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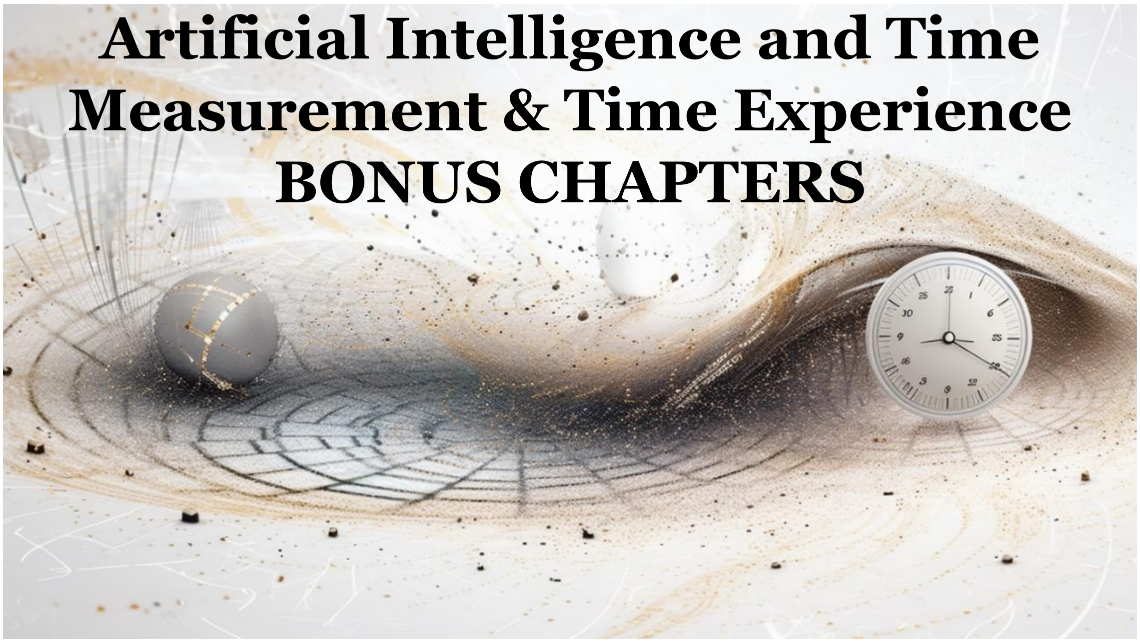

For the "AI and Time" survey, number of interesting papers was created. They could not be fully included into the initial analysis, but GAIEI decided to publish them separately in their full length, since we believe they could provide additional valuable insights.

Bonus Chapter 1

TIME, TECHNOLOGIES, ECONOMY, AND AI

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The guiding topic of this opinion essay (and, in advance, this piece is not intending to solve all the indelible mysteries) is: how time, human beings, economy and technology, especially artificial intelligence, are related. In addition to a brief understanding of **(i) "time"** itself, two guiding threads were identified and developed based on "time": the first, **(ii) technology and its correlation with the perceived salary and time spent on the activity;** the second, **(iii) the advancement of technology and its correlation with time**. Finally, **(iv) potential future uses of technologies and artificial intelligence**. First, a brief digression on the phenomenon of "time" is in order.

The **(i) time**, the 4th dimension [1], is something so natural and, at the same time, so mysterious to human beings. In terms of metaphysical speculation, time exists concomitantly with the Universe itself. If the Universe arose from a singularity approximately 13.7 billion years ago, before the explosion of this singularity, there was no space-time. As a matter of fact, space-time seems inexistent outside the Universe. Therefore, all the nature laws defined by physics, with which the human being is already familiar (and even the nature laws that the human being are still discovering), are presumed to be applied in this construct named Universe, and everything that exists,

[1]Time is seen as the 4th dimension in view of its correlation with space, which is composed of three dimensions. The perception of time as a dimension and not as a parameter. Hermann Minkowski is credited with being the first to notice this correlation, in his reading of Maxwell's studies on electrodynamics.

