Cryptographic Rewriting across Domains

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From the discovery of the Anthropocene, and the consequent decentring of humans, to the rapid diffusion of novel forms of rationality represented by Machine Learning (ML) methods, or the exploration of radio waves as in the Radio Explorations project, the present condition of all creative disciplines continuously confronts domains that escape human senses and cognitive abilities. The apprehension of these beyond-human domains relies on the implementation of technological prostheses, be it in the form of algorithms or physical devices. In all these instances, the recurrent issue at stake is the development of instruments and theoretical frameworks to orchestrate communication and exchange across domains. This chapter focuses on the evolution and significance of instruments and ideas in the field of computation, a domain that through the invention of abstract signs and operations has been developing a rich history of techniques dealing with what lies beyond both the perceptible, and, as we shall see, the intelligible.

The branch of computation that has been specifically tasked with the translation of signals or messages between domains is cryptography. The history of cryptography, in fact, provides a vast repertoire of techniques whose application impacted several fields and that will constitute

the central focus of this discussion. Though we will briefly survey some methods developed to safely transmit diplomatic secrets, the aim of the discussion is to think cryptography in broader terms, that is, to unpack how a series of abstract and arbitrary operations can resonate with and foreground aspects of complex, beyond-human phenomena. I will concentrate on architecture and urbanism (my area of research) as, with the penetration of machine learning methods in this field, a series of issues have come to the fore that benefit from being discussed through the lenses of cryptography. The aim of this discussion is to foreground a way of thinking about exchanges between domains that could also be relevant to grasping what issues and opportunities could characterise the *Radio Explorations* project.

In wider and more theoretical terms, cryptography in fact is a discipline that conjures up methods to create communication channels between what is inaccessible (noisy, in information theory parlance) and what is intelligible (and therefore amenable to manipulations). In the hands of philosophers such as Ramon Llull or Francis Bacon, cryptographic methods became bridges between what 'there is' (nature, in classical terms) and what can be created (in contemporary computational parlance, cryptography had 'generative' qualities). To devise the right cypher (the actual bridge between two or more domains) had the wonderous ability to let nature speak (Bacon) or a whole metaphysical system to reveal itself (Llull). Thought of along these lines, cryptography can be seen, as I will argue, as an object of design that can be conceived, tuned, and played with in order to move a certain domain in and out of intelligibility. As such, the theme is relevant to the Radio Explorations project as part of the issues dealing with radio signals also involves thinking how the inaccessible can be interfaced by humans, how an eminently non-human domain should be approached for it to speak, and what implications to creative processes it could have. The construction of notational systems to deal with abstraction and creativity and the individuation of a balance between prescriptive and aleatory procedures are some of the themes along which cryptography can provide fruitful insights for design and artistic endeavours as it deals with forms of rationality that are not human.

No matter which historical period we concentrate on, cryptography remains a central tenet of computation. Besides the preservation of diplomatic secrets, cryptography was also understood as a key, a cypher, to unlock nature's secrets. Today, one of the most powerful operations Machine Learning (ML) methods enable is to extract functions (cyphers) from heterogeneous sets of data and, perhaps even more remarkably, project cyphers onto any other dataset, teasing out potential correlations.

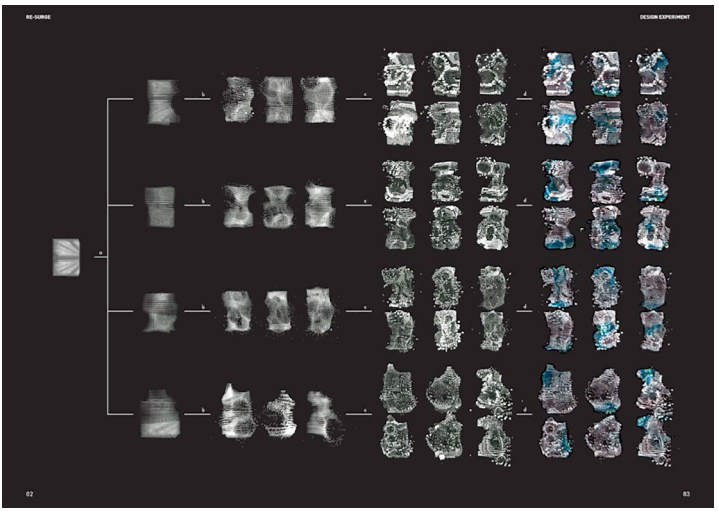
To give specificity to the arguments put forward, the discussion will focus on architecture and will briefly conclude by describing some of the projects developed within the Master in Urban Design which I direct at the Bartlett School of Architecture in London. The approach proposed here is also consistent with what is put forward in *Digital Architecture beyond Computers,*[1] which proposed a massively expanded historical perspective in order to grasp what is at stake when designing with computers, one in which the technical operations enabled by computation constitute the 'materials' digital designers need to think through.

