OPENNESS AND CLOSURE

Explainable Artificial Intelligence and Simondon's "Technical Mentality"

Otavio Morato otaviomorato@gmail.com
Universidade Federal de Minas Gerais, Brazil, ORCiD 0000-0002-0541-7353

Diego Viana vianadeoliveira@gmail.com
Universidade de São Paulo, Brazil, ORCiD 0000-0002-7041-4650

Tyler Reigeluth Tyler.Reigeluth@ulb.be
Université Catholique de Lille, France, ORCiD 0000-0002-9908-1052

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Corresponding author: Otavio Morato

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Abstract

Nearly seventy years ago, Gilbert Simondon introduced a transformative perspective on the relationship between technology and culture, emphasizing the need for a "technical mentality" arising from a renewed awareness of and engagement with technical objects. This article revisits the notions of technical object, technical mentality and open machine, in order to analyze explainable artificial intelligence (XAI). Our central question is: under what conditions can XAI be conducive to a technical culture? It is argued that XAI may contain an embryo of technical openness applied to algorithmic systems, fostering greater proximity and dialogue with humans as mediators of technical activity. However, XAI also embeds the tensions between openness and closure that characterize digital technology: while it may enable greater human understanding and intervention, it can also enhance elements of opacity and automatism. It is concluded that XAI has the potential to assist in promoting a broader and more participatory technical culture, conditional on integrating technology into human culture in a reflective and critical manner, provided that, as with any technical deployment, the ethical and structural challenges it entails are taken into account at its conception and not after the fact.

Plain Language Summary[1]

- This paper discusses whether explainable artificial intelligence (XAI) can genuinely help people understand and work with AI systems—not just use them. Drawing on the philosopher Gilbert Simondon's ideas about technicity, the authors explore whether XAI can reduce the "black box" effect and foster a healthier, more informed relationship between humans and machines.
- Simondon argued that modern societies suffer from "technical alienation" because their link to technical objects and systems is merely utilitarian. The paper revisits his concepts of technical objects, open machines, and technical mentality to examine whether XAI can reconnect humans with the inner workings of contemporary AI systems.
- XAI may contain a seed of openness: it can help users see why AI makes certain decisions, reveal underlying factors, and expose biases. This transparency can, in principle, promote more meaningful interaction, where users question, adjust, and learn from the system rather than passively accept its outputs.
- However, the paper warns that XAI also carries the opposite potential: explanations may be too shallow, too technical, or too simplified, creating an illusion of understanding without real insight, as in the case of scholarly papers accompanied by AI-generated summaries. If explanations are disconnected from people's actual knowledge and context, they may reinforce dependence on experts and algorithms instead of empowering users.
- For XAI to truly support a "technical culture," people must not only receive explanations but also gain the capability to interpret, question, and influence AI systems. This means designing AI that users can meaningfully interact with—not just observe—and strengthening education so people can understand technical systems in daily life.

[1] AI-generated; author checked and accepted.

- The paper concludes that while XAI does not automatically create openness or reduce alienation, it can contribute to these goals if developed critically and thoughtfully. To succeed, XAI must be integrated into broader cultural, ethical, and educational efforts that ensure people are not merely passive recipients of automated decisions but active participants in the technical world they take part in.

1 INTRODUCTION

As artificial intelligence (AI) systems become increasingly embedded in daily life, influencing activities ranging from product recommendations to medical and legal choices, growing efforts are emerging to make these systems comprehensible and trustworthy. In this light, explainable artificial intelligence (XAI) has been presented as an approach to help end users understand how AI systems make decisions, thereby enhancing the transparency, accountability, and legitimacy of those decisions (Alves & Andrade, 2024). Its overarching purpose is to provide tools to detect and mitigate biases, ensure compliance with regulations, build societal trust, and enable error correction. Explainability has been developed not only on a technical level but also in legal terms, as it has been incorporated as a principle in statutes like the European General Data Protection Regulation (GDPR) and Brazil's General Data Protection Law (LGPD) (Nunes & Andrade, 2025).

Indeed, there are pressing concerns about the possibilities introduced by AI technology, including algorithmic biases and failures (Alves & Andrade, 2024), job loss and technoprecarization (Andrade & Cupello, 2024), behavioral modulation (Andrade, 2022), as well as control and surveillance in the context of cybernetic citizenship (Reijers & Orgad, 2021). However, following the French philosopher Gilbert Simondon's insights, we wish to highlight that technical changes are not extrinsic to the social reality they affect, but express certain relations between technicity, history, and nature (Viana, 2024). In other words, these changes are not an inherent feature of the techniques, simply added to or imposed upon society. Instead, the invention, development, and use of a technical element, object, or network are relational processes that occur within and also constitute human collective existence. Thus, the problem of AI in general, and explainability in particular, can only be effectively addressed through an examination of their relational processes.

In his 1958 book *On the Mode of Existence of Technical Objects* (MEOT), Simondon provides a basis for reevaluating and reimagining our relationship with technical objects. This work explores the nature of these objects and their connection with human beings, arguing that while aesthetic objects are traditionally considered "cultural", technical objects, often seen as mere tools (utensils), are treated primarily in functional and economic terms. Consequently, Simondon (2017/1958) sought to foster a technical culture through forms of engagement with technical objects and ensembles that enable users to appreciate them beyond their mere functionality and instrumentality. Ultimately, he wishes to reconcile technical objects and cultural practices by showing how each involves and expresses the other. Informed by his own engagement with technical objects, Simondon's reflections addressed issues – such as technical networks and planned obsolescence – that would later become central to discourse surrounding contemporary technology.

