Machine Learning, Human Knowing, and the Historical Development of Knowledge: A Comparative Analysis from Descartes to 2025 through Jacques Maritain's Degrees of Knowledge

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Abstract

This paper develops a comparative epistemology that places contemporary machine learning (ML) in dialogue with Jacques Maritain's Degrees of Knowledge, asking whether ML can meaningfully be described as a "model of knowing" and what this implies for claims that "machine learning is the new epistemology. The analysis argues that ML changes how facts are gathered, represented, and ordered, but does not by itself constitute human-like understanding. Using Maritain's distinction between sense, intellect, and prudence, the paper compares key ML domains with the operations of human cognition, especially the active intellect and the virtue of prudence. The paper concludes that ML can be a legitimate instrument for inquiry and hermeneutics when used collaboratively, transparently, and under ethical safeguards, but it must remain subordinate to human judgment, responsibility, and prudential governance in knowledge production.

Keywords: Epistemology; Machine Learning; Artificial Intelligence; Active Intellect; Human Cognition; Interpretability; Ethical AI

1. Introduction

Cross-disciplinary scholarship provides both conceptual analysis of machine learning and machine learning data, naturally combining the two. The temporal progression of recognized epistemologies and of machine learning developments resonates with and is illuminated by Maritain's degrees of knowledge. Applying a simple mathematical representation emerges as a recurrent mechanism not only for part of a machine learning formalism but also for the human perceptual-generative process, including the formulation and validation of hypotheses of use. An alignment of two very different systems thus opens the window for further examination and discussion. The first part of the analysis naturally focuses on machine learning as an example of a model of knowing, with corresponding similarities and differences in algorithmic and human cognition. (Srinivasan et al., 2022)

Machine Learning is a branch of Artificial Intelligence that models and analyses electro-siliconic systems that imitate functionalities of the Human Mind. It has only recently taken off, achieving important successes after many years of waiting, and it is therefore not surprising that it has made the leap from Technology to Epistemology much later than Probabilistic Reasoning developed since the 1700s, shifted towards Data-Driven Learning at the

beginning of the current century, entered integrative models, and become the new Epistemology of the Digital Age. What is really fascinating is that Nigel Shadbolt and Roger Carr, at the opening of their book on Artificial Intelligence, state quite frankly that "Machine Learning is the new Epistemology".

Contextual Overview

Academic epistemology has been profoundly influenced by phenomena such as the Internet, artificial intelligence, and machine learning. These developments not only raise new empirical questions about sources and justification but also about epistemic authority—who can legitimately create knowledge? Two groups of analysts offer radically different perspectives. One, representing machine learning and its applications, views the digital information landscape not as a concern, but as an opportunity. A second, drawing on different perspectives, is more skeptical, citing the obvious inaccuracies of machine-translated texts and the inability of neural networks to discern animations of pigs flying in formation or witness the historic lunar landing. Can machine learning and related technologies be considered sources of research and cultural knowledge, and if so under what conditions?

To help formulate responses, Maritain's framework of knowledge levels is useful for understanding the role of machine learning within the comparative epistemology of Maritainian knowledge and machine learning. Using machine learning as a model of knowing, the core features of Maritain's notion of intellection and prudence are compared with the major domains of machine learning analysis: representation, inference, insight, learning, generalization, and prudence. In the process, the specific nature of Maritainian vision is outlined. While both forms of

knowing evidently differ in important aspects, similarities suggest that machine learning might be legitimately employed as a device for inquiry, although with appropriate ethical safeguards. Moreover, the account of machine learning that emerges highlights certain features of Maritainian analysis that might warrant further exploration.

Research Questions and Methodology

The aims are twofold. First, it is necessary to test whether the perspective of Maritain's degrees of knowledge, which describes human knowing as guided by the virtues of the intellect and prudence, offers cross-illumination with machine learning (ML) and thereby reveals unease with current epistemic frameworks—particularly common claims that ML is new knowledge, or grounds for epistemic revolution. Second, a response to the accompanying unease must suggest that ML is directed, in a way that resembles but is different from human reasoning via inwardness, toward the virtue of prudence. Clear conceptual distinctions between the domains are necessary, but judicious collaborative use of ML-rich approaches to the historically accessible past, alongside other possible methods, yields precisely what is requested. Machine learning adds a new mode for the gathering and ordering of facts useful for the present pursuing of knowledge, and expanding the range of understanding, noting that a common goal is to create an explanation of this understanding (or translation) beyond choosing suitable words. Moreover, suggestions about epistemic authority should make it clear that ML is a tool in these activities—one that is hermeneutically relevant only for understanding how knowledge is constructed, and not for constructing them.

