algorithmic catastrophe—the revenge of contingency
yuk hui

The magic of automation [is] literal-minded…A goal-seeking mechanism will not necessarily seek our goals unless we design it for that purpose, and in that designing we must foresee all steps of the process for which it is designed…The penalties for errors of foresight, great as they are now, will be enormously increased as automatization comes into its full use.[2]

—*Norbert Wiener*

CATASTROPHE AND ACCIDENT

All catastrophes are algorithmic, even the natural ones, when we consider the universe to be governed by regular and automated laws of motion and principles of emergence. A catastrophe first takes the form of an accidental disturbance generated by the internal dynamics of the universe. We can understand the term "accident" in two ways: firstly, as a non-essential property of a substance (such as the colour red predicated of an apple), as outlined by Aristotle in the *Categories*, meaning that its arrival and disappearance doesn't lead to the destruction of the

substance (e.g. when the apple has not yet turned red it is still an apple); secondly, as something arriving in a contingent way, which is what we more commonly understand by the term.[3] I will show later that the algorithmic catastrophe—which I define as any catastrophe that is the product of *automated* algorithms—results from the convergence of these two types or meanings of accident. We have witnessed many technological catastrophes besides those caused by human ignorance or technical immaturity—metal fatigue and brittle fracture, for example. But these material, technological catastrophes are not examples of what I am proposing here to call algorithmic catastrophes. Algorithmic catastrophe doesn't refer to material failure, but rather to the failure of reason.

In November 2002, the French philosopher Paul Virilio curated an exhibition at the Foundation Cartier in Paris entitled *Ce qui arrive*. In this exhibition Virilio wanted to analyse the arrival of a new kind of catastrophe—the kind due to technological developments—in recent decades; he also claimed that a reversal of Aristotle's distinction between substance and accident had taken place. In light of the anticipation of the normalization of catastrophes in the twenty-first century, Virilio hopes to go back to the question of responsibility and reflect on the problem of industrialization, which becomes destructive to both corporeal and spiritual beings. Virilio points out that for Aristotle accidents serve to reveal substance. For Virlio himself, on the other hand, substance is always accidental. What follows from accidents are new inventions to overcome them. Hence catastrophes are structurally necessary, since without them technological development would not be effectively motivated. He writes: "The shipwreck is consequently the 'futurist' invention of the ship, and the air crash the invention of the supersonic airliner, just as the Chernobyl meltdown is the invention of the nuclear power station."[4] Virilio further observed that accidents have also bypassed this relation to substance; indeed he writes, if we could talk about the "accidents in substance," now the "accidents in knowledge," of which "computer science could well be a sign, due to the very nature of its indisputable 'advances' but also, by the same token, due to the nature of the incommensurable damage it does."[5] The new form of accident that Virilio refers to—"accidents in knowledge"—is dominated by the second sense of the word accident, meaning the constant arrival of catastrophes accompanied by the "progress" of civilisation. We understand further the accident of knowledge as the accident of reason, or more precisely of exteriorised reason, which we call "algorithm." The dialectics of accident and invention lead to a systematization of exteriorized reason, which obtains its own mode of contingency.

The emergence of algorithmic catastrophe, as this article will argue, marks on the one hand the presence of a global technological system that is open to the repetitive arrivals of catastrophe *without* apocalypse. Hence the catastrophe I want to describe is different from the understanding of it in *tragedy* and *apocalypse*. Firstly, we are no longer talking about laws of nature but a global technological system, which displaces catastrophe from its tragic origin. Lets recall that the Greek word κατάστρέφω has two parts, κατά ("down") and στρέφω ("turn"), where each designates a movement in a chorus. Secondly, the apocalypse as understood by Christian culture is unable to fully explain the global situation. Apocalypse as a hope for a new beginning appears more and more deceptive. Hence the algorithmic catastrophe has to be articulated and understood beyond the association with ancient tragedy or post-industrial eschatology. On the other hand, it marks the completion of speculative reason in relation to the revelation of the concept of contingency in Occidental philosophy, first systematically explored by Plato and Aristotle, then in theology and medieval philosophy in relation to God's creation, then in the work of Émile Boutroux (1845–1921), and now fully exposed in the work of the French philosopher Quentin Meillassoux.

In a concise dictionary entry, the German philosopher Hans Blumenberg points out that contingency is one of those few concepts that are specifically of Christian origin. In Aristotelian philosophy there is no opposition between possibility and necessity, but rather between possibility and actuality; it is only when it is bound to logic that such an opposition is established. The ontologization of "possible contingency" is completed in the thirteenth century: "the world is contingent as an actuality, which, because of its indifference to its existence, does not carry the reason and law of its being in itself."[6] Through the voluntarism of the Franciscan scholastics, necessity no longer justifies contingency, which becomes accident (*Zufälligkeit*).[7] If accidents as predicates dominated the inquiry into being for the ancients, now we start to witness the domination of the other meaning of accident, i.e. contingency. Contingency is always there in the laws of nature and challenges all forms of necessity, as Emile Boutroux shows in *De la contingence des lois de la nature*.[8] The contingency of the algorithmic catastrophe is no longer the same as the natural one, but rather operates within technics as the "second nature."[9] This is the background of what I term the "algorithmic catastrophe," which describes our technological situation. An objection may be posed, since here we indirectly affirm the distinction between nature and culture (if we also count technology as part of it). It is true that such a categorization is to a certain extent cultural. However, we are not affirming that nature and technics are distinct and isolated realities, but rather that the traditional concept of nature, which ignores and

undermines technics, should be called into question.[10] Hence it is necessary to put forward a second nature, which contains such a distinction but at the same time sublates it.

