INTRODUCTION — CODING AS LITERACY

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“Je préfère une tête bien faite à une tête bien pleine.”
[I prefer a well-made head to an empty head]

Michel de Montaigne

In a recent article entitled “Quantum Words for a Quantum World” we find a reminder of a remarkable scene in Alfred Hitchcock’s movie *Torn Curtain* (1966), which tells a story of spying and science. It features a scene where two physicists confront one another on some theoretical question. Their “discussion,” the author of the article suggests, “consists solely in one of them writing some equations on the blackboard, only to have the other angrily grabbing the eraser and wiping out the formulas to write new ones of his own, etc., without ever uttering a single word.”[1] This picture of theoretical physics as an aphasic knowledge entirely consisting of mathematical symbols may

1 Jean-Marc Lévy-Leblond, “Quantum Words for a Quantum World” (pp. 1–18), lecture held at the Institute Vienna Circle, “Epistemological & Experimental Perspectives on Quantum Physics,” Vienna, September 1998. Draft manuscript accessed online on www.academia.net (March 21, 2015).

be very common in popular representations, the author maintains, but “we know [it] to be wrong […] and we have to acknowledge that, far from being mute, we are a very talkative kind; physics is made out of words.”[2] Of course, there is some distance between architectural theory and theoretical physics. However, insofar as contemporary architecture encompasses both engineering and design that is aided by computers, as implied by the name of our discipline, Computer Aided Architectural Design (CAAD), the two fields occupy a closer contextual relationship than might at first be apparent. The software environments provided to assist architectural design all provide their formulas and formulaic elements, neatly packaged into a clothing we know from drama and theater: we have “stages,” “casts,” “behaviors,” “properties,” and “actions” all prefabricated (formulated) in code. The as-yet, brief history of these environments proceeds in paths of greater and greater generality of those “formulaic elements” and they do so according to several different paradigms; a major one being the approximation of a unified system within which all the governing factors in the construction of spatial form and organization can be combined and put into accord with the greatest possible liberties—greatest possible thereby referring to the smooth mechanization of how the system as a whole can be operated.

Two predominant examples that follow this paradigm are the Building Information Models (BIM), as well as Parametricism; the former follows this paradigm by establishing a kind of a “semantic ontology” pyramid-like structure that can grow in “greatness” only from that which can be built with the elements that provide the base; the latter suggests that instead of a pyramid we have a dynamic apparatus, in which the hierarchical organization between classifications remains unsettled. A system as a dynamic apparatus can grow in “greatness” not only in one direction (the height of the pyramid), but in any direction because its organization is structural, not semantic. It provides a receptive environment for new elements that might be specified and added, its systematicity exists through its capacity to correlate the other elements in the system to the newcomers. We can perhaps say that BIM and Parametricism are committed to one and the same idea—to harness the power of a great system—but according to different modalities: the former in the modality that values increase of efficiency in general, the latter valuing increase of efficiency in and according to particular situations. In other registers, while the latter clearly stresses a “radical” economization of architecture, the former suggests a “planned” one.

Another strong paradigm in the short history of these provided environments, in which architecture and design are “aided” by computers, can be seen in the discretization and distribution of the kind of knowledge that goes into the “greatness” of the unified systems in

2 Ibid.

the abovementioned paradigm. Rather than establishing a systematicity through introducing a "general equivalency principle" (measurement devices or frameworks that govern either the "identity" of any "unit" classification in BIM, or a meta-metrics that arranges competing magnitudes solely according to the specified, singular, and locally pragmatic goal of the system in parametrics), this paradigm is instead interested in developing grammars and syntaxes that would be capable of affording the greatest possible scope of expression for the plays that are performed on the stages provided by computational environments for designing, modeling, and planning. Examples here would be Space Syntax, Shape Grammars, Christopher Alexander's Pattern Language, but also Rhino's Grasshopper, ESRI's City Engine, Logo, Processing, and others. This paradigm is also committed to a rationalization of the formulaic. It uses quantitative empirical methods to analyze contexts according to their syntactic, grammatical, pattern-based schemata such that "reality itself" can inform the kind of architecture computers "aid" one to design and build.

