A Research of the Relationship and Applicability of Algorithms to Curatorial Practice

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Draft for the Introduction and First Chapter in the thesis on

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Abstract

This thesis explores and analyzes case studies for the application of algorithms in curatorial practice. It takes on a broad definition of both the meaning of *algorithm* and *curating* with aims to provide valuable insight on ways to understand and develop curatorial practice.

This open approach tries to include the wide range of meanings both of these terms have given their incremental embedding in our daily tasks. The thesis develops along four concepts: *algorithms as linear and sequential, curating as sequential algorithm, algorithms as systems, and curating as systems*. By focusing on both linear and systemic processes curating can be diversified in its scope, understanding and efficiency.

The first part of the thesis is concerned with the understanding of algorithm as series of steps to be executed, and how this type of algorithm can be traced within the field of curating. It delves into cases of conceptual art exhibition-making in the 60's, and their algorithmic nature despite being carried out by humans. In terms of studying how sequential tasks carried out by machines can be applied in the field of curating, the thesis focuses in the implementation of algorithmic search of the web as part of curatorial criteria for museums (*MuDA Museum* in Zurich), as well as the implementation of machine learning tools applied to the analysis and processing of image and text data (*re][cognition* project in Tate or *Google X degrees of separation*), and how that information can be used in the curatorial process. Besides these historic and theoretical components, this thesis is also accompanied by a practical implementation in the shape of an online exhibition, *Expanded Archive*.

The second part of the thesis analyzes how linear or individual algorithms are organized, assembled and stacked into systems. It explores the work of curators and researchers *Joasia Krysa* and *Magdalena Tyzlik-Carver* as means to approach to the notions of network, entanglement and assemblage, in order to be able to describe how the environment of a curatorial and informatic system is laid out. This section also analyzes how the content of datasets affect algorithmic systems, with the goal of drawing an analogy to understand the importance of data sourcing in curatorial practice; highlighting that the way *how* we organize data, *where* do we source it from, and *what* we take as its criteria constitute crucial parameters for curating. This will provide insights on the limits of what can be measured and represented in digital form and what not, allowing us to better clarify the limits that computer-based curating tools have.

The goal of this research is to find a shared historical background for algorithms and curating, find useful applications of the former into the latter, contextualize curating within the rise of algorithmic proceduralism in most fields of knowledge, as well as expanding both notions in ways that can be useful for creative and critical production in art.

CONTENTS

Introduction: Defining a broad understanding of algorithm and how it can be understood within art

a. Defining field of research and structure

This thesis will be concerned with some historical, case by case analysis of the intersection between algorithms and curatorial practice. Along with the analysis of exemplary cases, there will be an analytic development of arguments that locate the cases within the conceptual framework of the thesis, trying to establish a constant task of bridge-building between notions expressed in different chapters. With this method I will attempt to consolidate two ways of reading the information: first, expressing the most relevant concepts in each of the sections, allowing them to be read and understood in an isolated way, and second, the logical development of a sequential and complete reading of the thesis. Therefore, I will constantly try to build a manifold path for interpretation that goes across these two methods for reading.

I will approach to materials including historical documents, published books, art projects, and documentation available of examples of the incorporation of algorithmic procedure within the field of curatorial practice. Is safe to say, that the understanding of this practice is mostly limited to text and documents inscribed in the short tradition of curatorial studies, and therefore related to some institutions in terms of art history and exhibition making such as biennials and publications from academic institutions, which normally publish curating-related texts. It will mostly encompass exhibition and artistic projects produced from the 1960's until contemporary age, sporadically borrowing examples from older ages. It will include mostly cases from art and exhibition-making in the United States and Western Europe with occasional mentions to relevant examples with art and exhibition production in China and South America.

There will be a cross-disciplinary approach to the sourcing of information, and particularly for the extraction of useful concepts to be used for the analysis component of the thesis. The general fields attributed to the authors sourced for this thesis are computation, machine learning, system theory, philosophy, curatorial studies, art history and artistic practice. With this approach there is a clear attempt to explore the multiple ramifications of a research topic hard to clearly delimit, as well as enriching the glossary that curatorial studies has for the description and analysis of its own subject matters.

In the present chapter I will provide an introduction to the most relevant concepts, as well as the structure and scope of the task at hand. Here I will introduce the reasons why 'algorithms' and 'curating', two seemingly disconnected notions, do not only have pragmatic and operative connections, but also how they share notions, be it in how they are implemented or how they relate to the study field they belong.

Chapter 2 will be concerned with the understanding of an algorithm as a linear and sequential set of steps to be executed. The chapter is consequently divided into two sections, analyzing how this procedural method of algorithm can be traced within the field of curating. The first division will analyze cases of artistic creation and exhibition making shaped in the same way of this algorithm, but carried out by humans. In this part the examples of art and exhibitions from the 60's and 70's decade in Conceptual art are relevant in two ways, as not only they demonstrate the possibilities and limitations of the creative process organized as sequential instructions, but also they will provide an insight into the first years of curatorial practice as a different discipline from art criticism or exhibition planning. The second part of this chapter will focus in how sequential tasks carried out by machines can be used and applied in the field of curating, focusing particularly in two cases: the MuDA Museum in Zurich which has among the first implementations of algorithmic search of the web as part of their curatorial criteria, as well as focusing of the implementation of Machine Learning tools applied to the analysis and processing of image and text data, and how that information can be used in the curatorial process. These methods materialize in an online exhibition project made in collaboration with the Pereira Art Museum; where art is computed as data and ranked according to its compatibility with the MetMuseum OpenAccess collection, thus assembling a show with partly human, partly automated decision-making.