The algorithm that we talk about today is the latest development of reason, totally detached from the thinking brain, and becoming more and more significant in our everyday life due to recent rapid developments in artificial intelligence (AI). Algorithmic catastrophe is expressed in the perception of technical development—from 2010 on, we have twice witnessed the so-called "flash crash," which paralysed the financial market in seconds due to the use of algorithmic trading. On the other hand, this anticipation of catastrophe becomes a design principle: "Design for failure, since everything fails" is a well-known slogan of Amazon's cloud computing. One should not miss the dialectics of accidents as predicates and contingency, luck (both as τύχη) and automaticity (αυτοματον), in the development of their meaning in laws of nature to their meaning in the laws of technics—the second nature. We have entered the global age of catastrophe, and a global post-industrial eschatology, as proposed by Virilio, seems in vain since it ignores the global technical system that is essentially the convergence between different subsystems and different cultures. In order to unfold the concept of algorithmic catastrophe, we must reconsider the historical relation between technics and contingency in Occidental culture. The history here presented, as the development of reason and its exteriorization in machines, significantly leads to a self-negation from the late twentieth century until now.[11]

NATURE, CONTINGENCY AND TECHNĒ

It may be worth noting that the ancients, in times of catastrophes such as drought or flood, placed their hope in the restoration of the cosmic order, an order that would triumph over all contingencies. Due to a lack of technical and scientific knowledge, contingency constituted the mythical and catastrophic moment of tragic time, as presented in the tragedies of Hellenic culture. This contingency is in itself not only accidental, but also a necessity for the understanding of the relation between the human and the cosmos. Oedipus, the intelligent man who solved the riddle of the Sphinx, failed to escape destiny, which is at the same time *contingent* and *necessary*. The birth of science or reason is a way to overcome the unforeseeable and uncontrollable nature of contingency. Hence Plato, the biographer of Socrates, has provided us with an anti-tragic theater, in which Socrates uses his reason to penetrate into things with the "Apollonian measurement."

In *Protagoras*, Socrates proposes to develop a *technē* as the ultimate measurement of good and bad, and as a response to the sophists' proposal of multiple ends. Martha Nussbaum, in her book *The Fragility of Goodness: Luck and Ethics in Greek Tragedy and Philosophy*, has shown that the ultimate aim of Plato is to handle the fragility of luck (τυχή). Luck is contingent, since if luck is always there, it will lose its semantic meaning, and hence not be desirable. The resort to science is one way to overcome the fragility of τυχή. Science here, meaning also τέχνη or its plural form τέχναι, allows a method of measurement and calculation that renders all ends into commensurable terms. Nussbaum also turns to Aristotle's definition of technics, highlighting four elements: (1) universality; (2) teachability; (3) precision; (4) concern with explanation.[12] *Technē*, claims Nussbaum, did not have a significantly different meaning from *epistēmē* during this period of Hellenic culture. *Epistēmē* is concerned with the objectivities of the *technē*, which can overcome the contingency and the ακρασία, the incontinence. Nussbaum didn't notice the tension of the two objects to overcome: τυχή as contingency, and ακρασία as incontinence, or the weakness of will. Technics is not only an overcoming of τυχή, but also the overcoming of ακρασία, that consequently opens a new situation in contrast to the *habitus*.

This technics is not a specific skill; it is the technics of all *technai,* that is to say, rational thinking. This rational thinking, here in the name of *technē* and *epistēmē*, has an anti-tragic gesture, since tragedy is always the sufferance of the τύχη, which goes beyond the governance of rules. The tragic spirit, which flourished in the Hellenic culture of 700 BCE, is condemned by Socrates's wisdom, as it is described by Plato. The rational thinking, which Socrates proposed to Protagoras as an absolute measurement based on pleasure, defeated Protagoras's own proposal of technics, namely the teaching of justice. The great sophist was challenged not because of his technics, but rather his inability to comprehend the technics that governs all the *technai*. This science based on pleasure is not the pursuit of Dionysian desire and inspiration, but rather of Apollonian order and measurement. This scepticism of bodily desire by rational thought was announced at the very beginning of Plato's dialogue. Let us recall: an anonymous friend made fun of Socrates's pursuit of Alcibiades, implicitly likening it to a dog hunting down its prey.[13] Socrates, however, admitted his desire for Alcibiades, and at the same time showed that there is something more important than this seduction: "I wish, however, to tell you something that is [strangely] out of place: you see, though he was present, I didn't have my mind [on him], and I forgot him quickly."[14] For Protagoras and his wisdom, Socrates was able to keep Alcibiades out of his mind. The science of pleasure is a science of planning and of foresight.

It refuses immediate pleasure in view of the long-term sufferance; it accepts immediate pain in favour of future beneficial consequences. The good is the long-term pleasure; the bad is the long term suffering. The science of measurement will be able to avoid the error caused by the weakness of the will and ignorance. As Nussbaum writes:

> The author of *On Medicine in the Old Days* recognized … that the absence of a quantitative measure in his art doomed it to deficient precision and therefore to error. He was still able to claim *technē* status for it. But some years later it will be forcefully argued that any *technē* at all, to be *technē*, must deal in numbering and measuring. The common concern of all *technē* and *epistēmē* whatever, insofar as it is *technē*, is 'to find out the one and the two and the three—I mean, to sum up, number and calculation. Or isn't it this way with these things, that every *technē* and *epistēmē* must of necessity participate in these?' The author is, of course, Plato; the text is the seventh book of the *Republic*.[15]

The measurement that carries the tendency towards absoluteness constitutes a new form of τύχη, of which reason wants to be rid. This is the confrontation between technics and nature: to control in order to become better, like the science of medicine. Howard Caygill has shown that artists are not the only ones who were expelled from the city, but also physicians, who have the *technē* to cheat, as in the myths of Asclepius. The god of healing was struck by lightening on the point of breaking the necessity of nature to heal a dead man.[16] The physicians were allowed to come back to the city as guardians, however, precisely because of their capacity of intervening into necessity and contingency, or in Caygill's words, the "task of legislation."[17] This is clearer in the *Laws*, where Plato juxtaposes *technē* with contingency and necessity:

> we are told, you know, that whatever comes, has come, or will come into existence is a product either of nature [*phusei*], or of chance [*tuchē*], or of art [*technē*].[18]

This separation between the laws of nature, the contingency that escapes them, and the technics which legislates them, opens up a differentiation between the contingent and the accidental in nature and in technics. Technics, which aims to overcome contingency, also generates accidents. The progress of technical contingency is driven by its own advancement. This is best demonstrated by fire, according to a story told by Protagoras in the dialogue. The fire that is given

to man by Prometheus has already opened up the twofold nature of technics in relation to contingency. Fire, which provides warmth as well as the essential element for cooking, stabilizes the household in resisting the sudden change of weather and the attacks of animals. Fire is the compensation for the accident caused by Epimetheus, since the giant famous for his hindsight distributed skills to all animals except humans, who found themselves "naked and shoeless and without bedding and without weapons."[19] Fire results, as a consequence of what Bernard Stiegler calls a default, and hence becomes the necessity of being, the "*défault qu'il faut*" or the default of the origin.[20] The accident is the origin—and it is also the possibility of necessities—transformed and stabilized by culture.

