpreted using MIME email protocols. Through this iterative mapping, or ‘folding’ of the space beginning as a pattern of electromagnetic waves, the resulting digital space can contain considerable complexity. (Lynch and Rose 1993, p.83)




This process of developing complexity through iteration occurs in numerous ways during the generation and interpretation of digital content. Computer programs were originally written using numeric 'machine code' that corresponded to the specific 'instruction set' of the processor used by a given system. To facilitate readability, this was then encapsulated by 'assembler', a set of abbreviations that described each underlying machine instruction. Later languages such as C and Pascal used a set of logic-based commands to allow for more complex, intuitive programming. Following the completion of programs in these low level languages, they would then be 'compiled' or 'interpreted', converting them into 'machine code'.

Further languages such as PROLOG and CIGOL were then created (often using languages such a s C) to allow more natural writing of programs in environments that approached natural language. This was taken further with the advent of graphical user interfaces where programming could be performed through the manipulation of icons in a graphical environment. While this style of programming may increase the users perceived separation from the physical machine, this is achieved through a recursion of complexity – each piece of code created must eventually be reduced to machine code in order to be executed by a computer's processor.

Kittler likens the "ever-growing hierarchy of high-level programming languages" to cryptography's one-way functions (1995, para.13). This evolution of languages reached a critical point with 'meta-programming', programming which operates on other computer programs as data (Bratko 1990, p.534). At the same time, the use of object oriented programming has also become common, combined with associated abstract data modelling methods. These are both means of defining "structure in terms of known, perhaps simpler structures" (Stubs & Webre 1987, p.459) allowing progression from one entity to another, in the construction of increasingly complexity.

This production of complexity through iterative folding is not only found in programming languages. Recursive structuring techniques are also used in numerous approaches to systems analysis and design. The 'spiral model' of system development involves the "development of successive prototypes, with each new prototype adding additional functionality and being integrated with the previous prototype." (Hawryszkiewycz 1998, p.136)

Delanda has written on this process of building iterative complexity. He observes that complex structure emerges over time, "with each new layer of accumulated 'stuff' simply enriching the reservoir of nonlinear dynamics and nonlinear combinatorics available for the generation of novel structures and processes." (1977, p.21)

## Virtuality

The discussion above has proposed a purely material digital space, suggesting that the digital is simply an abstraction drawing on the incredible complexity of defined areas of material space. The apparent simplicity of digital processes – from programming languages to user interfaces – hints at a mixture of complexity and structure in the way that the digital emerges from underlying materiality.

Further, it is apparent that this complexity and structure is increasing. Faster processing speeds and greater data handling capacity enable systems to be constructed from greater numbers of layers, resulting in further abstraction and interconnection. The ability for systems to modify their own activity implies that this growing complexity may even continue exponentially, purely through the operation of such systems.

This ongoing process is responsible for the growing presence of 'digital' machines. These are a subset of the 'technical machines', which Guattari suggests "install themselves at the intersection of the most complex and heterogenous enunciative components." (Guattari 1995, p.47)

Mindful of this growth, Delanda suggests that "[p]ast a certain threshold of connectivity the membrane which computer networks are creating over the surface of the planet begins to 'come to life'" (p.121). In this way, as computers are increasing in their prevalence, the behaviour of interconnected systems may dramatically change as "the portion of the 'mechanosphere' constituted by computer networks … [crosses] a certain critical point of connectivity" (1991, p.121).

Following Deleuze, Delanda explains this increasingly complex folding of the material as occurring through a process of 'actualisation'. This process is shaped by virtual "form generating resources", multiplicities that "specify the structure of spaces of possibilities, spaces which, in turn, explain the regularities exhibited by morphogenetic processes" (Delanda 2002, p.10). These virtual multiplicities structure not only the emergence of digital behaviour, but of all material activity.

The digital is particularly unusual because of the rapid rate at which this actualisation is occurring, repeatedly folding small areas of space into layers of intricate, complex machines. Philip Roe, in describing the role of the field of new media studies, suggests that exploring the nature of virtuality is a matter of identifying "actualisations which would fold back into the virtual." (Roe 2003, para.32) By examining the ongoing development of the digital, conclusions may be drawn anticipating the nature of virtuality, and the ways in which it will unfold into the actual.

As the complexity of the mechanosphere crosses the threshold described by Delanda, it "begins to be inhabited by symmetry-breaking singularities, which give rise to emergent properties in the system." (1991, p.21) Such singularities are points of transition at which order spontaneously emerges from the apparently chaotic behaviour of the interconnected mechanosphere (p.15). In this way, within the turbulent potentiality of the digital space of the present, emergent desires can be seen "struggling for form, and from this we can examine the virtuality of the future to come." (Roe 2003, para.27)

In developing digital technologies, humanity has introduced a new breed of heterogenous machines, machines that generate and populate their own folded material spaces. It is perhaps these machines, the assemblages they form, and the rhizomatic connections between them, that provide one of the best possible locations for studying the forces that will shape the future – not only of the digital, but of reality as a whole. As Delanda suggests, computers sit at the threshold between the concrete and the abstract, "midway between physical assemblages and processes of self organisation", both "concrete enough to allow control of physical processes" and yet "abstract enough to allow the spontaneous emergence of order out of chaos." (1991, p.229)

> "It is at the intersection of heterogenous machinic Universes, of different dimensions and with unfamiliar ontological textures, radical innovations and once forgotten, then reactivated, ancestral machinic lines, that the movement of history singularises itself." (Guattari 1995, p.41)

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