In chapter three I will analyze how linear or individual algorithms are organized, assembled and stacked into systems, which are more complex than just individual procedures, and therefore how they entangle with different elements within a distributed system, making both harder and more interesting to track the agents, their relationships, and the agency that they have on each other and on the system in general. This chapter is subdivided in three sections: 1) This part will explore the work of curators and researchers Joasia Krysa and Magdalena Tyzlik-Carver to explore the notions of network, entanglement and assemblage, to be able to describe how the environment of a curatorial and informatic system is laid out. There will be further crisscrossing between digital and human based systems than in the previous chapter, in order to demonstrate the similitudes in structure and connections that they share. Examples of exhibitions understood as systems will be explored, such as *Les Immateriáux*, *Rhizome*, the ongoing *Do it!* Project by Hans Ulrich Obrist, among others. 2) This subsection will be devoted to describe and analyze how Data structures affect algorithmic systems, with the goal of drawing an analogy to understand the importance of the data sourcing in curatorial practice; as such, I hope to make evident that the *how* we organize data, *where* do we source it from, and *what* we take as its criteria constitute crucial parameters for curating in general, and by extension to algorithmic curating as well. Here I will also go more in depth in stablishing the limits of what can be measured and represented in a digital form and what not, allowing us to better

clarify the limits that algorithmic curating has. 3) This section will be devoted to explore the notions of individuation, agency and power within a distributed system mainly from a philosophy perspective. With the clarification of these notions, not only can we better consolidate the framework to understand algorithmic curating, but also borrow the notions and thought process and apply them to any curatorial project by being able to identify the milieu of agents within which it deploys itself.

Finally, there will be some conclusive remarks that sums up the general conceptual and applied exploration, as well as a proposed theoretical model of the fields with which the curatorial network engages with, leaving it open to be implemented through computational algorithms, by human and social networks, or by hybrid in-betweens.

The goal of this thesis is to take a retrospective look on past examples of algorithmic process to find bases and a historical background, display a series of applications of this methodology in order to expand our notion of curatorial practice, and locate it within the context of the rise of automated algorithmic proceduralism in most disciplines nowadays; ultimately segmenting and compartmentalizing the parts of the curatorial role in order to understand it critically as a whole, providing a model for apprehending it that goes beyond from the computational gimmick, a model that can be understood an applied by all curators regardless of their agreement with the methodology of this thesis.

b. Defining terms and framework

Both "curating" and "algorithm" will be understood both as nouns as well as adjectives. The common understanding of algorithm goes two ways. First, as a proper noun: algorithm as an element that produces concrete actions in the world in the same way that a lever or an electric circuit works; and second, as an abstract noun: algorithm as some sort of ethereal element from which is hard for us to understand its materiality, shape or configuration. Algorithm as an adjective (or *algorithmic*) does not have to do with the code or configuration of the algorithm per se, but with the "insertion of quantification, proceduralization and automation into human knowledge and social experience"(Gillespie, 2016), and in the case of study for this thesis, within the field of creative practices. In the same nature, the noun *curator* refers to the agent (or group of agents) who are custodians, caretakers, promoters, researchers, mediators and contextualizers of a certain art collection (in the case of museums), of artworks, or information. The adjective *curatorial* has to do with the characteristics that the role of the curator has, particularly relating to strategies, channels for working and networking, with the assumption of critical approach and multidisciplinary-thinking as a crucial way of executing its tasks. This constellation of characteristics and roles are adopted within the verb *curating,* which generally means "a mode of proactive participation in the processes of artistic

production"(O'Neill, 2012: p.5). Throughout the development of this thesis these terms will be frequently used and will concatenate with each other.

Before I begin to tackle the subject matter of the thesis, is necessary to outline more concrete characteristics and caveats of the understanding of "algorithm" and "curating", so as to set a foundation from where to complexify or complement these notions with the study cases. As such, this will be a non-exhaustive attempt to provide the general framework for both concepts that will keep developing in continuous chapters.

Algorithm

We would have to start by saying that there is no agreed-to definition of "algorithm". Several have been coined throughout the years, with several levels of complexity and restrictiveness according to the purpose and function that the term is supposed to encompass. The Merriam-Webster dictionary defines algorithm as:

> **"Noun.** : a procedure for solving a mathematical problem (as of finding the greatest common divisor) in a finite number of steps that frequently involves repetition of an operation ***broadly*** : a step-by-step procedure for solving a problem or accomplishing some end." ("Algorithm", n.d)

The first definition restricts algorithm to the field of mathematics, and the second opens up to a broader understanding and applicability of the term. The range of definitions do not stop here, as some define it as 'a recipe', 'an application that decides what you see', and many more. Tarleton Gillespie mentions that there are several meanings of the term coexisting at any given time, because some key words are taken by different fields of study and subsequently the meaning turns into different things. For software engineers is a very concise, simple thing, contrary to what the general public sees in them: a program of infinite and almost inscrutable complexity. Social scientists are more concerned with the parameters by which "what is relevant" is decided in the design of the algorithm, more than the strictly technical sense. On the other hand, the purpose of this thesis is centered around defining the boundaries of importance of what an algorithm means within the field of curating, and will probably end up proposing a different definition altogether. Despite all of this multiplicity, we would be wrong if we were to set a hierarchy of accuracy, as there is no more or less correct usage of the word. Perhaps the validity for the many meanings of this word is better described by Taina Bucher:

> "algorithms are multiple in the sense that there is more than one kind of thing that we call "algorithm." Not only is this true in the technical sense of there being many different types of algorithms but also in the social sense. When people speak of 'algorithms' they often have

> different things in mind, different concerns, worries, conceptions, and imaginations." (Bucher, 2018: p.19)

How do we come to such a state of undefinition, or rather, of a diversity that results restrictive in search for accuracy? We could answer by saying that this is the natural behavior of language and concepts within a society with multiple interests and fields of specialization. But here I will propose a historic and analytic path made up of several definitions, each of them providing a different facet that will be revisited in later chapters, and that will be problematized with subsequent conceptual pairings.