We can easily imagine how representatives of these paradigms, exposed to competition both between each other as well as internally, stand in front of the blackboard in Hitchcock's movie and behave just like the physicists do: writing and erasing formulas, without speaking a word, but instead calling certain objectivities to the stand as "witnesses" for the "correctness" of their evaluation of the problem. Despite their aphasic behavior, the author of our text knows that physicists are a very talkative kind, and in very comparable manner, designers, engineers, and planners know that they too are a very talkative kind. Is it not to withdraw, at least to some degree, from precisely this querulent talkativeness that they take a step back and revert to equipping formula in code with greatest possible capacity to provide coexistence, consensus, common sense, between the disputing parties and all the stakes that are entailed in the problems at hand? We are convinced that this withdrawal can only be successful in relaxing tensions and confrontations if, instead of trying to find a lowest common denominator and a least common multiple (an englobing reference matrix), we regard such "frameworks" as "ciphers" (place-value systems) that establish a "code" (an algebra), and the code as being constituted by "alphabets" (finite ordered sets of elements). Like this, we can formulate locally concrete materially-categorically articulated universals. This means that it crucially depends upon a speculative mode of thinking that is both non-anthropological and non-cosmological insofar as it discredits any particular model of the Human or the Cosmos. But at the same time, the mode of thinking sought thereby must be logical, cosmic, and humane. We regard quantum physics, with its challenges regarding (among many more) the local/global distinction, as the empirical grounds capable of informing such a mode of thinking.

The scene in Hitchcock's movie represents a larger interest in the article from which it is taken, and it does so in our interest in this book as well. It addresses the problem of how we can learn to develop a quantum-understanding of our quantum-world that is capable of integrating the effort-demanding backgrounds into the very language that organizes such an understanding—even if the "technical vocabulary" is apparently so very detached from "concrete" reality. We say "apparently" because we all use electronic devices on a daily basis—we are used to photographs, recordings of music, washing machines, elevators, street lights, online shops, and e-mail, while also relying on body scans, blood scans, and x-ray scans with regard to our health. We fly across the planet and we are frightened by the simulations that simultaneously place a certain responsibility for the health of the planet in our hands; in short, we use computers on a daily basis for all kinds of purposes. Hence, the "reality" of quantum physics is not all that abstract, we actually live quite comfortably—but also quite "ignorantly"—in all the new manners of inhabiting places that it affords. It is only when we try to address these circumstances in words, when we try to reflect and be critical, when we try to take responsibility for how we act by questioning ways of how to proceed—in short, when we want to consider possibilities—that we find ourselves to be in trouble. We therefore revert to a vocabulary that feels trustworthy because it is already established, an englobed matrix of "plain" speech—a matrix that depicts vectors, however one that has been in use by scientists for over a century. If it seems "plain" now, it is only because it had time to settle down and sink in the modes of thinking that establish "common sense."

> Indeed, most of the classical terms he[3] seems to take for granted as having a clear meaning, were introduced in physics during the nineteenth century and certainly did not belong to ordinary speech. Consider for instance 'energy'—a term foreign to the language of Newton: the very concept was not clarified before the middle of the last century, and the word was certainly not used in common parlance, as it has come to be in the past decades. A stronger argument yet could be made around 'entropy'. Even the apparently elementary idea of 'potential,' although formally introduced by Laplace for gravitation and Poisson for electricity, was named only later on by Green, and at the end of the century was still considered as very abstract and introduced in academic courses with much caution.[4]

The argument of Jean-Marc Lévy-Leblond is quite straightforward: we need quantum words for a quantum world as much as we needed dynamic

3 Niels Bohr, with his demand that all statements referring to the quantum world must be couched in classical language in order to make sense with respect to our common experience.—V. B.

4 Lévy-Leblond, "Quantum Words for a Quantum World," pp. 4–5.

and electric words for a dynamic, electromagnetic world. If we are inclined to object now to something along the lines of: *but is a quantum world not a dynamic, electro-magnetic world, full of potentials from which have been and can be extracted all the possibilities modern science and engineering have realized during the past one hundred years and is going to realize in the future?*—then we are certainly in good company with many who would share this point of view. But this is exactly the problem. It stands behind our aphasic and harsh shielding-off from querulous discussions by fashioning particular formulas in apparently "neutral" code as if they were just what we have always known—plain speech. Ultimately, Lévy-Leblond is convinced, and we share this view:

> Quantum theory eventually is not more discrete or continuous than classical theory; it is only much more subtle as to the interplay of continuity and discreteness, for both these notations now relate to the same (quantum) entities instead of bearing upon different ones (classical waves or particles).[5]

