

# History never repeats itself... unless we let it to!

João Paulo Costeira

Instituto Superior Técnico, Dec 2022 ([published in 88 Vozes sobre a AI](#))

*The dismantling of the education system is the greatest risk we can face if AI is allowed to flow without rules. Abandoning the construction of the knowledge pyramid, cutting out essential levels for understanding the world and for the development of critical thinking, would be tragic. The temptation is great to replace “knowledge and thinking” by “doing without knowledge”.*

For decades, historians, economists, and futurists have announced a great transition of humanity toward well-being, largely pushed by technology. According to John Maynard Keynes' calculations, we should now be working 15 hours a week, and the corresponding income would allow a life filled with leisure and enjoyment. Despite digitalization already underway since the 1980s, economist Robert Solow noted that "computers are everywhere except in productivity." Only those who have never filled out electronic forms for public administration, insurance companies, or banks would find this strange, but in 2012, Paul Krugman realized that something substantially different was on the horizon. The economic growth game could soon have new pieces:



*If you follow these things, you know that the field of artificial intelligence has for decades been a frustrating underachiever, as it proved incredibly hard for computers to do things every human being finds easy, like understanding ordinary speech or recognizing different objects in a picture. Lately, however, the barriers seem to have fallen — not because we've learned to replicate human understanding, but because computers can now yield seemingly intelligent results by searching for patterns in huge databases.*

**Paul Krugman, NYTimes 27 Dez 2012 : Is Growth Over ?**

Krugman's observation took a decade to manifest publicly until, in October 2022, a chatbot named ChatGPT burst into our daily lives. As a scientist and engineer in signal processing and artificial intelligence (AI), it may seem somewhat out of place to place the discussion in a field that is technically foreign to me, but precisely because I have lived and participated in the phenomenon that Krugman so well perceived, I propose here to reflect on AI in the realm of people, not technology. This reflection is, essentially, a personal testimony, illustrated with examples based on the following premises:

- AI in general and ChatGPT in particular, do not possess any attributes of "intelligence" in the sense of human understanding of language or sensory perception. They do not represent concepts or knowledge explicitly, nor do they create new knowledge through internal processes. ChatGPT is a gigantic mathematical model that generates text based on the statistical positioning of words, with these statistics estimated from data extracted from digitized documents and the internet. If we insist enough times that the Earth is flat, ChatGPT will change its opinion as soon as the weight of opinion becomes favorable. The surprising performance in writing and text analysis instead suggests that some tasks we label as "cognitive" are, in fact, less demanding on the brain than we thought.
- ChatGPT will primarily be a powerful tool for performing repetitive or common cognitive tasks, allowing us to tackle more complex problems and generate new knowledge more easily! Personally, it has become a daily tool both in the production of code (software) from natural language descriptions and in routine administrative or even teaching activities. For example, manipulating spreadsheets, databases, or writing web pages becomes accessible to laypeople. Regarding the economy and development, it is undoubtedly a tool with enormous potential to make a range of very relevant services accessible to small businesses (analytics, promotion, data-driven decision-making), which would otherwise require scarce and inaccessible technical personnel (e.g., programmers, technical assistants). However, and this is critical, it demands a critical stance toward its responses, as it frequently produces incorrect information and "hallucinations."
- It seems of utmost importance that citizens and society at large appropriate this technology, both from the perspective of its use and in the discussion of its regulation. AI will likely contribute decisively to a substantial increase in productivity across vast domains, largely due to the automation of tasks currently performed by humans, causing significant changes in professions. It is undoubtedly an opportunity to increase the value produced and enhance inclusion. On the other hand, without changes to the current status quo, the risk of the opposite happening is also significant, **hence the history of unequal distribution of productivity gains may repeat itself!** The precariousness of work by expanding the "gig economy" to more professions is a risk. If the social disengagement of the "financial" sector continues, the gap between the few holders of technology and business owners and the rest of the population of "AI operators," more or less differentiated, will widen. As an educator and citizen, I see a truly frightening risk we cannot take: the belief that AI eliminates the need for learning and knowledge, abandoning understanding in favor of execution, and turning people into true robots!
- It is widely agreed that regulating AI is imperative, especially to prevent the continuation of the current monopolistic environment that has hindered innovation, its scaling, and its reach to more sectors of society. This has perpetuated an undue extraction of value by blocking access to the economy and stifling or acquiring competitors. The potential for producing fake news, fraud, and

societal manipulation is clearly a foundational problem, but since we are already submerged in this with social networks and since the implementation details are beyond my expertise, we leave this discussion to those better equipped to articulate public policies and law.