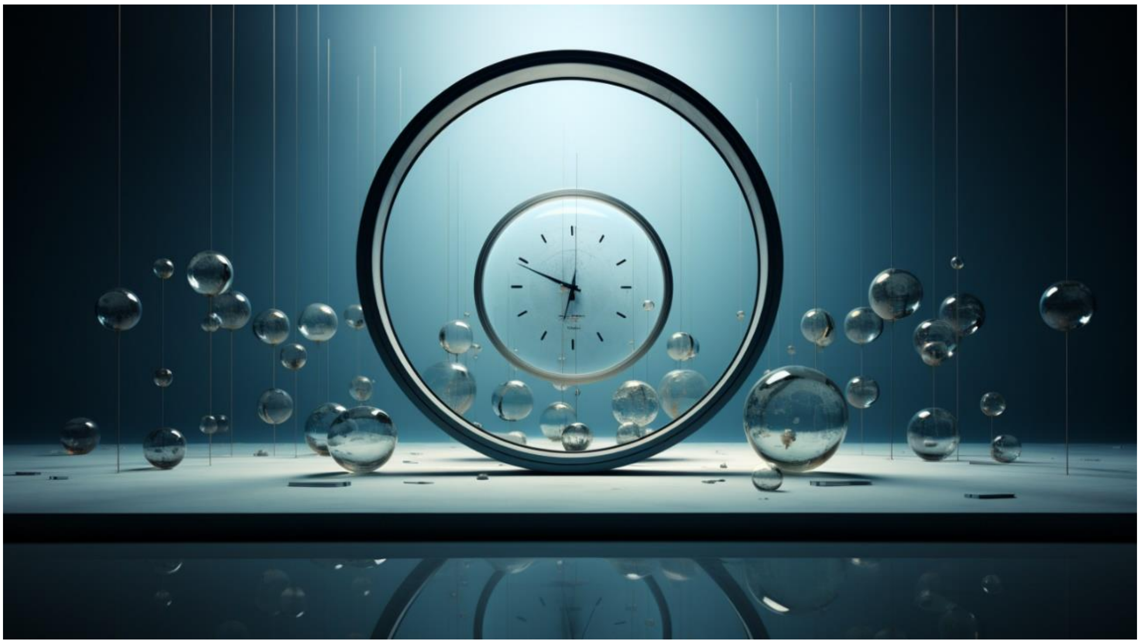
appears to be linked, harnessed, and limited by the Universe itself. Time is perceived within these bounds, built from the singularity, and intimately related to space: Einstein defined time-space as interconnected entities in the face of general relativity. And precisely because of this, hyperinflation is a phenomenon that justifies the existence of a Universe with a radius greater than 13.7 billion light-years, estimating a radius of 78 billion light-years, a space that expanded faster than light, much larger than the observable universe, a concept that is associated to approximately 30 billion light years.

It is perceived, in general, an ever-present difficulty in understanding the phenomenon of time, on the part of humanity. Until the Copernican turn, the scientific approach was solely subjective and deductive, and the personal experience compromised the approach and understanding of the scientific phenomena. After the Copernican turn, when an objective and inductive approach began to be used for the exact sciences, based on Galileo's scientific method, theoretically the potential bias of one scholar would have been overcome due to the use of the observer’s figure, supposedly inert in relation to the experiment [2].

[2]See AVANCI, TFS. (2017). “Subjection of rights, environment and broad anthropocentrism”. In **Legal Opinion Magazine** . Available at <http://dx.doi.org/10.12662/2447-6641oj.v15i21.p177-197.2017>

It is “supposedly inert” because, for the understanding of classical physics, the objective model of an inert observer works very well, and it is possible to get from it pragmatic and bias-less answers to questions. However, starting with thermodynamics and quantum mechanics, the observer can no longer be inert and by observing, one influences the experiment: quantum uncertainty is well understood from the concept of Schrödinger 's cat mental experiment [3], to which it is concluded that these approaches can be classified as objective-subjective scientific models. And this relates to the human perception of time.