The arguments presented in this chapter broadly divide into two parts. Each part is distinct as it addresses different historical moments and technological conditions, with no like-for-like comparison between the two being suggested. The first section outlines some paradigmatic conditions that emerged from the introduction of Machine Learning (ML) models in design disciplines. This part is firmly anchored in the present and, rather than dwelling on the technical aspects of ML, it concentrates on how ML models are changing design culture. The second segment focuses on the late Middle Ages and Renaissance when notational systems emerged in cryptography to affect fields as diverse as architecture, mathematics, and writing. The common thread linking these two distant moments in the history of cultural production is the role that cryptographic methods played. Designing with ML models demands a continuous exchange with systems that operate outside the

1 Roberto Bottazzi, *Digital Architecture beyond Computers: Fragments of a Cultural History of Computational Design* (London New York Oxford: Bloomsbury Visual Arts, 2018).

limits of human cognition. Operations of retrieval, translation, and rewriting are constantly performed to make intelligible the abstract space of massive data organised by automated algorithmic processes. These operations have been fairly common for cryptographers. The comparison between the present and early modern condition is obviously not literal, rather it exploits the distance in time to widen our perspective on the present. Cryptography is here understood as a paradigm; that is as a "single element within a set."[2]

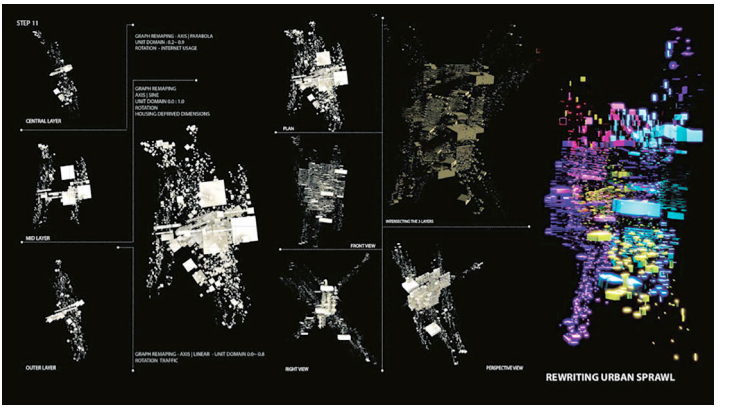
Figure 1: Rewriting. ReSurge (Abdimajid Aden, Su Keyu, Yubin Liao, Mohammed Puthiyaveettil, Zhou Zhou), Research Cluster 14 2019/20, B-Pro MArch Urban Design, The Bartlett, UCL.



Courtesy of Roberto Bottazzi

2 Thomas S. Kuhn, *The Structure of Scientific Revolutions*, Second Edition, Enlarged (Chicago: University of Chicago Press, 1970).

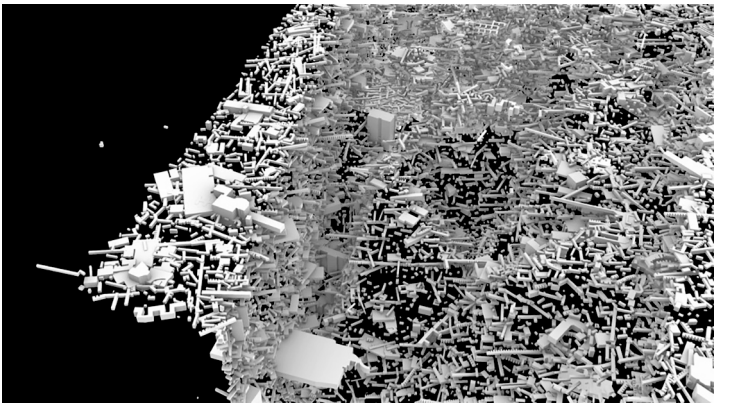
Figure 2: Rewriting. Flora Amritt, Research Cluster 14 2020/21, B-Pro MArch Urban Design, The Bartlett, UCL.



Courtesy of Roberto Bottazzi

Seen through the lenses of paradigms, cryptography is explored both ontologically and epistemologically. In the first case, cryptography helps identify a series of experiments in different fields such as philosophy, art, and language that resonate with present design issues. Secondly, by considering the examples chosen as a part of a single set, cryptography provides a new angle through which to read them. Therefore, the essay should not be read as a manual, a piece of technical literature, a complete account of what either ML models or cryptography are, and, even less so, as a ready-made design methodology to deploy. The essay juxtaposes cryptography and ML models so that, despite their obvious differences, common themes and concerns can resonate one another. This is the task of the conclusive part which draws out some final considerations that, whilst having first emerged some six or more centuries ago, could be useful to reconsider in the current debate on ML and design and in *Radio Explorations* project.