However, fire is also the source of accidents. It can easily burn down a well-established settlement and turn everything into ashes. It is not evident in this dialogue of Plato, since for him, its ultimate aim is to show the superiority of Socrates over Protagoras, challenging the latter's confusion of the former's teachings regarding justice, and Socrates's own conviction of the means of valuing and measuring the end of the justice. Socrates, in this respect, is loyal to Prometheus, for his abilities of foresight and planning:

> And so [it's evident] that Prometheus pleased me more than Epimetheus in your story; you see, using him [as an example] and foreseeing [with Promethean foresight], I'm arranging all my life's business, and, if you'd be willing, as I said at the beginning, I'd thoroughly examine these things with you with the greatest pleasure.[21]

The resistance to contingency marks the beginning of the history of Occidental philosophy. It is also here that we understand Bernard Stiegler's interpretation of European philosophy as *by accident* instead of *by essence*.[22] He writes, "*for the European necessity of philosophy is techno-logical. Which is to say, hypomnesic. And accidental precisely* in this respect."[23] Let us unpack this sentence and unfold its relevance to our investigation here. The word "accidental" here contains several meanings. Firstly, it is accidental since Epimetheus has forgotten human beings; it is an accident, which constitutes the origin, a lack. Secondly, for Stiegler *technē* is not *part* of European philosophy but rather a *founding question* of European philosophy. This is Stiegler's own ambitious project to reformulate the history of European philosophy based on "hypomnesis"—that is, the insufficiency of memory, i.e. forgetting. And if anamnesis is central to Plato's philosophy of the truth, it demands a material support, which is also a technics of hypomnesis, as when Plato shows in the *Meno* how Socartes instructs the slave boy to solve

geometrical problems by *drawing in the sand* and *tracing the lines*. Since *technē* is a means to exteriorize memories, by exteriorizing it in the form of a *technical object* (geometry in the case of the *Meno* as well as Husserl), *anamnesis* is freed from its total dependence on the human mind, and hence is also the source of *hypomnesis*.

In this reading of Bernard Stiegler, the history of European philosophy is one that renders the *techno-logical accident necessary*. This resonates with the two senses of accident that we have explained above: on one hand, the revelation of substance through accidents, meaning the accidents become necessary; on the other hand, the overcoming of the irrational through reason. We need to establish a link between Nussbaum's treatment of accident and that of Stiegler. Although they come from different traditions, it is clear that they refer to something in common. For Nussbaum, reason's role is to eliminate the fragility caused by contingent events. This is not possible without technique, which is also reason; and this technics is not possible without a material support, as in the example we just given from the *Meno*. A connection between reason and geometry is introduced in this episode, reason and *technē* find their common object in geometry. For Stiegler, geometry is an apodictic science (or idealization), and it is because of geometry's apodictic nature that reason achieves its absoluteness. Stiegler also sees at issue the *technological* globalization of European philosophy, which for him is the only future: "Europe is called to a global becoming (to exist on a global scale) *with* its philosophy—*failing which it will die*—and can become so only by 'de-Europeanizing' itself."[24] Stiegler sounds rather close to Heidegger here, in the sense that he sees a "system" on the verge of closing down, just as the latter sees the completion of Occidental metaphysics in the epoch of cybernetics. However, it must be stated that whereas Heidegger proposes a return to the origin, Stiegler proposes a "de-Europeanization."

FROM CONTINGENT TO AUTOMATIC

Aristotle has furthered his inquiry into the nature of the contingency, and affirms the distinction between two types of chance or cause: τύχη (*tuchê*) and τὸ αὐτόματον (*to automaton*). τύχη, as we know, refers to both contingency and to luck; Τὸ αὐτόματον is often translated as "spontaneity." Τὸ αὐτόματον, however, refers not only to spontaneity, but also to the automatic: the automatic in the sense that it is already within the possibility of being itself; for example, when throwing a die there are always six possibilities. In other words, Τὸ αὐτόματον is something that can be thought—or, more precisely, that can be determined by thought. On the other hand, τύχη cannot be determined; it is necessarily

undetermined. Aristotle gives the example of a man who went to a place where he found that his debtor was collecting money from others, and then got his money back, even though he didn't come for this purpose. This for-something or for-something-else is always already automatic. Hence, Aristotle says:

> Everything which is the outcome of luck is an automatic outcome, but not everything which is the latter is the outcome of luck.[25]

Luck, here, demands a choice; it is subjective and has to do with reason. In Book II Chapter 6 of the *Physics*, Aristotle states that "nothing done by an inanimate object, beast, or child is the outcome of luck, since such things are not capable of choosing," and continues: "the automatic, on the other hand, extends to the animals other than man and to many inanimate objects."[26] Aristotle gives another example, in which a horse luckily walked out of danger and saved itself. The chance that the horse had for saving its life was not really luck, but automatic. So accident has more to do with reason than with nature. There is an automatic causality, which follows the possible cases, e.g. the definition of horse and a tripod. Luck is never the outcome of one case over another, like throwing a dice. Throwing dice is not about luck; it is spontaneous and automatic.

