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Abstract

Learning Algorithms and Computed Space

The penetration of Machine Learning algorithms [ML] in many aspects of our lives has become one of the central themes of our present time. From security, to cryptography and, more recently creative disciplines, the transformation is both profound and lasting. ML algorithms are often praised for their efficiency in sifting through large datasets and their unprecedented – for a computer, that is – ability to predict and even 'learn' from input material. Although the power of efficiency cannot be overlooked, especially for practical purposes; this feature alone is not sufficient to grasp the penetration of ML in design disciplines, and, more importantly, it will not help to conceptualise how ML algorithm could impact design. Such endeavour will require to move beyond the mantra of efficiency to map out the broader range of disciplines and ideas that informed the development of some of the most promising algorithmic procedures employed in design. The purpose of the following considerations is part of an ongoing research that aims at establishing a fruitful and innovative relationship between learning algorithms and architectural discourse and, in so doing, redefine the theoretical framework accompanying such relationship.

This paper will begin by looking at the historical sources that have underpinned the emergence of learning algorithms to foreground what ideas of knowledge, organisation, and distribution that explicitly or implicitly promoted. Such critical overview will provide a context to better speculate what impact learning algorithm can have on architecture and urbanism.

On the Theory of Learning algorithms

As the debate on the impact of the digital in all aspects of society keeps evolving, so does the importance of developing a critical analysis of its main components and paradigms. In order to open up the discussion on the impact of digital technologies beyond a specialised audience, the digital is often compared to a language, particularly the communicational aspect of it, which in digital technologies combines the possibility of simultaneous exchange, at global scale between different media. Luciano Floridi points out that out the three main characters of languages, the communicative one has often attracted scholars' interest at the cost of side-lining the other two aspects: the conceptual and constructive [Floridi 2020]. The digital is also a generative language which is able to give rise to its objects and remap existing ones. Allegedly both characteristics exceed the ability of providing a medium for communication and demand the theoretical debate to go beyond the domain of media studies to move across several disciplines. ML algorithms are no exception to this general observation and the sustained emphasis on efficiency does not help to locate the conversation in a more fertile milieu. The architecture of learning algorithms not only provides to redescribe a given realirty (represented in a dataset), but it also shapes it, or better, re-conceptualises it to generate novel configurations. Beyond discussions on the disciplinary boundaries of the digital, it is the very mechanics, or, to put it better, materiality of the digital that needs to be scrutinised as it will reveal a rich landscape of ideas in which notions of playfulness and intuition can be reformulated rather than abandoned in favour of efficiency.

Part of the issue stems from the very field of Artificial Intelligence [AI] in which ML algorithms – effectively a subset of AI – offered the promise to simulate cognitive processes. The rich literature on this subject objects little to the use of brains as analogical and metaphorical models for the design of algorithms, but it is a lot more hesitant to claim that such algorithms can literally describe what intelligence is. As such there is little gain in thinking of learning algorithms as replicas or seamless extensions of human faculties. Such misalignment is mostly generated by the limited vocabulary we employ as words such as intelligence, intuition, etc. are indiscriminately used to account for either human or computational actions. This confusion is however rather recent as, for instance, in Leibniz's writings there was already an awareness of not only of the gap between machines and human intelligence, but also of the possibility to exploit machines to take care of the "inhuman quality of calculation" (Goldestine 1980, p.9). Additionally, Leibniz also gave machines an epistemological agency by positing "his very pregnant idea that the machine could be used for testing hypothesis" (ibid, p.9). More recently, as Noam Chomsky's often remarks, Alan Turing's famous paper on machine intelligence did unequivocally clarify that the question whether machines can think was "too meaningless to deserve discussion" [Turing 1950, p.442]. It is by now a well-trodden observation that the Turing Test focused on the performative aspects of intelligence, steering clear of providing any strict definition of intelligence which would also have implied certainty about the functioning of cognitive processes. In Turing's opinion words such as intelligence could only be used metaphorically rather than factually. In other words, computation does not perfectly remap onto human cognition, leaving only a marginal overlap, a space where the communication between the two domains occurs. The issue is therefore not so much to categorically establish whether a computer is intelligent – a task that anyway greatly exceeds the ambition of this paper – but rather to establish a communication channel between human and machining intelligence, a mutual cooperation which can impact architectural discourse.

A more fruitful avenue to begin to grasp how ML algorithms work and, therefore, what kind agency it has could emerge by approaching this subject through the field of cryptography. In this field we always deal with two domains: that of the encrypted code – the crypted message – and human language. The former is always 'alien', incomprehensible by definition – that is, without semantic value – and can only be made to converse with the human domain through a key or cypher – a decoding mechanics which needs to be designed. The origins of cryptography are deep and rich of mathematical ideas which have been extensively covered by scholarly research. Perhaps, less understood is their influence (amongst other important mathematics concepts) on the emergence of learning algorithms. The core of this junction is in the work of Andrej Markov and Claude Shannon in applying mathematical knowledge to encoding and decoding problems. Whether applied to text or binary strings, in both instances we see the emergence of different type of rationality, one that is fully grounded in mathematics and yet lacks – at least at its point of inception – semantic qualities. The repercussions of this work are profound not only because it informed many of the procedures employed by learning algorithms, but also because it fundamentally 'flattens' computation, turning a vast domain of phenomena amenable to mathematical treatment and, from our prospective, to design. We speak of flattening both on a technical and conceptual sense. With Markov and Shannon the transformation that had turned language into code took a decisive step further by becoming numerical and therefore treatable through statistical operations. With the demonstration of Godel's incompleteness theorem and, consequently the development of the Turing Machine, both information and logical operations would be translated into numbers. The possibility to express through numbers both data and operations not only does away any hierarchy between the two, but also vastly expands the domain of operations that can be computed. It is central here the notion of universality as stated by Turing in outlining his abstract machine. The Turing Machine can simulate any computable algorithm therefore flattens any apparent difference between algorithms and, therefore, can called universal. Conceptually, the work of the two scientists further withered any hierarchical organisation which privileged humans over machines, or living organisms over the inanimate computers. By dislodging a certain view of anthropocentrism, computation could expand and eventually engage with phenomena which had been considered impossible to automate such as the organisation and the transmission of language.