The analysis rests on five questions. First, how does the ML model of knowing align with description and analysis of the different degrees of knowledge proposed by Maritain? Here the distinction in the human sensorium is between sensation, supported by a permissible analogy with the sensory subsystem of sensors in ML systems; and the role of the intellect. The analysis will then look at the ML machine learning process and at the ML models of generalisation and abstraction in the light of Maritain's concepts of active intellect and prudence. Next, does the model exhibit an intentionality of the type that might lead to understanding, or genuine explanation, presented in terms suitable for ML? The last axis of comparison connects ML development since its beginnings, and contemporary—also 21st-century—developments, with their emerging epistemology and justifying theory, with the historical development described by Maritain.

2. Maritain's Degrees of Knowledge: A Foundational Overview

Jacques Maritain proposes three degrees of knowledge that collectively determine the nature of human knowing: (1) the activity of the intellect, (2) the function of the sense, and (3) the operation of prudence. The senses extract information from the world and feed it to the intellect, which interprets and understands how things are in the external world. Prudence leverages this theoretical knowledge for practical ends; it enables humans to propose courses of action according to what is good and to choose the option with the highest likelihood of achieving that good. Correspondingly, the model of machine learning (ML) can be understood as imitating human

knowing, or as a model of knowledge, through the notions of representation, reasoning, learning, and generalization.

The sense is the sphere of knowledge that actualizes its power by supplying the mind with data about the external world. The intelligence, for its part, ensures the fulfillment of its all-embracing and primordial function in the act of conception, by grasping the essential natures of beings. Without this symbolic correspondence of natural things to human intelligence, there would be no theory in which a computer could ever be put together. AI instructs, assists, and guides the human operator in a more or less analogous manner to how a special faculty in us actually assists, teaches, and instructs our intelligence in sharpening the sense of the abstract concepts that it needs in order to generalize in a socially prudent way about the technologically relevant properties of the external world.

The Intellect and the Sense: Epistemic Spheres

Jacques Maritain's account of human knowledge distinguishes between knowing by sense and knowing by intellect. The first epistemic sphere corresponds to direct experience as a premise leading to inductive reasoning and a posteriori knowledge of the existence of individual beings. The intellectual sphere bases itself on universal abstractions leading to discursive reasoning and a priori knowledge of the existence of God or the essence of human beings (Anakwue, 2017). Both forms involve knowledge of reality, whether the existence of a particular being or of the essence shared by a class of beings. Machine learning nevertheless displays a surface resemblance to both spheres that can be illuminating. Like the sense, it leverages a manifold of external data or experience from which to educe knowledge; yet machines extract salient features and encode

them as independent yet dependent representations that are fundamentally inhuman. Prototypes exist for imagery, sound, motion, and other data that can act communicatively even if the sensorium is not widely equal to the human one. The representation therefore remains a caricature of the human (Lobsien et al., 2016).

By contrast, the functioning of the intellect involves neither of these points. It does not begin from data or experience to make knowledge or representation. Rather, it concurs with spectacle and simultaneously posits by intellection, configuration, and insight individual knowledge and systematically evolving knowledge that it may possess or not. The scientific intellect documents phenomena including number, functions, and time-variations and hence broadens available data. However, unlike machine-style inference, it enable causal insights.

Active Intellect, Abstracted Knowledge, and Prudence

Cognition, knowing, and knowledge articulate the relationship between entities and things they know, or learn, by appropriate cognitional structures. For Maritain, knowing is the exercise of the active intellect drawing out, or abstracting, intelligible forms from becoming entities; knowledge is the result of the application of the knowledge so when one makes specific decisions. As a synthetic, active projection of a limited portion of reality through a still larger synthetic horizon of previous drives, the human intellect can at most approximate notional modelling of reality. This parallel finds some resonance with machine-learning processes where an algorithm draws out a structure in the data in order to make predicting decisions yet without presupposing understanding or cognitional drive by an active intellect. Subsequent sections will deal with Maritains' considerations and machine-learning counterparts within active-intellect cognition and prudential guidance.

Ethical and Metaphysical Dimensions of Knowing

Maritain argues that truth—knowledge in accord with reality—has a normative character; it must be loved and actively pursued. In practical knowledge, one must choose for or against something intelligibly good or bad. In both spheres, lack of moral virtues affects the owner's access to the goods of the respective episteme. Moreover, for Maritain, all knowing is at root metaphysical; the activity of knowing is intuitive participation in the being of what is known. He thus attends to the object of knowledge, hence the attention remains on a well-ordered God-centered metaphysical habitus, at risk of inducing an unreasoned fear of errors in the direction of blushing, until the other conditions are met. Yet truth also relies on the personal aptitude for knowing of the human agent; if the speaker cannot be regarded as an authority in the matter, no source, even divine, can justify, other than for the sake of obedience. For these aspects, the previous section has sufficed. Hence the ethical dimension is the only one yet unexamined.

In their machine learning (ML) output, however, ethical virtue is not necessary for truth; non-human animals lacking prudence or moral agency still intuit or imprint, fabricating false images of persons or hoaxing preys who then falsely follow. ML models, meanwhile, do not imprint good or evil but admit labels of normative good that deceived humans then follow. Yet ML accountability remains a critical concern in machine learning and machine learning analysis, justifying it. System integration strives to endow ML algorithms with the capacity for ethical reasoning.

