Systems Representing Themselves

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The term Web 2.0 is used to define the transition between the static web of the early Internet and the social-media-focused era that began in the mid-2000s. It is primarily defined by its focus on user-generated content, responsiveness, and real-time updates. But perhaps the most prominent feature of this shift was the emergence of the personal user and its consolidation at the core of many online services. In order to view content, post, chat, tag, or participate in any (if not all) of the services available on this "new version" of the Web, it is necessary to sign up for a personal account. This account stores personal information and becomes an index for all of the behavior tracking, pattern recognition, and targeted advertising that the Web has become synonymous with. The deciding factor for the shift from the early Web to the current Web is the introduction of the digital persona as the paragon of design in online services.

Nostalgia for the early days of the Internet often emphasizes the freedom, decentralization, and anonymity of Web 1.0: no data silos stored entirely within the servers of mega-corporations, no traces of any action. The personal user was not only the fundamental development that enabled the monetization of the Web, but at its core it represented the intrusion of what Yuk Hui, whose theories I consider in more detail below, terms a particular "cosmotechnical"[1] view that became embedded in the operation of this technical system. This transformation was not unprecedented: the computer went from being a large, collectively operated, and purpose-built machine, to the mass-market consumer product aptly called the personal computer. The consolidation of the digital personal user as the de facto method of interfacing with the Web is predicated on the augmentation of technical systems that build upon previous developments. This has led to a feedback loop of technical entrenchment: the

[1] Regarding cosmotechnics, Hui explains: "Scientific and technical thinking emerges under cosmological conditions that are expressed in the relations between humans and their milieus, which are never static. For this reason I would like to call this conception of technics *cosmotechnics*. One of the most characteristic examples of Chinese cosmotechnics, for example, is Chinese medicine, which uses the same principles and terms found in cosmology, such as *Yin-Yang*, *Wu Xing*, harmony, and so on, to describe the body." Yuk Hui, *The Question Concerning Technology in China: An Essay in Cosmotechnics* (Falmouth: Urbanomic, 2016), 18, emphasis original.

automobile as personal vehicle, the single-family home, the personal computer, and the smartphone. The ubiquity of individuated machinery has generated the need to keep track of all personal data gathered by devices, even those that do not inherently require such data to function, such as AI toothbrushes, for instance.

As technological processes, computation or information exchange do not have written rules which determine their social use by individuals. Although the instrumentalization of the natural world is the product of a particular cosmotechnology that can be traced back to Enlightenment rationality, this kind of instrumental rationality is not an inherent quality of computation or information exchange, but only one way of conceiving and operating them. The individualization and personalization of technology is the outcome of a certain worldview, of a distinct Silicon Valley version of the free-willed, self-determined individual who has been extrapolated onto the Web. In this worldview, the personal user is considered a "prosthetic extension of [the] individual ego."[2] The society and culture from which the personal user emerged is particular and contingent; yet the ubiquitous adoption and global expansion of this particular ideology has meant its consolidation as a technological monoculture.

Technological monocultures have a tendency to present themselves as universal, and narrate change as inevitable and unidirectional progress. The achievements of face recognition or robotic vacuum cleaners, for example, are touted as beneficial to all, yet they conceal the ideological contingencies that gave birth to these technical objects in the first place. Hui affirms that:

> There is a general misconception that all technics are equal, that all skills and artificial products coming from all cultures can be reduced to one thing called "technology." And indeed, it is almost impossible to deny that technics can be understood as the extension of the body or the exteriorisation of memory. Yet they may not be *perceived* or reflected upon in the same way in different cultures.[3]

It is this relationship between technique and culture that Hui defines as "cosmotechnics": the

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[2] Stephanie Sherman, "The Autocene: Towards a Post-Automotive Future," *Strelka Magazine*, January 25, 2022.

[3] Hui, *The Question Concerning Technology in China*, 9, emphasis original.

particular scientific and technical thinking that emerges from the interactions between humans and their milieus.[4] These milieus (or environments) are social, technical, and physical: they consist of the material configuration of a given environment, the tools developed to alter it, the various needs that drive this alteration, and the creation myths that give moral grounding to both the alteration and the needs. In Hui's terms, understanding digital information as attached to a digital persona is not an inherent or inevitable result of technological development, but rather the consequence of a particular cosmotechnical scaffolding, in which the cultural, economic, and technical interact at every layer.

Understanding technological developments as a consequence of cosmological views, and thus as fundamentally shaped by the particular ontologies and epistemologies that such views entail, is critical to questioning the embedded design flaws within a technological system. The same design that allows for personalized feeds and targeted recommendations also paves the way for digital surveillance, targeted marketing, pervasive facial recognition, and other forms of personal intrusion.[5] This particular blueprint for the interaction between users, data, communication, and methods of retrieval can be thoroughly dismantled and reassembled if approached from a radically different cosmotechnical perspective: that is, if the fundamental principles of its design are challenged and replaced by new or alternative principles. Only by grappling with the cultural and historical contingencies of a particular cosmology can one escape technological determinism and begin to open up alternative ways of being and thinking.

Traditional Chinese and pan-Amazonian indigenous cosmologies display an understanding of technology divergent from today's hegemonic global digital culture. By engaging with their respective ways of understanding the cosmos as a systematic mesh of actionable, living, and recursive information—while acknowledging differences that arise from their geographic and environmental contingencies—this essay seeks to shed light on alternative ways of conceiving informational and living systems, as well as the contrasting ways in which they are instantiated. These examples reach far beyond the understanding of computation as merely occurring in silicon-based machines or as the product of human inventiveness. They

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[4] Hui, 18.

[5] The data sovereignty movement is based on the recognition of significant discrepancies between the asymmetrical rights and ownership of digital personas in comparison to the living, sovereign individuals they represent.

provide a path to decenter the human as the main driver of design and communication, in order to place humanity alongside a multitude of equally relevant interlocutors.