This paper engages with the issue of explainability in AI from the perspective of Simondon's proposal of a technical culture, animated by a technical mentality[2]. Our central question is:

[2] In Simondon's thought, technical mentality and technical culture are closely related yet conceptually distinct. The former refers to a cognitive and affective disposition informed by technical reality – a mode of thinking shaped by schemas of intelligibility, affective openness, and voluntary norms of action. It is not just technical

"under what conditions can explainability in AI be conducive to a technical culture?". Our hypothesis is that XAI may reflect an openness in line with Simondon's concept of the open machine. Contrary to closed or perfectly automatic machines, open machines invite human engagement and participation, thus encouraging the development of a technical culture. In Simondon's diagnosis, such a culture would overcome the problem of technical alienation, which arises from the exclusion of technics from culture and generates unreasonable expectations or fears. Indeed, this exclusion positions machines, tools, and instruments as either wonders or threats – potential sources of liberation from work or of absolute subjugation. These two perspectives are often invoked in debates about AI's effects on the social order or the organization of labor. While the proponents of explainability in AI seek to avoid this trap, we would like to mobilize Simondon's philosophy to question the extent to which XAI can genuinely mitigate technical alienation.

This article is divided into three sections. First, we present two central concepts of Simondon's philosophy of technology: technical object and open machine. We then explore Simondon's framing of technical culture as a way of knowing the genesis of technical objects that reconciles technics (as the field of material operations) and culture (as the field of symbolic meaning). Finally, we problematize the idea of explainability in AI through the lens of the presented concepts.

2 TECHNICAL OBJECTS AND OPEN MACHINES

2.1 TECHNICAL OBJECTS

Much of Simondon's effort consisted of moving our understanding of technical objects beyond their functionality and instrumentality. Indeed, they are more than mere tools used for specific purposes. Understood as a certain mode of existence, technicity must be grasped as: (a) a system involving more than utensils and machines, encompassing the relationships between them, the humans who operate them and their conditions of existence within flows of nature; and (b) a continuous process of invention, in which tools evolve, are reconfigured, reinvented, and expanded through their human participation in their functioning.

For this reason, the technical object is best approached not as a static entity, but through its genesis, i.e., the "[...] process of concretization and functional over-determination that gives it its consistency at the end-point of a process of evolution, thus proving that it cannot be considered as a mere utensil." (Simondon, 2017/1958, p. 20, emphasis added). Simondon rejects classifications that distribute technical beings into genres and species according to abstract categories and functions, disregarding the operational lineages of technicity. His genetic method understands technical objects as moments in a dynamic process that progresses from the abstract to the concrete, where structures and operations converge.

An example of concretization, according to Simondon (2017/1958), is the bulb (*Guimbal*) turbine, in which water plays multiple roles: it provides the energy to drive the turbine and dissipates the heat generated by the generator. Similarly, oil serves multiple functions: it lubricates the generator, acts as a heat conductor, and aids in mechanical sealing. For Simondon, this turbine exemplifies a concretized object that integrates an associated milieu into its operation. Through its concretization, the technical system behaves more and more like a

knowledge, but a form of engagement and reasoning grounded in openness and operativity. Technical culture, in turn, is the collective process in which such a mentality can be cultivated and shared. For Simondon (2009), its scattered and undervalued presence in society reveals the need for broader recognition and transmission – turning individual experience into shared culture.

"natural" entity behaving within its environment. The machine's internal integration and its communication with the outside are two sides of the same process.

2.2 OPEN MACHINES

In the article Technical Mentality, Simondon (2009/2006) reflects on the correlation between technical objects and human cognition and how the former can be designed to foster a technical mentality – a way of thinking and relating to technical objects that grasps their evolution and concrete operations, thereby integrating them into human culture (Viana, 2020). Simondon (2009/2006, p. 19) identifies two aspects of technical mentality: modularity and entelechy. Modularity means technical objects are composed of subsystems that can be separated and repaired independently. Thus, a technical object can be designed for disassembly and maintenance, allowing for adjustments and part replacements to ensure its continued functioning. This invites repair and invention as users engage with the object's structures and operations. Users have the opportunity to evaluate and interact with the concrete functioning of the object, thus individuating their knowledge and experience of the object.

The second aspect is entelechy, a concept borrowed from Aristotelian philosophy, qualifying the dynamic by which an entity actualizes its potential and purpose. Simondon argues that the operational levels and regimes of technical objects should be analyzed in their entelechy, as they operate, rather than as form, in a state of inactivity. For technical objects to function properly, they must reach a certain "threshold" of operation where their potential is actualized. Below this threshold, they are dysfunctional or even self-destructive. Simondon uses the example of the Leduc ramjet (a type of engine used in hypersonic aircraft and high-speed missiles) to show that some technical objects function fully only under specific conditions. Given the high speeds it requires to operate, it performs poorly on the ground but optimally in flight when it can use airflow for propulsion. What a technical object is capable of thus partially depends on its associated milieu. Simondon aims to reveal the importance of appropriate conditions for technical objects to reach their full potential, avoiding superficial or reifying judgments about their effectiveness.

Based on these two aspects, Simondon underlines the importance of designing open technical objects that promote a technical mentality. These are the objects with the highest technicity: "If one seeks the sign of the perfection of the technical mentality, one can unite in a single criterion the manifestation of cognitive schemas, affective modalities, and norms of action: that of the opening; technical reality lends itself remarkably well to being continued, completed, perfected, extended" (Simondon, 2009/2006, p. 24).