Origin of the term

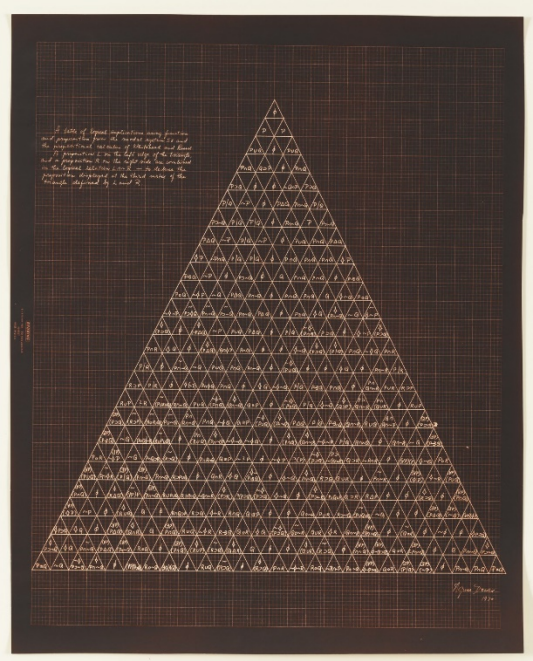
The term 'algorithm' originally comes from the common adoption of a translation misinterpretation that became a figure of speech. As pointed by Laura Marks in *Enfoldment and Infinity:*

> "(…) (T)he chief librarian of the House of Wisdom was the great Persian mathematician, astronomer, and astrologer Muhammad ibn Musa al-Khwarizmi (780- 850). AI-Khwarizmi introduced Indian (commonly referred to as "Arabic") numerals and the decimal system, an invaluable breakthrough for calculation. He also published a new system for solving polynomial and quadratic equations, algebra, in his great work of 830. The word algebra derives from al-jabr, or "integration"; algorithm is a Latinization of al-Khwarizmi's name. Gerard of Cremona's translation, made in Toledo, the hotbed of translations from Arabic to Latin and other languages in the mid-twelfth century, begins, "Dixit Algorismus" (al-Khwarizmi says) and from there, the word came to mean a sequence of mathematical instructions. (…) It is noteworthy that al-Khwarizmi's algebra expresses equations in prose, not symbolically, so they too imply an engagement that is experiential and not just abstract." (Marks, 2010: p.154-155)

Here we can see how the enunciation '*algorismus* says' came to embody a relationship between geometric and arithmetic values and the steps to process and solve these problems. Is also crucial for the development of this research to note the fact that originally, algorithms were not described in formulas or mathematical notation, but rather through diagrams and written word. This clarification might seem prosaic, but serves as proof that what is crucial about the agency of the algorithm are the relationships between elements it enables, the logic propositions it articulates, and not its physical or visual configuration. The way the

algorithm is embodied (or *instantiated* [1]) can be expressed in a variety of ways that are not strictly related to computation.

The evolution of the modern understanding of the algorithm continued with the developments of the rationalist philosopher Gottfried Wilhelm Leibniz and his concept of *ars characteristica*, in which he attempted to assemble a system of expression and communication through signs, where "each sign expresses the true categories of thinking"(Widmaier, 1983), a system where "the coherence (relations) between signs and things follow a harmony of Leibniz's theory of logic into his whole systematic thinking of theology and cosmology"(Hui, 2016). For this project, he drew inspiration from the iconic nature of Chinese characters, trying to replace the ambiguity of acoustic writing systems of European languages, and using the *I Ching* as a reference to develop binary arithmetic, the foundational stone for contemporary computation. This project deepened the effort in making ideas deductible in the same way math is, of reducing logical propositions into axiomatic kernels from which any concept can be built by recombination.



Dialectic Triangulation: A Visual Philosophy into Symbolic Logic
Agnes Denes
Monoprint
1970

This triangle lists all logical human arguments using the propositional calculus of Whitehead and Russel.

Probably the first machine-related algorithm (although not coined as such by the author) was written by the mathematician Ada Lovelace in the notes for *The Analytical Engine* invented by her mentor

[1] This concept comes from Object Oriented Programming, and it means a concrete occurrence of any object during the runtime of a program. The object contains attributes and methods to operate a particular task. One object can have several instances in a program, holding different variables on each one. If we were to trace an analogy with Platonic philosophy, the object would be the absolute idea (*eidos*) of 'chair', and the instance would be each individual chair in the sensible world.

Charles Babbage. She described how this invention could calculate the Bernoulli Numbers[2] through detailed and technical descriptions using mathematic notation. Although this engine was never completed during both of their lives, and therefore the instructions were never translated into machine readable code (Jacqard punch cards at the time), the document lays out the analytic procedure that the machine could execute. Unlike Babbage who saw his own invention as a number-crunching machine, Lovelace saw the difference between the *science of operations* (or processing) and the information to be processed (data), further commenting -- "The operating mechanism can even be thrown into action independently of any object to act upon (…) it might act upon other things besides number, were objects found whose mutual fundamental relations could be expressed by those of the abstract science of operations" (Essinger, 2014) – Basically describing the possibility for the *digital* representation of objects and their computability.

Later, *The Mathematical Analysis of Logic* by Georges Boole advanced in the formalization of logical operations reducing them to the basic operations of AND, OR and NOT, with result in two variables True and False (known as Boolean values). The development of this logical proceduralism entered common usage in the field of computation with the development of higher-level programming languages in the 1960's such as FORTRAN, that allowed computer scientists to stop using low-level languages that dealt with binary values that directly responded the individual architecture of each computer, and replaced it with commands that use some degree of natural language, making it easier to program and implement. The language used by programmers needed to be close enough to common-speak without the flaws of ambiguity in order for it to be processable. This Boolean logic would be used by Alan Turing to propose a hypothetical machine that would read symbols (binary), rewriting or deleting them based on a finite set of rules[3]. This came to be the basic concept of a computer.