Figure 3: Rewriting. Halfway between data visualizations and spatial compositions, rewritings are design exercises through which students develop a technical and aesthetic literacy towards working with large databases. Alankrita Amarnath, Research Cluster 14 2020/21, B-Pro MArch Urban Design, The Bartlett, UCL.



Courtesy of Roberto Bottazzi

On the introduction of machine learning models in design

There are two aspects of computation, in general, and Machine Learning, in particular, that are useful to foreground to define the argument of this paper.

First, computation can be thought of as an infrastructure to move signals between domains. Jean-Michel Salanskis pointed out that the fundamentals of modern computation, as laid out in close succession by Gödel, Turing and Church, did not constitute an exact language.[3] Each method proposed different approaches to computation, so much so that they could only be compared at a schematic level. More importantly for

3 Jean-Michel Salanskis, *Le monde du computationnel*, À présent (Paris: Les Belles Lettres, 2011).

this discussion, Salanskis contends that what unified all three methods was the focus on establishing syntactical rules which allowed them to function whilst bypassing semantic questions. In other words, the three computational procedures formalized an 'infrastructure' of calculation; that is, they prescribed *how* signals could be transmitted, not *what*. ML algorithms such as classification algorithms constantly reorganize input data by compressing or expanding them or by seeking correlations. In doing so, they move signals between domains based on statistical distributions that bypass issues of meaning. At the same time, they encrypt and decrypt data to extract relevant features assimilating the work of the designer to that of a curator that oversees these operations of compression and organisation.

Furthermore, some ML algorithms, such as the ones used for classification, allow designers to project datasets onto each other; that is, to remap a particular set of data onto a different one. This capacity of ML algorithms has genuinely radical implications for design as it allows designers to consider and work with domains and themes that have traditionally been intractable to design. The curatorial and infrastructural aspects of design become even more relevant in this context. In urban design, this shift opens up the possibility to work with aspects of cities that have not been traditionally considered by urbanists as well as simultaneously focusing on how functional, material, temporal aspects of city life interact. Issues of compression, translation, remapping and rewriting can be enriched by thinking of them through the lenses of cryptography. To think of data compression and projectability in infrastructural terms allows us to shift the focus away from single aspects of the city towards connectivity, and, consequently, framing the problems in terms that could also be useful for the analysis and representation of radio signals.

The second point concerns the relationship between intelligibility and representation that is at the core of both cryptographic and ML methods. Again, it is useful to frame the argument from an historical perspective as it offers a richer context to map out the discussion whilst giving a better sense of the scale of the disruption presented by the introduction of ML models in design. In very schematic terms, we

could broadly define the history of the epistemology of representation by three areas. The first one is characterised by reduction: the task of representation is to reduce the complexity of signs that make up our world in order to foreground new insights. This is, for instance, what maps perform through the depiction of selective aspects of reality. We could say that the greater the compression, the better the map (that is, more legible, more specific, etc.). The second phase is that of approximation. Once we accept that representation is a compression of reality, we can work towards reducing the gap between the two in order to generate 'high-fidelity' renditions of reality. This intellectual project had an enormous traction for several centuries across the whole of Europe.[4] In this group we could include the search for so-called perfect languages (whose development was also influenced by cryptography) or encyclopaedias which introduced the format of the open list to approximate as closely as possible the distance between knowledge and its classification. ML models usher in a new phase in which representation exceeds reality. Though ML models are trained on data coming from reality, they perform many mathematical and statistical operations that massively increase the complexity of the representation of the initial datasets. Tangible examples of this phenomenon abound. Though never fully confirmed, it is rumoured that each Facebook user is described by 52,000 types of data.[5] A hypothetical spreadsheet of all Facebook users would therefore consist of 2.96 billion rows (approximate number of Facebook users at the time of writing) and 52,000 columns or dimensions. Beside the impossibility for human cognition to navigate such a vast data space, it is plausible to imagine that the parameters do not represent sensory qualities of each user or even intelligible ones. More recently, Open AI's ChatGTP-3 model processes training data through

4 Paolo Rossi, *Clavis Universalis. Arti Mnemoniche E Logica Combinatoria Da Lullo A Leibniz* (Milano; Napoli: Riccardo Ricciardi editore, 1960).

5 Green, A. (2018). "Facebook's 52,000 data points on each person reveal something shocking about its future". Available at: https://www.komando.com/social-media/facebooks-52000-data-points-on-each-person-reveal-something-shocking-about-its-future/489188/ (accessed on 20.03.2023).

175 billion parameters. Again, cryptographic thinking and techniques can be useful to problematize these technologies and think of working with them as issues of translation of signals between domains, between reality and representation and between humans and machines. As Salanskis noticed, questions of meaning are irrelevant to procedural calculations. This new 'infrastructural' condition is what gives rise to a new paradigm of representation that we are seeking to problematize in this discussion.