The openness described by Simondon benefits from a network-like structure: while the technical object externally connects to a broader network of technical and social systems, its internal structure is also interconnected, with parts that are simultaneously interdependent and relatively independent in their functions. Like the "nodes" of a network, each component plays its role and can be replaced or adapted without compromising the system's overall functionality. In Simondon's view, an open object is one that balances durable components with others designed for adaptability, allowing it to be "completed, improved, maintained in the state of perpetual actuality" (Simondon, 2009/2006, p. 24).

Open systems are adjustable and preserve a margin of indeterminacy, irreducible to absolute automaticity and functional adaptation – a state Simondon calls hypertely, in which objects are over-adapted to conditions without which they cannot function at all. Open systems thus adhere to both aspects of technical mentality: (1) they reflect modularity by allowing substitutions and adjustments to their subsystems, ensuring continuous maintenance and adaptation while avoiding holistic judgements on their utility; (2) they express entelechy by operating through dynamic adjustments to their environmental conditions and use context.

Conversely, the closed machine is characterized by isolation, rigidity, and low technicity. Its automatic functioning expels indeterminacy, thereby becoming incapable of environmental adaptation or interaction. Its structure is difficult to modify, even for an expert operator. While the relative absence of a human operator makes them appear more efficient and self-sufficient, closed machines in fact express an economic and political desire for automaticity that reduces their technical scope of operation. Closed machines thus tend toward obsolescence and operational degradation, as they fail to keep pace with the processes of their environment and, more importantly, lose touch with the social practices within which they operate (Mérida, 2017). Furthermore, highly complex closed machines also distance users from the operation and invention of the technical object, effectively creating black-boxes. Their inventors and developers, in turn, are led to work with a narrow view of how the resulting object will operate, as myriad possible operations are left aside in the name of a smooth and turnkey functioning.

Although the technical entities we are interested in the case of AI, cannot be reduced solely to physical hardware but also involve algorithms operating within machine networks, the dichotomy between openness and closure remains relevant for understanding digital technologies (Grosman, 2016), and particularly AI, given its open-ended and interactive functioning (Regattieri & Antoun, 2018; Reigeluth, 2023a). From a Simondonian perspective, it could be said that algorithms are expected to modulate the circulation of information through technical networks at the electromechanical speed at which the information circulates. As such, algorithms are a necessary mediation in order to communicate with these technologies' physical level. This makes AI the most recent development in a history of feedback mechanisms that famously begins with Watt's governor avoiding the explosion of steam engines in the early 19th century (Stiegler, 2018, p. 40).

It is worth noting that AI technologies are often discussed for their ability to provide responses and outputs rivaling those of a human agent, particularly in cases like school essays, images for news illustrations, and music for YouTube video backgrounds. Moreover, with access to unfathomable volumes of statistical data, it can yield "better" results than humans in medical diagnoses, navigating urban traffic, and logistical decision-making. In all these cases, what is emphasized is the speed at which the output is achieved, while the technical relation with the operator or user is barely at stake. Instead, the user becomes a script provider and consumer of the final product.

The question then arises: Does explainability effectively constitute a step toward greater openness, i.e., greater communication between the technical device and the operator? If so, then what is required for explainability to become a guiding principle for developing AI consistent with a technical mentality?

3 SIMONDON'S CALL FOR A TECHNICAL CULTURE

According to Simondon, a lack of technical culture spawns technocratic desires; alienation from labor (not only in the economic but also in the technical sense); and conceiving the machine as a "slave" in the service of humans and a tool to subjugate nature (Simondon, 2017/1958, p. 141). He defines culture as "that by which the human being regulates their relationship with the world and with themselves" (Simondon, 2017/1958, p. 234) and technical culture as the knowledge and abilities enabling humans to interpret and integrate the functions and operations of machines meaningfully, so as to elicit meaning (signification) (Simondon, 2017/1958, p. 257). According to Bardin (2017, p. 53), this creates an ambivalence of culture, as both a closed system of rigidly symbolized practices and a continuous process of symbolic production tasked with manipulating the excesses of biological impulses and technical gestures.

Through the association of technics and culture, humans would assume the role of mediators of open machines, engaging with technical systems in a horizontal relationship (that is, without dominating or being dominated by machines). The figure embodying this ideal relationship would be the “technologist” or “mechanologist” who possesses technical wisdom and serves as a vector for the development of technical culture[3]. Practically, this includes placing technical initiation on the same foot as scientific education: “a child ought to know what self-regulation is, or what a positive reaction is, in the same way a child knows mathematical theorems” (Simondon, 2017/1958, p. 19). Simondon further identifies this figure as the pure individual, one who unites the two conditions of reflexive thought: organic life and technical life (Duhem, 2008). This technicist, like the doctor, magician, or priest, is capable of standing out from the community of stereotypical roles through direct dialogue with the world, enabling inventions that reshape social norms (Bardin, 2017).

Simondon argues that specialization narrows the technician’s perspective, hindering understanding of the principles behind the machines they operate (Mills, 2016). He illustrates this with the example of someone shaping clay to form a brick[4] – a technical gesture that contributes to mediation without fully revealing the broader process it belongs to. This partial disconnection becomes more acute in complex operations, where only inputs and outputs are perceived, while the machine’s inner functioning remains opaque (Simondon, 2017/1958). Contemporary examples include a call center employee using CRM[5] software without grasping how it processes data, or a judge relying on AI tools like COMPAS[6] to assess risk without understanding their internal logic. These workers are functionally close to technical systems, yet epistemically and praxiologically distant – unable to modify, repair, or (re)invent them.