The contingent and the automatic are conflated today, since the automatic produces accidents, by which we assume contingency. In fact, we may be able to say that luck moves in the direction of the automatic. This automatic is at the same time spontaneous, meaning real-time, thanks to the effect of automation. The automatic of the second nature produces a new form of contingency, which doesn't oppose that of nature but rather contains it, as we can see in the example of Fukushima in 2011. The tsunami is not really the cause of the catastrophe, but rather part of the cause. That is to say, the contingency of natural law (which includes natural disaster or material failure) cannot alone explain the catastrophe, since nature (the sea) is integrated into the technological system as a cooling agent of the nuclear plant.[27] This could be further grasped as a techno-logical history of metaphysics. The completion of metaphysics according to Heidegger means that there is no longer a beyond; rather, all is present. What is present is considered to be analysable and controllable, and there one finds the beginning of cybernetics. We shall go back to this later and explain that contingency in cybernetics is no longer the one that Aristotle was referring to, nor is it that of traditional metaphysics. Cybernetics's premise of "control" is fully expressed in the title of Norbert Wiener's book—*Cybernetics: Or Control and Communication in the Animal and the Machine*—and by other authors writing on him. The control paradigm

of early cybernetics was characterised by the mathematization of different mechanisms: mechanical, biological, social, economic, and organizational. We can trace this effort from Leibniz's *characteristica universalis* to Charles Babbage's analytic machine, and on to the Turing machine, a story with which we are familiar. Mathematization took its most materialized form in algorithms. The algorithm understood as a process or an operation only expresses abstract thinking, and gains a quasi-autonomy when it is realized in machines. This is one of the modes of existence of the algorithm in its most "objectified" form. An algorithm is fully expressed in its functionalities in operation. How different is the algorithmic contingency and the contingency of the laws of nature?

There are two aspects that we can observe. Firstly, the contingency of the laws of nature always comes from outside, meaning that the system cannot be totalized. Emile Boutroux has shown in his book *De la contingence des lois de la nature* the limit of the concept of necessity. Boutroux reproached the two necessities of right (namely, analytic and synthetic) and the necessity of fact by showing that these necessities are actually open to contingency. The analytic necessity always needs to reinvent a new postulate. For example, Boutroux shows that passing from logic to mathematics, from the notion of classes and genre to those of quantity and space, a new postulate of continuity is demanded to bridge what is not continuous. The synthetic necessity, though, pretends to be *a priori* and always demands empirical experience; the necessity of fact, as already shown by Hume, is only maintained by habits. This scepticism can be extended to well-formalized physical laws. For example, according to the rule of Mariotte, considering a container of gas, the product of the pressure and its volume is a constant: PV=C, but this constant is only derived from experience and hence can be contingent. Boutroux tried to show that any necessity is always open to something outside it, or even demands something outside for its law to be completed; while for a technical system, a certain case of contingency is always already presumed, and understood as necessary. Like Leibniz's best-of-all-worlds hypothesis—the world created by God as the technical system created by its designer—is implemented in the way that it anticipates contingency, meaning that they are only *relatively contingent*.

These accidents are expected and integrated into the evolution of the technical system. In other words, there is no law that governs the necessity of the causation between the algorithmic thinking and its actualization in machine operations; there is no necessary causation between the will of human agencies as intervention and the automation of machines. Failures and errors are accepted not only as

a necessity for technological progress, but also have become immanent to its operation and maintenance. Algorithmic catastrophe becomes quotidian. This is exemplified in the design of Amazon cloud computing, known as "design for failure." An Amazon engineer has fully explained this in a research paper:

> In particular, assume that your hardware will fail. Assume that outages will occur. Assume that some disaster will strike your application. Assume that you will be slammed with more than the expected number of requests per second some day. Assume that with time your application software will fail too. By being a pessimist, you end up thinking about recovery strategies during design time, which helps in designing an overall system better.[28]

This technical realization involves the redefinition of the responsibility of the application component and infrastructure (which is allowed to be less reliable than the traditional model), and the use of NoSQL data stores and the cloud management tool, although it is not our intention to examine these technical details here.[29] In this perception, what is contingent is no longer contingent as with the natural disaster as traditionally conceived, but is necessary in the second nature constituted by "accidents." As an engineer and designer, one has to be assured that it is *normal* to have a catastrophe. If catastrophe is thus anticipated and becomes a principle of operation, it no longer plays the role it did with the laws of nature. This use of anticipation to overcome catastrophes can never be completed, however, and indeed accident expresses itself in a second level of contingency generated by the machines' own operations. Herein also lies the second difference between the algorithmic contingency and the contingency of laws of nature, which we would like to approach in the next section. It doesn't mean that the algorithm itself is not perfect, but rather that the complexity it produces overwhelms the simplicity and clarity of algorithmic thinking. This necessity of contingency takes a different form from the necessity in tragedy and in nature, which presupposes an outside of the empirical realm, or the supreme gods.

ALGORITHMIC CATASTROPHE

If we look at the early mathematical history of the algorithm, we see that it mostly concerned the problem of developing mathematical proofs in a systematic and logical way. Speaking from a purely mathematical point of view, an algorithm always confronts the question of incomputablility; indeed, as the mathematician Gregory Chaitin proposed, it appears that way in most cases.[30] The outside, or the

supplement, shares a similar logic with deconstruction. But when an algorithm becomes detached from the mind of the mathematician, in the passage from Gödel to Turing, we observe that the question of incomputability is no longer the major question concerning the algorithm, which is rather that of efficiency and reliability.[31] The Turing machine has to be distinguished from Gödel's concept of general recursivity or Church's Lambda Calculus, though in the end they are doing more or less the same thing mathematically. The Turing machine went beyond the conceptual recursivity through the exteriorization of reason in concrete and material terms. After the Turing machine and the proliferation of personal computers, mathematical proofs are still one important stream of computer science, but practical studies in computer science don't pay much attention to mathematical proofs and focus rather on the functionality and performance of algorithms. Hence an algorithm is open to contingency, which occupies another order of magnitude.

