Deconstructing Digitality

Dismantling some of our preconceptions about the foundations of the Information Age[†]

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August 16, 2007

Of all the terms associated with the computer revolution, none are more celebrated than "information" and "digital." Both have been vaulted to prominence as emblematic of our age. A search for "information" on Amazon.com returns more than half a million books; for "digital," the number is more than twice as high—close to 1.3 million.

The notion of information has received critical theoretical analysis in multiple disciplines—from biology to engineering to philosophy to sociology. Digitality, on the other hand, remains remarkably unreconstructed. Perhaps digitality is taken to be simple, or computers' digitality to be obvious. Whatever the reason, questions about digitality are rarely asked. Not that digitality is unimportant. Arguably, the invention of the digital computer was the major development in the history of computing. Sure enough, there are analog computers, too: old ones, of resistors and capacitors; and new ones, such as artificial retinas and cochleae. But think of what digitality unleashed: universal machines, programming languages, implementation and data structures—to say nothing of e-mail, the Internet, compact discs (CDs) and virtual reality. Somehow or other, digitality—or "discreteness," to use an equivalent term—lies at the core of the computer revolution.

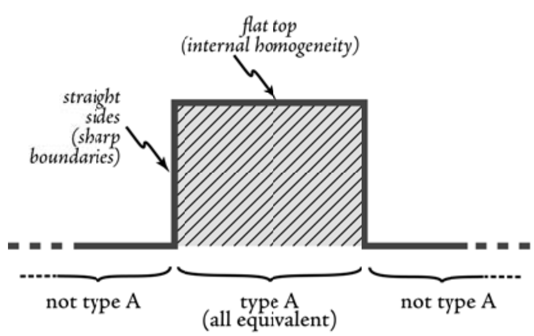
More abstractly, computers' presumed discreteness, or "absoluteness," plays a major role in our computational *Zeitgeist*. That computer science is a "formal" discipline, that computing is amenable to mathematical analysis, that computer science is a science—all these classifications rest on the premise that the appropriate theoretical concepts for studying computing have a formal, or discrete, character. Similar assumptions underlie the widespread view that computers are nothing more than dry and desiccated machines. Indeed, it is exactly the alleged contrast between the cut-and-dried, neat and sharp categories of the formal computational world, and the messy, contested, inevitably metaphorical and, ultimately, "wet" categories of human life-as-lived that drives the wedge, many people would say, between the monstrously mechanical and the sacredly humane.

But is it true? Are computers, in fact, digital?

And what does "digital" mean, anyway? What would be it for the myth to be true?

1. Abstract Perfection

A first cut at the nature of digitality is best conveyed with a picture.



As suggested in figure 1, two things are required. The first, depicted by the vertical edges, has to do with a digital state's boundaries: they must be absolutely sharp. Whether a system is in a given state—on or off, 0 or 1, yes or no—must be a totally and completely definite question. Either it is, or it is not—with no room for ambiguity or degree. Digitality, thus, manifests what we never find in nature: an absolute, perfect, 90° cliff.

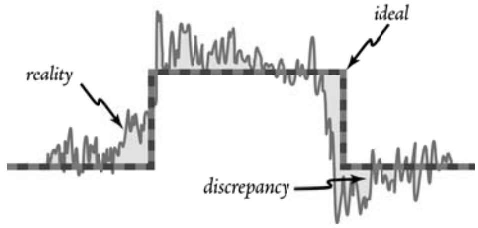
The second aspect, depicted by the flat top, is that digitality requires utter internal homogeneity or uniformity, with no internal variation. All instances of a digital type must be exactly equivalent. One "0" state is as good as another "0" state—completely interchangeable. Again, there are no matters of degree; there is no possibility for the system to be partly 0, or mostly 0, or vaguely 0, or more-or-less 0. Everything is absolute, determinate, and clean.

Needless to say, nothing in the real world is quite so neat. But that is all right. In fact, the construction of digital systems is expressly aimed to accommodate such cases. Departure from the ideal is not so much forbidden (which would be difficult to achieve, let alone sell for cents per megabyte), as almost magically rendered irrelevant. That is, the idea is not that things are discrete in some absolute or ultimate metaphysical sense, but that they are fashioned so as sustain a digital level of description.