This distance extends to software developers whose functional role does not prevent them from being partially alienated from the products of their labor. If the model, application, software is itself subjected to a logic of closure, then so will the professionals involved. Their highly specialized programming skills are put to work as decomposed and disconnected gestures, not unlike the industrial proletariat's labor force (Pasquinelli, 2023).

In the final pages of MEOT, Simondon (2017/1958) broadens the horizon of the Marxian notion of alienation, arguing that it is neither a result of techniques themselves nor solely limited to capitalist exploitation (Reigeluth, 2017). There exists a more fundamental alienation stemming from the exclusion of workers from the design of machines and their ability to participate in the continued invention. Simondon opens the conclusion of MEOT by stating that technicity has

[3] Although influenced by Wiener’s cybernetics, Simondon criticizes its limitations, particularly the excessive emphasis on homeostasis – an ideal of equilibrium in which technical or social systems remain stable by compensating for variations (Simondon, 2017/1958). In Simondon’s view, this focus on homeostasis disregards the evolutionary dimension of sociotechnical relations: societies and technical systems are dynamic structures that must seek transformation, integration, and reconfiguration of their functions. Building on this critique, the figure of the technologist or mechanologist takes on a central role in fraying the path of technical culture: more than maintaining systems, they should facilitate their evolution, transforming the relationship between technics, culture, and society into an adaptive and creative process.

[4] Simondon (2017/1958) criticizes the Aristotelian hylomorphic model, which reduces the genesis of objects to the union of form and matter. Using the example of a brick, he shows that there is always a technical process involved: the matter is prepared, the form is already concrete, and molding requires energy and specific conditions. Creating something is more than combining clay and mold – it involves labor, technique, and transformation.

[5] Customer Relationship Management (CRM) system used to manage and automate interactions with current and potential customers. It streamlines communication, organizes data, and enhances efficiency in sales and support processes.

[6] COMPAS (Correctional Offender Management Profiling for Alternative Sanctions) is a software used in the United States to assess the risk of criminal recidivism. The system gained notoriety after allegations that its algorithms exhibited racial biases, influencing judicial decisions in an opaque and often unjust manner (Alves & Andrade, 2024).

been relegated to a “background behind the reality of human work” (Simondon, 2017/1958, p. 327).

One consequence is that technical objects are seen merely as instruments or products of labor. Yet, technicity is a broader reality of which labor is only a part. Once freed from the totalizing effects of industrial production and labor, technical objects can play a central role on the psychosocial stage, namely at the level Simondon terms transindividual (Simondon, 2020/2005, p. 410-412). Indeed, because technical objects carry something of the humans who produced them (not merely their famous inventors, but all the gestures and uses that shape them over time through a continued process of invention), they transcend the norms of predetermined functions, creating space for new configurations and forms to emerge from a reservoir of pre-individual potentialities. In this sense, technical culture is always collective or more-than-individual as it also expresses and shapes a certain mode of relationality between humans, technics, and their environment. This relational mode is what Simondon refers to as the transindividual dimension, where invention and technicity become shared processes that exceed individual subjectivities, enabling the co-constitution of technical objects and collective modes of existence.

Ultimately, technical culture is concerned with knowing technical schemas, that is, shared operations and ways of functioning of different objects that allow humans to move between objects and not simply use a given object according to its abstract function. Simondon emphasizes that the process of invention is not merely labor but a cognitive, affective, and active engagement that surpasses utility, encompassing function, operation, and innovation, and has the potential to foster modes of connection among individuals through shared knowledge, experiences, and aesthetics (Beaubois, 2016).

Technical alienation extends from the workplace to the classroom, particularly when there is a strong distinction maintained by schooling systems between liberal (intellectual) and professional (manual) learning, as true technical culture emerges from the articulation of the two (Simondon, 1953). Current educational institutions often design curricula tailored to supply the labor market with “custom-fit” professionals. These individuals generally exhibit a limited perception of technology and its relationship to human labor or its social and ecological dimensions. In a similar vein, Emerson Freire (Faculdade de Educação da UFRJ, 2022) notes that even in technical courses, increasingly specialized curricula distance students from true technical culture. Focused on instrumental skills and meeting the demands of the labor market, these programs train professionals to handle technical objects, yet neglect critical reflection on their own role, reducing them to repetitive executors of predefined tasks. This perspective challenges the notion of labor as the sole technical relationship between humans and nature, expanding it into a broader cultural relation involving imagination, invention, and care. The points raised in this section allow us to expand the questions posed earlier.

4 EXPLAINABLE AI AND THE ASPIRATION FOR OPENNESS

4.1 FUNCTIONING OF XAI

AI has faced increasing criticism due to its growing complexity, lack of transparency, and tendency to reproduce social biases. Many algorithmic systems – especially those based on deep learning – are described as “black-boxes,” even by experts, because of their opaque and difficult-to-interpret operations (Alves & Andrade, 2024). This opacity can result in decisions that are hard to justify and may lead to discrimination in contexts such as recruitment, credit scoring, and law enforcement. While these criticisms raise important concerns, they often focus on specific applications and outcomes, accepting the current shape of AI systems as given and remaining external to their internal technicity. This perspective leads to an emphasis on fine-tuning rather than on questioning the operational schemas that structure algorithmic systems. However, the “black-box” issue deserves deeper attention: What can be achieved by making algorithmic operations “more understandable”? Is it possible to track deep learning processes, influence them directly, and align them with human and environmental communication? And how might explainability contribute to that effort? (Nunes & Andrade, 2025)

An explainable AI (XAI) system is designed to explicitly present, in a way comprehensible to humans, the underlying logic behind its predictions: what has been done, what is in progress, and what might happen next. The ability to understand the processes inherent to AI requires the use of communicable representations, such as linguistic or logical expressions, mathematical equations, and visual graphs (Alves & Andrade, 2024). Thus, while the lack of transparency creates a “black box,” limiting human comprehension of an AI system’s decisions, explainability relies upon explanations and representations of the underlying technical operations and structures to achieve a situated understanding of the complex processes behind an algorithmic outcome through discursive and visual mediations.