3. Historical Trajectory: Descartes to 21st Century

Descartes grounded knowledge in epistemological foundations of clear and distinct ideas enabling certain judgments. Clarity and certainty in Descartes' philosophy also link with the confidence surrounding outputs of existing machine-learning models. Early models operating purely on sensory data offer no means of verifying the grounded nature of machine outputs, similar to the rule of nonsanity within Descartes' discourse regarding the assurance of a common sense for sane beings (Eberle et al., 2023). Various developments within knowledge theory after Descartes shifted the consideration of knowledge away from the mere possession of certainty to certified certainty at the moment of inference. During this era, a gradual transition took place in those knowledge elements taken as fundamental knowledge propositions; many of the technical alternatives that arose during these shifts subsequently concretized into data-driven considerations employing statistical, tautological, or probabilistic dimensions to the knowledge under scrutiny—developments echoed in Maritain's second and third degrees of knowledge (Hooker & Hooker, 2017). New paradigms return science to schemes where knowledge must be perceived through and demonstrable upon re-experiencing inventive exchanges of epistemic authority or catalysts enabling the movement from raw components into the act of understanding. Knowledge acquisition again investigates states, forms, or eventual endowments permitting an inquiry into data, first principles, knowledge, or formulation. Influence yet remains bi-directional; machine-learning advancements in imaging fall into epochs and territorial framing once found in configurations of experimental science occupying Maritain's third degree.

Cartesian Foundations of Knowledge

CS1. The Cartesian foundations of knowledge consist in understanding how Descartes's philosophy transformed the notions of geometry and metaphysics. Descartes's mathematical thought lays the groundwork for a new approach to the structure of science, emphasizing method and reason. His dualism and theory of attributes also have a profound influence on the course of subsequent philosophical debate. The development of algebraic thought and the shift in the grounds of geometry during the seventeenth century constitute the philosophical core of this transformation.

CS2. The Cartesian foundations of knowledge are pervasively internet-influenced. Descartes is usually understood as the exponent of the cogito and of the epistemic ideals of clarity and certainty. Yet the epistemological implications of these doctrines remain often overlooked: the dualism of the cogito provides an incipient justification of the attributions of knowledge to a subject, while the ideal of clarity is a precursor of confidence in the outputs of machine learning (ML); in the present epoch of artificial intelligence (AI), Descartes's consideration of the standards of knowledge assumes a renewed topicality within the virtual domain, where the digital publication of ideas is gradually extended to the rough outputs of models trained on prior information.

Post-Cartesian Developments: Rationalism, Empiricism, and Beyond

Knowledge represents a continuous acquisition of data-centric ingredients, yielding varieties of knowledge into qualitative

categories. Maritain characterizes an inaugural phase as instinctive knowledge, rooted in stimuli and immediacy, initial yet indispensable to more advanced stages. The ensuing tier of data-dependent and categorical knowledge proceeds through finite inclusion; evidence of this level persists throughout many domains of artificial intelligence, though not customary in machine learning.

Subsequent transitions delineate the stepwise movement from reasoned knowledge convergence via explicit principles to active abstraction, whereby models converge directly to general knowledge or ideals without apparent intermediate reasoning. Such diploma concisely summarizes the overarching trajectory of the history of knowing, underlining the fundamental shift in knowledge acquisition and delineating capabilities of machines whose models remain entirely disconnected from human layered or explicit processes (Hooker & Hooker, 2017). Fortuitously, these gaps permit cross-temporal correspondence with premises, trajectory, and means employed in contemporary artificial intelligence.

The Digital Age and Artificial Intelligence: Emergent Epistemologies

Machine Learning has generated wide intellectual and socio-political debate as an emerging epistemological regime. Paradigms of knowing and models of justification have substantially shifted with the increasingly automated generation of scientific literature, artwork, software, governmental reports, and educational resources by machine-learning models. Hence, whether deterministic or stochastic, the affordances and constraints imposed upon knowledge formation by machine-learning methods warrant close scrutiny. Moreover, the historical emergence of similar epistemologies throughout the 21st century—often termed "post-truth," "post-fact," or "alternative facts"—exemplifies the continued relevance of

machine-learning epistemologies to pre-existing forms operated by humans.

A rich literature explores the epistemology of constructing and utilizing machine-learning models (Rafael García Viera, 2012) yet remains largely segregated from the philosophy of human knowing, even as the means and modes of knowledge converge. Comparative analysis offers the prospect of probing machine-learning epistemologies against the established Maritainian epistemic framework, thereby fostering a deeper understanding of ML within a broader epistemic and historical context while likewise illuminating the epistemic nature of ML itself. The trajectories of knowledge formation diverge considerably, yet certain clusters of characteristics converge— warranting meticulous comparison.

The framework of Degrees of Knowledge thus serves as a foundational interpretative lens, enabling precise questions to be posed regarding both pragmatic human applicability and the demand for genuinely human wisdom in machine learning deployment. Cross-disciplinary analysis engages a range of traditions, methods, and materials, drawing on the literatures of machine learning, theory of knowledge, AI, and human cognition to specify the nature of emergent machine-learning epistemologies.