So then, the question we posed in the conference (whose contributions are collected in this volume) regard a new kind of "literacy" a literacy in coding, we suggested, a literacy that overcomes the machine-operator distinction just as it overcomes the distinction between intelligence "proper" ("human" or "natural") and intelligence "artificial." While recourse to a notion of "literacy" is often discarded today because it apparently holds on to the problematic (anthropocentric) notion of some genuinely "human" and "cultural" subject vis-à-vis some genuinely "natural" object, we think it is a dangerous short circuit if we attempted to rid ourselves of that legacy. Rather, we want to listen to and understand what that novel language that—despite all the abovementioned difficulties—has emerged in the past decades can tell us. We want to take seriously that it applies the jargon of theater and drama to the setups of computational modeling environments, and we want to take seriously that it refers to the particular codes applied as "alphabets." We want to take seriously that probabilistic analysis analyzes 'fictions' and that such fictions are not spelled out between two book covers but are depicted in snapshots of assumed spectra (of light, of flavor, or any kinds of intensities among properties) that can be "measured" only in the circuitous terms of "frequencies" and "phases." By tentatively trying to comprehend code as an abstraction and a generalization of the classical understanding of the phonetic alphabet as a geometry of voiced (articulated) sound,[6] we want to explore the idea of seeing in code a

5 Ibid., 12.
6 We regard Eric Havelock's study on how to account for (and even only how to take note of) the relatively sudden leap in abstraction that was thought and formulated not only into words but also into novel ways of reasoning in ancient Greece as an invaluable source of reference that the development of such an analogy could draw from. See Eric Havelock, *Preface to Plato* (1961).

geometry of spectrality. It is clear that this spells out a bill of exchange larger than can be answered with this book. It nevertheless reveals the horizon toward which our ambitions strive, and we hope at least quickens a broader interest in this idea.

The book collects its contributions from information scientists, mathematicians, philosophers, design-culture theorists, and architects that attended the 5th Metalithicum Colloquy held at the Werner Oechslin Library in Einsiedeln, Switzerland, from May 22 to 24, 2014. The overall theme of the conference was to consider computational procedures beyond a strictly case-based analytical paradigm, and instead as embedded in a more comprehensive "computation literacy." The main item of reference for the discussions was one particular procedure called Self-Organizing Maps (SOM) in relation to data-driven modeling. Regarding SOM as receptive to a form of skill or mastership (*ein Können*, as we would say in German) that allows for many degrees of sophistication, exposes within it significant inherent capacities that seem as yet to be largely unexplored. On a more speculative level, our reference point was to attempt thinking of the "data" in data-driven modeling within quantum-physical terms. Despite the diversity of the backgrounds and expertises brought together, it turns out that there is a common thread that runs through the contributions: namely a quest for terms that afford the projective, fictitious, and yet measurable articulation of a "common ground" for example, according to information as a multiplicative notion; transferable structures and geometrical kinds; pre-specific models that feed from and grow specific in their distinctive character in the environment of data streams; categorially measured and articulated concept maps; how modeling conceptual spaces can contribute to achieve clarity regarding the possibility and conditions of intersubjectivity between different concept spaces; architectonic ichnography, and the grammatical case of a cryptographical locative that renders the locus of fiction measurable according to the discernment of a plot that is being narrated in a story. The articles are introduced below according to their order of appearance in the book.

Teuvo Kohonen is an information scientist and the inventor of the SOM algorithm. Due to health reasons and his age, he was not able to join the colloquy in person. However, he generously contributed a short introduction to our book about what the SOM algorithm can do, and how it has evolved since its inception some thirty years ago.

Ludger Hovestadt, architect and information scientist, considers in his article "Elements of a Digital Architecture" geometry as "the rationalization of thought patterns amid known elements."[7] He develops the provocative suggestion that we should, on the one hand, distance ourselves from the idea that there is only one "true" geometry, while, on

7 Ludger Hovestadt, "Elements of a Digital Architecture," page 34 in this volume.

the other hand, also distancing ourselves from claiming recognition for the plethora of "new geometries" as they are today being delineated, e.g. projective, affine, convergent, Euclidean, Non-Euclidean … For Euclid as well as for Félix Klein, geometry originates in "encryptive" and "algebraic" thinking and brings about a geometric manner of thinking only on that very basis. Hence it is to computational code that we must look to find a new geometry, one that can accommodate in a new manner all the classical concepts and distinctions that make up knowledge as knowledge, including architecture as architecture (rather than architecture as design or engineering or science or art). The text is an epic poem written in computational meter that works like a sudoku.