As a scholar with scientific activity in the field, I was surprised by some reactions of near panic regarding ChatGPT from colleagues, students, and friends. I realized that most professionals outside the tech field subconsciously adhere to the anthropomorphic idea of AI. They fear they are in the presence of a machine more intelligent than humans and, feeling their jobs and well-being are threatened, try to resist, hoping that some barrier will rise to stop the “invader.” Few have experimented ChatGPT outside of a recreational context and have not realized that their potential as professionals can increase vastly if they embrace tasks that rely on the knowledge provided by their education and training. With AI, we will be better equipped to combat a certain technological obsolescence, which is difficult to counteract due to constant change and which I experience firsthand.

It is in this context of amazement, where fear of the unknown mingles with the excitement of discovering something transformational, that we address especially our fellow citizens who, by training or circumstance, view this device with strangeness and distrust. To make communication more direct, we provide some concrete examples focused on the points synthesized above.

### **Artificial Intelligence and the Other Intelligence**

Ironically, AI has developed in a methodologically different, even opposite direction, from what John McCarthy, the creator of the term "Artificial Intelligence," envisioned. What is commonly called AI today refers to a certain type of computational system capable of encoding enormous amounts of information, generating mathematical representations of “unusual” data, such as images of people's faces or other “objects.” Simply put, an AI system "learns" by adjusting the parameters of a mathematical model, so that for a given set of input data, it reproduces output data or decisions with as much accuracy as possible, mimicking those made by another “system”, such as a human being. These methods work because they are trained with thousands (millions or billions) of input/output data pairs, previously annotated, typically by humans.

We use an example developed between IST (Instituto Superior Técnico) and Carnegie Mellon University, illustrated in the image alongside, where some of the 900,000 vehicles used to train an AI system for vehicle counting in an urban environment are shown. Identified by “boxes,” the training vehicles were identified by human “clicks” to estimate the parameters of the mathematical model, which, based on the original image, predicts the number or position of the vehicles. Once the model is calculated, the system works by



counting vehicles in images it has never seen before, with remarkable accuracy, even with partial occlusion of the vehicles. However, the AI system has no idea what a vehicle is; it can only answer the question "how many vehicles are in the image?"

Now imagine what an electric vehicle maker like Tesla can do by frequently (daily?) training the system from huge volumes of images captured by its fleet of millions of vehicles in circulation.

However, it was the public release of ChatGPT that created a perception of social disruption, surprising both the scientific community and society at large. ChatGPT interacts with us in natural language, answers questions on any subject, and performs tasks that are surprising because they were thought to require a high cognitive level. The technology it is based on is well-known and common (see Ref. GPT3), but we were surprised by the effect that the scale of training produced. From what is known, GPT3 contains the astounding number of 175 billion parameters. For reference, systems like the vehicle counting described above have about 30 million variables. Hundreds of billions of words were used for training, extracted from millions of documents, books, and web pages, such as Wikipedia. Training involves extracting sequences of words of variable lengths (up to 3000 words), optimizing the mathematical model parameters so that ChatGPT predicts the next word in the sequence with maximum accuracy. Intuitively, training is meant to reinforce or decrease confidence (probability) in selecting a word based on its observed co-occurrence with all previous words. This process takes months to compute on a cluster of tens of thousands of processors, whose costs only a handful of entities, like Microsoft or other "tech giants," can afford.

If this explanation suggests to you that ChatGPT is "just" a number cruncher that builds a "statistical model" with  $1.71 \times 10^{11}$  variables... you understood it correctly! Considering that a language like English has about 40,000 commonly used words, the number of possible combinations is staggering, even after discounting nonsensical combinations. That ChatGPT can generate meaningful sentences, for example, poems, using words in combinations it has never seen before is surprising and seems hardly achievable this way. In more specific contexts, its ability to generate code (programming) that enables the execution of complex tasks on a computer, processing spreadsheets, and even, astonishingly, proving mathematical theorems is equally surprising. In short, ChatGPT demonstrates a remarkable ability to construct text it has never seen, which almost always "makes sense."

### **An Impressive Parrot, But Still a Parrot**

Evidently, sentences that make sense and sentences that are correct are different things. Intuitively, let's say that ChatGPT generates language it frequently observed across the internet. However, to avoid always giving the same answer (the most probable words), it generates "variants" by randomly choosing less probable words that occur naturally in a given context. Thus, it randomly "steers" the discourse to different places, "wandering" through the vast possibilities. On the other hand, it was trained with everything "at hand," particularly uncensored data. One of the undesirable consequences is the production of "hallucinations,"

where, after a correct and structured text, ChatGPT adds factual absurdities sometimes disconnected from the subject at hand. It often blatantly fails when answering questions that involve specific knowledge, regardless of the field, behaving essentially like a "stochastic parrot." ChatGPT always has an incorrect answer to give, but be careful, for a layperson or the inattentive, the text "makes sense" because it uses words that often appear in sequence.



compare portugal e onomic indicators to spain

**Gross Domestic Product (GDP):**

In terms of GDP, Spain has a larger economy than Portugal. According to the World Bank, Spain's GDP was \$1.4 trillion in 2020, while Portugal's GDP was \$238 billion.