Cosmological and Technical Systems

Before delving into concrete cases, it is relevant to clarify the relationship between technical and cosmological systems, or simply put, between systems of belief, thought, and action. "Technics" here is taken as the general category of all forms of making and practice.[6] It designates the artificial operations that serve to interact with and alter a given environment. Consequentially, "technology" can be understood as a complex method of action, as the aggregation and consolidation of these techniques into a cohesive, interoperable, and consistent system. One of the ways in which separate techniques become technical systems can be found in the work of the French philosopher Gilbert Simondon.

Simondon's work is concerned with technology as seen from a phylogenetic perspective, examining technology in terms of evolutionary processes and relationships. For him, the "technical object" is not given, nor the outcome of an inventor's inspiration, but something that emerges from a process of refinement. Several iterations, changes, and mutations occur to the technical object over generations. Technical objects, such as the steam engine, the calculator, or encryption techniques, are designed with a particular purpose in mind and improved with each iteration, developing the object's intrinsic qualities. These technical objects undergo a process by which they become "concrete," meaning that the isolated elements out of which the object is constructed are unified in a system that has a functional coherence and internal resonance.[7] Isolated technical objects can come together to form a larger system, a collective arrangement that potentiates their separate qualities and opens up new possible functionalities for each component. An example of this would be the Internet, whose individual components (connection protocols, encryption techniques, user interfaces, etc.) emerged as generational improvements on individual technical objects, and their crystallization into a system exceeded their original

[6] Hui, 4.

[7] Pascal Chabot, *The Philosophy of Simondon: Between Technology and Individuation*, trans. Aliza Krefetz with Graeme Kirkpatrick (2003; London: Bloomsbury, 2013), 15.

problem-solving capacity and purpose.

A careless interpretation of Simondon's ideas would mistake intrinsic development as proof of technological determinism: technical objects naturally concretize into systems that refine their internal components, and this refinement can only follow a path of universal improvement. However, it is crucial to note here the relevance that a given milieu has in defining what constitutes a problem, what is identified as a need, and what emerges as the driver of refinement. For instance, the paths of development that a technical system might take will differ if it is concerned with optimizing water use, freedom of speech, productivity, military communication, or crude oil extraction. The definition of these needs will be driven by the system of thought and belief that articulates certain aims or goals, which in turn determines the boundaries of what is possible.

The term "system," as I am using it in this essay, also requires further elaboration. If defined by its early use in first-order cybernetics, a system involves complex interactions that are determined by the ability of a centralized authority or chain of command to control its internal processes and potential outputs, either through mechanical or protocolary agency. However, the study of open or complex adaptive systems has revealed how organized behavior can emerge without centralized planning, creating sets of relations that grow in complexity to the point where they become incalculable. In this scenario, what maintains any system as an identifiable collection of agents is its verifiable relationship to the emission and processing of signals, as well as the establishment and enforcement of boundaries that engage in the exchange of matter, energy, or information.[8]

Neuroscientist Karl Friston proposes the "free energy principle" to characterize the functioning of an open or complex adaptive system: the human brain. As an adaptive system, the brain captures information about its environment through sensory epithelia, generates internal models of said environment that minimize disorder or "surprise" in newly sampled sensory data, uses the newly generated models to make assumptions on the causes of the sensory samples it captures based on a Bayesian model,[9] and then recursively updates both the models and its

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[8] Denis Robilliard, review of *Signals and boundaries: building blocks for complex adaptive systems*, by John H. Holland, *Genetic Programming and Evolvable Machines* 14 (2013): 279–80.

[9] A Bayesian model is a statistical model that uses probability to express the degree of belief that an event will occur, given previous experience of its occurrence. See Andrew Gelman et al.,

sensory epithelia in order to minimize prediction error.[10] This principle not only describes the behavior of the human brain, but can be analogically extended to any configuration of objective entities collectively identifiable as a system. Of particular importance to the free energy principle is the "model generation" step, which accounts for how a system can sustain itself in time by generating *representations* of itself and its surrounding milieu, gathering and assembling proof of itself, adapting the way in which it captures this proof to perpetuate its existence. In other words, a system that sustains itself in time is a system that represents itself.

Systems are, by definition, complex yet identifiable. Despite the fact that their components may be multiple and various, there are ways to determine where to draw the boundary that delimits the elements and relationships composing a system from those that do not.[11] At this point, cosmological scaffoldings become relevant again. The boundaries around the agents[12] that engage in a given system are outlined following an underlying worldview. Whatever is deemed relevant within a particular cosmovision (such as angels for Catholics, the stock market for financiers, or DAOs for crypto-enthusiasts) is bestowed a status that acknowledges its agency in the world. Whatever is deemed implausible or unrealistic (such as the idea of natives possessing souls for conquistadores, or the reality of climate change for denialists) is dismissed from the framework and any influence it may have on a technological system is neglected.

Bayesian Data Analysis (New York: Chapman & Hall/CRC, 2013).

[10] Karl Friston, "The free-energy principle: a rough guide to the brain?," *Trends in Cognitive Sciences* 13, no. 7 (June 2009): 293–301.

[11] "Markov blanket" is the term used by the "free energy principle" and refers to the limit or subset of variables that are selected in a statistical model or in machine learning, which allows to infer a particular variable, leaving out those less relevant. See Judea Pearl, *Probabilistic Reasoning in Intelligent Systems: Networks of Plausible Inference* (San Mateo, CA: Morgan Kaufmann, 1988).

[12] In actor network theory, an intermediary is any entity that transports meaning or action without transforming it, while the mediator is an agent that transforms, translates, distorts, or modifies the meaning or elements that it is supposed to transport. An agent is anything that has the ability to act upon or affect its environment with some degree of intentionality. See Bruno Latour, *Reassembling the Social: An Introduction to Actor-Network-Theory* (Oxford: Oxford University Press, 2005), 39.

