Disclosing AI Inventions

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Abstract

Given the significant increase in the number of artificial intelligence (AI)-related publications and patents, this article examines the required standard of disclosure concerning AI inventions. Machine learning algorithms are used as a test case to show the differences between AI inventions and conventional software. The article then examines how the non-deterministic and black-box nature of AI models distinguish them from traditional software. Furthermore, it discusses the relationship between the predictability of a field of technology and the required disclosure.

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Accordingly, it explains the issue of predictability regarding the field of biotechnology and compares machine learning models with biotechnology inventions. The article concludes that AI inventions may require an elevated level of disclosure compared to conventional software.

Introduction

Artificial intelligence, one of the most influential technologies in recent decades, has revolutionized all aspects of our lives.[1] It has been said that the fourth industrial revolution is happening as a result of artificial intelligence.[2] Artificial intelligence, a subfield of computer science,[3] is an algorithm,[4] a system,[5] or a mechanism[6] that simulates the functionality of the human brain or imitates human intelligence.[7] There are weak and strong artificial intelligence systems.[8] Strong artificial intelligence is the intelligence that is equal to human intelligence, and it has not yet been developed. In contrast, weak artificial intelligence is capable of doing narrow tasks like predictive analytics for businesses, medical diagnostics, voice recognition, etc.[9]

Today, many startups around the world have been established based on AI systems. Usually, intellectual property (IP) is the start-up's most valuable asset , and its protection is one of the most critical challenges.[10] AI startups can use different types

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1 *See generally* Adam C. Uzialko, *How Artificial Intelligence Will Transform Business*, BUSINESS NEWS DAILY (Apr. 22, 2019), https://www.businessnewsdaily.com/9402-artificial-intelligence-business-trends.html; *See generally* Mike Thomas, *The Future of Artificial Intelligence*, BUILTIN, https://builtin.com/artificial-intelligence/artificial-intelligence-future (June 8, 2019).

2 *See generally* Alan Crameri, *Artificial Intelligence: The fourth industrial revolution*, INFORMATIONAGE, https://www.information-age.com/artificial-intelligence-fourth-industrial-revolution-123475170 (Oct. 3, 2018); *See generally* Elizabeth Schulze, *Everything you need to know about the Fourth Industrial Revolution*, CNBC, https://www.cnbc.com/2019/01/16/fourth-industrial-revolution-explained-davos-2019.html (Jan. 17, 2019).

3 "Artificial intelligence", MERRIAM-WEBSTER, https://www.merriam-webster.com/dictionary/artificial%20intelligence (last visited Mar. 9, 2020) ("[Artificial Intelligence is] a branch of computer science dealing with the simulation of intelligent behavior in computers.").

4 *See* Derik Pridmore, *Buzzword demystifier: Artificial Intelligence*, ABB (June 4, 2018), https://new.abb.com/news/detail/4346/buzzword-demystifier-artificial-intelligence.

5 B.J. Copeland, *Artificial Intelligence*, ENCYCLOPEDIA BRITANNICA, https://www.britannica.com/technology/artificial-intelligence (last visited Mar. 5, 2020) ("The term [artificial intelligence] is frequently applied to the project of developing systems endowed with the intellectual processes characteristic of humans.").

6 *See generally* Kenneth Evans, *How Does Artificial Intelligence Enhance the Internet Of Things*, THE NEXT TECH, https://www.the-next-tech.com/artificial-intelligence/how-does-artificial-intelligence-enhance-the-internet-of-things (last visited Mar. 23, 2020).

7 *See generally* Jake Frankenfield, *Artificial Intelligence (AI)*, Investopedia, https://www.investopedia.com/terms/a/artificial-intelligence-ai.asp (last updated Mar. 13, 2020).

8 *See generally* Kathleen Walch, *Rethinking Weak Vs. Strong AI*, FORBES (Oct. 4, 2019), https://www.forbes.com/sites/cognitiveworld/2019/10/04/rethinking-weak-vs-strong-ai/#1344c7526da3.

9 *Id.*

10 *See generally* Amanda Ciccatelli, *Intellectual Property: The Most Valuable Asset of a Technology Startup*, LAW.COM (Sep. 20, 2017), https://www.law.com/insidecounsel/2017/09/20/intellectual-

of IP protection, including patents, copyrights, trademarks, trade secrets, confidentiality agreements, and privacy policies, or a combination of them.[11] For this paper, I will focus on AI patents, and specifically, I will discuss the required level of disclosure and enablement for AI-related patents.

Public disclosure, one of the requirements for patentability, informs competitors of the details of the invention.[12] Typically, the issued patent is territorial and thus geographically limited to the country in which the patent was granted.[13] Despite the exclusive rights obtained as a result of the patent, competitors can "invent around," or make similar products with the minimum required modifications to avoid infringement.[14] Nonetheless, due to the limitations regarding the required public disclosure of the patents, the inventor can still avoid the full disclosure of his invention by keeping some of its features secret.[15] Consequently, this partial disclosure may impede competitors from inventing around the claimed invention.

According to WIPO Technology Trends 2019 on Artificial Intelligence,[16] the United States is among the top two countries with the highest number of AI patent applications. The number of AI-related acquisitions has been increasing rapidly since 2016.[17] As shown in the following graphs, Figure 1[18] and Figure 2,[19] the number of AI inventions has been booming globally since 2013.[20]

property-the-most-valuable-asset-of-a-technology-startup/?slreturn=20200209162537.

11 *See generally* Richard Harroch, *10 Intellectual Property Strategies For Technology Startups*, FORBES (Jun. 6, 2017), https://www.forbes.com/sites/allbusiness/2017/06/06/10-intellectual-property-strategies-for-technology-startups/#60cbf970ab1b; *See generally* Jacqueline Hooper, *Safeguard Your Startup With An Intellectual Property Strategy*, ENTREPRENEUR (Oct. 16, 2018), https://www.entrepreneur.com/article/321714.