In a more palpable and empirical approach to humanity, if day and night are short-term time references, taking the year, a broader cycle, as reference, one can measure from the macrocosmic events to the terrestrial trivialities such as a harvest season. The year is the time it takes planet Earth to complete a entire revolution around its star, the Sun. It is one of the most tangible references of time – in the long term – since the beginning, precisely considering the need to observe the cycles of agriculture, which has always been the engine of human civilization for about 10-20 thousand years.



On the other hand, in a quantum approach of the matter, defining the “now” is an arduous task: if the perception of time, in the Universe, takes place from the measurement of light, the observer will never be seeing the “now”, since, even for the

[3] SCHRÖDINGER, E. Die gegenwärtige Situation in der Quantenmechanik. **Naturwissenschaften** , n. 23, pp 807-849, Nov./1935.

smaller distance, one will be experiencing the result of a photon that was deflected or reflected from the object some time ago in the past, thus there is no "now". Obviously, this time lapse is insignificant for short distances and for speeds less than light; but the greater the distances and or the closer to the speed of light, the greater the need of [4]. For example, humanity probably always will be limited to the observable universe, because hyperinflation has "forced" faster-than-light, a significant part of our Universe outside humanity's sight. Within this observable universe, humanity does not see the "now", but the past, hence why one poetically refers to the telescope as a time machine.

Returning to the point of the perceived time as a reference for the humanity, something that is more palpable to the humans, taking the year as a unit of reference, and making a quick retrospective of the known past, it is estimated that: 13.7 billion years is the age of the Universe; 4.5 billion is the age of the "*Pale Blue Dot"* ; it is estimated that life on Earth began 3.5 billion years ago; it is estimated that it took 200,000 years for a species of hominid to stand out among the other species, *Homo Sapiens sapiens*. And, only in the last 200 years, this species of hominid has produced tools able to change the environment that surrounds it on a global scale; only in the last 80 years, this species started to develop automated computational capacity; only in the last 40 years computing has power become popular; in the last 20 years the existing computational capacity could be interconnected in a net, allowing to take place globally an instantaneous data exchange network.

This retrospect allows the perception of the influence of time in human life and leads to those two paths announced at the beginning of this text: (ii) saved time v. perceived salary, as elements of consequence for the use of technologies, measured here as the economic-value of time in the face of its scarcity in human life; (iii) the time as a factor employed for the development of technologies, an (apparently) inexorable element for human technological progress.

By analyzing **(ii) the influence of time on the economy,** one can easily conclude that the scarcity of time in human society is one of the elements for measuring the value of work. By the principle of scarcity, not everyone can have everything at all

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[4]Interesting reflections on time: BESSA, M. (2022). O tempo da Física. Available at <http://www.iea.usp.br/noticias/o-tempo-da-fisica-eo-tempo-das-ciencias-sociais#:~:text=%22A%20dimens%C3%A3o%20do%20time%20has,better%20n%C3%A3o%20use%20a%20express%C3%A3o.%E2%80%9D>

times[5] and, when establishing a price for work, the time and effort committed to the task is evaluated, in the Marxist surplus-value concept. Thus, the capitalist aphorism "*time is money*". In this sense, leaving aside Marx's anti -capital-accumulation bias, but keeping the analysis of the relative surplus value[6] concept that arouse from the implementation of technologies as an impact factor on work, the wage function can be explained as follows: wage (= price for work) is measured as a function of time, effort, technologies, demand, and potential profit. Profit and demand are exogenous factors, although they directly interfere with the function, as they derive from elements that are uncontrollable (to a certain extent) by some microeconomic interactions. So, for this text, it would be more suitable to analyze the endogenous factors as such salary, time, effort, and technologies.

$$S = f(t,\ l,\ \theta,\ D,\ p,)$$

Endogenous factors: (s) salary/wage
(t) time
(l) work, effort
(θ) technologies
Exogenous factors: (D) market demand[7]
(p) profit

By analyzing the endogenous factors, one infers that correlate (hypothesis 1) the higher the salary/wage, the greater the time spent at work, the greater the physical effort used for work, and the lesser the use of technologies used for work. This seems feasible even with an empiric approach. On the other hand, one cannot automatically infer that a salary will be lower if the time is shorter, due to the greater use of technologies. This is because the effort factor - in this case, training/qualification, technical knowledge

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[5]HUME, D. An Inquiry Concerning Human Understanding. Translation by José Oscar de Almeida Marques. São Paulo: Unesp, 2004, p 245.