Cryptography and machine learning

The branch of computation has historically been tasked with the translations of signals between domains of cryptography. The cryptographic paradigm is also useful as ML models can solve very complex tasks (well beyond what humans can achieve) without availing themselves of any elements that we have associated with human intelligence. So, rather than dwelling on whether a computer is more or less intelligent than a human (an irrelevant question as both conditions are true), we should recognise the emergence of a different type of rationality and establish methods to communicate and interact with it; hence, the focus on cryptography.

Foregrounding the infrastructural condition of computation leads us to focus more on the connection between different domains and how they can be interacted with. These observations shift the focus from identity (form) to communication (infrastructure). The introduction of ML models in design has reinforced such a condition: ML models are proving to be incredibly effective in managing unprecedented amounts of complexity, be it about working across scales, timelines, or disciplines. In this new condition, form decreases its importance to make room for organization and curation based on mathematics and statistics. Though the field this piece is preoccupied with is urban design, these observations can be extended to radio signals and communication. To think of the relation between design and ML models through the lenses of cryptography not only provides a novel perspective, but it also mobilizes a set of computational techniques and ideas that have

a very central place in the history of computation and yet have been overlooked. The first element to consider is that cryptography firmly places us outside anthropocentrism and the temptation of considering ML methods in relation to human intelligence. Cryptographic problems are animated by mathematical, logical, and semiotic concerns which clearly distance them from psychological or anthropocentric ones. Secondly, the particular examples from the history of cryptography will show how they operated relationally. Relationality can be understood in two ways: first, as we shall see, early cryptographic methods intersected many fields ranging from mathematics to language and philosophy. Also, cryptography can also be defined as the art of finding relations across different domains: namely, the encrypted text (ciphertext) and decrypted one (plaintext).

These points also help move the conversation on ML models beyond purely technical concerns characterized by functionality and optimization to include cultural ones. To progress the understanding and applicability of technical instruments it is often more fruitful to shift our point of view; that is, to widen the frame of reference rather than narrowing it down. To do so, we ought to develop a literacy for ML models in design: again, not so much focus on the actual ability to master ML methods, but rather on providing a historical (what place ML methods occupy in the history of representation techniques) and a conceptual framework to operate within (which fields and knowledge are useful to mobilize).

We will explore the cultural dimension of cryptography by focusing on a specific moment in its history: the early Renaissance and the emergence of non-mimetic cryptographic methods. This transformation will also involve Leon Battista Alberti whose contribution to architecture included, amongst many things, the conceptualization of notational drawings (in addition to representational ones). Notational drawings like cryptographic methods lack mimetic qualities: they do not employ iconic signs (in the sense that Peirce defined them) and, consequently, require encoding and decoding. Once again, notions of literacy, translation, and mathematics are at work enabling architectural representation to avail of properties that had pertained to cryptographic methods.

Figure 4: Diagram of Leon Battista Alberti's cipher as described in the De Cifris (1466).

Courtesy of Roberto Bottazzi

Figure 5: Diagram of Ramon Llull's wheels as his Ars (1283–1308).

Courtesy of Roberto Bottazzi

Early cryptographic methods and notational representation

First, we should understand cryptography beyond its use in diplomacy where it had been used to transmit cables and preserve secrets. We are rather drawn to cryptography because of the rich series of techniques deployed when confronted with beyond-human conditions. Framed along these lines, cryptographic techniques initiate a process to mobilize and elicit the emergence of knowledge in a non-mimetic fashion, that is, by solely availing of mathematical and logical means. On these premises, therefore, cryptography resonates with the kind of issues arising from engaging with the classification and translation of radio signals or ML methods in design as they both deal with signals that lie beyond our immediate sensorial perception and challenge what can be intelligible. The bridge between these different domains is the cipher: the actual instrument which tunes plaintext and ciphertext.[6]

6 Roberto Bottazzi, "Crypto Architecture: Notes on Machine Learning and Design," in *Ghosts of Transparency: Shadows Cast and Shadows Cast Out*, ed. Michael

Ciphers can be understood as infrastructural elements that bridge between domains. The etymology of the word 'cipher' derives from the French *chiffre,* denoting 'the arithmetical sign for zero', which in turn descends from the Arabic *sifr* and the Hindu *sunya* 'zero, empty, nothing'. In identifying the empty set and consequently the 'zero' sign, ciphers reorder different domains. Brian Rotman showed how the introduction of the 'zero' sign in Western culture (which also took place in the Renaissance) reconfigured disciplines as different as mathematics, finance, and art.[7] Ciphers are artefacts, they are designed objects, that is, the rationale to account for their mechanics needs to be invented. Such mechanics will have to negotiate between syntactic rigour and semantic intelligibility. A cipher may not signify in itself, but it makes a whole domain speak; that is, its infrastructural qualities are the means by which we can appreciate it. Ciphers have had an important role in history of philosophy, art, and computation as they were part of the techniques developed in the quest for the mechanization of thought and its augmentation to venture into beyond-human domains. Thought of along these lines, ciphers were popular intellectual and practical instruments that intrigued many thinkers in different periods (from Ramon Llull to Francis Bacon, Gottfried Leibniz, and Michel Serres)[8] and cultures (though not the main focus of this essay, there is an equally rich literature on Middle Eastern and Asian ciphers and their influence on European cryptographers).[9]