**GDP per capita:**

However, when looking at GDP per capita, which is a better measure of economic well-being, Portugal is slightly ahead of Spain. Portugal's GDP per capita was \$23,131 in 2020, while Spain's was \$29,659.

For example, ChatGPT does not know (does not represent!) the concept of number or dollar, nor the relation of greater/lesser. It essentially chooses words that co-occurred during training and might have flipped a coin to decide between greater/lesser since they are equally plausible in context. Unfortunately, this time it ... revealed its "nature" ! Evidently, these types of errors will be trivially resolved by integrating "calculators" (like Wolfram's), and with time and updates, the errors will become less frequent. However, it will always be somewhat unreliable, precisely because its intelligence is... artificial! The most sarcastic metaphor I've encountered about ChatGPT is that:

**"ChatGPT is as vast as an ocean, but as deep as a puddle."**

We recommend reading the opinion of Prof. Michael Jordan, one of the leading names in Machine Learning, whose suggestive title is clear: *"AI – The revolution hasn't happened yet."*

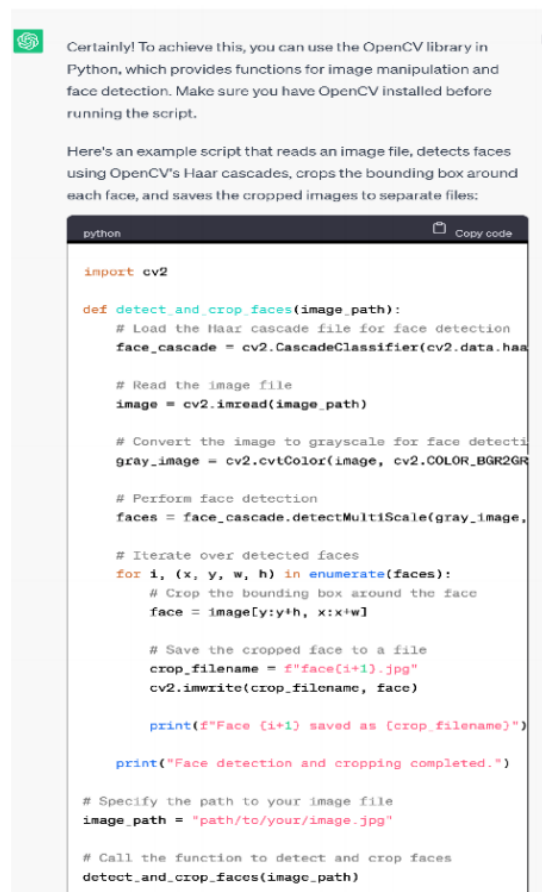
## AI and the Professional

In the professional context, tools like ChatGPT have become invaluable assistants and accelerators in bringing projects to fruition that otherwise would have remained at the “idea” stage. Often, career progression brings with it the inevitable loss of proficiency in tasks that require continuous practice (e.g., programming). Moreover, the unavoidable obligation to satisfy the various bureaucrats regulating the daily life of institutions consumes time, which becomes scarce for competitive innovation activities that require constant attention to the “state of the art.” These are just some of the contexts in which tasks can be executed by requesting ChatGPT to do them, preferably in English since it constitutes 93% of the training data. The figure shows an academic example of Python code for detecting faces in images, produced in response to the request: “write a python script to read an image file, detect faces, crop the bounding box and save the bounding box in a file.” With a few more minutes of interaction, you could create a system that scans your photo archive and identifies all the people in it!

We cite programming because, being a fundamental skill, in Portugal, it is absent or underutilized in numerous professional classes, particularly in the social sciences. “Computational social science” has become a fundamental discipline supporting the direct or indirect observation of the current or past state of society. From writing economic history to quantifying the impact of public policies or monitoring social phenomena on a large (or small) scale, the ability to “dig” through data and process it is immensely facilitated for those with the knowledge to understand it. Evidently, a more cynical view would predict the reverse movement, i.e., ChatGPT is an opportunity to de-skill programmers, replacing them with less qualified people since much software production is automatable, as demonstrated above. This is certainly a scenario that will happen, but only by sheer inertia, immobility, ignorance, or incompetence will we let growth opportunities slip and succumb to threats.