If we want to further speak of the algorithm in terms of automation, then we can probably distinguish two types of automatization: the automatization of instructions (or pure repetition) and automatization through recursions. What is recursivity? To put it in its simplest terms, it is the function, which calls itself and stops at a certain point when the constraint is met. This abstract thinking, however, has to be understood mathematically; we can probably put it like this: it is how a number could be computed in terms of a function, which calls itself until a halting state is reached. Let's consider the example of computing the fibonacci number (1, 1, 2, 3, 5, 8, 13, 21...): in the recursive step, the function calls itself, and enters a "spiral" operation until it arrives at its halting status, e.g. when the value of the variable number becomes 0.

```
long fibonacci(long number) {
  if ((number == 0) || (number == 1))
   return number;
  else
   // recursion step
   return fibonacci(number - 1) + fibonacci(number - 2);
 }
```

The common comparison between an algorithm and a recipe is almost wrong since it ignores this difference. To be sure, instructions are a sort of algorithm with the lowest perfection, that is to say, with the lowest intelligence. Instructions like recipes are fundamentally instrumental and non-reflexive; they allow for simple automation through repetition. If we define instructions as sequential step-by-step schematizations, and understand them as one pole of the algorithm, then the other pole of the algorithmic spectrum would be recursive and non-linear operations. This spectrum contains different notions of algorithm according to different specific functionalities. The evolution of machine intelligence is a progress from linear functionality to recursive functionality, taken from its mathematical foundation. We can go further by saying that even a sequential procedure is also recursive since the Turing machine itself is recursive; however, there is another type of recursion, which is based on the programmability of the Turing machine. If the recursivity of the computer (e.g. low level) is correlated with the incomputable or the contingency of the first nature, then the recursivity of the programs on the higher level has to do with the contingency of the second nature. Algorithm is understood in our context as automation through recursion. Recursion here means that the object to be computed can be understood in terms of repetitions of a function conditioned by a halting value. For example, a natural number could be understood as the operation of a function.[32] For *technē* to overcome τύχη in nature, it produces a contingency of the second nature. Algorithmic culture is the culmination of this contingency, through the standardization and globalization of the exteriorized reasons.

To elucidate this argument, I will present two cases, and analyze the algorithmic catastrophes in three temporal dimensions: 1) acceleration; 2) delay; and 3) immanence. We remember the famous newspaper article in the *Financial Times* after the financial crisis entitled "Market: Rage Against the Machine," which blamed the machines for causing the financial crisis.[33] This blame of machines continued in the financial industry following the "flash crash" of the New York Stock Exchange in 2010, and then of the Singapore Stock Exchange in 2013, both caused by algorithmic trading. Algorithmic trading can be defined simply as the use of algorithms to automatically execute purchasing commands. By profiting from short term buying and selling, known as high-frequency trading, the market can explode due to the "black box" effect—in which we see the evaporation in the aforementioned cases of $4.1 billion and $6.9 billion USD in seconds.

The speed of algorithmic automation also creates a delay, which limits the intervention of human agents. In 2012 a midsize financial firm, Knight Capital,

took 45 minutes to find out that one of the programs, which was supposed to have been shut down, was actually running. Every minute cost nearly 10 million USD. The market works on speed, which depends on the automatic speculative reasoning of the software. When the input to the software becomes random, and multiple softwares participate in speculation, unexpected results are yielded. The operation of an algorithm, temporally structured according to logical statements, may 1) fail to digest the input or 2) fail to guarantee the output; hence one can observe a 10 euro book suddenly become worth thousands of euros on Amazon when the algorithm looks for the highest possible price instead of considering it absurd. As the financial journalist Nick Baumann has noted, during the 2010 flash crash the share of the consulting firm Accenture traded at both $0.01 and $30 in the same second.[34] The mutual speculations of machines, which value each other according to the limits of their own data, failed to know their own follies.

The late Norbert Wiener had already anticipated this scene. In his article entitled "Some Moral and Technical Consequences of Automation," published in May 1960,[35] Wiener criticized the layman's understanding of automation, in particular "the assumption that machines cannot possess any degree of originality" and the belief that "its operation is at any time open to human interference and to a change in policy." The automation of machines will be much faster than human intelligence, and hence will lead to a temporal gap in terms of operation. The gap can produce disastrous effects since the human is always too late, and machines won't stop on their own. In face of our inability to fully understand the causality, Wiener warns us that "if we adhere simply to the creed of the scientist, that an incomplete knowledge of the world and of ourselves is better than no knowledge, we can still by no means always justify the naive assumption that the faster we rush ahead to employ the new powers for action which are opened up to us, the better it will be."[36]

CATASTROPHE AND SPECULATIVE AESTHETICS

Heidegger was very clear when he claimed that cybernetics is the end of Western metaphysics.[37] The end means that reason's ability to overcome contingency created a total transformation, in which thinking can no longer be detached from the accidents (predicates) of the techno-logos. The techno-logos occupies itself with beings, and no longer with the question of Being. Hence the techno-logos defines the end of metaphysics, meaning that it cannot go beyond beings towards Being. If Being is present in tragic thinking, as Heidegger reads Nietzsche as saying, then this Being is a whole held together by contingency. Contingency delimits

the knowledge of beings, and reveals the profundity of what is not yet present and what cannot be present. This "outside" serves as a new strategy to reorient; as Blumenberg states, "with the beginning of the modern period [*Neuzeit*], man looks for an exit out of the conquest through the world consciousness and self-consciousness of contingency."[38] Socrates's reason, projected in Plato's anti-tragic theater, is the beginning of the end of the ancient Greek tragedy. In the age of mathematization, contingency is equivalent to a causality, which can be logically and technically deduced. The introduction of the algorithmic contingency through the re-reading of Plato, Aristotle, Leibniz, Boutroux, Blumenberg, which shows the existence of a superior order through the *causa finalis*, cannot be fully captured by the law of nature. Jean de La Harpe writes:

> It [contingency] marks the limits of our knowledge, the necessity where we are able to demonstrate the real by examining the parts of it; we will probably—and here the probability is practically equivalent to the certitude—never be capable of demonstrating this clock of infinite gearwheels, of superposing worlds of common sense full of contradiction with a scientific universe at the same time real and intelligible; also the contingency endures long beyond science itself and humanity, and relies on reality in order to be assimilated and to be understood, but this is a limit which moves back infinitively and tends toward the ideal for a necessary determinism.[39]

In contrast to what Jean de La Harpe says, Quentin Meillassoux beautifully draws an end to the role of contingency in traditional metaphysics. I would like to engage with Meillassoux's work here, firstly because his speculation on absolute contingency characterises the *aesthetics* of the algorithmic catastrophe, meaning that contingency shouldn't be taken as exceptional, but rather unavoidable, and hence acquires certain *normativity*; and secondly because his analysis of contingency through mathematics shatters any rationalist justification of the necessity of the laws of nature. Because of this relation to nature instead of technical systems, Meillassoux's contingency cannot be squared with the algorithmic contingency that we are dealing with here. However, certain questions and formulations of Meillassoux's arguments resonate with and provide the opportunity for further reflection on the algorithmic contingency. In the following passages, I will sketch several key concepts of Meillassoux's argument, at the same time situating them within our own inquiry.