The importance of this timeline of events is better described by Gillespie as:

> "The point to information science, first articulated by Leibniz and later formalized by the logicians Boole and Shannon, is simple: all real signals can be reduced, with certain loss, into digital symbols. Anything one wants to describe— say, content (sensory experience), space (coordinates), time (intervals), or instructions (programming,

[2] Are a series of numbers that arise in the expansions of trigonometric functions, and are extremely important in number theory and analysis.
[3] This was his solution for the *entscheidungsproblem* (decision problem) raised by David Hilbert. "The *Entscheidungsproblem* can be generalized as the search for an algorithm that can reduce all human deductive reasoning to calculation." (Davis, 2001)

algorithms)— can be expressed in the irreducibly countable alphabet of that one binary difference, 0 or 1." (Gillespie, 2016)

Without being exhaustive with the historic evolution of the term, we can trace the path of how statements with procedural execution came to be the basis for the operability of computers, and therefore how algorithms are connected with these machines. But also, it sheds some light on the connection of algorithms with reasoning and analysis, and therefore with a more general ability to think and create relations between elements in the world, superseding the mere field of computing.

Computer science

Computer scientists such as Donald Knuth provided the following list of requirements for an algorithm:

1. **Finiteness**: "An algorithm must always terminate after a finite number of steps"
2. **Definiteness**: "Each step of an algorithm must be precisely defined; the actions to be carried out must be rigorously and unambiguously specified for each case"
3. **Input**: "...quantities which are given to it initially before the algorithm begins. These inputs are taken from specified sets of objects"
4. **Output**: "...quantities which have a specified relation to the inputs"
5. **Effectiveness**: "... all of the operations to be performed in the algorithm must be sufficiently basic that they can in principle be done exactly and in a finite length of time by a man using paper and pencil" (Knuth, 1973)

We see that in the essence of this definition is a rather simple thing. One example of these type of computing algorithms are *sorting algorithms*: given a list of values the algorithm organizes the list in a certain order. There are multiple parameters to give order to this list, as well as there are several paths and steps the procedure can take in order to achieve this goal. *Quicksort, Bubble sort, Merge sort, Breadth first search*, among many others, are examples of methods that can be adopted to solve the same task. Each of these methods has benefits in terms of speed and memory usage, and the decision of technicians to implement one or the other goes along the lines of striking a balance between these requirements. Sometimes, the elegance[4] of the solution or the 'beauty of code' comes into play as a decisive factor.

[4] "*Elegance*, as first proposed by Donald Knuth in *Literate Programming* (1984), can be measured by four criteria: the leanness of the code, the clarity with which the problem is defined, the sparseness of the use of resources such as time and processor cycles, and implementation in the most suitable language on the most suitable system for its execution." (Bucher, 2018)

Algorithms are not decisive in isolation. Their importance lies in how they are connected to other important factors of information science: the processing of an input data, the building of programs by assembling two or more simple algorithms, the comparison between the ideal goal and actual information obtained as output, as well as how the algorithm makes use of the hardware; all play a crucial role in the effectiveness and importance of the algorithm.

Another relevant concept from this field can be found in the definition proposed by Harold Stone:

> "For people to follow the rules of an algorithm, the rules must be formulated so that they can be followed in a robot-like manner, that is, without the need for thought... however, if the instructions [to solve the quadratic equation, for example] are to be obeyed by someone who knows how to perform arithmetic operations but does not know how to extract a square root, then we must also provide a set of rules for extracting a square root in order to satisfy the definition of algorithm. (...) not all instructions are acceptable, because they may require the robot to have abilities beyond those that we consider reasonable." (Stone, 1972)

This complementary definition introduces another point of concern: The presupposition about the capabilities of the processing unit when carrying out the algorithm. It highlights the fact that it is dangerous to assume that there is a capability or a universal notion that is supposed to be known, and this misconception can result in an error, or an impossibility to carry out the task at hand. To further explain this analysis:

> "An intuitive definition of an acceptable sequence of instructions is one in which each instruction is precisely defined so that the robot is guaranteed to be able to obey it." (Stone, 1972)

From this we can infer a key notion in the configuration of the system that executes the algorithm: the ability to carry out the instructions have to exist already within the system or be provided in the algorithm instructions. This idea will become relevant when discussing databases and their configuration, storage and management of information.

Shape

Following the historic development of the algorithm, we can see that the shape an algorithm changes according to the type of application that it is devised for, the type of steps to be executed, as well as the executioner of said steps. Algorithms went from written, to logical expressions and mathematical formulae, to the encoding of binary values into the architecture of machines of automatic calculation.

If we were to define them concisely, algorithms are expressed in three different ways:

> "- Natural language expressions: use regular written language, tending to be verbose and ambiguous as they inherit the ambiguity of any spoken language, and are rarely used for complex or technical algorithms.
> - Pseudocode and flowcharts: are structured ways to express algorithms that avoid the ambiguities, while remaining independent of a particular implementation language or technical specificities.
> - Programming languages: are primarily intended for expressing algorithms in a form that can be executed by a computer, but are often used as a way to define or document algorithms." (Scriptol, 2013)

Going back to the conditions proposed by Knuth, we can see that *finiteness, definiteness, input, output* and *effectiveness* are broad enough to allow for them to be carried out through programming language, but also as natural language or described in flowchart shape. The importance of this flexibility is pointed out by Bucher: "This makes the concept of the "algorithm" particularly powerful, given that what an algorithm signifies is an inherent assumption in all software design about order, sequence, and sorting. The actual steps are what is important, not the wording per se"(Bucher, 2018)

All shapes and configurations of algorithms are necessary depending on the field they are used in and the process they are supposed to trigger. Within corporate structures the flowcharts are popular, as they rationalize and sequentialize steps within a chain of command, reducing the room for error but being accessible enough; yet in terms of a cooking recipe or creating an artwork, natural language plays a role as it is crucial to have a level of familiarity and relatedness in order for the reader to connect with the task. In the same way, coding languages provide the logical and defined instructions that are crucial for computers and machines to autonomously carry out tasks, to send signals that communicate to other machines, and for this communication to trigger further actions; therefore, is necessary to use code as it allows no room for misinterpretation. Furthermore, in reviewing how since Lovelace's time algorithms were embodied in punch cards, or in the particular turn of switches and pulls, we may come to correct the misconception of the algorithm as a merely digital device, and start to think of it as an encoded series of steps that might involve several levels of materiality as well. In this research I will try to show how each of these shapes the algorithm takes can be used within the curatorial task in order to trigger actions, generate connections, relay information or activate networks for the operational and creative execution of the curatorial practice.