In the broad colonial-capitalist paradigm of thought that characterizes the current technological monoculture, which is defined by quantifiability, accountability, and individuality, as well as by the division between nature and culture, any output of a system that involves artifice, craft, or human labor is considered to belong to "civilization," while anything produced by undomesticated nature is placed outside of the system. However, there are plenty of cultures where human beings, as well as their labor and techniques, are not ontologically subtracted from the rest of existence. Environments, tools, and actions are understood as belonging to a continuous spectrum between human and nonhuman entities. For example, the Amazonian *chagra* (sustenance farms in small forest clearances)[13] is not understood by the community as deforestation, but as a metabolic regulation of canopy density that enriches the soil and communes with both living species and spirits; and some hydraulic channels constructed in ancient China can be understood as fostering natural tendencies in bodies of water rather than enforcing domination upon riverways.

This reframing of technology as not merely a human trait but as derived from—and belonging to—the world, can be found in digital information systems when viewed through the lens of these non-Western cultures. Under these cosmotechnical scaffoldings, computation can be interpreted as something discovered instead of invented,[14] as naturally occurring instead of provided by multinational platforms. In order to raise cosmological frameworks that acknowledge computing as a process where humans are participants instead of masters, it is worth examining two traditions of thought originating from antipodal geographies (namely, Chinese and Amerindian cosmologies), as well as their interpretations of information and its availability in the world. The aim here is to understand "computation" beyond consumer electronics, "technology" beyond what is designed in Silicon Valley, and "systems" beyond the

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[13] The *chagra* is an agricultural system of Amerindian cultures in the Amazon rainforest, consisting of the controlled clearing of forest patches and the planting of various edible and nonedible species. These clearings are usually used for up to two years, after which they are left to regrow. The diversity of plants that grow there, and the natural fertilization provided by wild animals that forage on the chagra, results in a highly fertile soil that renews forest growth.

[14] Amerindian healers such as Jésus León Muipu and Tarsicio Vanegas identify computational systems, tools, and protocols in the procedures necessary to heal a body or its immediate environment. The journey of learning to identify these elements has been a long, multigenerational process of discovery, rather than one of invention.

mechanisms for control, marketing, and surveillance that characterize today's global technological monoculture.

Yin and Yang as a Code for the Cosmos, and Computation through Data and Dao

Exploring notions related to computation in Chinese traditional cosmology demands consideration of two sets of ideas. First, the contact point between western computation history and the Chinese principles of *Yin* 阴 and *Yang* 阳, and second, the relationship between two concepts that articulate the way technology is conceived as part of the cosmos, namely, *Dao* 道 or "the way," and *Qi* 器 or "tool."

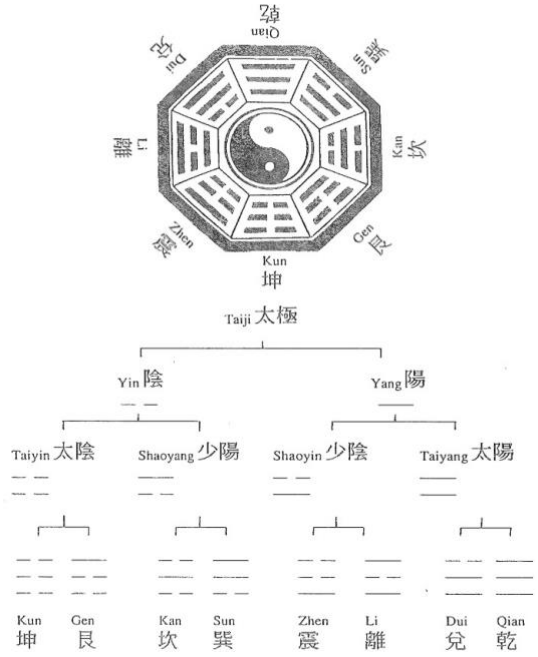

Diagram of Shao Yong's Early Heaven Sequence and the subdivision from the absolute. Courtesy the author.

This division follows the detailed commentary on the *Book of Changes*: "The nonmanifest engenders the manifest [absolute, *Taiji*], the manifest engenders the two appearances [*Yin Yang*], the two appearances engender the four images [*Taiyin Shaoyang Shaoyin Taiyang*], the four images engender the eight trigrams [*Kun Gen Kan Sun Zhen Li Dui Qian*], the eight trigrams decide good or ill luck, good or ill luck engender everything."[15]

[15] Original text: "是故，易有太极，是生两仪，两仪生四象，四象生八卦，八卦定吉凶，吉凶生大业." Yang Fada 样发达, "Zhouyi Xici Zhuan" *Chongbian: Zui Gulao Ye Zui Xianhuo De Xueshu Lunwen*《周易·系辞传》重编：最古老也最鲜活的学术论文 (Shenzhen Qinghua Yuan 深圳清华园, 2009), 5. Translation by the author.

The *Xian Tian Bagua* 先天八卦, translated as the Early Heaven Sequence, alludes to being created by the great sage FuXi 伏羲 and refers to the archetypal order of things before change. It departs from the limitless, nonexistent, or nonmanifest (*Wuji* 无极), which produces the delimited, existing, or formed (*Taiji* 太极). Taiji engenders Yin and Yang, the two fundamental concepts of Chinese philosophy. They constitute two polarities of the world's natural cycle: heaven and earth, attraction and repulsion, light and dark, waning and waxing (*Xiaozhang* 消长), etc. These natural, complementary, and contradictory forces are present in every phenomenon in the world, and form the basis of duality. Polarities are not mutually exclusive, as one cannot exist without the other. This principle of complementary duality is what allows for contradictory ideas and entities to coexist, for things that are simultaneously one thing *and* the other. It is therefore radically different from deterministic thought that identifies things as *either* one *or* the other. These two forces/principles[16] subdivide until everything is produced by their permutations, and the cyclical transformation[17] between waning and waxing is the only constant. Yin and Yang are represented as continuous and broken lines that combine in order to create four images (*Taiyin*, *Shaoyang*, *Shaoyin*, and *Taiyang*), which are present, for example, in the moon's cycle, followed by eight trigrams, forces, or principles (heaven, earth, water, fire, wind, thunder, mountain, and lake), which are associated with natural phenomena, cardinal points, energy flows in one's body, etc. The subsequent combination of solid or unbroken lines

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[16] "Two forces" comes from the mandarin *Liangyi* 兩儀, also interpretable as "two appearances." See James A. Ryan, "Leibniz' Binary System and Shao Yong's *Yijing*," *Philosophy East and West* 46, no. 1 (1996): 59–90, here 66.