Meillassoux starts with a critique of correlationism, which according to him creates the deabsolutization of metaphysics. The project of returning to the question of the absolute, or the infinite, wants to free reason from the structures to which it has shackled itself, and move towards a new terrain which no longer submits causalities to myths and superstition, but rather provides a new foundation for science. How far can reason reach? Can reason reach a temporality where it itself ceases to be, for example in the ancestrality where humanity was yet to appear? Meillassoux wants to understand ancestrality as the limit of correlationism and its product—modern science; namely: how can one think about the ancestrality where there was not yet anything human? In other words, if there were no human, we would be able to derive that the experience of objects didn't exist; however according to correlationism, then we wouldn't be able to make sense of objects. A similar argument can be applied to the algorithms—exteriorized reasons, where we find more and more that human reason is becoming less and less capable of understanding the system that it has succeeded in constructing.

The deabsolutization of metaphysics has to grant something (for example, the unknown) that reason cannot include but nonetheless becomes reason's protection. It is exactly around the question of the archi-fact (e.g. facticity of the correlation) that Meillassoux distinguishes different variants of correlationism, for example those of Fichte, Schelling, Hegel, and down to Husserl. The subjectivists (Meillassoux chooses to use the word subjectivists instead of idealists) wanted to approach the archi-fact through enforcing the power of thought; that is how thought can penetrate into the realm of the unknown. For Meillassoux the absolute has to be posited outside thoughts, outside the reach of the mind, outside all causalities. In contrast to what he calls the "facticity of correlation" of the correlationist tradition, Meillassoux wants to propose what he calls the "principle of factuality," meaning to identify a reality or material that is independent from thought. For example, we cannot say if God exists or not, since he may exist or may not; he may appear in front of you tomorrow morning when you wake up; or you may not see him at all within the finitude of your life. I quote Meillassoux: "We will call 'contingent' any entity, thing, or event which I know could be, or could have been, other than it is. I know that this vase could have not existed, or could have existed otherwise—I know that the falling of the vase could have not happened."[40] Distancing from correlationism is a way to open up a new inquiry into the existence of the possible.

The mission of speculative reason could be understood in terms of Meillassoux's new treatment of facticity, which proposes "we propose to make facticity no longer the index of a limit of thought—of thought's incapacity to discover the ultimate reason of things—but the index of thought's capacity to discover the *absolute* irreason of all things."[41] Meillassoux wants to produce a new ontology, in which one can find a new category or entity called "over-chaos" (*surchaos*), which he wants to distinguish from chaos theory in mathematics. The over-chaos is "an absolute" that "escapes the desabsolutization of correlationism." This over-chaos is not purely chaos, meaning without any possibility of deriving order or law. Since within an absolute inconsistent being, there is hardly any contingency, as he writes "an inconsistent—universally contradictory—being is impossible, because this being could no longer be contingent. For the one thing that an inconsistent being cannot do is to *change*, to *become other*, since, being contradictory, it already is what it is not."[42] The necessity of contingency is not a proposal for a return to chaos (as in some mistaken impression of the postmodern), but rather to affirm the absoluteness of contingency.

In *After Finitude*, Meillassoux goes back to Hume's questioning of the existence of the necessity of causality, and turns it against Kant's attempt to solve the Humean problem, meaning that Kant uses the faculty of representation against the contingency of the laws of nature.[43] Kant, in his *Critique of Pure Reason*, didn't really address pure speculative reason; instead, pure reason can be established only because it bypasses the *Schwärmerei* of speculation. The return to Hume's question that the necessity of causality is only habitual, and hence vulnerable to contingency, is also a return to the speculative reason. However, the introduction of absolute contingency also needs to address the question *why is there stability instead of total chaos*? Meillassoux attempts to find the answer in Cantor's concept of the transfinite, which according to him distinguishes contingency from chance. The transfinite is the concept that mediates the infinite and its beyond (which is also itself infinite), meaning that it is larger than any finite number, but less than an absolute infinite number. Expressed in philosophical language, we can understand Cantor's transfinite as: "the (quantifiable) totality of the thinkable is unthinkable."[44] This doesn't mean, according to Meillassoux, that either the non-totalizing axiomatic is the only possible one, or that the possible is always untotalizable; however, there is always more than one axiomatic.[45] In a retrospective manner, the transfinite is only graspable when it is given the symbols like omega and aleph, meaning that a certain technicity and systematicity has to be assumed, which distances from the mere concern of the laws of nature towards a technical

system. And from this point, the question of algorithmic contingency comes in.

If we follow Heidegger's understanding of the term metaphysics and his announcement of Nietzsche as the last metaphysician, metaphysics was completed since Being is no longer comprehended as a whole. In the digital age, accidents in both senses come to the fore and beyond, as indicated by the contingency, the unknown, which also comes to the front. The necessity of contingency in the thought of Meillassoux goes beyond the effort of Boutroux, and has lowered contingency as the signifier of the supreme order (which bears the name of Being or God) to immanence. This reference to Heidegger doesn't mean that we are longing to construct a new metaphysics, but in view of overturning of ground and form, it is rather, as he says, "raising questions on, or about metaphysics."[46] The limit of human knowledge or reason is no longer something which can be improved through scientific research based on causality; one has to accept that some knowledge outside correlationism exists or is possible. If I am allow to follow Heidegger that Nietzsche was the last metaphysician, and cybernetics has drawn an end to Western philosophy, we may also be able to conclude that Meillassoux has completed speculative reason, in the sense that the arrival of catastrophes has become a perpetual movement: what arrives is no longer an "accident," but rather it just happens; the catastrophes are accompanied and *normalized* by speculative aesthetics.