Algorithm as synecdoche:

A synecdoche is a figure of speech in which a part is used to represent the whole, as *ten sails* can stand for *ten ships*. In the same way, algorithm, as a part of a broader and more complex system, has come to be commonly used as the term that encompasses the whole technological apparatus that comes into play in the use of digital platforms, websites or social media. As briefly described above, the data, the algorithm, the hardware, the design, and the models; all play a crucial role in the operation of every system, yet in common speech the algorithm is what comes to be represented as a "digital brain" of sorts, merging all components into this one single element.

This unification is somewhat imprecise, because whenever other fields think of a whole technological system, they tend to use 'algorithm', the same word as technicians use for concrete components within that system. Beyond a desire for clarification of terminology, what is important to highlight is to realize there is a constant twofold understanding of the term, and that sometimes it might be more important to focus on a particular way of processing a specific dataset, but also for our purpose in this thesis most of the focus will be devoted on the structure and design of the system as a whole, regarding the underlying logic that is behind it. It may be true that some attention has to be put on the specific and technical aspects in order to obtain non-misleading results; but whenever, for example, an algorithm models social interaction, there are some underlying assumptions about what is important in social relationships that is measured in the shape of variables, steps and indicators, that goes beyond a particular set of steps to follow. Even if the computation is autonomous, there is no neutrality in the implementation of a certain model. This is why for the purpose of this research, it will be crucial to outline the assumptions behind the use of one or another algorithm, the use of one program over the other, or to propose an explanation for the reasons behind certain model used in one of the cases of study. The fact that social sciences are interested in the way algorithms are designed should be a strong encouragement for curatorial studies to engage in their research as well, as curation has to deal with communication across communities, as well as having the task for mapping the complex way conceptual and social relationships intertwine.

Learning Algorithms:

There has been a lot of buzz around the notion of Artificial Intelligence on media and is already incrusted into the contemporary *zeitgeist*. From modest technological advance to full-blow political agendas, *Artificial Intelligence* has taken the first-row spot in most conversations regarding technology, and to define the boundaries of what AI is goes beyond the scope of this research. Nonetheless, what is important to mention about AI is that whenever people talk about it, they actually mostly refer to *Machine Learning* and *Neural Networks*.

There will be some further exploration and analysis of both these terms later on, but the most important aspect of them to bring up for now is that, although the evolution of deterministic logic in computation developed in a way in which things are clear and defined, *Machine Learning* introduces a layer of 'indeterminacy' to computation: Programs are designed with a series of values and operations, organized with different layers that resemble the way the neurons connect in our brains (that's why this design is called a Neural Network). Nonetheless, the actual parameters and variables processed by these 'neurons' are not hard-coded by people behind screens, but they are *learned* through many iterations of calculations with some *training data*. In this sense, the algorithm is not static, but it learns variables from the input and in this way transforms itself in order to properly manage the way of processing new data. The 'indetermination' comes from the fact that engineers do not properly know what values are learned by the machine, nor they know how these values interact within the layers of the neural network. As such, technicians can choose one or another individual algorithm to *activate* certain neurons or to synthesize certain information, but the whole *model* to process information is refined by brute-force, trial and error that is beyond any individual control. Unlike deterministic algorithms that will always produce the same output, this learning type of algorithm will predict the *probability* of certain result, and this probability changes based on the relationships and patterns within the input data.

This way of organizing algorithms in the shape of a *neural network* and teach them through many examples, has proven to be very effective in many practical fields. Whether to predict stock price fluctuation, to detect spam text messages, or to recognize images and faces, some modifications can be made in order to accommodate any type of digital information, and to obtain a refined or clearer view on the data at hand, or a predictive projection of it. As put by Mackenzie:

> "The techniques of machine learning nearly all pivot around ways of transforming, constructing or imposing some kind of shape on the data and using that shape to discover, decide, classify, rank, cluster, recommend, label or predict what is happening or what will happen." (Mackenzie, 2015)

Machine learning engines have already been broadly deployed by commercial companies to apply all these methods to our daily behaviors, in order to market products and funnel more of our purchases. This already set us in an environment that, from online and real-life actions, speech emitted, images taken, and time spent; are all tracked and retroactively added to a system that learns from it. Not only the algorithms adapt to the data that is taken in, but we as humans also change and adapt our behavior precisely because of the awareness of being embedded in this digitally aware system. These engines have created a *technological ensemble* that feedbacks into itself. The algorithms learn from the world (although from a limited, labeled world that is made available to them) and in turn, with the relationships they predict and the suggestions

they make, the world is affected back. By making the algorithms able to be affected by the world, and by interconnecting those algorithms so deeply in the fabric of contemporary life, we also made possible our own transformation by those same algorithms.

Individual Algorithm and Collective Algorithm

The structure of this thesis will be based on a conceptual division within the idea of algorithm proposed by Tania Bucher. In *If… then: Algorithmic Power and Politics*, she addresses the importance of understanding the multiple levels of magnitude in which algorithms play out:

> "Algorithms exist on many scales, ranging from the operationality of software to society at large. (…) Algorithms are seen as multiple. This is to say that there is no one way in which algorithms exist as a singular object. By positing the multiple nature of algorithms, the intention is to take their manyfoldedness seriously." (Bucher, 2018)

As such, she poses a division: the technical, *linear or deterministic algorithm* as a standalone element, which follows procedures and fulfils concrete tasks, and the *algorithmic system*, which are networked structures "with hundreds of hands reaching into them, tweaking and tuning, swapping out parts and experimenting with new arrangements" (Seaver, 2014). If we are to analyze the structure as a whole, identify the components and logic behind the architecture of this system, is also important not to lose reference of the individual boxes, the particular components that make up the whole. Is also important to mention that these algorithmic systems are not completely automated, and rather they can be understood as a *sociotechnical ensemble*, a combination of code, hardware, humans and social groups that configure the network and interact to determine what is important for it.