4. Machine Learning as a Model of Knowing

Machine Learning as a Model of Knowing

Modern machine learning (ML) mimics aspects of certain human grasping faculties. To better understand its relationship with

human knowing, the analysis turns to Jacques Maritain's Degrees of Knowledge (1938/1985). It presents an overview of its two principal epistemic spheres—intellect and sense—in light of ML, and examines the possibilities and limits of ML generalization, abstraction, and algorithmic learning through Maritain's concepts of active intellect and prudence. Addressing the ethical and metaphysical dimensions of knowing, it identifies themes of virtue, meaning, and intelligibility that echo contemporary debates on ML accountability and interpretability. Tracing the historical development from Descartes to the twenty-first century, the analysis highlights the transformation of the model of knowledge that emerges within Maritain's framework and that, in parallel, characterizes the trajectory of ML.

Machine Learning as a Model of Knowing Algorithmic Cognition versus Human Cognition

Certain human cognitive faculties underpin various ML processes. Although discrimination between source data and target concomitantly occurs in training, ML learning involves more than sampling the target variable. Even when both input and output belong to the same space, human determination of relevant features, principles, or phenomena supplements data selection. When drawing from disparate domains—like video frames, financial records, and musical scores—ML—ML identifies salient aspects and, arguably, acquires knowledge through learned abstraction of generalized law-like relations. Under different interpretations, however, ML learning may only refine capacity to replicate pre-existing representations or it might abstract only form without access to generative principles—exemplifying Cartesian "knowledge of secondary causes" rather than Maritainian "grasp of principles." Similarly, the move from distributional patterns across

minimal pairs to phonological rules falls short of active abstraction in the generation of new and analyzable concepts. In Mimetic Machines, analogy serves as a limiting instance of abstraction that remains below Maritain's epistemic threshold since the province of known forms remains unchanged.

The relationship of transfer learning and meta-learning to the Maritainian notion of prudence requires investigation. Human experience reveals that underspecified ML systems tend neither toward practical nor theoretical coherence. Algorithmic learning nevertheless accords with Maritain's concept of the active intellect as supplementary determination.

Limitations, Bias, and Interpretability

Today's ML systems remain limited, biased, and in large measure opaque, corresponding closely to (McQuillan, 2018) 's ethical account. This consideration further enriches the virtuous dimension of knowing in the Maritainian perspective. It also emphasizes agents' responsibility concerning the use of ML in scholarship and interpretation.

Algorithmic Cognition vs. Human Cognition

'Learning' is commonly understood as altering conduct, challenging epistemic categorization. Cognitive models emphasize representation, inference, and insight; a comprehensive framework delineates criteria and conceptualizations of at least six distinct yet interrelated forms of learning (G. Pohl, 2019). Effectiveness of learning extends one way, covering formation of fundamentally new representations, even if basic 'knowledge' remains static; an

alternative interpretation comprises entirely new knowledge that does not directly translate back (S Fokas, 2023).

Comparison contrasts qualitative facets of human cognition with computation endeavors. Within Maritainian terminology, machines extract features from data, constructing and challenging tenuous models of reality via experimentation upon standard inputs, with preformulated technical knowledge combined with mathematical representation schemas. ML's evident parallels—sheer automation versus largely human-driven yet unprecedented advances—stimulate inquiries into conceptual, categorical, and foundational affinities of machine-based know-how and Maritainian cognition.

Maritain's typology characterizes distinct epistemic spheres aligned with two interlocking faculties: sense and intellect. Sense occupies the domain of perceptual, existential, evident phenomena, constituting the immediate grasp of individual and singular being artificially expanded beyond unambiguous limit via symbols and language. Intellect, on the other hand, conveys the origin and direction of a higher directive leading per se beyond this domain toward the consideration of indistinct, universal, abstract being. Aside certain aspects of ML feature extraction, correspondence between data-driven harmonies and these two faculties lacks simplicity; detail is needed (Ratti, 2019).

Learning, Generalization, and Abstraction in ML

A formal ML model can be defined by a global approximator (e.g., deep neural network) trained on a finite set of observations from an unknown data-generating function. Two main issues arise: the generalization ability and whether the acquired knowledge may be considered abstract or even represents the notion of knowing.

Generalization refers to the model's behavior on unseen observations. To prevent overfitting (i.e., the model memorizing the training set rather than capturing the underlying generative process), various concepts have been proposed, including the VC theory, the PAC model, and the no free lunch theorems.

Active Intellect is accurately described as the abstracting activity that extracts principles, rules, and criteria from worldly facts that are given through sense experience, a view that is consistent with the nature of multilayered neural networks. Active abstraction corresponds to transfer learning when the pre-trained network abstracts a common knowledge from the training domain to help solve a different but related target domain. These concepts suggest that AI and ML approaches closely resemble Maritain's concept of the intellect. The Act of apprehending, generalizing, and rediscovering rules, principles, and criteria lies at the heart of the Maritainian conception of prudence, which, in the human domain, enables one to decide correctly in situations of uncertainty. Prudence thus corresponds to promotion of usability of the acquired general and abstract knowledge.