[17] "Between heaven and earth there is only *xing* (form) or *chi* (energy) […] *energy* transforms in *form*, and *form* returns to *energy*, although, we are not aware of it […] when *shen* (spirit) transforms into *form* from *energy*, we see it; when it returns to *energy* from *form*, we do not see it." Pang Jixing 潘吉星, *Song Yingxing Pingzhuan* 宋應星評傳 [Critical biography of Sung Yingxing] (南京大学出版社 Nanjing University Press, 1990), 338. Translation by the author.

(Yang) and broken lines or lines with a gap in the middle (Yin) makes up the sixty-four hexagrams that describe the world and all of its phenomena, which are grouped and depicted in the *I Ching* 易经 (*Book of Changes*).[18] Used as a diagnostic tool and a divination device, these organized and variable sets of solid and broken lines, positive and negative, action and receptivity, distill into everything that exists (*You* 有) and does not exist (*Wu* 无).

Historical records indicate that instead of the sage FuXi, the Early Heaven Sequence was developed by the Chinese philosopher Shao Yong 邵雍 (1011–1077) in a quest to describe the primeval configuration of the world. In this sequence, he identifies the principles that drive permutation cycles, the polarity within which energy flows and transforms all. This diagram found great receptivity on behalf of both nobleman and general populace at the time, given the elegance and coherence with which it described reality and its phenomena.[19] This a priori understanding of the world as an aggregation of binary energy states would influence another philosopher centuries later, the German polymath Gottfried Wilhelm Leibniz (1646–1716). In his quest to propose a *characteristica universalis*,[20] Leibniz aimed to develop a universal and analytical language for thought that would express any concept as a combination of elements from a basic set.[21] For that purpose, he refined binary arithmetic, which besides being useful for

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[18] The *I Ching* 易经 or "Book of Changes" is one of the important classical Chinese texts, fundamental to Taoist, Buddhist, and Confucian cosmologies that has been historically used for divination, cleromancy, and decision-making.

[19] It is worth noting that this diagram derives part of its legitimacy from the fact that Shao Yong referred to it as the *Fuxi Bagua* 伏羲八卦 (*Eight trigrams of Fuxi*), implying that it was Fuxi 伏羲, a mythical emperor and world creator who supposedly lived around 2000 BCE, to whom the trigrams were revealed by heaven. This claim would lead Leibniz to consider Fuxi as a religious figure similar to Moses.

[20] "Universal characteristic" is a formal and universal language that can express mathematical, scientific, and metaphysical concepts, proposed in Leibniz's book *De arte combinatoria* ["On the art of combination"] (Leipzig, 1666).

[21] Frank J. Swetz, "Leibniz, the *Yijing*, and the Religious Conversion of the Chinese," *Mathematics Magazine* 76, no. 4 (2003): 276–91.

practical applications, could express all ordered mathematical permutations as operations in a binary number system. This arithmetic represented for him the perfection of ex nihilo creation by God, where everything that exists is composed by permutations between one (God) and zero (nothingness).[22] Because information is more easily stored and transmitted in binary states, Leibniz's binary arithmetic is the foundation of contemporary computing systems, the fundamental basis for representing and operating the world in all its complexity—expressed as symbols of ones and zeros, as the fullness of the sacred and the emptiness of void, as the continuous and broken lines of Yin and Yang.

As such, Yin and Yang can be said to compose both the natural world, as well as the "second nature" of digital techniques and technologies that assembles upon it. Nevertheless, to put both realms in equivalent terms would be contrary to the thoughts expressed by Shao. While Leibniz was a strong advocate of rationality as a means of understanding and deciphering divine creation, Shao considered reason to be subject to human passion. "For Shao, a necessary condition for objective[23] observation was the overcoming of the self's egocentric point of view, for the self tends to take things as real which are not real."[24] In his view, Yin and Yang are principles that can be obtained and observed, yet cannot be explained through mere forms or sensible appearances.[25] The world is in constant change, in a waning and waxing cycle, and as

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[22] This idea is based on the Genesis passage where creation comes from a primary void (0) and God (1) who, on the second day of creation, had made heaven and earth (10 in binary). On the seventh day, creation was complete (7 is 111 in binary, further cementing the perfection of God's creation). See: Ryan, "Leibniz' Binary System and Shao Yong's *Yijing*," 69.

[23] It must be clarified that Western the notion of objectivity associated with rationality is not a completely accurate interpretation. This is a translation from the Chinese *Fanguan* 反观, which is composed of *Fan* (opposite, against, anti-) and *Guan* (observe, watch, perception), i.e., "self-perception" or "self-reflection."

[24] Ryan, "Leibniz' Binary System and Shao Yong's *Yijing*," 78.

[25] "The images and numbers of heaven can be obtained and calculated, but the working of its spirit cannot be obtained and measured. Heaven can be exhaustively explained with principle, but it cannot be exhaustively explained with forms. How can the techniques of astronomy exhaustively explain heaven by means of forms?" Shao Yong 邵雍, *Huangji jingshi shu* 皇極經世書 [Book of sublime principle which governs all things within the world], ed. Sibu beiyao [1060], ch. 8A, p. 16B. Translated and cited in Ryan, "Leibniz' Binary System and Shao Yong's

such, any empirical science applied to the world is nothing but an attempt to capture a momentary form,[26] and thus Shao considers it a selfish and mistaken effort to control nature through techniques. These techniques, or *Shu* 術, refer to divinatory practices or numerological arts that pretend to gain personal control upon the world, measuring and quantifying it in a simplistic way. Because of this, Shao considers science to be on the same level as esoteric arts.[27] According to him, the only way to attain an objective apprehension of things is from the point of view of things themselves, which can only be achieved through the "meditative"[28] practices of no-mind (*Wuxin* 无心) and no-idea (*Wuyi* 无意), given that it is through these practices that things do not become individualized or subjective, do not become selves, and rather allow for things to manifest by themselves.