To summarise without concluding, the aim of this article was to introduce the notion of the algorithmic catastrophe as related to the history of the metaphysical concept of contingency. Τέχνη, as Nussbaum has shown, is reason's attempt to overcome contingency. It has nevertheless created a contingency of the second nature. Along with the exteriorization of reason passing through the mechanical and thermodynamic ages, and now the digital age, we have witnessed the emergence of the algorithmic catastrophe that must be distinguished from industrial or military accidents. The causality of an industrial accident could be traced and avoided, but the control of algorithmic catastrophe is increasingly beyond the capacity of human beings; however, it is also self-evident that industrialization has a great tendency towards the implementation of algorithmic automatization. The distinction between *tuché* and *automaton* raised by Aristotle has been transformed due to the automatization of reason. The twofold nature of technics (to both overcome and generate contingency) in its relation to contingency can be understood as *pharmakon*, both a remedy and a poison.[47] One would be able to take the algorithmic catastrophe further than computational algorithm, for example in

the research of genetic engineering, military development, nanotechnologies, etc. However, this article can only focus on the mathematization and actualization of algorithms in machines. The algorithmic catastrophe also resonates with current research on speculative reason, especially what Meillasoux proposes as the absolutization of contingency, which reinvents the metaphysical concept of contingency as necessity while it renounces the subjectivist approach towards knowledge. The celebration of speculative reason seems to be an appropriation of the catastrophic aesthetics of our time, where the unknown and black box become the sole explanations.

In May 2014, the world-renowned professor of physics Stephen Hawking and three other professors—Stuart Russell, Max Tegmark, and Frank Wilczek— published an article in the British newspaper *The Independent* after the launch of the film *Transcendence*, questioning the success of AI and the long-term problems associated with it. The science professors affirmed the benefit of AI for different domains, but also warned that "this would be a mistake, and potentially our worst mistake in history." The maturation of AI theory and the rapid developments driven by industrial and military investments have left any reflection behind—it always arrives too late. The future of AI development is unknown, but now it has to be questioned:

> One can imagine such technology outsmarting financial markets, out-inventing human researchers, out-manipulating human leaders, and developing weapons we cannot even understand. Whereas the short-term impact of AI depends on who controls it, the long-term impact depends on whether it can be controlled at all.[48]

This warning resonates with that of Wiener's 1960 essay discussed above: it would be ignorant to just dismiss the algorithmic catastrophe as something from science fiction. The words of the physicists also remind us of Book III of Plato's *Republic*, where the physicians return as guardians of the polis. Should these guardians be scientifically well-trained philosophers or philosophically trained physicians is not a question without importance, since it means a new pedagogical program and a new conception of responsibility. Beyond the reach of this single article, what Virilio proposes as a rethinking of responsibility remains largely undiscussed. If this article serves a critique of the algorithmic catastrophe and speculative reason, this critique is only one in the Kantian sense.[49]

NOTES

1. I would like to thank Katian Witchger and the reviewers for their valuable comments.

2. Norbert Wiener, *God and Golem, Inc. A Comment on Certain Points where Cybernetics Impinges on Religion*. Cambridge : MIT Press, 1966, 63.

3. André Lalanda, *Vocabulaire technique et critique de la philosophie*. 7ème Édition. Paris: PUF, 1956, 13.

4. Paul Virilio, *Original Accident*. Trans. Julie Rose, London : Polity, 2007, 5.

5. Ibid., 6.

6. Hans Blumenberg: "Kontingenz", *Die Religion in Geschichte und Gegenwart. Handwörterbuch für Theologie und Religionswissenschaft*. Eds. Kurt Galling. 3. Aufl. Bd. 3. Tübingen: Mohr Siebeck, 1959, 1793–1794, "Die Ontologisierung des » possible contingens« ist erst im 13.Jh. abgeschlossen: die Welt ist Kontingent als eine Wirklichkeit, die, weil sie indifferent zu ihrem Dasein ist, Grund und Recht zu ihrem Sein nicht in sich selbst trägt."

7. Ibid., 1794, "Das Notwendige enthält keine Rechtfertigung der K. mehr; K. wird jetzt Zufälligkeit." There is still a nuance between contingency and accident, for example, in Emil Angehrn's "Vernunft und Kontingenz: zur Standortbestimmung der Philosophie," in *Studia Philosophica*, vol. 51 (1992, 221–240). Angehm proposes that one can probably say that all accidents are contingent, but not all contingents are accidents. However, this nuance, as I will show later, exemplified by the contingent and automatic of Aristotle's *Physics*, has slowly converged along the development of *technē*.

8. Émile Boutroux, *De la contingency des lois de la nature*. Paris: Librairie Félix Alcan, 1921.

9. I take this term from Bernard Stiegler: see Bernard Stiegler and Elie During, *Philosopher par accident*. Paris: Galilée, 2004.

10. The distinction between nature and technics is not simply a Western distinction, I believe that in other cultures, at least in the East Asian culture, technics has never been taken into the realm of nature, though technics can behave according to the principle of nature. In this case it no longer concerns technical objects but rather body techniques. A significant example is the butcher PaoDing in the Taoist classic *Zhuangzi*, whose knife loses its importance after he has acquired into the Tao (nature) of the cow, since he knows how to enter into the void instead of confronting the bones and tendons. See, Zhuangzi, *The Complete works of Zhuangzi*. Trans. Burton Watson, New York: Columbia University Press, 2012, 19–20.

11. This follows Lyotard's conception of the postmodern as the negation created by technologies—the product of the modern; see Jean-François Lyotard, *The Postmodern Condition: A Report on Knowledge*. Trans. Geoff Bennington and Brian Massumi, Minneapolis: University of Minnesota Press, 1984.

12. Martha Nussbaum, *The Fragility of Goodness: Luck and Ethics in Greek Tragedy and Philosophy*, Cambridge: Cambridge University Press, 2001, 95.

13. Ibid., 92.

14. Plato, *Plato's Protagoras : translation, commentary, and appendices*. Trans and eds James A. Arieti and Roger M. Barrus, Polymouth: Rowman & Littlefield, 2010, 309a.