It is worth noting at this stage that explaining is an inherently relational activity: someone explains something to someone else. This involves an “expert” being able to communicate technically adequate information about an AI system to someone (e.g., a user or operator) who does not understand the system’s functioning. Thus, there is no absolute explanation that could possibly include all of the potentially relevant information needed to inform all the possible levels of technical culture (or lack thereof) of those concerned by the explanation. Indeed, from a Simondonian perspective, we could point out that it is the receiver for whom the information process has value (Berns & Reigeluth, 2021). For an explanation to succeed, the receiver’s representation of the technical system and ability to interact with it need to be transformed by the explanation. In other words, explainability is not simply about giving the correct information to a user, but about the user deeming they understand what has been explained to them and that the information that was given to them was of value and informed their understanding of the system. It is thus about generating actual information in the Simondonian sense, “not a thing”, but “the operation of a thing that arrives in a system and transforms it” (Simondon, 2010/1962, p. 159).

4.1.1 Existing approaches to XAI

According to Arrieta et al. (2019), explainability’s objectives are: to demonstrate the causal relationship between input and output; transferability (the ability to explain multiple systems); informativeness; trust; fairness; accessibility; interactivity; and privacy.

The authors distinguish six categories of explainability techniques: (a) textual explanations aim to illustrate the algorithm’s functioning through written or symbolic language, making its logic more accessible without exposing the full code; (b) simplification-based explanations extract rules to summarize the predictive process, selecting the most relevant elements and presenting a reduced version of the original model; (c) visual explanations use graphs, tables, or diagrams to make algorithmic predictions more comprehensible and can be combined with other techniques for greater effectiveness; (d) feature relevance explanations reveal the weight of each variable in an algorithmic decision, allowing users to understand which factors influenced a prediction; (e) local explanations provide justifications for specific segments of the model, highlighting crucial parts of the system that significantly impact outcomes; (f) finally, example-based explanations allow the algorithm to extract analogous or similar data samples to the generated results, enabling users to grasp the model’s reasoning through analogy. When applied to AI models that are not inherently interpretable, these approaches facilitate understanding of automated decisions. In Figure 1, we have an example of a textual explanation (a) where ChatGPT provides a step-by-step breakdown of date calculations using Python code.

While these approaches clearly focus on the end-users interfacing with the system's outputs, that does not mean they do not affect developers' training and fine-tuning the model. Therefore, the openness and agency enabled by XAI may unfold, if unevenly, across these distinct layers of human interaction. The extent to which each actor is affected and engaged is contingent on how the principle of explainability is instantiated in each particular model and software.

In the current context, where AI models, particularly deep learning algorithms, are increasingly employed in socially and legally sensitive areas, explainability is proposed as a feasible solution to combat the opacity inherent to these systems' operations. A system's ability to make explicit its processes would not only assist in identifying potential biases but also facilitate accountability, in turn grounding algorithmic trustworthiness. Importantly, explainability