Following this reasoning, it is possible to assert that modern computation, despite being composed by a binary architecture that might mirror a cosmos structured by Yin and Yang, is unmistakably an intellectual product of Enlightenment and Modernist thought. From Shao's perspective, modern computation would be an extension of a deterministic ego, a forceful projection of self and its propensity to delimit and render the world understandable, measurable, and quantifiable. In this sense, one might say that the digital realm is a distortion of the natural world[29] on behalf of the ego. Despite the fact that the digital realm can replicate the natural world

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Yijing," 80.

[26] *Xing* 形 means appearance or form. It is opposed to the elements or the real composition of things, which are those described by the trigrams.

[27] Ryan, "Leibniz' Binary System and Shao Yong's *Yijing*," 80.

[28] These ideas are present in Buddhism and Taoism. However, this meditation is not necessarily the sitting type as it is usually characterized. This meditation can be done while walking, in a mountain or garden, while painting or doing *Taiji Quan* 太極拳 and is based on removing oneself from worry and intention, striving for resonance (*Ganying* 感应) with the surroundings.

[29] In this case, "natural" is translated as *Ziran* 自然, which is composed of *Zi* (self, own) and *Ran* (right, occurrence). In this sense, "natural" does not imply the Western connotation of "nature" as opposed to "culture," but only refers to that which occurs by itself, the naturally unfolding, "acting and behaving according to the self without pretention, or letting things be as they are" (Hui, *The Question Concerning Technology in China*, 64), "the force of the spontaneous self-so"

in a useful manner, it is only in the natural flow and constant transformation of real things that it becomes possible to apprehend the reflection of a world that computes itself without the need of techniques or contraptions. From Shao's view, the world is already computing itself in exchanges that are set in motion by the waning and waxing cycle, in the change of seasons and the mutation of the living, in the constant recalculation of the hexagrams that compose and rule everything there is, in the binary language that encodes reality in a way that does not need to be instrumentalized or entrapped by tools that ignore the true nature of things.

Shao's and Leibniz's thoughts expose how seemingly equivalent cosmological scaffoldings can end up fundamentally different. While binary determinism reads Yin and Yang as an affirmation of a world that can be codified into discrete categories, a careful look at the underlying cosmology reveals the opposite. The non-mutually-exclusive nature of Shao's worldly composition is what allows things to create, change, and interact with each other. Yin and Yang are the fundamental signals that update the self-representation of the system, yet they are not the tools used to shape it as we please. It is in the confluence, juxtaposition, and entanglement of these simultaneously contradictory yet valid statements that things can exist contrary to the deterministic, exclusive, and quantifiable states that underlie the normative conception of computation.

The theories of Shao and Leibniz do not imply that there is no place for technology in Chinese cosmology. On the contrary, many sages and philosophers have maintained that it is through tools, or *Qi* 器, that technology and the cosmos can achieve compatibility. In Chinese cosmology, *Dao* 道 does not designate the cosmos but its fundamental fabric, the structure that enables it. "The way" is the omnipresent principle that resists any description, such as "the supreme order of beings,"[30] "the original harmony of the productive force of the cosmos,"[31] or the natural course of things. More than being the substance of the material and sensible, Dao is

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(Eske Møllgaard, *An Introduction to Daoist Thought: Action, Language, and Ethics in Zhuangzi* [London: Routledge, 2007], 15). This is the intended interpretation of the word "nature" throughout the text, even when not referring to Chinese thought.

[30] Hui, *The Question Concerning Technology in China*, 65.

[31] Hui, 66.

instead an unquantifiable vector of movement,[32] a directionality principle, an order that everything follows. Qi is the technique that "must be compatible with Dao in order to attain its highest standard."[33] This relationship is complementary and inseparable: "Dao needs Qi to carry it in order to be manifested in sensible forms; Qi needs Dao in order to become perfect (in Daoism) or sacred (in Confucianism), since Dao operates a privation of the determination of Qi."[34]

From this perspective, the "natural" and "technological" are not antithetical, but instead, technology is a vehicle for the manifestation of the natural, at the same time that any technology can only be considered complete as long as it abides and behaves according to the principles of nature. A perfect example of this relationship is the story of PaoDing 庖丁, a very talented butcher who, after being praised about his perfect and rhythmic technique to dissect bullocks, replies that "What I love is Tao, which is much more splendid than my skill"[35]—this love is what taught him the way to thrust his knife. As he would always follow this path of intuition, he would never encounter hard tendons or bones, and thus his knife would retain its original sharpness after nineteen years of use, while most butchers would have to sharpen theirs every few months. The artisan relies more on Dao than on the tools at their disposal, and tools reach their optimal functionality when applied in synchrony with Dao. Since Dao is the basis for the movement and development of natural things, a tool that acts in accordance with Dao is a tool that modifies its environment by following the environment's own logic. This complementarity principle between

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[32] This dimension of direction and movement is characteristic of several descriptions of Dao, including those of Zhuangzi when Møllgaard writes: "Things flourish and decay, but the Way, which is the *movement* of this flourishing and decay, does not itself flourish and decay. Things complete and destruct, but the Way, which is the *movement* of this completion and destruction, does not itself complete and destruct. Like Heaven, the Way is the transcendental life that gives life to the living but does not itself live and die." Møllgaard, *An Introduction to Daoist Thought*, 22, emphasis original.

[33] Hui, *The Question Concerning Technology in China*, 65, emphasis removed.

[34] Hui, 101, emphasis removed.

[35] Zhuangzi 庄子, *Zhuangzi: Library of Chinese Classics; Chinese-English*, trans. Wang Rongpei, Qin Xuqing, and Sun Yongchang (Changsha: Hunan People's Publishing House, 1999), 43.