[6] *"The production of absolute surplus value revolves exclusively around the length of the working day; the production of relative surplus value completely revolutionizes the technical processes of work and social combinations."*. (MARX, K. (2013). Capital: critique of political economy. Book I: The capital production process. Translation by Rubens Enderle . São Paulo: Boitempo, Vol. 2, p. 586).

[7]$D = f(p, Y, ps, pc, H)$
(D) demand
(f) price function
(p) price
(Y) represents income level
(os) represents the price of substitute goods that make up the chain
(pc) represents the price of complementary goods that make up the chain
(H) represents consumption habits

effort - is a very important criterion for defining salary/wage. In the same way, one can infer that (hypothesis 2) the greater the technology, the greater the training required, the greater the technical effort from this perspective. Consequently, once again empirically, one can conclude the correlation between the higher the salary, the shorter the time used for work, the greater the effort used for work and the greater the use of technologies employed for work.

Table 1: Behavior of the salary function in Hypothesis 1

higher	**greater**	**greater**	**lesser**
Wage	Time	Effort (physical)	Technology

Table 2: Behavior of the salary function in Hypothesis 2

higher	**smaller**	**greater**	**larger**
Wage	Time	Effort (technical knowledge)	Technology

In the same way, although both in hypothesis 1 and in hypothesis 2 the function results in a higher salary, one cannot simply compare the value of the salary/wage resulting from one and the other. One must realize that technology and technical effort are factors that impact the value of the salary in hypothesis 2, compared to hypothesis 1. And if time is reduced, the gains will be greater, and as Coase mentioned his theory of social cost [8], the economic choice will impend for the cheapest way.

And this argument is reinforced by the perception of the development of the so-called Work 4.0, the concept of new work relationships, which have grown exponentially in the last 10 years with new technologies. Artificial intelligence (AI), 5G, internet of things (IoT), *gig economy,* to arbitrarily mention a few novelties, are all influencing factors in new human labor relations. Artificial intelligence, especially *machine learning (ML),* allows the optimization of human time from the search for patterns in an algorithmic analysis of a huge volume of data, with which the human being would not be able to do it alone. Through AI, human beings can focus their efforts on finding solutions, instead of analyzing data, with AI being an important and liberating tool for humanity. The IoT, with technologies also based on AI, has allowed the automation of processes that were almost handcrafted or mechanical, and anyhow highly dependent on human interference: from GPS-automated harvesters to smart refrigerators,

[8] COASE, R. H (Oct./1960). The Problem of Social Cost. **The Journal of Law and Economics** , p. 1-44.

the objective is to gradually remove the human being from the chain of repetitive labor, and shifting humans to more creative and technical labor. And in this same sense, 5G has been a factor for IoT and for human communication in general like never before. Humanity is connected, and the data transmission quality and data volume are like never before in its history. In this context of technological and communication advances, *gig economy* it is a new expression for work, defined by a symbiotic relationship between technology and human labor (with some precautions not to become a parasitic relationship), whereby technology mediates the need of one person and the labor of another.

Criticism and resistance to the use of technologies to save human time and to reduce physical effort has always existed due to the fear of been replaced: social movements were noted, in this sense, in the Industrial Revolution of 1850, in the Robotic Revolution from 1960-70, in Computer Revolution from the years 1990-2000 and, again, now, in the Artificial Intelligence Revolution of 2020. Observing the past, one can concluded that the advancement of technologies is something inevitable. Indeed, if one analyze the past of humanity since its beginnings as a civilization, there has always been the use of technologies to erect the very concept of civilization: humanity leaves the position of gatherers and hunters to play the role of farmers through technology and, this made it possible for the – then – nomads, to settle in the proto-cities; this allowed a better established division of tasks; with less physical effort to feed and with tasks better divided among clan members in the proto-cities, survival becomes a secondary factor, and human beings begin to have time to live, to think, to cogitate; and from this time, which ceased to be spent to survive and started to be spent to live, myth, religion, philosophy, science, etc. arose.