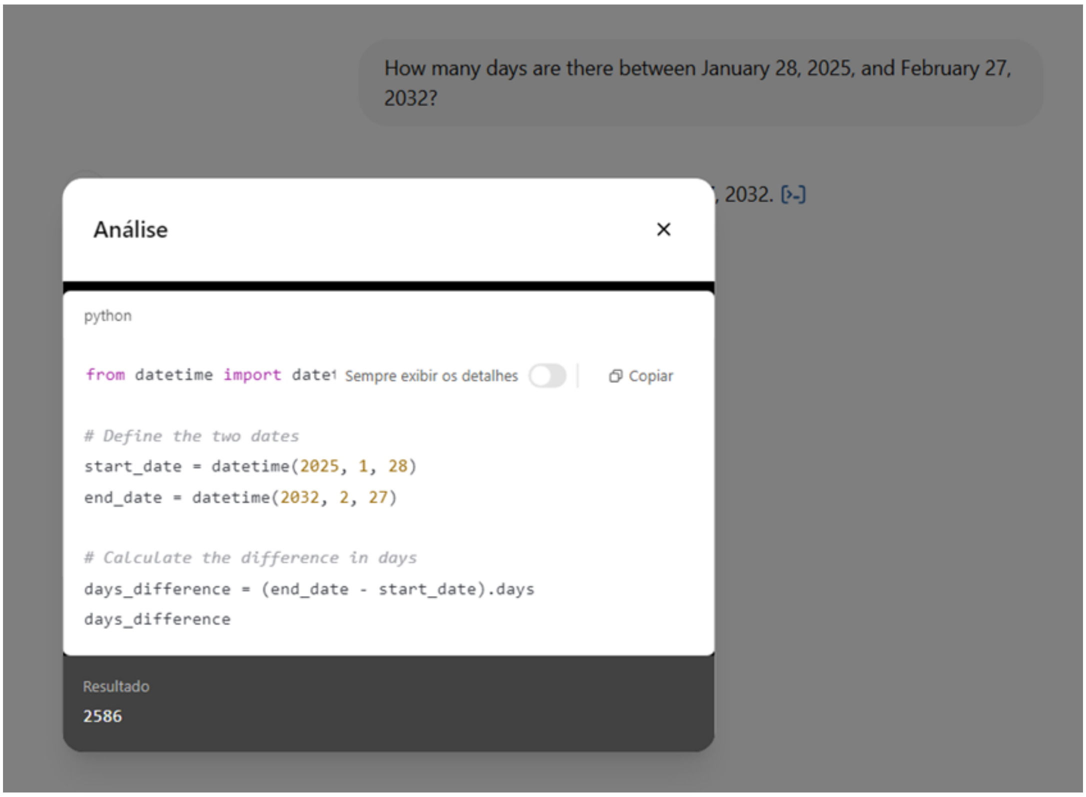

Figure 1. Explanation provided by ChatGPT: After being asked to explain how it counted the number of days between two dates, ChatGPT presents the Python code lines and functions used to reach the output.

sidesteps a reductive opposition between transparency and opacity by instead introducing contextual, representational, and narrative dimensions to understanding the functioning of these technical systems.

The example above exposes the code, thus undermining the alienating illusion by which users are led to believe the algorithm "thinks" like a human. On the other hand, while this technical explanation might deflate certain anthropomorphic or magical projections regarding AI systems, it is not clear that everyday users have the technical culture to consider this an "explanation". These formal representations of how algorithms operate tend, in fact, to reproduce a distinction between experts and lay users, thus deepening a gap in technical culture whereby there would be only one legitimate path towards knowing these systems adequately. Technical culture that encourages openness, however, supposes a plurality of approaches and forms of knowledge anchored in practical situations.

Using the six techniques identified by Nunes and Andrade (2023), we can examine their alignment with tendencies of openness and technical mentality, as developed by Simondon. By providing justifications (i), assigning responsibilities (ii), indicating the origin of data (iii), questioning the neutrality and fairness of decisions (iv), exposing the determinants of performance (v), and monitoring the impacts of decisions (vi), the principle of explainability expresses an inchoative concern with modularity and especially entelechy, albeit primarily at the user level. However, from a Simondonian perspective, theoretical understanding does not necessarily entail transformation: true technical culture presupposes the user's ability to modify or repurpose the system, which so far most XAI methods do not afford – in fact, most platforms actively seek to deter users from “gaming the system”.

4.1.2 Right to explanation and principle of explainability

Alongside the technical development of XAI, some legislators have introduced the right to explanation and even a principle of explainability, that is, the obligation to ensure that individuals can understand the logic or rationale behind decisions made by AI systems. Since 2018, the European Union’s (EU) General Data Protection Regulation (GDPR) has incorporated the right to explanation, notably through Articles 13 and 14, which ensure citizens' access to information about the logic involved when their data is processed automatically (European Commission, 2016). Article 22, reinforced by Recital 71, guarantees data subjects the right not to be subject to decisions based solely on automated processes (European Commission, 2016). More recently, the AI Act, adopted by the EU in 2024, has strengthened explainability requirements, particularly for high-risk AI systems.

In the United States, explainability in AI systems is addressed through specific legal frameworks, particularly in financial and credit decision contexts. The Equal Credit Opportunity Act (Regulation B, §1002.9) mandates that creditors provide specific reasons for adverse actions, such as denying credit, and explain the primary factors influencing such decisions (Consumer Financial Protection Bureau, 2011). This approach ensures individuals receive transparent explanations, fostering accountability in automated systems. However, broader legal provisions for a generalized “right to explanation”, similar to those seen in the EU, remain under debate, reflecting the tension between protecting individual rights and promoting innovation in AI deployment.

In Brazil, explainability was pioneered by the National Council of Justice (CNJ) through Resolution 332/2020. Article 8, subsection IV, of this regulation mandates the provision of clear and auditable explanations for any AI-driven decision, particularly in judicial contexts (National Council of Justice (Brazil), 2020). The AI Framework in Brazil, currently in its final legislative stages through Bill No. 2338/2023 (Brazilian Chamber of Deputies, 2023), will likely consolidate the principle of explainability within the legal system, with significant legal consequences[7].

Despite recent legislative advances, it is essential to emphasize that, while legal and political normativities interact with technical normativity, they do not replace or guarantee its development. Only technical activity itself can drive the emergence of a technical mentality and, ultimately, a technical culture, even if such activity takes place within the normative framework established by references to the principle of explainability. In other words, algorithmic systems

[7] The bill establishes explainability as a principle (Art. 3) and guarantees the right to explanation in cases involving high-risk AI systems (Art. 6), requiring information that is “sufficient, adequate, and intelligible”. It also demands that explanations be provided in clear language and within a reasonable timeframe (Art. 7). Public authorities must ensure effective access to this right, including human review of impactful AI decisions (Art. 23). Lack of explainability is listed as a criterion for classifying AI as high-risk (Art. 15) (Projeto de Lei nº 2338/2023, 2024).

crystallize multiple normativities and must be approached as multi-faceted sites of sometimes conflicting tendencies (Grosman & Reigeluth, 2019).