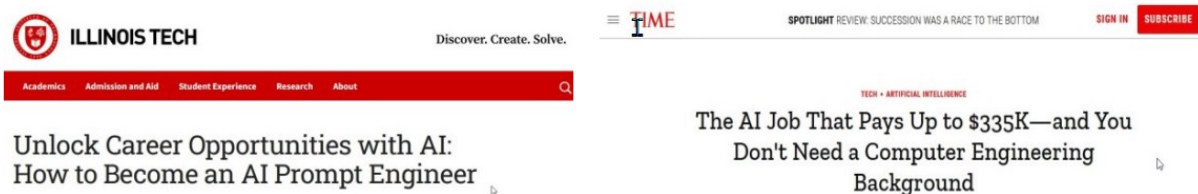
### AI and Education:

As we mentioned earlier, the dismantling of the education system is the worst risk we could face if AI is allowed to flow without rules. Abandoning the construction of the knowledge pyramid, cutting out essential levels for understanding the world and developing critical thinking, would be tragic. In truth, we are already experiencing a process of “short-circuiting” academic paths, with shortcuts being introduced that will come at a high cost later. The temptation to replace knowing how to think with just doing... without knowing, is



great. This is especially tempting in today's society, where schools are increasingly seen as providers of "educational services."

It's not surprising for a teacher in ICT engineering to encounter graduates who increasingly use tools they don't understand. Neural network AI is based on concepts of linear algebra, calculus, statistics, probability, and optimization, all wrapped in a programming interface that allows this "toolbox" to be used without understanding what's underneath. ChatGPT and "generative" AI point to another scenario, where even programming becomes unnecessary. The U.S., for better or worse, is far more dynamic and deregulated than Europe and has already created institutional and informal offerings for an emerging profession, that of the "Prompt Engineer." The PE is a conductor of dialogues (prompts) with ChatGPT to extract the correct answer. As we've seen, ChatGPT is bad at math, so you have to explain that 23 is less than 29!



The comment is not trivial because while Illinois Tech rushed to launch "prompt engineer" courses, major schools like MIT, Carnegie Mellon, or Stanford did not. Instead, they reinforced the basic components and included AI subjects in traditional courses. For example, unlike the Instituto Superior Técnico, which has drastically reduced its math components in recent years, schools like EPFL and ETH have gone in the opposite direction, precisely because these increasingly complex systems require deeper knowledge and more capacity for students to think independently.

For a small country like Portugal, the risk is that, through institutional atavism or incompetence, AI will dismantle high-level education and turn into a factory of "call center" substitutes, with the relocation of "soft" engineering sectors to Portugal while our talent emigrates to foreign schools that do "hard" engineering. Of course, what has been illustrated here for engineering applies, *mutatis mutandis*, to all other fields of knowledge.

## Regulation and Monopolies

Finally, another burning issue is regulation. We all understand that AI must be regulated, but the bad omen came when Sam Altman, one of the owners of OpenAI and creator of ChatGPT, testified before the U.S. Congress. Altman made an emotional appeal for regulation, warning of the dangers of AI, a potentially "existential" threat. This expression of concern can be read as "give us the regulation because OpenAI, with its partner Microsoft and other big players, will take care of the danger." Simply put, it will almost certainly be as difficult for a new startup to enter the AI business as it is for a small company to enter the pharmaceutical industry today.

The AI ecosystem is in an explosive phase of creation, and as OpenAI itself exemplified, this creation does not happen in large "big tech" conglomerates but in small companies with highly qualified and motivated founders. Moreover, it seems evident that it is possible to improve ChatGPT's performance in specific fields, where quality data and proprietary know-how can make all the difference. Smaller and more environmentally sustainable systems than ChatGPT may be more reliable and cost-effective. Sam Altman knows that ChatGPT is replicable with relative ease, although he has the assurance that very few companies, not even most countries, have the resources to build and maintain something on the scale of their system.

In other words, the danger in the regulation process is that it will be captured by monopolists/oligopolies, making it impossible for systems that are not part of the "big players" club to gain certification. Without detailed knowledge of the regulation process, it seems to us that Europe has taken serious steps to impose rules that respect privacy and AI ethics, though transparency in these systems—something more difficult to regulate—still needs to be enforced. It remains to be seen whether Europe will have the ability to resist the initiative and overwhelming economic leadership of the U.S. in this domain. Without having read technical documents or having personal knowledge, something tells me that Margrethe Vestager, Vice-President of the European Commission, knows what she's doing. She has the status, proven track record of not colluding with monopolists, and a bold and courageous way of defending civilizational values. Even her "body language" and assertiveness inspire confidence about the direction of European regulation.

Now, that's a conclusion ChatGPT would never reach: Without being fed a ton of data that violates GDPR, it would be incapable of understanding the importance of "body language"!