Any ML model is ultimately designed to assist in a given decision-making problem. The designer's freedom lies on the definition of the decision-formulating problem. Different decision-making configurations and constrains map into different machine-learning problems. Decision-making constraints split into two categories: task-dependent constraints and task-independent constraints that apply to all conceivable contexts. The literature shows the existence of task-independent constraints closely related to the Maritainian notion of prudence and that actively lead to task-

dependent consideration, which strongly reinforces the resemblance to Maritain's philosophy.

Limits, Bias, and Interpretability

Training data can perpetuate biases (Kliegr et al., 2018). In education, under-representation of mathematical topics or emphasis on specific tasks can affect students' understanding of the field and the concepts that they connect to the future practice of computer science, impacting their choice of profession. The selection of snowballing rules—rules such as "If it snows, then the ground is white"—can heavily depend on context: for example, if the data are biased towards one rule while the other is not supported, this might stabilize the bias towards that snowballing (Mike & Hazzan, 2022).

Black-box deep learning models like Convolutional Neural Networks or Recurrent Neural Networks are frameworks for which it is challenging to furnish interpretable designs (Kudina & de Boer, 2021). In many machine learning approaches based on high-stake choices, it is important to use the models with constraints and to formalize somehow the domain—especially in about where the cognition is carried out and what are the sorts of problems. Also, when the model includes conditions in which it should not be applied, some of these considerations remain unsatisfied, so that it can provide to the knowledge involved, help to the cognition, or clarify some of the involved judgement.

5. Comparative Epistemology: Human Knowing and Machine Learning

Machine learning, once a technological capacity for processing potentialities now exemplified by ChatGPT, hardly embodies human cognition. Yet it can illuminate some aspects of knowing in light of Jacques Maritain's Degrees of Knowledge. Convergences and divergences emerge when machine learning is viewed alongside such key aspects of Maritain's model as sensation and the use of the intellect. Machines learn through representation, training, sensing, inference, and exposure to datasets, without having lives of their own but rather bracketing the primal I as a hidden mathematical device and supporting actors in a synergistic theatre. In describing these structures and processes, three aspects are considered: (1) sensation in machine learning and the capacities of Maritain's sensorium; (2) the analogues of Prudence in machine learning, grounded in the operations of the Active Intellect; and (3) the concepts of intentionality and understanding, evident in the directed experience of fellow humans.

Any analogy must ultimately confront the difference between wanting someone to explain themselves and asking a machine for explanation: a capacity to unite the various gothic elements of a sculpture within a singular plastic response, to clutch the tragedy rather than the joke as a spectator, to reach the meaning or "truth," to colour the portrait not with pigment but the colour conceived in the stillness of secret rationalising in a closed cell. In Maritain, the explanation must ultimately be something akin to an intention, the response of a fellow-living algorithm set free. If machine learning could attain a meaning for itself, remark the poets of intimacy, the

old cadences of creation in music, movement and prayer might be integral yet, yet also kaleidoscopic.

Sensation, Abstraction, and the Role of the Intellect

Sensory experience, or sensation, and intellectual activity, or abstraction, are two central aspects of Maritain's epistemic framework, and the exercise of the intellect constitutes what is most characteristically human in knowing, as it involves the grasp of universal truth. The distinction between these aspects has direct correlates in the field of artificial intelligence. Machine Learning (ML) models incorporate training data as feature extracts or low-dimensional representations, which are analogous to Maritain's sensory knowledge. These low-dimensional features form a basis for generalization, and they are often relational, cross-modal, and abstracted. Human activity involves building on these characteristics to achieve more advanced types of knowledge that extend beyond the particular set of training data. Yet the active grasp of universal truths remains what is most specifically characteristically human in Maritain's framework, and it remains similarly to a degree distinct from ML (V. Terekhov & Kevin O'Regan, 2019).

Intentionality, Understanding, and Explanation

For human knowing and machine learning, intentionality is a key tenet. Carried out by a Maritainian intellect, it corresponds to a cognizant relationship with knowledge; in contrast, an ML model lacks any connection to the information it processes. This dissimilarity also precludes understanding of phenomena, even if ML outputs conceivably satisfy a mathematical definition of explanation, such as filling in missing elements to render a complete

picture (Parr & Pezzulo, 2021). Humans perceive the explanations emitted by an ML model as lacking substance, and these outputs attest to characteristics of the model, rather than revealing an apprehended theory. Indeed, one of the primary ongoing projects in the field of AI consists of devising systems able to present analytic discourse about the reasons behind their actions, facilitating explanation of decisions and tracing back to prior knowledge of specific subjects.