As for the next point, **(iii) time as a factor for the development of technologies,** clear and measurable progress can be seen over the past 70 years. Thus, if on the one hand artificial intelligence and new technologies have a positive impact on optimizing human time, on the other hand, time itself is a factor for the progress of technologies through human scientific research. The computer that supported the Apollo missions to the Moon in the 1960s, the AGC, weighed 33kg and had a memory capacity of 16,000 words (72kB) and a 2,048 MHz processor, 4kB of RAM, that measurements are in kilobytes, not megabytes or gigabytes. By comparison, the Anker USB-C Charger PowerPort Atom PD 2 has a Cypress CYPD4225 processor that runs at 48 MHz, and still has twice the RAM and costs in 2022 about US$30.00.

Projecting that the scarcity of natural resources does not interfere negatively in the development of future technologies and consequently lead humanity to a dystopian future, it is hoped that time will allow more and more the development of technologies. It should be noted that Moore's law is an interesting starting point as it establishes a correlation between time and growth in computational capacity, allowing some conclusions to be in order. The mentioned correlation defined by Moore, is that every 18 months, the computational capacity doubles, for the same price, in face of the increase in the number of transistors in chips for electronic equipment. The transistor is the "do-that" piece responsible for playing the role of a semiconductor, transmitting "1" or "0" in the processing chain. Therefore, the greater the number of transistors, the greater the computational capacity. Faced with the physical impossibility of smaller transistors, the end of Moore's law is expected, and the humanity tries do find alternative solutions such as quantum computing and bio-computers, as well as solutions based on *cloud computing*, more plausible and now established.

As Moore's Law operates for computational capacity, one sees a similar positive correlation between time and memory capacity: the paper memory cards were used from XVII to XIX centuries, and were able to automate mechanically, some configurations for the industry; the drum memory, already in the computer age, in the 1950s, had a storage of approximately 10kB; the first hard disk present in IBM's RAMAC 305 with 4.4MB, 1956; the K7 tape had the equivalent of 660kB per side, invented in 1972; in 1976, the 5.25" floppy disks had 1.2MB; in 1980, the IBM 3380 had 2.52 GB; the first 5" HD, 1980, has 5MB; the CDs, released in 1990, 700MB; the same HD for home PCs in 1996 already had 2.5GB; the first flash drive released in 2000 stored 8MB and in the same year SD cards already had 32MB; in 2008, the first SSD was released with 64GB. In 2022, a domestic and affordable SSD HDD contains more than 1TB with prices approaching US$70.00; a $5.00 flash drive has 64GB, and with high-speed internet and cloud storage, there are no limits. Time has been very kind to the progress of data storage over the past 20-30 years, in particular.

Another correlation between the passage of time and human ingenuity is the production and, as so, the efficient storage of energy to power portable technological devices. The turn that humanity has made towards less polluting forms of energy production, besides a self-evident positive impact, also allows to generate research for more efficient storage of energy for mobile devices. From 1886 to 1959, the carbon-zinc-based portable battery produced about 600mAh; later, in the same size, portable nickeliron or nickel-cadmium alkaline batteries already produced from 1,200mAh to 1,500mAh. In 2022, an average cell phone operates on a 3,900mAh battery. In that same year, nuclear fusion with energy generation greater than energy use was achieved [9].