4.2 TOWARDS AN OPEN MACHINE?

Let us now look closer at the possible convergences between the objectives and functioning of XAI and Simondon's framework for a technical culture. Explainability can be related to the concept of the open machine, insofar as openness refers to a system's regulatable functioning, accommodating a margin of indeterminacy that enables interaction with other technical and human elements. As a principle that allows for the detection and correction of issues like algorithmic biases, and the constant negotiation of what is considered an “error”, explainability indicates a path to a more sensitive and responsive communication with the user, who determines the timing and specifies the nature of the required explanations.

It is important to note, however, that the reverse side of this dynamic is the requirements placed upon the developer and the user. The user is incentivized to abandon the passive position of expecting agile and automatic responses. They are instead encouraged to interrogate the machine in its operations (i.e., its entelechy). The developer is required to design the software or application in such a way that the model’s instructions and even the sources and conditions of its learning are rendered explicit (i.e., its modularity). The user, in turn, may engage with these conditions, accepting or rejecting them, eliciting responses from the developer in the form of modifications to the code. In an open-source scenario, this would also point towards giving the user the possibility to act as developer themself, tweaking or adjusting the model’s instructions beyond the level of prompting.

Thus, if explainability is to be operative and meaningful for the development of technical culture, it needs to enable an active appropriation of the system’s logic and functioning. This ability is a call to action: when the involved parties, particularly the user, come to terms with how technical processes underlie decisions, they are given the chance to question them, even criticize them, and ultimately, demand or promote changes. Thus, taken in its more radical scope, explainability subverts the predominant production chain of AI applications from developers towards the “end-users”, by including the latter as an integral concern and stakeholder of the design process. Explainability is not about promoting “user-centered” solutions that take the user as a passive target to be reached, but about allowing the user to determine whether or not they recognize the system’s outputs as legitimate, fair, useful, helpful, etc.

Consider the example of an XAI system for credit analysis. Besides providing an automatic decision on credit approval, the system would be considered explainable if it provided an account of the factors behind the user's score and what led the system to the decision, such as income, credit history, or default risk. In a further step, the same system should show where the data were obtained, how they were treated, and with which criteria they were weighed and chosen, thus sharing a portion of its technical schema. If the user understands what took place, they would gain knowledge of the technicity of financial decision-making. The user could also interact with the system. Firstly, by requesting detailed explanations or simulating scenarios, such as the impact of increased income. But ultimately, they might be able to negotiate different conditions with the bank, join pressure groups, or collective legal action that could demand rule changes.

This approach opens possibilities for users to go beyond passively receiving results, allowing for more meaningful interaction with the system and fostering a deeper understanding of how it operates. It also engages the developers in a kind of work that will not simply be driven by results and services provided, but by an actual communication with the user. This communication is both social and technical, insofar as the technical operation is a vector for social relations which constitute the transindividual dimension of technical mentality. Consequently, the fact that the system is not entirely closed off aligns with the principle of the open machine, where humans act as ongoing organizers in a relationship guided by technicity rather than mastery or instrumentality. Ultimately, going back to the credit analysis example, the interaction itself could even lead those involved to question the very desirability of automating credit transactions.

Let us briefly examine some commonly used AI algorithms, such as GPT-4 (OpenAI) and Gemini (Alphabet). These are cases in which the models feed off the digital environment, harvesting material in real-time from the internet to inform their decision-making and provide responses to user prompts. On the one hand, their agility could be seen as a form of openness, given that some degree of modulation is involved. However, these more versatile models interact with their environment in a particular way: they mine the data in such a way that it counts as a resource, the “raw material” of their output (cf. Viana, 2015). Between the two poles – collected data and the output provided, which may be highly accurate when it aligns with user expectations, such as choosing a route that avoids traffic congestion (Waze) – there remains a dark operational core that, to the user, appears indistinguishable from magic. In this regard, AI systems can be seen as reinforcing a longer trend with relation to technology brought about by industrialization that can be seen as “fetishistic” (Kaika & Swyngedouw, 2000) and which effectively hides the systems’ operations and materiality behind a seamless veneer of efficiency for the user (Young, 2021; Reigeluth, 2023b).

By contrast, an explainable AI system (XAI) might, for instance, tell the user which data center the data comes from or how much energy was used to compute the output, or how many workers trained the model or maintained the servers, thus revealing aspects of the system's materiality and human labor. Thus, explainability would not only be about formal representations of the algorithmic logic but would address concerns about how the collected data were made to fit together, what is considered an appropriate or “correct” answer (as opposed to a “hallucination”). Including these systems’ social, material, and ecological conditions of operation (i.e., their associated milieu) helps move beyond the fetish of automaticity, which tends to keep them at a distance from users because they are supposedly “too complicated” or “too technical”.

4.3 XAI AND TECHNICAL CULTURE

Freire (Faculdade de Educação da UFRJ, 2022) has shown that much of what Simondon criticizes about the status of technics in modernity relates to a certain depoliticization. In Freire’s example, technical/technological courses and even complete degrees advertised as technical education are, above all, market-oriented. Graduates often lack the ability to reflect critically on the knowledge they acquire, its applications, and their role within the labor system. Thus, technical education is not truly technical (and not truly education) but rather professional training.

From a Simondonian perspective, one might argue that the relationship between AI and the professional labeled as a technician is no less characterized by closure than its relation to the lay user. Notwithstanding the control of outputs via possible scripts, participation in effective operations – not to mention design and maintenance – is notably absent. These concerns are precisely some of the issues that the principle of XAI seeks to address. By requiring that the models be developed so as to present users with the operational conditions executed through deep learning layers, XAI introduces the dual expectation that users maintain an active relationship with the device and that the algorithmic system does not work automatically.