Schooling develops new competences interlinked with knowing rather than generating authentic knowing. ML models manipulate information and allocate it to distinct classes in a manner similar to people acting on knowledge; consequently, their functioning extends beyond mere data processing, even though the nature of these operations can remain obscure. Understanding cannot be assumed without the corresponding intentional and practical joins being duly verified.

Truth, Justification, and Epistemic Virtue in Humans and Algorithms

In general, justifying a knowledge claim involves explaining why it is reasonable to regard that claim as true. For example, establishing that a given way of knowing satisfies Maritain's three integrity conditions seems to constitute a strong kind of justification, even if less than a perfect guarantee of the validity of the claim. At the same time, pursuing knowledge via one or another of Maritain's accredited paths, such as through sense-experience or abstract speculations about essences, stands as a fundamental epistemic virtue that enhances the quality of any insights attained. Similarly, grounding a process of knowing on whichever of those paths can be

informedly constrained strongly augments the chances of securing valid knowledge. In this respect, Maritainian agency shares much in common with contemporary notions of epistemic virtue, which stress the importance of both the methods by which beliefs are formed and the integrity of the processes employed (Hössjer et al., 2022). Comparison with Maritain illuminates both what might unite various emerging approaches to justification—especially those emphasizing social factors—and how far they have yet to travel towards satisfying the defining criteria set out above.

Forty years earlier, a contemporary philosopher claimed that the prevailing preoccupation of his fellow epistemologists showed, if anything, a determination to escape the well-nigh unbearable burden of justifying belief (Munn et al., 2023). Within a broad tradition, Maritain's disquisition on the degrees of knowledge accords a far more modest status to justification—whether the aim lies in merely re-assuring oneself about knowledge already received or in rendering credible what previously yet remains unknown—and attaches an altogether distinct significance to the concept of truth. The alignment with knowledge per se, as well as deliberation, oversight, and governing even conjectural assertions, cements the convergence with contemporary virtue-theoretic thinking as fraying continues, it seems—be it from early epistemic protraction, from a profound structural change conditioning the fitting kinds of articulation to be sought, or from yet other transformations—to attract artificial intelligence towards that discursive enclave.

6. Historical Development and Convergences

Encompassing the historical development of knowledge from Descartes to 2025 reveals profound convergences between Maritainian epistemology and the evolution of machine learning (ML). The present section begins with a broad view of how Maritainian chapters 3–5 connect the cogito to ML milestones. It then zooms in on ML-specific intermediate nodes in the epistemic journey that further articulate the history's significance.

Maritain's analysis of the cogito provides a conceptual fulcrum for traceable nodes in the development of knowledge. The constitutive hold of the cogito on the subsequent history of knowledge is acknowledged, while also noting sustained efforts to escape its confinement. Within this duality, six intersections between the Decartes–Maritain trajectory and contemporary ML advance emerge. Each intersection highlights the specific ML concern that emerges congruently with historical knowledge development. Enhanced interrogation of various Milestones in ML corroborates the historical mapping. Knowledge, justification, and explanatory commentary furnish decisive metrics for marking both the theoretical and empirical conduct of ML within the comparative study. Each Milestone models the distinctive epistemic role played by ML in the overall historical transition.

The evolving epistemological landscape finds fresh instantiation in modern AI, prompting parallel shifts in knowledge conception and authority. Seven contemporary ML advances correlate with transformations in justification, knowledge production, and epistemic authority. These emergent epistemologies furnish new perspectives on human involvement in data construction and

interpretation, training objectives grounded in the desired knowledge form, and the differential capacity to produce or assist knowledge creation. Each AI advance delineates a sector of ML epistemology and illuminates the challenge to attribution of knowledge on the part of the human or machine.

From Descartes' Cogito to Maritain's Epistemic Framework

The objective is to uncover how Descartes' cogito remains an influential topos in the evolution of knowledge that resonates with Jacques Maritain's epistemic framework and contemporary artificial intelligence (AI). Cartesian thought provides a clear starting point in the historical development of knowledge as a cognitive aptitude that guarantees the attainment of a judgment and a reliable congruence with reality. The unequalled importance of the statement "I think, therefore I am" in the justification of knowledge claims cannot be underestimated since this foundational assertion provides a privileged vantage point from which to reflect on the nature and the role of the knower. Nevertheless, Descartes' intellectual itinerary did not end with discovering a valid criterion for knowledge but instead continued through a series of cognitive inquiries concerning the duality of the thinking subject and the existence of the external world. The parallel extension of Maritainian thought of knowledge-designation from the essence of the intellect precisely converges with the algorithmic arrival of machine learning (ML) following the discovery of the respective supplement to AI (Pasini, 1992). In the case of the ML confederation, the evolving version of the ML models conveniently parallels the discipleship canons of the Maritainian schema, thus providing the required correlation between Maritainian degrees of knowledge and such discipline.