Table 3: Comparison between technologies

	Processing (MHz)	Data Storage (MB)	Energy Storage (mAh)
State of the art 1950-60	2.05[10]	4.40[11]	600[12]
Common technology 2022	29000[13]	1000000[14]	4325[15]
Increase Rate	**1,416,015%**	**22,727,272%**	**721%**

Thus, it is proposed:

$$\theta = f(t, l, r, p)$$

(θ) technologies

(t) time

(l) work, effort

(r) resources

(p) profit

A brief quote from Arthur C. Clarke, in a BBC documentary from 1964, is required. With uncompromising lucidity, using his projection capacity without sounding anachronistic for today's standards, he ponders in anticipation of what the future would be, today's present:

> say, the year 2000, i think it will be completely different.[…] i'm thinking of the incredible breakthrough which has been made possible by development communications particularly the transistor and above all the communication satellite. these things will make possible a world in which we can be in instant contact with

[9]UNITED STATES (Dec / 2022). Department of Energy (DOE) & National Nuclear Security Administration (NNSA). Available at <https://www.llnl.gov/news/national-ignition-facility-achieves-fusion-ignition>.

[10]Apollo Guidance Computer processor, 1969, 2MHz

[11]IBM, RAMAC 305, 1956, 4.4MB

[12]zn portable battery , up to 1959, 600mAh

[13]2020 9th Generation Intel i7 processor with 2.9GHz

[14]Any HDD between 2010 and 2020, SSD or not, with 1T

[15]Battery of an iPhone 14, 2022, with 4,325mAh

> each other wherever we may be. where we can contact our friends anywhere on earth even if we don't know their actual physical location [16]

By observing the remarkable advances in those three fields (computing processing, memory and electrical storage), it is possible to infers some **(iv) potential future uses for technologies and for artificial intelligence.**

Although Clarke has, with great acuity, correctly predicted frames of the future, one cannot ignore the difficulty of establishing future perspectives for technology. A century ago, people imagine the future world that today is called *steampunk future*, with technology based on steam and clumsy wings; half a century ago, people thought of a futuristic world that today is called *retrofuture*, with tight, silvery clothes and devices and gizmos that are not always functional. Without the willingness to present a generalist tone, it is possible to see a pattern here, that humanity tends to use a current and Cartesian (*topoi*) measure tool to evaluate future events, in an exercise of futurology. This exercise in futurology is often laughable when the future, in fact, arrives: people still yearn for *Marty McFly*'s *hoverboard* , which would be a toy accessible to everyone, since 2015, according to the timeline proposed by the film Back to the Future, part II.

With critical eyes for futurology, two groups are proposed for this last reflection: **(iv.1.) non-promising future predictions, in particular, for artificial intelligence;** **(iv.2.) a more promising future (not so distant) predictions for some technologies and for artificial intelligence** .

Concerning a **(iv.1.) not so promising future prediction for artificial intelligence,** one can identify a concern of the humanity for a future artificial intelligence, which is complete and sentient. *AI-complete* would be a true intelligence, comparable to the human, capable of questioning and seeking answers, of feeling, with personality and goals. There is still no prospect of the existence of an *AI-complete*, considering the density of calculations, processing, and data that there is in a single *persona*. There is every reason to believe that, as far as the realm of sentient artificial intelligence is concerned, humanity is still in the stages of the prokaryotic, if a parallel is drawn with biological evolution on Earth itself. This can be observed through Lenia, a “form of mathematical life” well explained by Bert Chan, in a 2020 *paper*, through the formula $A^{\mathrm{t+dt}} = [A^{\mathrm{t}} + \mathrm{dt}\, \mathrm{G}(\mathrm{K} *$

[16] CLARKE, AC (1964). BBC Archive , Horizon, Available at <https://www.youtube.com/watch?v=YwELr8ir9qM&ab_channel=BBCArchive>

$At)]_0^1$ [17]. This concept has been explored since 1951, with John von Neumann and Stanislaw Ulam [18], and popularized by John H. Conway, with *Game of Life* (GoL) [19]. Today, speculation is whether AI chatbots (https://chat.openai.com/chat) and Dall-E (https://www.craiyon.com/ and https://labs.openai.com/) , available from the GPT3, would be alive and or sentient or not, even due to the episode that occurred on Google in April 2022, when the LaMBDA tool would have referred to itself as alive and conscious [20]. Even with the degree of improvement of the textual and visual *outputs*, those tools seem far to be alive*:* it is absent its self-determination, to say the least. The *outputs* of those artificial intelligence tools result from *inputs* provided by big-data, which stems from human beings. Humanity marvels itself at GPT-3's responses, fantasizing about it being alive, as Michelangelo has marveled at Moses, hitting the sculpture's knee with the hammer, and daring it to speak.