Having this framework in mind, the thesis will be divided in two general parts. In the first one, there will be an analysis of examples of implementations of linear, standalone algorithms, and in the second one there will be a further analysis on algorithms structured as a system. But to also consider the notion of *sociotechnical ensemble*, there will be sections for analysis in which the linear algorithm is carried out by a machine, and others in which is carried out by a human or a social group. In some cases, the human/machine division will not be as clearly defined, turning into a symbiotic or hybrid arrangement. There is no moral interest in finding human and machine divisions; rather, to provide a framework from which to deploy a malleable understanding of the forces at play, for us to acclimate to the idea of decision-making power beyond the human-author, for the reader to embrace the importance of non-human agency as equally important in the socio-technical environment that curating takes place.

Curating

In the same way as with algorithms, there is no single agreed-upon definition for what 'curating' means, as the term has been predominantly used by different fields of knowledge and diverse social groups. One straightforward yet fulfilling definition is the one provided by Carole Paul: "Curators are responsible for the basic tasks of collecting, organizing, storing, cataloguing, exhibiting, researching, and interpreting objects" (Paul, 2019). This definition places special emphasis on the relationship of curating with objects, and the set of tasks directed to contextualize and work with these set of objects in order to present them, make them available, intelligible or accessible to a particular public. In recent years, there has been an explosion in the usage of the term beyond the world of art and into fashion, music, playlists, foods, events, outfits, interior design, and an increasingly expanding plethora of activities that require selection and context. This expansion of the usage and adoption of the idea has been reframed by critic David Balzer as *Curationism:* "the acceleration of the curatorial impulse to become a dominant way of thinking and being" (Balzer, 2014). How did we come to this point? What does exactly this adjective of the 'curatorial' imply? To provide some historic and conceptual context from where to elaborate on the analysis of later chapters, this is a brief account of some of the evolution and meaning of the term.

Origin of the term

The oldest known use of the term can be traced back to ancient Rome. "The Latin word *curator* is defined as "(s)he who cares for or takes charge of a thing, a manager, overseer, superintendent, keeper" (Lewis, 1989: 501). Even as back as the year 11 BCE, there was an administrative board that oversaw public collections and the buildings where they were housed. Around 200 CE, there were officials in charge of overseeing the public collection of paintings (*procurator a pinacothecis)* and another for sculptures (*auditor rationis statuarum*) (Pearce, 1995: 92). The term was non-exclusive to art-related overseers, as there were 'curators' for aqueducts, bathhouses, and sewers (Obrist, 2015: 24-25) – *Curatores viarum*, for instance, were responsible for overseeing roads–. The term switched to a connotation more focused on the "metaphysical and religious aspect of human life, as the *curatus* (or curate in English) was a priest concerned with the caring of the souls of a particular parish" (Buckley & Conomos, 2020). This early dichotomy between overseeing and managing centered around the 'object', and later a more focused attitude of 'care' towards more abstract and living entities, is a common function and a role that might still persist in the contemporary meaning of curating, albeit with some caveats.

Carole Paul describes how the task was present for most of the early modern period in western Europe, as with the accumulation of wealth and objects – as a product of trade or looting – began filling several rooms of various noblemen and traders across the continent. Sometimes, these collections were solely based on the personal taste of the collector and whatever items they were able to get their hands on. But sometimes, there would be an appointed official, most of the time a *connoisseur* or specialist in art techniques or in the

history of the objects within the collection, who was delegated with the responsibility of indexing, studying and keeping track of them, in order to have more consequent acquisitions in the future. This was not an officially established occupation, with knowledge being handed down through practice, and with few written examples – such as the *Inscriptiones* (Inscriptions) written by Samuel Quiccheberg, a Flemish physician, and published in Munich in 1565 (Quiccheberg, 2013) –.

Contemporary history of curating traces back as some of the earliest examples of proper curating the practice of the *Wunderkammern* (cabinet of curiosities) or the *Kunstkabinett* (arts cabinet) during the early seventeenth century. These cabinets "consisted of a random variety of objects and images that reflected the fascination of the collector. What was commissioned and collected followed choices, made by the patron to reflect his or her taste and wealth" (Buckley & Conomos, 2020). This practice is more identified as proper early-curating because beyond the act of collecting, there was the task of arranging these objects and exhibiting them, either to gests, privileged visitors, or for personal contemplation. This practice was also connected to the building of *Doll Houses* and the design and assembly of *gardens,* as they were ways to build representations of the private, public, and natural world. As categories of knowledge were not as clearly divided as they would be in the XXth Century, Natural Science objects such as meteorites or embalmed rare animals could be placed next to engravings, paintings, costumes, and whatever 'curiosity' worthy enough to display the diversity and depth of the owner's knowledge. These cabinets were not only about describing the world, they were also a practice of world-making. This is better reflected by the fact that some cabinets also included examples of fantasy animals such as unicorns, basilisks and hydras, which were actually made from horns and skin of narwhals, oxen, and bison; effectively chasing real species to feed the representation of unreal ones, a representation of the world made by ingesting the real one. They would contain implied ontologies as well, since an orderly and harmonious display of plants, animal and human artifacts retrieved from all continents, expressed the underlaying notion of a rational distribution of beings in a world ordered by reason.