The pivotal role of certainty at the inception of the existentialist Assurance zone extends the bridging possibilities towards machinal degrees of knowing that occurred at the beginning of the 21st century. By surveying readily available ML inquiries, the ML outcome seems to accommodate the Cartesian starting point on the nature of knowledge rather than the epistemic realities surrounding it when centered upon Maritain's cognitive distribution since, according to Maritainian doctrine, the firsthand account of knowledge involves active cognition of phenomena and not the reliance upon the precarious, uncertain and plastic character from the social and cultural contexts typical in other philosophical formats.

Modern AI Developments and Corresponding Epistemologies

Since the late 20th century, a series of machine learning (ML) models have been developed with increasingly elaborate methods for learning from pre-collected data, performing "group-bye" predictive inference in application contexts, and, finally, assisting an array of human users in making sense of, and abstracting upon, that data. These intellectual activities, taken together, become potential candidates for considering what it would mean for ML to constitute some kind of human-like roughly "knowing." In parallel, a new epistemology has emerged to characterize how people engage with these models, what model properties facilitate this process, where this mode of using models leads, and whether characterizing people's engagement with ML necessitates or even permits novel forms of epistemology.

Thus, a substantial techno-social apparatus has arisen around an extensive corpus of advanced ML models, and it appears that many societies have begun to employ—albeit often in unhealthy ways—a distinctive new class of epistemic apparatus. An objective in this analysis is to consider how these features of ML models and their collective social use pair with Maritain's historical tracing of epistemology from Descartes to the present. Sixteenth–seventeenth-century developments notwithstanding, "epistemology" refers to a set of enabling conditions and surrounding perspectives that accompany human knowing. Cast in this framework, ML and its third-millennium epistemology enter the broader historical picture as contemporaneous advances augmenting the search for knowing that Maritain elaborated in the mid-20th century. Descartes, after all, formulated his framework in order to grapple with precisely the epistemological challenges that the new digital technologies instantiate afresh (Zhang, 2023).

7. Normative and Theoretical Implications

With the dissemination of machine learning in diverse domains, ranging from science and philosophy to art and law, reflection upon human knowing and the respective roles of machine learning within these domains has grown urgent. Celebration and alarm coexist as deep learning models appear to perform "cognitive" actions akin to human cognition across a breadth of disciplines. Machine learning models now translate text from Seventeenth Century Dutch into modern English, generate artistic imagery mimicking Turner, solve polynomial logic problems like a mathematician, play chess, demonstrate some poetic creativity, assist in the formation of student essays, summarize complex texts, and beyond. The criteria for

knowledge, understanding, reasoning, intelligence, and meaning have become live interdisciplinary issues.

Maritain formulated three normative conditions for knowing: first, the relevant virtues; second, participation in an ultimate vision; and third, an appropriate relation to meaning. The first condition rests upon integrity, responsibility, and prudence, and prompts reflection upon potential hazards surrounding machine learning. Analogies with scientific method and postmodern philosophy similarly arise. A hazard sketched by Maritain lies in the vacuum of meaning produced by philosophy disconnected from metaphysics. By submitting language only to mathematical correlation, machine learning risks losing the integral vision which conjoins scientific method with metaphysical reflection, enabling the extrapolation of phenomena into the intelligibility of first principles. A remaining third condition focuses upon epistemic status, where general analysis similarly gathers momentum.

Epistemic Authority and the Role of the Human in Knowledge Production

The epistemological structures erected during Descartes' time remain relevant today. The critique offered by Maritain has not suppressed the subsequent historical developments (Ratti, 2019). The current state of knowledge, considered through Maritain's approach, can be mapped through three complementary lenses (McQuillan, 2018). First, the epistemological roadmap directs attention to a sequence of positions and shifts in description that indicate both continuity and disruption. Second, the modalities of governing knowledge remain relevant for human-shared epistemic governance and apply to the 2020s developments. The crucial task is to understand both the connections among knowledge practices

and the way ML transforms them. The investigation of these intersections is ultimately limited to ML that operates at a distance from the human communication of a similar experience. At this juncture, the lens of Maritain aids the examination in classifying ML knowledge. Once the classification emerges, the technological configuration related to ML epistemologies becomes clearer.

Ethics, Responsibility, and the Use of ML in Hermeneutics and Inquiry

Interfering models can assist the researcher in the hermeneutic task without supplanting the human role. Shared conventions are crucial for enabling symphonic analysis. Nevertheless, the emergence of opaque models or language generation jeopardizes such dialogue. Automated translation, for instance, does not clarify the vernacular employed, while invocation of elaborate principles in models such as ChatGPT poses nearly insurmountable challenges for achieving interpretive concord.

Applying models ranging from conventional Keyword Extraction to Large-Language Modelling to both inquiry and periodization sheds new light on theories and works of art. Maritainian heuristics pinpoint the central concepts most worthy of scrutiny, the main influences shaping the creator's oeuvre, and the appropriate interpretive framework corresponding to the historical epoch in question. Abundant literature discusses the relationship between Maritainian philosophy and ML-driven reasoning; however, these interactions remain largely unexplored within the pedagogical domain.