Dao and Qi has had several interpretations across Chinese history, but in general terms it characterized the technological development of classical China. However, in the context of modern technology and information systems or contemporary cybernetics, this harmonic relationship between Qi and Dao has many insights to offer.

Data stored and processed in computers can be seen as an exosomatization[36] of memory, as the exteriorization of abstract thought and sign remembrance from human bodies, and as information processed and archived outside of human brains. Data is a representation of the world, gathered through a sensory layer of artificial nerve endings that translate pressure, light, temperature, and any other quantifiable phenomena into a series of binary symbols. More than being collected, data is produced by particular devices and people with a premeditated goal in mind: a task to fulfill, a form to complete, a description to provide. Far from being neutral, data becomes the organization of a series of signs that can be communicated, recorded, or decoded; it constitutes a common language between different computational systems. As a surrogate of the world, data provides a symbolic representation that is nevertheless very distant from the systems producing it. While it is important to acknowledge the limits of representation, data nonetheless has a capacity that mere human reason cannot achieve: the ability to place a set of nonhuman entities at the center of measurement and interpretation, which can disclose the agency of unaccounted third parties in natural phenomena. Worldviews can alter or obscure readings of data, loudly imposing a noise that renders inaudible the voices produced by events, objects, and living entities. Even so, whenever airborne pollution levels decide which machines operate and which shall stop, or when indicator species give snapshots of the general composition of entire ecosystems and thus inform preservation policy, living and nonliving entities can take decisions that contravene anthropocentric logic or intuition. The free flow of data and its computation could ensure that a system, which both accounts for and represents itself, carries out its functions without encountering obstructions or "hard tendons."

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[36] Exosomatization refers to the production of objects which are analogous to our internal organs, but built and used outside our organic bodies, such as video cameras and our eyes. These external organs are modeled and maintained by human activity. See Maël Montévil, Bernard Stiegler, Giuseppe Longo, Ana Soto, and Carlos Sonnenschein, "Anthropocene, exosomatization and negentropy," in *On Transition: In Response to António Guterres* (Internation, 2020), https://internation.world.

With this new way of enframing reality, we can find brief moments where nonhuman components also participate in the self-representation of the system, subverting the anthropocentric logic of systems based on individuated humans. Within this framework, computational systems, originally built with anthropocentric goals in mind, can be repurposed to incorporate an aggregate plurality of entities. In this proposed scenario, data can be interpreted as Qi, as the tool that reaches its highest standard, a technique that perfects itself as it materializes the path of least resistance and exhaustion, and through which the Dao of material and environmental conditions can become manifest. In this case, Qi encompasses both the "immateriality" of computational protocols, signals, and memory, as well as their physical terminals, such as backhoe excavators, dam floodgates, and oil drilling machinery, etc.

What the extractive and resource-intensive version of computation that is currently hegemonic requires is the inclusion of the compatibility principle between Qi and Dao. This entails designing tools to be used in accordance with Dao, and conceiving of technology that attains its fullest realization when in harmony with planetary conditions and environmental limitations. Insofar as the computational systems and extractivist cycles of capitalism continue to ignore this model of the communion between technique and cosmos, they reinforce a culture of technological "development" that continues to break while accelerating climate change, eroding prematurely just like the knives used by those insensitive to Dao.

Transistor-Less Informatics of Amerindian Thought

The harmony between technology and the composition of the world is analogically present in foundational views of pre-Columbian cultures in the Americas. Several cultures in the pan-Amazonian region have been able to discover that memory, communication, and representation are not characteristics unique to the human being, but rather the commoning element of the multiple beings that populate the cosmos. Just as cosmological thought across China cannot be indisputably generalized as "unified," trying to find a common thought that can identify the hundreds of language groups and creation myths of indigenous tribes throughout the Colombian and pan-Amazonian territories increases the problem by several orders of magnitude. This issue can only be mitigated by treating any comparison as an analogy, and any attempt at generalization as a mere analysis from an outside perspective, carried out with conceptual tools

that are used in an attempt to fill a gap in service of bringing several traditions of thought closer together; generalization as an adaptation made in order to attain a certain degree of understanding.

Amazonian Amerindian thought can be characterized as "systemic" (or behaving in a system-like manner) for two main reasons. First, its notion of continuity shared between human and nonhuman living beings on a spiritual level: plants, animals, and humans are spiritually the same, and the only thing that differentiates them is their appearance. "The common condition to humans and animals is not animality but humanity."[37] When all living entities host their own version of humanity, "everything is human, [and] the human becomes a wholly other thing."[38] The ability to use language, reason, and technology is understood, not as an essential privilege that grants humans absolute dominion over their environment, but as a mere means of representation of the world that implies an intrinsic connection between humans and the thousands of beings who share the forest. Representation, as Eduardo Kohn demonstrates, is not unique nor exceptional but rather the fundamental characteristics that unite living beings as such. In his work with the Ávila and Runa communities in the Ecuadorian Amazon, Kohn argues for leaving behind the idea that humanity is the only species capable of semiotic meaning.[39] "What we share with nonhuman living creatures, then, is not our embodiment, as certain strains of phenomenological approaches would hold, but the fact that we all live with and through signs."[40] People, animals, and plants are conceived according to a similar ontological category: they all share the same attributes of mortality, social and ceremonial life, intention, and intelligence.[41] This principle allows the Barasana tribe to interpret the melody of swallows and sparrows as chants which indicate the proper time to work the *chagra*[42]—or the fall of certain fruits, the

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[37] Eduardo Viveiros de Castro, *Cannibal Metaphysics*, trans. Peter Skafish (2009; Minneapolis: Univocal, 2014), 68, emphasis removed.

[38] Viveiros de Castro, 63.

[39] Eduardo Kohn, *How Forests Think: Towards an Anthropology Beyond the Human* (Berkeley: University of California Press, 2013).

[40] Kohn, 9.

[41] Philippe Descola, *Beyond Nature and Culture*, trans. Janet Lloyd (2005; Chicago: University of Chicago Press, 2013), 8.