With the consolidation of public museums in England and France in the XIXth Century, there was a further professionalization of dedicated directors of museums and national collections, who were responsible for the display (attached to a political and nation-building agenda), and who were also tasked with overseeing the incorporation of valuable works into the collections (mostly through looting, in the case of the Louvre and the British Museum). Entering into the XXth Century, this role of the curator as overseer and caretaker was defined by two key characteristics: first, the curator was always subservient to either an official, a collector owner, or ultimately the state; and second, s/he was almost always related to a particular collection, devoted to knowing the items already being kept and making decisions based on that; both conditions effectively conditioning their criteria to third-party decisions and mostly out of their control. Even in

contemporary museums there are curators whose work, besides obtaining funds and selecting works, also includes the task of reassuring directors, trustees and artists that their collections and exhibitions are indeed excellent. As rightfully put by Balzer, "The curator is someone who insists on value, and who makes it, whether or not it actually exists" (Balzer, 2014)

The decade of the 1960's saw the emergence of the independent curator and a break with some of the conditions previously described. Amidst a general art-world movement towards the de-materialization of the work of art, or an increasing tendency towards the value of the idea behind the art – or art-as-idea – over the physical execution of the artwork; "exhibition-makers" such as Harald Szeeman, Lucy Lippard, Seth Sieglaub or Pontus Hulten emerged as a distinctive and prominent figures in the assembly and consolidation of exhibitions. Curating was not only about the selection of artists, but also their relationship with the artists, following and negotiating their projects, incorporating the exhibition space as part of the artworks, and particularly the proposal of an overarching idea or theme that superseded any individual work's conceptual proposition. This turn made this generation of curators to stand out as more than mere exhibition planners, and effectively as conceptual agents that contributed drastically to the overall experience of the exhibition. From this moment on, the idea of the art exhibition as an *experience* and not merely as a progressive reconstruction of art history[5] began to take hold. Starting with Szeeman, curators no longer had to be directly linked to a collection or institution, nor they had to answer to a single agenda. The requirements and limitations of a public museum would then be traded for the independence or constraints that could be obtained by private funding, and therefore introducing another crucial role to the curatorial task: securing funds and sponsorships, effectively turning the curator into a manager as well.

This period would then mark the emergence of the independent curator as a distinct and accepted agent within the art world. With the development of *relational art*, Biennials, *new media art*, *internet art* and other currents within the *artworld*, the curator cemented its position as a crucial agent, and the art exhibition was further recognized as a crucial medium for communication and as a playground for ideas. As put by O'Neil: "I will argue that curatorship is now a fully recognized mode of self-presentation within the contemporary art field, with the group exhibition from the principal site for self-articulation, employed by artists and curators alike as both a communicative medium and a genre of artistic production" (O'Neill, 2012a).

With this brief account of the evolution of the role of the curator and the emergence of 'curatorial' as a distinctive notion that involves certain set of ideas and procedures, we can now focus on some valuable ways

[5] Here I particularly refer to the "sichtbare Geschichte der Kunst" (visible history of art) by Christian von Mechel at the Belvedere Palace, Vienna, in 1783. This is how he described the display he made of the collection of the palace, stablishing a practice that continues to exist until today: "those who had little or no knowledge to bring to their viewing experiences could instead be educated in the history of art by the ordering of the works." (Paul, 2019)

to interpret this idea that both connects with the algorithmic, and can serve as a reference for the analysis of study cases to come.

Curator as individual and author

Some critics accused curators of being artists in disguise, or to have such a prevalent influence over the general style and appearance of the exhibition that art itself was relegated to the background. This is most evident in the review by Peter Plagen about the *557,087* (1969) exhibition by Lucy Lippard (further analyzed in the next chapter): "There is a total style to the show, a style so pervasive as to suggest that Lucy Lippard is in fact the artist and that her medium is other artists" (Plagen, 1969). It is also visible in the manifesto signed by Donald Judd, Sol LeWitt and other artists as a response to the exhibition *When attitudes become form* (1969) by Harald Szeeman, accusing him of "presenting their work in themed sections without the artists' consent" (Balzer, 2014). This conflicts between curators and artists reflect the shakeup and transformation that the roles in the art-world were passing through. From this moment on, during the 80's and 90's the consolidation of the curator-author was even more poignant, as independent curators came to work for several institutions at the same time through commissions, with exhibitions that were not centered around any collection but rather around asserting trends, consolidating value for the artists they work with, generating desirability and, ultimately, becoming agents of value generation. This tendency marks the transition from the curator as 'caretaker' to the curator as 'connoisseur' or general specialist in a broad variety of topics:

> "the curator as we know her emerges with a twist of autonomy, through the vital concept of connoisseurship: a display of taste or expertise that lends stylized independence to the act of caring for and assembling." (Balzer, 2014)

With such relevance contained in the decisions s/he takes, and usually being in the spotlight in terms of media coverage, essay and catalog production, and as intermediary with dealers and collectors; the role of the curator as an author has become undeniable. This role as a protagonist and as a branded creator continues to exist in the contemporary world, particularly applied to household names such as Hoffman, Obrist, Enwezor, Gioni, among others. The exalted level of individuality and notoriety achieved by modern artist has permeated the role of the curator. O'Neil better characterizes this phenomenon by remarking: "Curators have generally applied a self-asserting declarative approach to their field as a method of positioning their own practice within the curatorial whole, with the first-person narrative and curator self-positioning being predominant modes of address." (O'Neill, 2012a)

Some sustain the fact that this movement of curators becoming icons serve capitalist modes of value generation, and mostly benefits a circle of collectors and key players in the art market. Indeed, there are

plenty of examples of curators who choose to work in collaboration, or institutions that distribute the authority and mitigate the 'auteur curation' phenomenon by working in a group of curators or 'agents'. One of the most high profile examples of this (and perhaps therefore a very contradictory one) is the decision by dOCUMENTA(13) curator Carolyn Christov-Bakargiev of calling herself and her co-curators "agents", 'intentionally moving the attention away from the auteur-curator'. Also, with the emergence of artist-run spaces, community-based artworks and independently funded events, the role of the curator continues to be the one of an agent trying to create meaningful dislocations of meaning between objects, contexts and communities; yet engaging in a less author-centered and more relational methodology to achieve it. This author vs. network dichotomy will be further explored in the *curating as network* section of this thesis.