The Renaissance is often a misunderstood historical period as well as largely neglected from the point of view of computation. If Eugenio Battisti's *Antirinascimento*[10] challenged the image of harmony and balance associated with it, more research still needs to be carried out to grasp its

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R. Doyle, Selena Savić, and Vera Bühlmann (Birkhäuser, 2019), https://www.degruyter.com/document/doi/10.1515/9783035619171-002/html.

7 Brian Rotman, *Signifying Nothing: The Semiotics of Zero*, Language, Discourse, Society (Houndmills, Basingstoke, Hampshire; London: Macmillan Press, 1987.

8 Michel Serres, *Hominescence* (Paris: Edition Le Pommier, 2001).

9 For instance, the King Faisal Center for Research on Arabic Origins of Cryptography located in Riyadh tasked to collect all the majors works on cryptography in the Arabic region.

10 Eugenio Battisti, *L'antirinascimento* (Milano: Feltrinelli, 1962).

relevance in the history of computation. To best appreciate the innovations that the Renaissance helped develop in the field of cryptography, we ought to take a step back and consider cryptography in the Middle Ages. Most cryptographic methods prior to the late Middle Ages were still relying on mimetic representations by utilizing visual images as ciphers. Though not technically a cryptographic method, the visually stunning *De Laudibus Sanctae Crucis* (810–814) by Rabanus Maurus already featured an overlay of letters and figurative and ornamental elements to encrypt his poems.[11] His work exhibited a complex relation between text and images indicative of a different sensibility. The proto-computational work of Ramon Llull constituted a significant turning point in the evolution and application of cryptography. Llull's tasked notational representation and cryptography to articulate its metaphysics: by spinning a series of concentric wheels with engraved letters (from *b* to *k*), the user would obtain strings of letters that could be decoded with the help of Llull's own charts, de facto giving rise to a semantics. The whole system as explained in Llull's *Ars* (from 1283 to 1308) replaced entirely any reliance on images in favour of a non-mimetic (notational) form of encryption/decryption that provided access to the order of the universe. Llull's ambitions were far greater than perfecting cryptographic techniques. His machines could reveal the hidden order of the cosmos beyond its potentially deceiving appearances. Though using a limited number of signals in form of letters, Llull's wheels already encountered what in computation is termed a combinatorial explosion. This is the computational phenomenon describing the exponential growth of possible combinations generated by a comparatively small set of signals.[12] As a result of it, the computational system quickly stepped into beyond-human domains

11 Katherine E. Ellison and Susan M. Kim, eds., *A Material History of Medieval and Early Modern Ciphers: Cryptography and the History of Literacy* (New York, NY: Routledge, 2020).

12 Daintith, J. and Wright, E., eds. (2008). Combinatorial explosion. In: *A Dictionary of Computing*, 6th ed. [online] Oxford: Oxford University Press. Available at: https://www-oxfordreference-com.libproxy.ucl.ac.uk/view/10.1093/acref/9780199234004.001.0001/acref-9780199234004-e-857?rskey=LRpMhl&result=959 (accessed 18.03.2023).

for which Llull had limited instruments or desire to manage. Llull's response was to eliminate all combinations which could potentially contradict the initial assumption of his metaphysics which was premised on the superiority of the Christian doctrine. Leibniz, who showed great interest in Llull's wheels, disappointingly noticed that curbing the number of possible combinations contradicted the potential of the very method adopted. Llull did not set up a system for searching, for venturing outside what was known or understood; rather, his proto-computational wheels were a verification device, a way to mechanically prove a thesis that had already been predetermined.

Leon Battista Alberti's *De componendis cifris* (1466) also made use of concentric wheels (very similar to Llull's) for his cryptographic method. More sophisticated than any method known at the time, Alberti's cryptography was polyalphabetic: that is, it made uses of multiple ciphers that changed numerous times throughout the encoding/decoding process. Particular alignments of the concentric wheels would provide a cipher for substituting letters in the ciphertext (or encrypt the plaintext). The problems caused by combinatorial explosion were even more pronounced than in Llull's system as every time the cipher changed, the size of the combinatorial space of all possible combinations also exponentially increased. On the one hand, the system immediately ventured into a territory that exceeded human capacities (a useful quality for a cryptographic method); on the other, mathematics became the only instrument to navigate the vast space of signals combinations and to make intelligible and, as we shall see, perceptible the abstract domain of encrypted signals. Notational systems also opened new ways of thinking that Alberti could take to art, whilst philosophers, such as Francis Bacon, would task cryptography to decrypt the Book of Nature. Notational systems no longer pertained to mimetic representation and allowed designers to design with the artificial. Notation allowed artists to implement the combinatorial methods of cryptography that the emergence of mobile characters printing had also made materially visible.[13] Alberti used a simi-