Nonetheless, while XAI represents a significant step toward more open systems, its implementation also faces certain limitations. Most importantly, while XAI could contribute to building a technical culture, in the absence of such a pre-existing and widespread culture, there is no guarantee of its adoption. On the contrary, a trend of excessive simplification might emerge, creating a misleading sense of control disconnected from the actual processes at play. One of XAI's assumptions is to provide accessible and relevant information to the end user, avoiding, for instance, the use of programming language to explain concepts to laypeople. However, even if the user receives basic information, unless the explanations are accompanied and undergirded by a technical education that enables the individual to critically interpret and apply the knowledge provided by XAI, the explanation could turn into mystification and further entrench the monopoly of engineering communities over “legitimate” technical knowledge. This could perpetuate dependency on specialists and limit XAI's potential as a tool for technical democratization. The absence of a robust technical culture risks transforming XAI into an additional layer of complexity, rather than fostering a closer relationship between humans and machines.

It should also be emphasized that XAI is not an ethical guarantee of fairness in AI systems. Even when decision-making processes are explained, this does not ensure they are just or free from discriminatory or harmful effects. Indeed, transparency alone cannot resolve the underlying structural issues of biases in the data and metrics underpinning algorithms (Berns & Reigeluth, 2021). Insofar as the Simondonian perspective of explainability developed here inverts the typical determination of information value by placing the receiver (i.e., the end-user) at the center, explainability is rather at odds with transparency as a regime of information supply by platform developers. In this sense, XAI must be accompanied by systematic efforts to review and correct the criteria and context in which AI operates, ensuring that its explainability does not inadvertently validate or legitimize harmful decisions (Ananny & Crawford, 2016; Alpsancar, Matzner, & Philippi, 2024).

5 FINAL REMARKS

This article has argued that XAI can be interpreted through the lens of Simondon as a potentially more open technique that may, under certain conditions, represent a step towards fostering a truly technical mentality of AI. Drawing on the concepts of the technical object, technical culture, and open machine, XAI was identified with principles of adaptability, dynamic interaction with the environment, and sensitivity to human demands. Explainability can be framed as a contemporary vector for the development of technical culture, whereby devices do not simply perform tasks efficiently but also communicate with their operators, creating space for human engagement in technical processes from invention to functioning, from development to use. By detailing its internal processes in a way that is comprehensible to end users, XAI invites, at the very least, human operators to strengthen their roles as mediators and regulators of machines. However, such communication does not necessarily translate into transformation. While most users interact only with the inference stage of AI systems, their capacity for intervention or redesign will be limited at best: openness in design does not necessarily translate into openness in use, especially when the system’s architecture remains inaccessible to most users.

Therefore, when comparing the theoretical framework proposed by Simondon with the current state of explainability in AI, we need to attend to elements of a more concretized and open system. We have argued that the epistemic and praxiological openness for all actors (inventors, developers, users, workers) is a call to action in transforming our digital ecologies. However, as underlined by Freire (Faculdade de Educação da UFRJ, 2022), a certain circularity is present in this challenge: in order for the seed of technical mentality to germinate, metastable conditions (i.e., a minimal level of technical culture making such a mentality desirable or imaginable) are necessary - conditions which tend to be continuously sapped by the utilitarian and profit-seeking approach to AI development. At this point, it is worth underscoring that fostering explainability does not entail sacrificing technical performance. The assumption that greater transparency, explanations, or interpretability must come at the expense of accuracy is not empirically supported. In fact, Rudin and Radin (2019) have shown that in many high-stakes contexts, interpretable models can perform just as well as black-box alternatives. This is akin to how a well-written drug label enhances patient understanding and safe usage without diminishing the medicine's effectiveness. This reinforces the idea that technical openness and functional efficacy are not mutually exclusive.

As Alpsancar, Buhl, et al. (2024) have shown, the idea that "good AI is explainable AI", merely providing explanations, is insufficient if such efforts fail to account for users' diverse needs or reinforce existing power imbalances between developers and operators. This ambivalence is not a flaw of the principle of explainability, but rather a reflection of the broader infrastructural constraints of contemporary AI systems, which often remain inaccessible or non-modifiable to the majority of users. Precisely because it enables a partial de-alienation without guaranteeing transformation, XAI represents both a step toward and a limit to the open machine and technical mentality. In this sense, while XAI does not yet fulfill the ideal of openness, it may contribute to its preconditions – especially if its principles are deployed critically, with attention to the distinction between understanding and transforming, between design and use.

Ultimately, in order to fully harness the potential of XAI, it is necessary to reframe explainability as an enabler of human agency and a bridge between technics and culture. If the principle of explainability remains confined to optimizing outputs or mitigating failures, without reshaping the technicity of the system itself, it risks reinforcing the very alienation it seeks to overcome. Realizing the potential introduced by this principle requires ensuring that humans occupy more than just the role of specialized operators or passive end-users. In other words, humans must possess a technical knowledge embedded in their foundational cultural education that encourages collective and collaborative forms of knowledge building that can meet the complexity of contemporary technical systems. Considering all of this, XAI has the potential to help mitigate alienation in the context of AI technologies, bringing humans closer to the processes of assembling, inventing, and coordinating machines.

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No new datasets were generated or analyzed in this study. Data sharing is not applicable to this article.

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Otavio Morato: Conceptualization; Methodology; Writing – original draft; Writing – review & editing.
Diego Viana: Writing – original draft; Writing – review & editing.
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