[42] "[A] small roadrunner lives in the chagra, a swallow and a hawk guard the crops and the

change of swimming patterns of some fish, and the type of flutter of particular birds as indices that allow several species to foresee the mating season of leaf-cutter ants.[43] Superior pattern recognition is said to be one of the distinctive traits of human sapience. Yet, in a forest, pattern recognition takes place across multiple species. The recognition that all species are capable of producing semiotic systems is essential for a worldview that assumes all living entities as equals, with humans being one among many in this symphony of communication.

The second systemic characteristic of Amerindian thought is the recognition of fractal analogical structures that are to be found in processes at micro and macro cosmological levels.[44] The structure of the cosmos repeats itself at the level of the universe, territory, house, and body. Tukano, Tatuyo, and Itana tribes understand the *maloka*[45] (tribal house) as a projection of all life on the planet, a structure[46] that mirrors the design and distribution of the cosmos at a smaller scale. This is the reason behind the precise orientation and proportion of the maloka building, as it must contain the world symmetrically, since only through this symmetry can the building be

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forest. That hawk guards the Worlds Above, and that is why he sings at 4:30 in the morning: ¡Oah, Oah, Oah!, 'good morning, how is your day my friend, today we are not going to work, today it will not rain, calm down, in order, sharpen and take your machete, women let's clean the chagra, today is a good day.'" Bárbara Santos, *Curación como tecnología: Basado en entrevistas a sabedores de la Amazonía* (Bogotá: Alcaldía de Bogotá, 2019), 52–53. Translation by the author.

[43] Eduardo Kohn, "Natural engagements and Ecological Aesthetics: Among the Ávila Runa of Amazonian Ecuador" (PhD diss., University of Wisconsin-Madison, 2002), 104–5.

[44] "Akin to our scientific thought, the thought of Eastern Tukano ethnicities is grounded on a series of analogies, what we would call fractal analogies in mathematical terms. They use a series of structures and processes at different scales that contain identical organization. And these structures are the human body, the house, the territory, and the cosmos." Santos, *Curación como tecnología*, 79. Translation by the author.

[45] A *maloka* is a multifamily dwelling structure that houses several families, generations, and animals. Its construction and usage is not mundane; during rituals they become mediums through which to access ancient knowledge, as well as the knowledge available in the forest.

[46] This denomination as "artificial" corresponds to the notion of anything produced by humans as external to and in opposition to the "natural." However, this idea has no place in Amerindian cosmologies, given that even their labor, such as agriculture or construction, is constantly performed by spirits (and therefore, natural actions). Also, tools like the axe are part of creation myths, such as those of the Yucuna people.

used as a medium through which to think and connect with all beings during rituals. The fractal representation of the universe contained in objects of sacred and daily use is shared across various ethnicities. It can be found in the biconical Yucuna structure (meant to support sacred beverages during rituals) that represents a universe with identical structure,[47] in the Kogi temples and looms that are oriented according to the trajectory of the sun,[48] and in the spiral weaving of traditional Misak hats that replicate the flux and unfurling of time.[49] Harmony and proportion between artefact and cosmos are not only important as an aesthetic principle, they are fundamental factors that allow a particular device to fulfill its function and enable its ability to access the knowledge and thought process of the world. Tools are isomorphic with the cosmos because they are contained within and produced by it, while humans are merely their incidental manufacturers.

The link between indigenous thought and informatics becomes evident in the interviews

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[47] "The world is also represented symbolically, the biconical support known in Yucuna as *umichiripucueste* is an artefact that corresponds to what they now called the black hole in physics; it is a balanced piece that is used to keep balance in the use of nature. The [thought] bench is used to manage the world in interaction with all the other benches; this means that we are the whole and we are a part, and by managing each part well, the whole is managed well." Carlos Rodríguez, "Áreas protegidas y visiones interculturales: conociendo nuestra biodiversidad," II Congreso colombiano de áreas protegidas, Parques Nacionales Naturales de Colombia (2014; report 2015): 1–85, here 40–41. Translation by the author.

[48] "The light ray goes from one stove to the other in between solstices, but every day advances very slowly from north to south, according to the inclination of the sun. This movement has led to a concept of great importance for kogi thought, namely, the idea that the *sun is a big weaver*. They envision the earth as a giant loom around which the sun moves in a spiraled and swaying motion." Gerardo Reichel-Dolmatoff, "Templos Kogi: Introducción al simbolismo y a la astronomía del espacio sagrado," *Revista Colombiana de Antropología* 19 (July 1975): 199–245, here 221, emphasis original. Translation by the author.

[49] "The *kuarimpoto* or *tampal kuari* is the traditional hat of the misak people. Is made from a band that is woven in spiral shape, synthesizing their notion of spiraled time and space. For the misak, history repeats itself at the same time it changes, *turning itself around*. Likewise, people are tied by an *ancestry thread*, one that *unfurls* circularly, tracing the path of everyone's life." Wall text for *kuarimpoto*, Cod. ICANH 538-E – Instituto Colombiano de Antropología e Historia, in *Ser Territorio* (*Being Territory*), part of the permanent collection exhibition of Museo Nacional de Colombia, Bogotá, 2019–ongoing. Translation by the author, emphasis original.

published in *Curación como tecnología* (Healing as technology) by Bárbara Santos. In the book, Tarsicio Vanegas from the Itana tribe compares digital technologies with healing practices: "A feather is a very special sacred material; for the outside world is a simple feather, but for us is like a folder inside a computer, the feather provides the light that illuminates my thought, that guides me where I want to go."[50] In another analogy, he compares the techniques and sciences related to the study and diets followed by a *kumu* (knower, healer, spiritual leader) in order to heal or prevent disease, to the process by which a programmer creates an antivirus.[51] Perhaps only now that Western technology has developed distributed systems which refine and specialize through evolution, can the Western mindset be closer to understanding the similitude between technical objects and natural processes, and as a result, get closer to understanding some of the fundamental ideas of non-Western cosmologies. In this sense, Vanegas's metaphors are not mere narrative resources that allow him to explain his thoughts to a foreign public.