13 Quinn DuPont, "The Printing Press and Cryptography: Alberti and the Dawn of the Notational Epoch," in *A Material History of Medieval and Early Modern Ciphers:*

lar device as the one illustrated in the *De Cifris*, albeit in a modified version, to survey the city of Rome[14] or the human body as he explained in his treatise on sculpture *De Statua*. Through operations of translation, substitution, and rewriting, ciphers generated intelligible sets of signals out of random ones (and vice versa). Such operations relied on syntactical rigour to establish a meaningful relation between noise, intelligibility, and perceptibility. Though manipulation of signals did not belong to mimetic representations, the outputs produced by the wheels did give letters an aesthetic quality, which also contributed to making them amenable to further transformations. The aesthetic dimensions of the cryptographic methods work of both Alberti and Llull is also detectable in the way in which letters, charts, and devices are presented in the actual manuscripts.

As we have seen the adoption of cryptographic methods based on notation distanced representation from the mimetic tradition and embraced mathematics as an orientation instrument. These two conditions were explored further by Pico della Mirandola, the famous Renaissance philosopher, who conceived them as instruments for surveying uncharted domains: a sort of literacy for the unknown. It is along these lines that it is useful to approach our final example, as Pico della Mirandola is not usually evoked in discussions on cryptography or computation. However, his last work, the *Heptatlus* (1489) which focused on a philosophical account of the creation, is relevant to this discussion as his combinatorial logic bridged between domains in a way that is analogous to cryptography methods. Pico did know Llull's work on combinatorial logic which he had dubbed *revolutio alphabetaria*, once again highlighting the relation between notation and language. However, whilst Llull's letters had only a symbolic value as the actual elements to be manipulated was the content of his metaphysics, Pico,

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Cryptography and the History of Literacy, ed. Katherine E. Ellison and Susan M. Kim (New York, NY: Routledge, 2020), 95–117

14 Leon Batista Alberti, *Descriptio Urbis Romae*, trans. Mario Carpo and Martine Furno, Cahiers d'Humanisme et Renaissance 56 (Genève: Droz, 1999)

who was much closer to the cabbalistic tradition, thought of combinatorial logic as applicable to the substance of expression, that is, to the actual letters without referring to secondary meanings. Umberto Eco observed that Pico's approach could no longer be described as an *ars combinandi* but rather as an *ars inveniendi*, that is, a generative system. Whereas in the former system combinatorial logic offered innumerable ways to reach the same, predetermined conclusions, in Pico, letters were rigorously combined to search for a truth that was yet unknown.[15] Eco drew attention to a passage of the *Heptatlus* in which Pico "launches in the most uninhibited permutational and anagrammatical operations" to manipulate the words of the *Bereishit*.[16] Pico finally exploited the

15 Umberto Eco, *From the Tree to the Labyrinth: Historical Studies on the Sign and Interpretation*, trans. Anthony Oldcorn (Cambridge, Massachusetts: Harvard University Press, 2014).

16 The precise passage quoted by Eco is: "Applying the rules of the ancients to the first phrase of the work, which is read *Beresit* by the Hebrews and "In the beginning" by us, I wanted to see whether I too could bring to light something worth knowing. Beyond my hope and expectation I found what I myself did not believe as I found it, and what others will not believe easily: the whole plan of the creation of the world and of all things in it disclosed and explained in that one phrase. Among the Hebrews, this phrase is written thus: בראשיח , *berescith*. From this, if we join the third letter to the first, comes the word אב , *ab*. If we add the second to the doubled first, we get בד ב, *bebar*. If we read all except the first, we get ית ראש, *resith*. If we connect the fourth to the first and last, we get שבת, *sciabat*. If we take the first three in the order in which they come, we get רא כ, *bara*. If, leaving out the first, we take the next three, we get אש ר, *rosc*. If, leaving out the first and second, we take the two following, we get , אש, *es*. If, leaving out the first three, we join the fourth to the last, we get ,שת, *seth*. Again, if we join the second to the first, we get רב , *rab*. If after the third we set the fifth and fourth, we get יש א, *hisc*. If we join the first two to the last two, we get ית בר, *berith*. If we add the last to the first, we get the twelfth and last word, which is תב , *thob*, the *thau* being changed into the letter *thet*, which is very common in Hebrew. Let us see first what these words mean in Latin, then what mysteries of all nature they reveal to those not ignorant of philosophy. *Ab* means "the father"; *bebar* "in the son" and "through the son" (for the prefix *beth* means both); resit, "the beginning"; *sabath*, "the rest and end"; *bara*, "created"; *rosc*, "head"; *es*, "fire"; *seth*, "foundation"; *rab*, "of the great"; *hisc*,

full potential of combinatorial logic and notational representation. In doing so, we begin to appreciate what the project of cryptography and computational literacy implies. Eco noticed that with Pico "… we pass from the idea of man as subject to the laws of the cosmos to that of a man who constructs and reconstructs without fear of the vertigo of the possible, fully accepting its risk."[17]