15. Nussbaum, *The Fragility*, 107–108.

16. Howard Caygill, "Drafts for a Metaphysics of the Gene," *Tekhnema 3 A Touch of Memory*, Spring 1996. tekhnema.free.fr/3Caygill.html.

17. ibid.

18. Caygill, "*Drafts*," cited from Plato, Laws, Book X, 888e.

19. Plato, *Progoras*, 55, 321c.

20. Bernard Stiegler, *Technics and Time, v.1 The Fault of Epimetheus*. Trans. George Collins and Richard Beardsworth, Stanford: Stanford University Press, 2004.

21. Plato, *Protagoras*, 108, 361d.

22. Bernard Stiegler, "The Magic Skin; or, The Franco-European Accident of Philosophy after Jacques Derrida," *Qui Parle* 18: (2009, 97–110).

23. Ibid., 99.

24. Ibid.

25. Aristotle, *Physics* Book I and II. Trans. William Charlton, Oxford: Oxford University Press, 1992, Book II, Chapter V, 197b.

26. Ibid.

27. Gilbert Simondon has explored the concept of a "geo-technological milieu" in *Du mode d'existence des objets techniques,* Paris: Aubier, 1958, 2012, when he talked about the associated milieu of the Guimbal engine; this point is further made explicit by Bernard Stiegler, "Preface," in Yuk Hui, *On the Existence of Digital Objects*, Minneapolis: University of Minnesota Press, 2016.

28. Jinesh Varia, "Architecting for the Cloud: Best Practices," https://media.amazonwebservices.com/AWS_Cloud_Best_Practices.pdf.

29. George Reese, "The AWS Outage: The Cloud's Shining Moment," broadcast.oreilly.com/2011/04/the-aws-outage-the-clouds-shining-moment.html.

30. Gregory Chaitin, *The Unknowable*, Berlin: Springer-Verlag, 1999.

31. This is also the limit of deconstruction: see Kojin Karatani, *Architecture as Metaphor*, Cambridge, MA: MIT, 2000. Karatani drew an analogy between deconstruction and the question of the outside in the mathematical proof of Gödel and Wittgenstein's critique of Russell.

32. It should be noted that it is not only limited to natural number; one can also understand it in political terms, for example the quantification of an object or an individual in terms of recursive function.

33. Michael Mackenzie, Arash Massoudi and Stephen Foley, "Markets: Rage against the machine," *Financial Times*, October 16, 2012; http://www.ft.com/intl/cms/s/2/fd9c4e38-16ee-11e2-b1df-00144feabdc0.html.

34. Nick Baumann, "Too Fast to Fail: Is High-Speed Trading the Next Wall Street Disaster?," January/February 2013 Issue; www.motherjones.com/politics/2013/02/high-frequency-trading-danger-risk-wall-street.

35. Norbert Wiener, "Some Moral and Technical Consequences of Automation," *Science*, New Series, Vol. 131, No. 3410 (May 6, 1960): 355–1358.

36. Wiener, *Some Moral and Technical Consequences*, 1358.

37. Martin Heidegger, "The End of Philosophy and the Task of Thinking" (1969), *On Time and Being*. Trans. Joan Stambaugh, New York: Harper & Row, 1972.

38. Blumenberg, "Kontingenz," 1794.

39. Jean de La Harpe, "L'idée de contingency dans la philosophie d'Émile Boutroux," in *Revue de théologie et de philosophie*: 43:10 (1922, 121). "elle [contingency] marque les limites de nos connaissances, la nécessité où nous sommes de démonter le réel pour en examiner les rouages ; nous ne serons probablement — et ici la probabilité équivaut pratiquement à la certitude — jamais capables de la remonter cette horloge aux rouages infinis, de superposer au monde du sens-commun plein de contradictions un univers scientifique à la fois réel et intelligible; aussi la contingency durera aussi longtemps que la science elle-même et que l'humanité, penchée sur la réalité pour se l'assimiler et la comprendre ; mais c'est une limite qui recule indéfiniment et tend vers la forme idéale du déterminisme nécessitaire."

40. Quentin Meillassoux, "Métaphysique, spéculation, corrélation," *Ce peu d'espace autour. Six essais sur la métaphysique et ses limites*. Eds Bernard Mabille, Paris: Les Éditions de la Transparence, 2010; the citation is based on the manuscript instead of the book, I would also like to thank Robin Mackay for assuring the translation. "On dira "contingente" toute entité, chose ou événement, dont je sais qu'elle peut ou qu'elle aurait pu effectivement ne pas être, ou être autre. Je sais que ce vase aurait pu ne pas exister, ou exister autrement- je sais que cette chute du vase aurait pu ne pas se produire."

41. Ibid. "nous proposons de faire de la facticité non plus l'indice d'une limitation de la pensée- de son incapacité à découvrir la raison ultime des choses- mais l'indice d'une capacité de la pensée à découvrir l'absolue irraison de toute chose."

42. Ibid., "un être inconsistant- universellement contradictoire- est impossible, parce que cet être cesserait de pouvoir être contingent. En effet, ce qu'un être inconsistant ne pourrait faire, c'est se modifier, devenir autre, puisque ce qu'il n'est pas, étant contradictoire il l'est déjà."

43. Quentin Meillassoux, *After Finitude, an essay on the necessity of contingency*. Trans. Ray Brassier, London: Continuum, 2008, 89

44. Ibid., 104.

45. Ibid., 105.

46. Ibid., 109, "The end of metaphysics is still largely identified with this type of dissolvent approach—it is no longer a matter of asking oneself metaphysical questions, since the latter are mere semblances of questions, or questions that are now irremediably obsolete, but rather of raising questions on, or about metaphysics. "

47. See Jacques Derrida, "La Pharmacie de Platon," *La Dissémination*, Paris: Editions du Seuil, 1993; and Bernard Stiegler, *Ce qui fait que la vie vaut la peine d'être vécue : De la pharmacologie,* Paris: Flammarion, 2011.

48. Stephen Hawking: "Transcendence looks at the implications of artificial intelligence - but are we taking AI seriously enough?," *Independent*, May 1, 2014

49. Jean-François Lyotard has attempted to start such a reflection during the period when he developed the concept of the postmodern (in view of the computational power of the Minitel).