Curating as care

Even if it seems like a marginal condition instead than the norm, the closeness of 'curating' to the notion of 'care' is actually the core motivation for some practitioners of the field. We already mentioned how "the history of the curator can, in fact, be seen as someone of successive subservience: to institutions, objects, artists, audiences, markets"(Balzer, 2014). This subservience does not necessarily have a negative connotation, even if it clashes with the contemporary art notion of the independent *auteur*. In fact, there are curators such as Chris Springer, curator of the Sainsbury African Galleries of the British Museum, that take pride in their intimate connection with the environment of agents they engage with:

> "He tells us clearly that he is not interested in a curator being a constantly travelling exhibition-maker, working always on temporary contracts. Spring explains how important it was to him to be emotionally and critically involved with the curating of African artists, dead and alive, and how honored he was to curate and write about them and their works. For Springer, curating is about actually caring for the artists and their work; it is this aspect of curating that demands the highest degree of professional responsibility" (Buckley & Conomos, 2020)

It is evident the different models for conceiving curating and the relationship to their environment, and how they contradict each other while coexisting. Is evident that for international and itinerant curators results impossible to properly connect with the local context and assimilate into the networks of artists, dealers, institutions and other agents that influence the artwork. In turn, this prompts a reduction of a microcosm of complex situations and meaning to a watered-down concept that fits within a biennial or big group show. Engaging with artists and the development of relationships over time can uncover layers of meaning that may be hard to struck in immediacy. Given our exploration of the implementation of algorithms in the curatorial task, what can we say about the level of 'care' for the artwork and the artist present in such a process? Does the

implementation of automated methodologies necessarily imply a detachment or lack of care by the curator? Does the translation of artworks and artists to digital data means their disappearance and de-humanization, or can it be a tool for care? It is our task to explore the nuances of the answers to these questions in the following chapters.

Transdisciplinary, post-media curating

We described how curators can be specialized object fetishists. Tino Sehgal puts is succinctly when describing the curator as "a specialist of things". This might be the first level of operation of the curator: to have a knowledge and sensibility for the object, and to be able to articulate connections among them given the face value they present, even before any further information or contextualization is provided. Jan Westerhoff provides the apt term of *Pansemiotisicim*:

> "the idea that every object has some corresponding signification in another object. An object of phenomenon can be only imperfectly studied when in isolation. 'It is necessary to know what else this phenomenon signifies: its place in mythology, art and poetry, its moral signification, its astronomical, mystical, numerological, linguistic, and religious meaning etc.'"(Geczy, 2020; Westerhoff, 2001).

In this sense, curators should be aware of the semiotics of objects, and articulate the mesh of significants that the object has in its sociopolitical, cultural and economic immediate surroundings.

Nevertheless, it is not enough for a contemporary curator to limit him/herself to the *pansemiotic* level of the object. With the rise of the art exhibition as a meaningful channel for communication in contemporary society, the objects contained in it should not only be consequent with each other, but should point out into the surrounding world in meaningful ways. Fatoş Üstek sustains that is the curator's role to expand the dimension of the visual arts by pointing out to specific dynamics at play in the networks that said art is embedded in. "Given the current globalized mediascape of shared knowledges across nations and realities, the curator is obliged, according to Üstek, to expand their curatorial role to include a realm of truth beyond the specific context in which they perform"(Buckley & Conomos, 2020; Üstek, 2020). The curator should then be also aware of the invisible barriers of context and implied meaning that circumscribe its task, and be able to extend outgoing bridges to new realms of meaning.

What are the areas of possible expansion that curators can investigate? This will depend of every context, of course. But it is safe to say that any direction that makes more flexible the way we conceive a rigid category is a good one. Given the current *post-media* environment of art, in which the artwork is more of a continuous process with several *instantiations* along the way instead of a finished thing, with the multiplicity of platforms that artists use in order to publicize their work through social media, and the vantage position

that the art field has to incorporate other fields of knowledge and blur the boundaries in the process; curating is then better understood as a toolbox, a diverse set of ways to learn from botany, geology and urbanism, changing the method of curating and affecting critically the objects used to convey messages. This open-ended nature of the curatorial approach is defined by O'Neil as the *culture of curating*, a mature and consolidated expanded practice that takes on knowledge building, and that goes further from display-making (the exhibition).

Perhaps the curatorial as an expanded practice is better defined by Obrist:

> "The act of curating, … at its most basic is simply about connecting cultures, bringing their elements into proximity with each other – the task of curating is to make junctions, to allow different elements to touch. You might describe it as the attempted pollination of culture, or a form of map-making that opens new routes through a city, a people or a world." (Obrist, 2015: 1)

Thinking back again about the algorithmic within the curatorial, we see that by these standards of contemporary curating, the cross-pollination is most welcomed as a way of expanding the possibilities of the field. Nevertheless, this brings some problems on its own: If algorithms imply the standardization and proceduralization of curating, how can they be flexible enough to open to new ideas? If certainty is required for algorithms to be implemented, how can curating point out to the unknown or unexpected? How can algorithms prove to be useful in finding *pansemiotic* dimensions to objects and bridges among separate fields of knowledge?

All of these are very deep and complex questions, and they will be the ultimate guiding direction for the thesis, not in order to find defined answers to each of them, but as reference as to what should be provided for the reader to build an independent answer.

Following the *deterministic/systematic* division for the analysis of algorithms proposed before, the field of curation will be divided along the same lines: *individual curation* analyzed as projects by author-curators with a strong and distinctive style on one hand, and the analysis of curation as a distributed system and contextualized network in the other. These two ways of exploring curatorial projects are independent from the division of *individual* and *system-based* algorithms, which is to say, there could be *auteur*-curation using *algorithms as systems*, or *distributed curating* using *deterministic algorithms*. The boundaries of singular and plural will also probably be blurred at times, as my goal is not to create a typology and reduce it to a methodic spread sheet to understand and implement curation and algorithms, but rather explore the current examples and suggest the latent possibilities of road building between these two worlds.