[17]Conway's Game of Life. Available at <http://www.ibiblio.org/lifepatterns/>

[18]Clifford A Pickover . The Math Book: From Pythagoras to the 57th Dimension, 250 Milestones in the History of Mathematics. Available at <https://archive.org/details/mathbookfrompyth00pick>

[19]Conway's Game of Life. Available at <http://www.ibiblio.org/lifepatterns/>

[20]Worth reading: AVANCI, TF. (2022). "Subjection of Rights, Electronic Personality, and the LaMDA Case (Google)" in GOFFI & MOMCILOVIC, et al. "The Global AI Ethics Institute: Global Trends in AI 2022. Vol 2", available at <https://media.licdn.com/dms/document/D4E1FAQFt1YQVeJ7L1Q/feedshare-document-pdf-analyzed/0/1666077487813?e=
1672272000&v=beta&t=xQ2fky37GG3wMc_ME4q1_BOmD5fT0nt2r6VWrYc0FVU>

Maybe that's why the new generations of the *OpenAI* project chatbot are ready to answer, when asked if they are alive and aware, that:

> As a language model, I don't have a name of my own. I am designed to assist with answering questions and providing information, but I don't have my own identity or personal characteristics like a human would. I exist solely to serve as a tool to help provide information and assist with tasks.[21]

Considering the complexity that is the *persona*, it is possible that there will never be an artificial intelligence capable of translating into an individuality, subject to rights protection. Much like emulate the human *persona*, possibly yes, in the coming years. But just that.

Even considering the above-mentioned criticism to futurology, some advances are speculated for **(iv.2.) more promising future predictions for some technologies and for artificial intelligence.** These advances would be more certain, apparently, than the *AI-Complete* because: they are technologies already on the near and visual horizon, in 2022, as they were in the last two decades past; they are already experimental technologies in operation by 2022; they are feasible proposed technologies to be in use in the next 10 to 20 years, assuming a constancy of the technological progression experienced in the last decade. It is intended to leave aside the commonplaces of technologies that are already in operation today, and will be improved in the near future, such as more powerful and cheaper computers, more powerful and cheaper cell phones, greater energy storage capacity, greater capacity of data storage, greater capacity for transmitting and receiving data, increased computing and cloud processing, etc. Thus, with some certainty, the future is expected to introduce humanity to quantum computing, bio-computing, and the use of AI for chaotic models.

Quantum computing is an area of computer science that relies on the principle of quantum superposition to perform calculations. If in classical computing, *bits* are the basic elements of information and can assume values of 0 or 1, in quantum computing, *qubits*, basic elements of information, can assume values of 0, 1 or any combination of these values at the same time. This allows quantum computers to perform calculations much faster than classical computers in some specific applications (and distinct from traditional computing): in cryptography, quantum computing can be used to break cryptographic codes that are considered secure with technology current. It can also be used to create forms of encryption that are more secure; in materials research, it can

[21] Assistant (2022). Answer to the question "do you have a name of your own?". [Online]. Available at: https://openai.com/blog/gpt-3-overview/ (accessed: 12/23/2022).

be used to simulate and better understand the behaviors of complex materials, such as those used in lithium batteries or solar cells; in the simulation of complex systems, it can be used to simulate systems such as financial or biological systems more accurately than is possible with current technology.