Working across domains

Several aspects of this short overview of Renaissance cryptography can resonate with our contemporary condition vis-à-vis designing with ML models. Cryptography is in fact syntactical and algorithmic and requires the presence of a grammar robust enough to be shared by both sender and receiver. By extension, similar operations can be performed on visual documents such as drawings or computer renderings, whose signs can be manipulated and generated through algorithmic operation, as in the case of mathematical perspective. Cryptographic techniques work across domains and are instrumental to seek intelligibility where one can only see noise. ML models not only work across domains, but the recent emergence of cross-modal ML models provides much wider range of inputs and outputs superseding the distinctions between different fields.

The exchange between mathematical operations and visual representation is also an important aspect that is at work in both ML design and cryptography. Here the work of Sybille Krämer helps us structure this relationship in order to expose the sensuous side of mathematics

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"of the man"; *berit*, "with a pact"; *thob*, "with good." If we fit the whole passage together following this order, it will read like this:
"The father, in the Son and through the Son, the beginning and end or rest, created the head, the fire, and the foundation of the great man with a good pact." This whole passage results from taking apart and putting together that first word." *Ibid.*, p. 412. Giovanni Pico della Mirandola, "Heptaplus," in *On the Dignity of Man, On Being and the One, Heptaplus*, trans. Douglas Carmicheal (Indianapolis: Bobbs-Merril, 1965). pp. 171–172.

17 Eco, *From the Tree to the Labyrinth*, p 414.

and, conversely, the intellectual aspect of visual representation.[18] In challenging the assumption that "computation is a nonsensual kind of operation,"[19] Krämer identifies three moments in which mathematics and visual representation intersect to offer us three trajectories along which to articulate the relation between cryptography, ML models and design. The first one concerns the relation between imagination and intuition. When performing mathematical operations, such as the decryption and encryption of strings of signals, visualizations should not be relegated to *after* having understood or resolved the problem; they would merely be illustrative gestures. Rather, visualizing aspects of mathematical problems is part of the instrumentation necessary to trigger intuition and imagination and, in turn, to make strings of signals intelligible and solvable. The sensual and visual dimension that drawing in the past or computer visualizations today adds to algorithmic operations is an essential step to navigating complex and abstract domains of cryptography or the latent space generated by ML models. Visual operations such as data visualizations are necessary to move from the particular to the general or to foreground specific aspects of the data analysed. The second aspect highlighted by Krämer is that of perception. Here the use of visual operations to translate between different data domains and media is essential to getting accustomed to the abstract space of ML models and beginning to develop a design sensibility towards it. Finally, Krämer foregrounds the role the symbolic representation can have in generalizing knowledge. In discussing Descartes' work, she uses the examples of algebraic notation as a generalizing system that makes all quantifiable objects comparable to each other and therefore computable. These considerations can be extended to the cryptographic examples we surveyed in which ciphers were the instruments through which signals moved across domains and could be made amenable to further manipulations. In ML design classification,

18 Sybille Krämer, "Mathematizing Power, Formalization, and the Diagrammatical Mind or: What Does 'Computation' Mean?," *Philosophy & Technology* 27, no. 3 (September 1, 2014): 345–57, https://doi.org/10.1007/s13347-012-0094-3.

19 Ibid., p.345.

algorithms perform analogue operations allowing for the projection of datasets onto each other and the expansion of the remit of what can be analysed and designed. By simultaneously playing with mathematical and artistic conventions, cryptography offers a material approach to abstract, intellectual problems that resonate with the ones designers are confronted with when designing with ML methods. The examples from cryptography and literature we discussed showed a playful relationship between mathematical operations and visual and material artefacts. They charged the physical act of writing or combining symbols with the possibility to launch a bridge towards what cannot be perceptible.

Finally, the examples from cryptography all required the intervention of humans. Early modern literature on cryptography did emphasize the importance of intuition and agility. After all, the whole idea of cryptography is to present humans with "situations… in which traditional rules of behaviour, or even the typical choice of tools, no longer applied."[20] Working with ML models, or radio signals, is also characterized by a breakdown in communication resulting from the innovation that a new technology introduced. Intuition, agility, dexterity are useful skills to make use of in order to orient ourselves in a new context. They are not purely intellectual skills, rather, they are hybrid, since moving between software, code, renderings, and models necessitates different sensibilities.