Sha Xin Wei, mathematician, artist, and philosopher, delineates in his article "A Non-anthropocentric Approach to Apperception" an a-perspectival mode of apperception that does not presume any particular model of a human perceiver. His point of reference thereby is a discussion of how models of computer vision are conceived in machine learning. Drafting a transversal lineage between Edmund Husserl's phenomenology, Jean Petitôt's interest in regarding qualities as extension in discrete notions of time and space, and Gilbert Simondon's conception of the individuation process, he develops his own approach to conceive "information" as a multiplicative notion, according to which we can embrace abstraction by deploying mathematical concepts without aiming at the production of representations that are supposed to describe reality. Rather, a multiplicative notion of information allows one to see in abstraction, modes of material articulation. For him, quantum mechanics "articulates the profound observational inextricability of the states of the observer, the observed, and the apparatus of observation."[8] With this he formulates a "fiber-bundle mode of articulation" in which we have a "non-ego-based, number-free, and metric-free account of experience that respects evidence of continuous lived experience but does not reduce to sense perception or ego-centered experience."[9]

Vahid Moosavi, a systems engineer and information scientist, in his article entitled "Pre-Specific Modeling. Computational Modeling in a Coexistence of Concrete Universals and Data Streams" criticizes as well what he calls " idealization in modeling."[10] Moosavi distinguishes different modeling paradigms that he regards, each in its own right, as a pair of glasses that impact the way in which we encode the real world. The paradigms he discusses are Computing Power, Computational and Communicational Networks, and Data Streams. With regard to the latter, he proposes a mode of modeling that he calls "pre-specific." According to this mode, one doesn't select a set of properties to represent the object

8 Sha Xin Wei, "A Nonanthropocentric Approach to Apperception," page 130 in this volume.
9 Ibid.
10 Vahid Moosavi, "Pre-Specific Modeling," page 132 in this volume.

in an exhibited manner, discrete and decoupled from the object's environment. Rather, given a plurality of coexisting data streams we can depict our object in the totality of the connectivity we see it to be entangled in; that is, in the conceivable relations it maintains to other objects. Moosavi thereby introduces a manner of modeling that conceives of an instance (the "object" of a model) as the implicit complement to the totality of all those properties one can negate. Thereby, the real world instance depicted by the model is regarded by the model itself as infinitely richer than any representation that it could yield.

Andre Skupin is a geographer and an information visualization expert. He is one of the pioneers in the application of SOM in geographical and spatial analysis. In addition to spatial analysis, in many of his previous works he establishes a kind of interface between geographical maps and the final maps of SOM in the form of abstract landscapes. By this he can transfer the language of geography into many classically non-geographical domains, such as creating a semantic landscape of Last.fm music folksonomy.[11] In his contribution in this book, Skupin analyzed the scientific literature dealing with self-organizing maps, based on more than four thousand papers ranging from Teuvo Kohonen's well-cited paper from 1990 up to papers that will appear in 2015. The titles and abstracts of these texts underwent a series of computational transformations, with the aim to uncover latent themes in this field of literature. The SOM-based visualization he contributed to this book highlights one rendering of this process. The result can be understood as one version of a kind of "base map" of the SOM knowledge domain.

Elias Zafiris, a mathematician and theoretical physicist, considers in his article "The Nature of Local/Global Distinctions, Group Actions and Phases: A Sheaf-Theoretic Approach to Quantum Geometric Spectrums," the limits of observation as a theoretical paradigm. The local/global distinction in quantum mechanics is of a topological nature and does not involve any preexisting set-theoretic space-time background of embedding events. Observation is based on measurement, and Zafiris suggests that rather than holding on to the idea that a particular measurement can represent space in a homogenous and englobing manner, we can obtain topological spaces via the practice of measurements. Such a topological space counts as the geometric spectrum of the particular algebra underlying the measurement. This is how he sees "observability" being constituted together with "operability": the same geometrical form can be manifested in many different ways or assume multiple concrete realizations. Zafiris suggests to speak of "geometrical kinds" that incorporate the distinction between "the actual

11 Joseph Biberstine, Russell J. Duhon, Katy Börner, Elisha Hardy, and André Skupin, "A Semantic Landscape of the Last.fm Music Folksonomy using a Self-Organizing Map" (2010), published online: http://info.slis.indiana.edu/~katy/research/10-Last.fm.pdf.

and what is potentially possible."[12] Yet crucially, such geometrical kinds can still be considered in terms of geometric equivalence; the space *where* they are equivalent, however, is one of projections, fictions, a quantum regime.