From this perspective, one can acknowledge how minerals fulfill identical roles in both binary and Amazonian computation. Gold and quartz are crucial components in measuring time and conducting electrical impulses as data in computers, and are found in every recording device. These minerals are also crucial to the preservation of memory in Amazonian cultures, and fundamental to the process of healing the world. Although for this healing to work, the minerals must remain buried in their place of origin, without exploitation or refinement, so that the healer can activate the energy they emanate. Davi Kopenawa from the Yanomami ethnicity says, "the gold makes *xawara*. *Xawara* is a disease. Gold creates a disease to harm people. Omama [Yanomami creator deity] considered that gold should remain kept under the ground, beneath the earth."[52] These underground mineral concentrations determine sacred places within the forest, hubs from where energy and knowledge can be drawn. Instead of extracting them physically, their properties are accessed through "sacred materials," the fruits of the sacred ground: tobacco,

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[50] Santos, *Curación como tecnología*, 56–57. Translation by the author.

[51] Santos, 57.

[52] Davi Kopenawa, interview during a book presentation of *A queda do céu* at the Festa Literária Internacional de Paraty in Rio de Janeiro, 2014. Author's notes and translation. Davi Kopenawa and Bruce Albert, *A queda do céu: Palavras de um xamã yanomami*, trans. Beatriz Perrone-Moisés (Rio de Janeiro: Companhia das Letras, 2015).

coca leaf, cassava, nettle, and breast milk.[53] These are activated by generational knowledge, by the tales, stories, and invocations that connect living practices to a place. It is through living layers of knowledge that the materials become interfaces between the energy exuded from the sacred places and the wise who can curate them.

An analogous technical process to how the kumu identifies the appropriate *yagé* (ayahuasca) visions that guide healing practices would be the functional similarity of a TCP/IP protocol. This protocol, widely used on the Internet, ensures that if at any level (application, transport, network, data link, or physical) there is an authentication mismatch between the sender and receiver of information, the data packet will be discarded or otherwise delivered when every data level match is fulfilled. When explaining the healing process, León Muipu mentions:

> […] I had a vision of yagé, and that vision is what later appears again when healing. It gives you the explanation, it tells you where the diseases originate, how you should speak, and how your soul or you as a living person makes that flow in a spiritual world linking with the other person, so that you can prevent or heal the disease.[54]

To transcribe the above case in the language of a TCP/IP protocol, the protocol becomes Muipu himself, whose work authenticates the correct signals form the yagé server, matching it with the right procedure in the face of the disease, inhabiting the healing body, and guiding the disease to its conclusion with himself as vehicle. Tarsicio Vanegas expands the understanding of visions caused by yagé as the quintessential interface between the kumu and the vast knowledge available in the forest:

> With knowledge achieved through yagé, the kumu goes around the planet, turns around, turns around knowing what is happening and in a single vision everything is recorded, he never forgets it. With that vision, the kumu analyzes through symbols and data to determine what is that information useful for, if for healing, for protecting the children, for dancing. And you must close it in

[53] Santos, *Curación como tecnología*, 82.

[54] Jesús León Muipu, interviewed in Santos, 38. Translation by the author.

the end, to prevent viruses from coming in.[55]

This knowledge points to an understanding of technology that does not necessarily consist of artefacts, that does not lie in the recipients who are treated by sacred plants nor in the materiality of the tobacco, but in an immaterial technology that is manifested during the act or performance of healing itself. Healing the body implies healing the forest, and neither of these actions can be accomplished without the technical object being treated as a living object as well. The forest is both home, mother, and data center; a network of networks, one that contains a myriad of terminals and users, that reads and writes information as part of its metabolism, that apprehends and represents itself with each interaction, that seeks its own continuity and homeostasis. From this perspective, one might begin to understand how traditional Amerindian thought is intrinsically cybernetic. It is telematic without the need of transistors or antennas. It requires energy in the shape of sacred materials and is only enabled by the links, servers, protocols, interfaces, and terminals that are provided by the rivers, animals, plants, and metabolic cycles of the forest.

The lessons of Amerindian thought are harder to translate into contemporary information systems than the principles of Qi and Dao. Some, such as Roy Ascott, have advocated for the use of the telematic abilities of yagé in cybernetics, for the merger of vegetal and virtual reality in the so called "Moist environment, located at the convergence of the digital, biological and spiritual, […]."[56] Others propose the development of wetware computation, biocomputation, or phytoindication in cybernetic systems to include forests either as signaling nodes or as processing units. However, to interpret the metaphors presented here as design principles for revamped extractive technologies would be contrary to the reality of their practice. Amazonian telepathy only works when alive and situated, while "Western telepathy, at its core, is an extractive telepathy."[57] Plugging the forest's interests into the data and geoengineering stack could result in protection and preservation of the forest, while it could also result in extractivist encroachment in the Amazon. In the eyes of many, plugging in the forest could not address the

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[55] Tarsicio Vanegas, interviewed in Santos, 59. Translation by the author, emphasis removed.

[56] Roy Ascott (ed.), "Edge-Life: technoetic structures and moist media," in *Art, Technology, Consciousness: mind@large* (Bristol: Intellect Books, 2000), 4.

[57] Juan Pablo Pacheco Bejarano, "Telepathy without the internet" (2020), 4.

fundamental design problem that extractivist infrastructure is predicated on: the industrial complex cannot unmake the problems brought about by industrial design itself. As pointed out by Dupont, transforming the forest into an extension of sensing tech cannot resolve the problem that an already objectified infrastructure presents.[58] Instead of merely instrumentalizing Amerindian knowledge in the Western context, it should be understood as a parallel operating system that comes from, runs on, and is also part of the world. These cosmotechnical models offer an alternative path for mediating thoughts and environment with available tools, all of which will be crucial for planetary ecological regeneration.

[58] Julian Dupont, "Convertirse en Jaguar Como la Nube Automatizada" (master's thesis, Universidad Autónoma Indígena Intercultural, Bogotá, 2021), 63.

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