Cryptography is essentially relational. Deciphering messages requires constructing a network of relations between disparate signals through different instruments. Crypted strings of signals remain meaningless until the identification of the right grammar will begin to return intelligible messages. Again, these are operations that not only resonate with those developed by linguists and artists, but also with ML models. The emphasis this paper puts on the cultural dimension of ML stresses the importance of framing ML models within a broader, diverse, and sophisticated cultural milieu. To think of design as a series of operations to let data speak and to embed it in the long tradition of cultural tech-

20 Ellison and Kim, *A Material History of Medieval and Early Modern Ciphers*, p 18.

niques developed to deal with unknown domains is both a promising and exciting prospect for ML methods in design.

Discussion

Selena Savić: This resonates with some of the problems we are encountering, namely the fact that radio is in a domain beyond our sensory and cognitive capacities and that the recordings of the signals we work with do not mean anything to us. What and how can we know about them? Framing things as 'search' opens quite an interesting, if rather obvious, realization about the extent to which combinatorics of search determine what you can know. The same applies vice versa too. The search results themselves get organized through search. Both directions of searching for and having found organize that which we know.

Roberto Bottazzi: Search is very easily understood as an open search when perhaps it is not. This is implicit in graphs, for example. When we speak of graphs in a historical context, we often speak of search too. The graph itself always implies some sort of pre-existence of the nodes. This notion of search needs to be problematized.

Selena Savić: Another important thing is your notion of cryptography as a way to establish communication. How can one establish communication between the domain of human knowledge and radio signals? We know that radio signals are happening in a purely technical domain, broadcast by antennas somewhere in the world and received by other antennas to be decoded by electronics or software. Radio signals are intentionally encoded on carrier waves, as part of human telecommunication activities. It is about bringing together aspects of technology being in the environment and being instrumental to our exchanges, as highlighted by Sarah Grant, with the way to understand that which is already there through abstraction and cryptographic movement across the data that is always partial, but also always complete.

Miro Roman: The stories about ways to classify knowledge are very relevant to the discussion on computation, big data and machine intelligence today. I fully agree with you on the level of cryptography. Could you expand on the kind of knowledge they were trying to classify? I think there is a difference in scope between the earlier work with memory palace and Camillo's Theatre. A memory palace would be a kind of a personalized algorithm while the theatre would be an algorithm searching for the underlying structure. If we were to apply the logic of Facebook and their databases, in principle, we would not care about underlying structures. Some of them even do not care to classify knowledge: they 'just work' with knowledge to produce new correlations. With Shannon or Markov, on the other hand, it is about the mechanics of knowledge rather than classifying or ordering.

Roberto Bottazzi: We could exclude Llull's wheels as they would not serve particularly well in this kind of conversation. In terms of the scope of these experiments, Pico della Mirandola's poems are no longer about knowledge within a predetermined scope, but an opening to the generation of new kinds of knowledge. More contemporary projects of search are naturally very different in scope. The problem of meaning gets totally removed here. Markov and Shannon deal with knowledge on a purely mechanical level, and it does not need to mean anything. In the older examples that I showed, the starting point and the body of knowledge had to be meaningful, which is perhaps the largest difference. A way to continue the conversation today could be to remove any kind of criteria, any parameter. Anything becomes possible. The experiments I discussed are interesting because they try to reason about some sort of commonality. If you destroy commonality, there is no knowledge either. It is knowledge that has to have a public face. It has to be shared, otherwise it is just my opinion. It is not a form of knowledge. This is a big political question today.

Here I would like to introduce a thought that comes from Massimo Cacciari.[21] If we were to contextualize the work of Pico della Mirandola work within the Renaissance, the argument Cacciari makes is that his efforts emerge out of the desire to find a form of publicness, of shared communication between the three major religions that surround the Mediterranean. The reason for this is that the late 15th century was a period of incredible difficulties to establish this form of communication. It is also the period when a truly multicultural Europe ended with the Expulsion of the Moriscos from Spain. Pico makes use of Kabbalistic methods and combinatorial logic within his project. These techniques are integral to the project of searching for a plan for peace that is grounded on philosophy. He was aware that if he would have grounded such a project in politics, it would have to result in war. But if it is indeed possible to argue philosophically, it turns entirely into a problem of interpreting and exchanging between different kinds of cultures. Pico della Mirandola was one of the few people in Florence that mastered Latin, Greek, and Hebrew, he could speak all three of them. And the reason was that if literacy were the first step towards peace, you would have to be able to speak the other's language in order to strike a philosophical plateau on which to confront differences, which goes into the 900 theses that Pico wanted to discuss with the Pope. I think mediation speaks towards them in a deeper, or bigger motivations that animate this kind of work.

21 Palazzo Ducale (2015). "Massimo Cacciari Oration de hominis dignitate di Pico della Mirandola. Available at: https://www.youtube.com/watch?v=DvMzSK8anHQ&t=3863s (accessed on 16.03.2023).