On Computed Space

The paradigm shift operated by the introduction of information as a domain controlled by mathematics – and therefore computable – has further reinforced the emergence of post-humanism and the consequent offsetting of the centrality of humankind. Abstraction has been playing a central role in this shift as an essential ingredient to significantly widen the range of computable objects and flatten the distinctions between them as described above. Abstract operations have met with suspicion by the architects and designers whose training by definition focuses on applied, visual, and intuitive knowledge. These issues are all the more relevant now as learning algorithms confront us with even more abstract operations which, as in the case of unsupervised learning, do not seem to match the mental steps we take to apprehend information. However, a closer look at the relation between computation and design returns a more nuanced and complex picture in which abstraction and implementation, logic and intuition are not mutually exclusive but rather inform one another.

Design methods can be seen as translators or, better, cyphers to articulate the relation between the abstracted domain of learning algorithms and that of spatial design. Design in this context can be strictly defined as problem of dimensionality reduction in which not only the computed, but also other issues traditionally informing a piece of design are held together in a productive tension. The work of Sybille Kramer on this subject provides a fruitful insight on the relation between science and design defined as the "concretion through visualisation and spatialization of theoretical entities and abstract "epistemic entities" (Kramer, p. 347). Design processes are therefore understood as a form of operative re-writing establishing a communication channel between statistical abstractions and spatial articulations. This form of re-writing can be explored along the three main vectors that Kramer identifies as connecting abstract and intuitive domains in mathematics and computation. First, the visual-spatial axis in which internal numerical relations need to acquire external agency sufficiently complex to activate an exchange with other design preoccupations. Secondly, the tension between symbolism and technique in which technical operations gain ability to describe more than themselves. Finally, the operation-interpretation vector thanks to which the abstraction of calculations becomes an instrument of "cognition and knowledge generation when it refers to the domains of epistemic objects" (Kramer, ibid., p. 349). The coupling of numerical and interpretative models is an open act of design and, as such, should be understood as part of the design process.

Beyond the indexical nature of these design processes, the notion of operative re-writing sketches out an initial method to probe large datasets, an object whose abstraction and complexity greatly exceeds that of human cognition. Here we can see a point of contact between such design protocols and the statistical treatment of data opened up with Markov and, subsequently, Shannon as we see rigorous syntactical operations without a corresponding semantical meaning. Design operations in the context of learning algorithms short-circuit the relation between the symbolic and physical aspects of language [traditionally represented by the symbol and the index]. Dimensionality reduction algorithms necessarily employed to navigate in the multi-dimensional data space to slice it into manageable constructs. This design process has no definitive beginning or end, collapses diagrammatic and architectural domains without offering the emergence of semantic qualities.

Though rigorous in its approach, operative re-writings open up the possibility to articulate complex relations between data and design which are also open to different frames of interpretation. Previous hierarchical structures often accompanying the discussion on digital design process are also superseded by operating with learning algorithms. For instance, re-writing operations can be implemented on large datasets at once, bypassing the need to operate from the small to the large, playing with the large dimensionality of big data without prior reduction. As such the dialectical tension between top-down and bottom-up that has been animating much of the debate on digital design methods dissolves in favour of an approach that is indifferent to these categories. Contrary to early experiments in conceptual architecture, the flat nature of data and algorithms allows the designer to expand design operations beyond strictly formal aspects. Perceptual programmatic, time-based behaviours are equally amenable to manipulation and exploration considerably expanding both the design palette and the spatial qualities of the artefact. Operative re-writing here provides a device to move from the abstract rigorous of statistical clustering and prediction towards the domain of spatial effects, atmosphere, and dynamic behaviour. As in Aby Warburg's *Mnemosyne Atlas* flattening traditional categories for art classification not only provides greater freedom to move within the complex landscape of art history, but also returns an atmospheric image of a particular aspect of artistic production which could have not been revealed otherwise.

Conclusions

Whilst the introduction of learning algorithms in the design process is still very much in its early days, it is important to quickly understand what is at stake in their application to spatial design. This not only involves a technical literacy of the actual operations performed by learning algorithms – their "material" component – but also a revision of the theoretical framework through which we can analyse them and think them through in the design process. Such step necessarily involves looking at the domain of information theory as well as the disciplinary discourse in architecture and urban design.

Finally, the notion of operative re-writing speculates on what robust design methods can be conjured up to explore the complex space of multi-dimensional datasets, the value of dimensionality reduction algorithms, and what they could offer to place making and users' experience. As part of an initial mapping of the design domains in which such operations might find an innovative application and give rise to novel organisational models, the designers' attention would need to direct itself towards spatial issues whose complexity greatly exceeds that of human cognition. Climate change, the increasingly instability of the notion of public space in cities, and the development of richer, higher density urban environments are three of the most pressing urban challenges that can be innovatively addressed through the implementation of ML algorithms in spatial design.

References

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