Rather than attempting to eliminate variation, engineers build digital systems by arranging things so that the inevitable individual variations do not matter, such as

 Extracted and abbreviated from "Indiscrete Affairs," forthcoming.

voltages wandering up and down around some standard. To whatever extent is necessary, offending properties are cleaned up, boxed in, confined to certain limits, kept from spilling outside a protected region. As a result, errors neither accumulate nor propagate, and results do not get out of hand. The trick is to ensure, with respect to the overall or future state of the system—i.e., with respect to everything that matters about the system at the digital level of abstraction—that all present and future behaviour, such as whether the system will be in state B, depends only whether the system is now in state A1 or A2 or … or Ai, not on the way in which it is in one or another of those states. As long as that condition is met, any potentially distracting variations will be locally contained—washed away, made invisible. As a result, the relation of the system to the (digital) property of being in state B is reduced to a single "bit" of information. Yes or no. On or off. Black or white.



You can see what is going on in figure 2. Taking an electrical pulse as paradigmatic, the green line indicates what the electrical circuit is actually like. The dotted red line indicates the "digital idealization." The yellow region indicates the "discrepancy" or "departure from the ideal"—the difference between idealization and actuality.

The amazing accomplishment, for digital systems, is that they are built to work as if they were red, instead of what they actually are, which is green. In constructing the rest of the system, that is, or in analyzing its behaviour, you can assume that it is red—in spite of the fact that the red line does not exist! This is a more impressive achievement than may be obvious—easily, in my view, worth a passel of Nobel prizes. It is certainly far from obvious that such a construction is possible. If you were to build a building with this kind of error between how it was supposed to be and how it was actually built, it would likely fall over.

Contrary to popular myth, in fact, the lowest levels of computers, far from being adamantine 0s and 1s, are not all that stable. Situations regularly occur where the implementing physical parameters get out of hand, wrecking any simple digital abstraction. Compact disks are a dramatic example, where a fingernail scratch can leave a wake of devastation hundreds of bits wide. Cosmic rays and the conveyor-belt motors at security checkpoints similarly can produce decay, to say nothing of a background slow drift and general disintegration in underlying materials. In a curious sense, in fact, modern digital media are more vulnerable than traditional non-digital ones. As is often pointed out, high-quality paper can last for hundreds or even thousands of years; disk drives are lucky to last 10. Optical media do better, but only somewhat, at best lasting a few decades.

How is the digital abstraction maintained, given these inevitable processes of dissolution? An extraordinarily impressive surrounding structure of routines and mechanisms prop up the digital abstraction. Compact disks employ staggeringly complex error recovery schemes to preserve and even recover the idealized digital "signal" in the face of catastrophic tracks of microscopic destruction. Laptop memory is rewritten every 15 milliseconds, in order that rapidly accumulating "bit-rot" does not take over. Internet packets are checked and resent when they have eroded en route beyond the point of digital recognition. Disk headers are stored redundantly; fragile memories are backed up on disks; mission-critical applications are run in parallel on identical computers, in case one fails. The full gamut of such coding strategies and error recovery schemes is extraordinarily impressive. Certainly the popular idea that a visitor from Mars could examine a single CD and simply "read off" the music is a severe stretch, if not an outright error.

What is digitality for? Why all the fuss? Why construct a system that—at least at this abstract level—is so pure, so crystalline, so fixed? John Haugeland gives an apt answer. Digitality, he writes, is "a practical means to cope with the vagaries and vicissitudes, the noise and drift, of earthly existence" ("Analog and Analog," Philosophical Topics, Spring 1981). Discreteness, that is, more than anything else, is about protection—protection from the ravages and uncertainty and exigencies of the local surround. Winds might blow; the power supply might suffer a brownout; moth and rust might corrupt; someone at the next table might say something distracting. If you are a digital system, you need not care. Your constitution guarantees that you will not be buffeted unseemly by such local aberrations. In fact, you will not be unseemly at all. In a certain "abstract" sense, digital systems are intrinsically perfect.

2. The User Experience

How do we experience the digital? At one level, the answer is obvious: we construct programs, automate processes and transformations, store data, send e-mail, interact with other users, manipulate "information." All of these things "exist"—are coherent and intelligible—at the digital level of abstraction. But that is not all. Something else we do, as quickly as we have achieved the digital level, is do our best to hide it.

Think again about CDs—but this time, about the music. For example, think of a recording of Charlie Parker.

Or a scanned original of a hand-written Walt Whitman poem. Or a late-night phone conversation with a lover. In each case, the medium or substrate will be digital in several respects: frequency, volume, hue. Yet, it does not follow that the music itself, or the nuances of the image, or the inflection in the caller's voice, are thereby themselves rendered phenomenologically discrete. Rather, what these examples show is that you can implement or encode or represent something non-digital on a digital substrate, but continue to experience it as continuous.