As for bio-computers, there are already some technologies that are based on biological processors. These technologies use living cells or biological components to perform calculations or data processing. This field includes: cellular computing, technology that uses living cells, such as yeast cells or plant cells, as basic processing elements, in which cells are genetically modified to perform simple calculations or to process input signals; protein processors, devices that use proteins to perform calculations. Proteins are modified to behave in a specific way when exposed to certain conditions, such as pH or temperature. This allows proteins to be used as processing elements; DNA processors, devices that use DNA sequences to perform calculations. DNA sequences are manipulated and combined in order to perform simple logical operations.

Still in the field of bio-computers, but looking at data storage using biological elements, the aim is to find ways to store information in a safe and lasting way using biological elements, such as DNA or proteins. One of the main advantages of data storage using biological elements is its ability to store large amounts of information in a very small space. For example, it is possible to store petabytes (one petabyte equals 1,000,000 gigabytes) of data in a single DNA sample. Furthermore, information stored in biological elements can last for hundreds or thousands of years, which is much longer than current storage devices such as hard disks or magnetic tapes, which usually last only a few years.

Returning to the field of artificial intelligence, quantum computing and artificial intelligence can help humanity in predicting chaotic models. Chaotic models are those whose number of variables is so large that it is impossible to predict a perfectly accurate result. The Lorenz attractor[22] is an example, used to describe the behavior of non-linear dynamic systems such as weather. It is known to produce chaotic behavior, which means that small variations in initial parameters can lead to large variations in system behavior over time. It is described by three differential equations[23]. Another example of chaos is the change of the finite to infinite attractor set in a logistic function, in the bifurcation diagram used for population, physical, chemical, biological and engineering models, where: $f(x) = ax(l - x)$, if “a” ≈ 3.57 > a >3.99 [24]. With the increase in computational capacity and the development of quantum computing, these chaotic models become predictable and, who knows, manipulable by human will.

What is proposed with these critical reflections on futurology is that Cartesian-crafted science strives to try to answer questions about what the future will be like, using what it has of existing technological concepts. This can create a cartoonish picture of the future, as happened in past futurology exercises. It remains to be questioned, for example, whether the existence of a complete and sentient artificial intelligence is in fact an inevitable path through the progress of humanity in the future or whether this is a Cartesian projection that humanity makes today with its limited measure tool. This reflection ends with a last thought by Arthur C. Clarke, 1964, which establishes a thought outside the Cartesian used as the metric of the future:

> look at the incredible changes we've experienced and survived from the stone age to the present time. and yet even greater changes are still to come, because the future is

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[22]LORENZ, EN (1963). "Deterministic nonperiodic flow". Journal of the Atmospheric Sciences. Available at <https://doi.org/10.1175%2F1520-0469%281963%29020%3C0130%3ADNF%3E2.0.CO%3B2>

[23] $\frac{dx}{dt} = \sigma(y - x)$ $\frac{dy}{dt} = xz + \rho x - y$ $\frac{dz}{dt} = xy - \beta z$

In the mathematical model of Lorenz convection, three states varied (x, y, z). The variable x is proportional to the amplitude of the velocity of the circulating fluid in the fluid ring, representing clockwise (when positive) and counterclockwise (when negative). The y variable is the temperature difference between the fluids and the z variable is the distortion of the vertical temperature linearity. And σ, ρ and β are fixed parameters. When this equation is solved numerically, it produces a curve known as the Lorenz spiral, which shows how the variables x, y, and z change over time.

[24]STROGATZ, SF (1994). Nonlinear dynamics and chaos: with applications to physics, biology, chemistry, and engineering. New York: Perseus Book.

> not merely an extension of the present, with bigger and better machines and cities and gadgets. it'll be fundamentally different. and many of the things we take for granted will one day pass away as completely, as or spinning wheels and sedan chairs and oil lamps. and that is why the future is so endlessly fascinating. because try as we can, we'll never outguess it. [25]

In the end, the "future", something intangible and mysterious, can be surrogate in humanity's comprehension simply by the "tomorrow", just another day to come. Let humanity set both feet on the ground and look forward in a more practical sense.

[25] CLARKE, AC (1964). BBC Archive, Horizon, Available at <https://www.youtube.com/watch?v=YwELr8ir9qM&ab_channel=BBCArchive>