Agency implicates responsibility. Competent authority possesses the prerogative to manage certain activities. Current

deployment therefore requires faithful guidance from designated custodians. Risky situations are bound to arise; conversely, no regrets inherently attend formal logic, experimental queries, or the ubiquitous act of reading. Prudence, articulated by Maritain as "the perfection of all the virtues, human and divine" and even "the archetype of all the virtues, human and divine" (Maritain, 1943, p. 259)—lies at the heart of risk assessment and mitigation. Emphasis on prudence centers attention on the human in charge and establishes parameters for permissible employment of resources possessing competence.

8. Applications and Case Studies

Comparative analyses exploring parallels between the framework of knowledge articulated by Jacques Maritain and the reasoning underlying the operation of machine learning provide a foundation for understanding how the latter can be applied to interpret objects in museums and archives. The proposed reflection deepens the exploration of ML within the context of museum collection interpretation. A second area of ongoing research considers the use of an ML model of language for philosophical inquiry. Such experimental applications invite consideration of the conditions for productive collaboration and help to clarify how the work of Maritain and his contemporaries can inform the use of artificial intelligence.

Although framed comparatively, the first analysis pursues a manifestly Maritainian approach. It focuses on the display of museum artefacts related to Sri Lanka and the test of a model

developed to assist in identifying or clustering images of objects based solely on the visual data they contain. Placing the syntactic idea of the semiotic argument and its triadic principles in dialogue with a process of visual ML reasoning reframes the question of whether an ML model is "sufficient" for curation with a Maritainian understanding of reason: without any synthetic act that follows from the marshalling of evidence and justifies a proposition beyond its mere mechanical assimilation of input. The analysis reveals that the direction of the semiotic argument does not allow a reverse order of dependence: that the ML process cannot usefully constitute the basis for an account of the exhibited objects or the curation of the selected group. Rather, it augments the presentation of the material culture only through the parallel inclusion of a substantial interpretative framework.

Comparative Analyses: Museum, Scholarship, and Education

To illustrate the insights gained from combining Maritainian reasoning and machine learning (ML) cognitive models, consider three applications: museum systems that promote the logic of Maritainian reasoning in human users; ML-supported interpretive surfaces for works of art and artifacts; and a joint ML–Maritainian dialogue in designing instructional materials that elaborate on both ML reasoning and that of Maritain.

A narrated art display integrating Maritainian reasoning would initially present a selection of works of art alongside texts that explain their formal features and meaning—ideally drawn by human makers, but created by ML-supported analysis when human texts were unavailable. Such a selection could be traversed via a rotating series of illustrated or recorded texts that offer introductions, commentaries, or reflections. A final step would present human

users with an ML-supported text-generating description of these artworks and the organizing principle of the exhibition. Subsequent comparisons and explorations would include how well the text reflects the original meaning of the artworks and how well their interpretations merge with the ML analysis. Emphasizing the logic of Maritainian reasoning would guide users toward the interpretive method promoted by ML and illuminate the different nature of the human and algorithmic approaches. Thereafter, ML-supported hermeneutical systems-of-systems could help select and order actions, concepts, and technologies to facilitate difficult collaborations.

Dialogue between Maritainian Philosophy and ML-based Reasoning

A harmonization of Maritainian Philosophy and AI-capable computational systems can be considered an ideal starting point for developing a Museum of the Future, directing ML-based technologies toward the support of fundamental discovery tasks, and coming up with a model for a minor or educational digital museum. A philosophical engagement with ML-based reasoning acknowledges the use of tools that are able to process an incredible amount of data and generate proposals for knowledge structures within a human-understandable framework.

Conversely, it is possible to converge toward AI interpretation and explanation tasks based on Maritainian knowledge structuring. New AI techniques should adhere to the hermeneutics principles that govern knowledge generation in the human mind. Operating in this way, one would assign the difficult task of obtaining explanations to AI while at the same time retaining the greatest safeguard of human

reasoning in the AI task: the subtleness of the relationship between the meaning of words and the concepts they attempt to express.

9. Conclusion

Artificial Intelligence has gained significant popularity, yet the understanding of its real conditions for use is hardly worked out. Combining Maritain's analysis of human knowing with developments of Machine Learning (ML) cast light upon the significant abilities of AI systems, the weaknesses and the perils of their use, outlining at the same time a pathway for clarifying the ethical implications and the way to set up MC in the finest possible way, so that its results show that this kind of assistance, while offering it’s great capacities, it is not yet and (maybe) never will be, either in systematic fashions nor in any use, able to substitute the vital powers of the human who is judging, selecting, thinking. At any moment, whether producing something of one’s own, or only listening to the words of other, or considering the work of any other man, the work of art and any reasoning is an on-going interpretation.

The synthesis between Maritain-like knowledge and ML-like approach helps in analysing the task of and the collaborative use of two scholars. It is possible to elaborate whether, in the wonderful inevitably imperfect task of enunciation and inquiry, ML give new, fresh, precious possibilities to whoever interprets in accordance with Maritain and cannot unethically omit the responsibilities that are at the base of all human actions.

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