This fact about the relation among one and the same system at three distinct levels of description, only one of which is digital, is as (if not more) important to the computer revolution than the simple fact that there is one level of abstraction at which most computers can be taken to be digital, even if from a physical perspective they are not. The situation is depicted in figure 3. Even if it has grown familiar to the point of the banal, it is still amazing that we can construct a single system—one and the same "thing," a single patch of metaphysical reality—that can be analyzed, simultaneously and correctly, at three different levels of abstraction: (i) a top level, such as music, poetry, and the like, implemented (encoded, represented, constructed, etc.) on top of (ii) a "digital" level (the non-physical abstraction depicted as a red line in figure 2, which obeys the criteria of perfect discreteness), implemented, in turn, on top of (iii) a bottom physical level, at which it is not discrete.

top · not digital ← user
intermediate · digital (discrete)
bottom · not digital ← physical

Three levels of a computational system

Arranging things in this triple-decker fashion simultaneously gives you the best of all possible worlds. It is fortunate that the lowest level, the level of the physical substrate, is not digital, since that means we can actually build things out of circuit components, metal parts, light guides, slightly varying components, and so forth—i.e., stuff made out of the messy, decaying, material clay supplied to us as the basis of all that exists. If we arrange that layer properly, however, mechanically and dynamically, we end up with a device that, at a higher level, supports the digital abstraction, with all of the resulting perfection discussed earlier: freedom from buffeting, protection from the ravages of time, insulation from unwanted or unwarranted influence. The astonishing part is that this protection from the world's dishevelment apparently extends upwards to all levels implemented on top of it. And yet—and this is the crucial part—this immunity of upper levels from buffeting and decay is accomplished without requiring that the higher level phenomena (the music, the meaning, the caller's sotto voce intimations) themselves be rendered experientially digital or discrete. In virtue of being "digitized," that is, the music, meaning and intimacies need in no way be neatened, straightened up, clarified or disambiguated. No boxing on the ears is required in order to force them into the strictures of the discrete.

When we talk about "digitizing" music and art, in other words, strictly speaking we are using shorthand for "digitally encoding." To render the music itself digital would mean taking away from the Bird the ability to transform one melody continuously into another, or to build gradually from a whisper to a growl, or to have every performance of the "same" tune be unique. Fortunately, CDs don't require that.

The simplest way to understand the achievement of the digital age, therefore, is the three-level structure depicted in figure 3. This is what our future rests on: an intermediate level of digitality, sandwiched between a lower, non-digital level of the brutely physical, subject to inexorable material buffeting and decay, and an upper, non-digital level of music, meaning, social praxis. Between the two lies the abstract, but terrifically consequential, intermediate, digital level, which, by virtue of its achievement of almost magical perfection, affords the upper level complete protection from the ravages of the underlying lower-level physics, thereby enabling arbitrary mobility, perfection and replication, without requiring that that upper level itself be digital.

The protection of the digital without the price of the digital—that is what the intermediate level provides to everything above it. Moreover, given that we have the intermediate level of digitality, we can use it to harness the almost arbitrary powers of algorithms, programming, data, and information processing, in order to engender limitless patterns of transformation and interaction, configured so as to instill arbitrary creativity in the uppermost level.

It is a three-level confection of historic power—with society, needless to say, dining out on the results. And remember: the different "levels" are not separate, modular pieces of an integrated whole. They are all the very same system or phenomenon, analyzed at different levels of abstraction.

3. Conceptual Discreteness

From what has been said so far, you might take the conclusion to be this: that (i) while nothing is physically digital, (ii) we can, nevertheless, build physical things to sustain a digital (i.e., "computational") level of abstraction, (iii) on top of which we implement all kinds of non-digital things. Doing so gives these implemented things an unprecedented degree of stability and mobility—even virtual perfection. Society's slogan should be "The Digitally Implemented Age," not "The Digital Age." And that's where things would stop.

It is not a bad, as a first, cut, but even it is wrong. And this time, it is a major falsehood—or perhaps we should say, an expensive falsehood. Getting over it will cost a great deal of the modern intellectual tradition.