Barbara Hammer is an information scientist and mathematician. In her article "Self Organizing Maps and Learning Vector Quantization for Complex Data" she discusses different paradigms in the field of machine learning and data analysis that distinguish themselves from each other by different approaches of how learning vectors can be quantized. Thereby, Hammer discusses the limits of the common practice of relying on the Euclidean distance measure for decomposing the data space into clusters or classes. Her point of interest is how to deal with situations where electronic data cannot easily, and without imposing theoretical bias, be converted to vectors of a fixed dimensionality: biological sequence data, biological networks, scientific-texts analysis, functional data such as spectra, data incorporating temporal dependencies such as EEG, time series, among others. Here, data is not represented in terms of fixed-dimensional vectors, but rather dimensionalities are phrased in terms of data structures such as sequences, tree structures, or graphs. She considers how prototype techniques might be extended to more general data structures.

Michael Epperson is a philosopher. Together with Elias Zafiris he has developed the philosophical program of a Relational Realism, whose central point of departure is that in quantum mechanics the conditionalization of probabilities (the "reasoning" of probabilities) requires a rule that depicts the evaluation of quantum observables as a fundamentally asymmetrical relational process. Outcome states yielded by quantum mechanical measurement are not merely revealed subsequent to measurement, he explains, but rather generated consequent of measurement.[13] Epperson discusses in his article "The Common Sense of Quantum Theory: Exploring the Internal Relational Structure of Self-Organization in Nature" the limits of a globalized "Boolean"—bivalent—logics within a classical paradigm that assumes that all observables possess well-defined values at all times, regardless of whether they are measured or not. However in quantum mechanics, probability not only presupposes actuality, but actuality also presupposes probability. This yields a mutually implicative relation between form and fact, fact being "evaluated observables." Quantum theory cannot solve the philosophical problem of predicating totalities, but what it can specify, he argues, is an always mutually implicative relation between global and local, such that neither can be abstracted from the other.

12 Elias Zafiris, "The Nature of Local/Global Distinctions, Group Actions, and Phases," page 172 in this volume.
13 Michael Epperson, "The Common Sense of Quantum Theory," page 214 in this volume.

Timo Honkola is an information scientist. In his coauthored article "GICA: Grounded Intersubjective Concept Analysis. A Method for Improved Research, Communication, and Participation" he introduces a method quantifying subjectivity that recognizes that even if different people may use the same word for some phenomenon, this does not mean that the conceptualization underlying the word usage is the same: "In fact, the sameness at the level of names may hide significant differences at the level of concepts."[14] The GICA method uses SOM to model conceptual spaces that are built upon geometrical structures based on a number of quality dimensions. Such modeling can distinguish and articulate in explicit form (1) subjective conceptual spaces, and (2) intersubjectivity in conceptual spaces.

Vera Bühlmann, media philosopher and semiotician, presents in her article "Ichnography—The Nude and Its Model. The Alphabetic Absolute, and Storytelling in the Grammatical Case of the Cryptographical Locative" different modes of how the ominous "all" can be plotted as "comprehension" via narrative, calculation, and measurement. Her interest thereby regards how the apparent "Real Time" induced by the logistical infrastructures established by communicational media becomes articulable once we regard "Light Speed" as the tense proper to spectral modes of depicting the real in its material instantaneity. The "real" in such depiction features as essentially arcane, and its articulation as cryptographical. The articulation of the real thereby takes the form of contracts. Bühlmann suggests to take cryptography at face value, i.e. as a "graphism" and "script," whose (cipher) texts she imagines to be signed according to a logics of public key signatures: while the alphabets that constitute such a script are strictly public, a cipher text's "graphism" cannot be read (deciphered and discerned) without "signing" it in the terms of a private key. This perspective opposes the common view that we are living in "post-alphabetical" times, and instead considers the idea of an "alphabetic absolute." It bears the possibility for a novel humanism, based not on the "book" (Scriptures) but on the laws of things themselves. The article traces and puts into profile classical positions on the role of "script" in mathematics, the possibility of a general and/or universal mathesis, the role of measurement in relation to conceptions of "nature" e.g. by Descartes, Leibniz, Dedekind, Cantor, Noether, Mach.

Furthermore, we don't want to introduce this book without mentioning especially the work of Klaus Wassermann on Self-Organizing Maps. It is his way of thinking about them that raised our interest in this particular algorithm in the first place, and we have drawn much inspiration and insight from his blog *The Putnam Program|Language & Brains, Machines and Minds* (https://theputnamprogram.wordpress.com).

14 Timo Honkola, "GICA: Grounded Intersubjective Concept Analysis," page 236 in this volume.