The problem is that there is a more abstract form of digitality—what Haugeland calls "higher-order digitality"—that applies, not to the specific waveforms and measurable quantities of a concrete phenomenon, but to the very concepts themselves, in terms of which things are explained. Thus, consider force, mass, velocity, charge—staple concepts in physics. Specific forces and velocities can be as continuous as you please (23.759 kilograms, 0.3335640951981521 x 10-8 seconds, etcetera). However, the concepts in terms of which such things are analyzed are as pure, discrete and distinct as any digital states: nothing is ½ of a force and ½ of a mass, or partway between a momentum and duration. The concepts of physics are like the monoliths at the opening of the movie *2001*: unadulterated and distinct.

In contrast, consider arrogance—and the boundaries between it and pride, egocentrism, self-confidence, braggadocio, and the like. Sharp edges do not apply. Nor is the issue just epistemic, of judging whether someone is one or other; the point is that the concept does not (and could not) not be sufficiently precisely determined for there to be an exact metaphysical answer as to whether someone is arrogant or not. Moreover, the internal structure of arrogance is not uniform, either—implying that the concept is not internally homogeneous. People are more or less arrogant, arrogant in this or that particular way—in ways that make a difference, with respect to their arrogance.

The problem is that actual computer systems deployed in real-world situations betray the fact that a large number of computational categories, in spite of being built on top of our now-familiar abstract form of discreteness, are more like arrogance than they are like mass. Consider four notions fundamental to the analysis of any real-world computer system:

1. *Subject/object*—and allied notions of *representation/represented*, *symbol/referent*, *sign/signified*, and so on;
2. *Form/content—syntax/semantics*
3. *Inside/outside—internal/external*, *intrinsic/extrinsic*
4. *Abstract/concrete*

In each case, concrete, lived experience (rather than theoretical constructs built on assumptions to the contrary) shows that they are far from being neat and clean, "clear and distinct"—i.e., digital—concepts. That is not to say that these (or a host of other such) distinctions are useless, inapplicable or untenable. The point is just that, at best, they demarcate a complex, intermediate region or territory—not a "gradual" or "continuous" or "smooth" compromise, but rather a turbulent locus of ferment and activity, a place where things are stretched and pulled and splintered into a thousand other considerations, considerations that no longer line up and pull in one direction, nor line up and pull in the other, but sunder, cross-fertilize and lead to more distinctions—all the way (as it is said) up to "the edge of chaos."

Ultimately, instead of being discrete, the situation begins to resemble that depicted in figure 4.

And so it goes—to deeper levels and broader scopes. Not only do specifically computational properties fail to be discrete, but the same moral applies to more general distinctions, of which computer systems are sometimes used as models: between nature and society, the sciences and the humanities, subject and object, mind and body. Computers are wonderfully disruptive precisely because, if properly understood, they make a sham of the ultimate sharpness of every one of these classical dualisms. Computers are symbol manipulators par excellence, but does that mean they validate those who claim that language is merely an endless play of signifiers? No, they do not. They spend too much time mucking around in their own (semantic) task domains. In fact, they tell the lie to that postmodern mantra.

Ultimately, in fact, it is wonderful historical irony. Computers are supposedly objective, scientifically "OK"—intellectually respectable, naturalistic, not spooky. It is in virtue of this pedigree that they are *echt* denizens of the modern academy. But this alleged respectability, so innocuously garbed in the idea that computers are "mere machines," may turn out, historically, to reflect no more than sheer prejudice.

Loosed into the wild, computers play the trumpet outside the digital walls of Jericho. The boundaries of conceptual discreteness are tumbling down.

4. Conclusion

Why does it matter whether the digital level of abstraction is "real"? That much of what we call digital is neither physically nor experientially digital, but only digitally implemented? That the concepts and categories of computing are not conceptually discrete?

In part, the answer stems from a point with which we started—that notions from the computer revolution, such as digitality and information, have assumed such importance in our collective imaginary. As said there, many people assume there is a fundamental (discrete!) divide between people and computational "machines"—that the latter, by virtue of a presumptive neatness, formality, and cut-and-dried conceptual structure, have no purchase on the contested and metaphorical "wetness" of human existence.

I would be the last to claim that anything anyone has built so far can manifest care, chuckle ironically or make a surreptitious gesture. But it is not a fact from which I would extract metaphysical comfort. We have a long history, after all, of striving to maintain the human as fundamentally distinct from the other systems with which we share our habitat: the heavens before Galileo, the animals before Darwin. Reaching for non-discreteness as a way to secure us from the encroachment of the Information Age is just as likely, in my view, to be grasping at metaphysical straw.

Any importance (and humility) that we humans are worth must stem from concrete facts about our actual existence, not from any presumptive immunity from being reproduced—or perhaps more elementally, from belonging to the world.