12 *See generally* Andrew Beckerman-Rodau, *The Choice between Patent Protection and Trade Secret Protection: A Legal and Business Decision*, 84 J. PAT. & TRADEMARK OFF. SOC'Y 371, 394 (2002).

13 *Id.* at 395; Intellectual Prop. Rights Info. & Assistance*, Is My U.S. Patent Good in Other Countries*, STOPFAKES.GOV (Oct. 17, 2018), https://www.stopfakes.gov/article?id=Is-My-US-Patent-Good-in-Other-Countries.

14 Beckerman-Rodau, *supra* note 12, at 395.

15 Brenda M. Simon & Ted Sichelman, *Data-Generating Patents*, 111 Nw. U. L. Rev. 377, 383 (2017).

16 *See* WORLD INTELLECTUAL PROPERTY ORGANIZATION, WIPO TECHNOLOGY TRENDS 2019: ARTIFICIAL INTELLIGENCE 82 (2019), https://www.wipo.int/edocs/pubdocs/en/wipo_pub_1055.pdf.

17 *See id.* at 16.

18 *See id.* at 40.

19 *See id.* at 42.

20 *See id.* at 13.

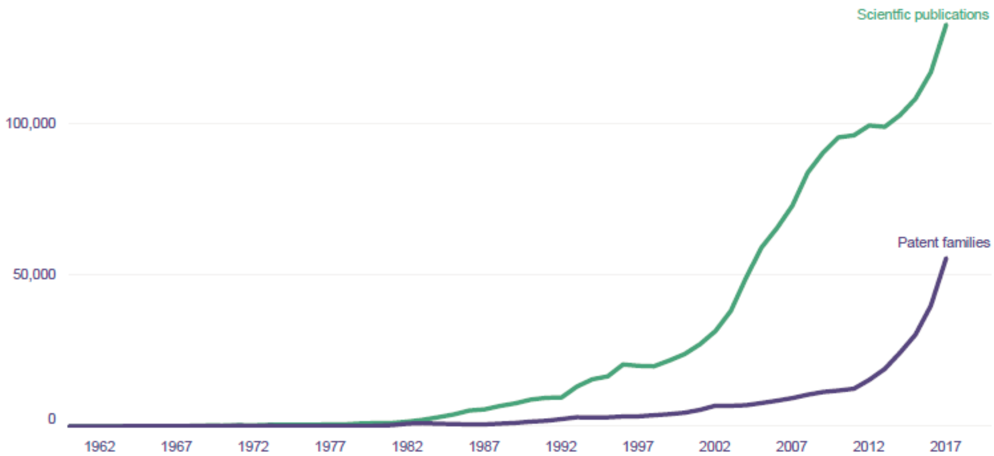

Figure 1: Growth in AI patent application and publications[21]

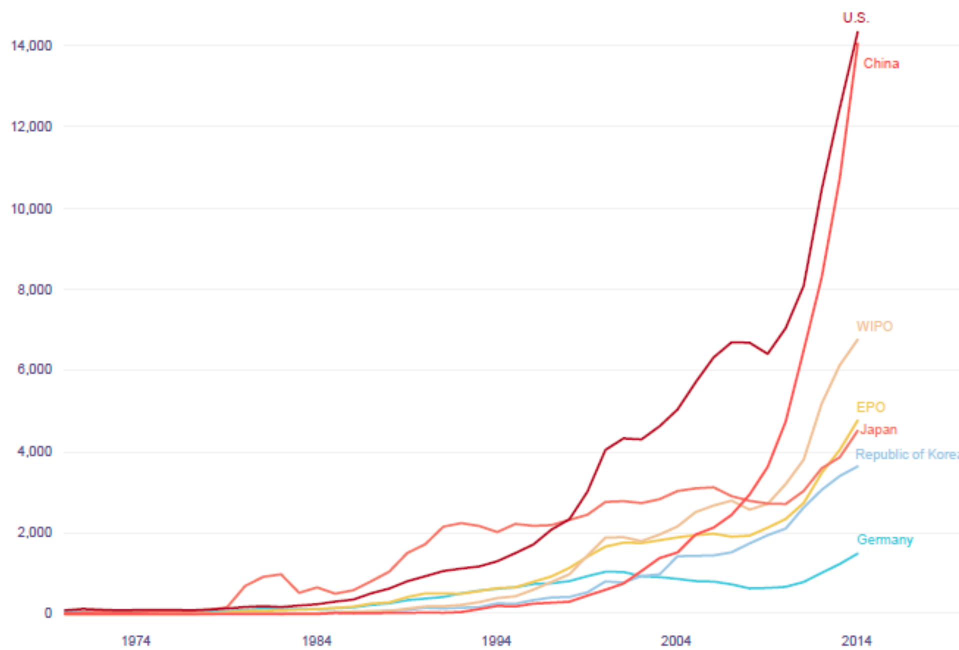

Figure 2: Number of AI patents filed in the US compared to other countries[22]

On August 27, 2019, USPTO published a public notice on the Federal Register requesting comments regarding AI invention and its intersection with patent law.[23] In the notice, USPTO likened software with AI because they both use a computer as

[21] *See id*. at 40.
[22] *See* WORLD INTELLECTUAL PROPERTY ORGANIZATION, *supra* note 16, at 42.
[23] Request for Comments on Patenting Artificial Intelligence Inventions, 84 Fed. Reg. 44,889 (Aug. 27, 2019), https://www.federalregister.gov/documents/2019/08/27/2019-18443/request-for-comments-on-patenting-artificial-intelligence-inventions.

a medium to carry out specific tasks.[24] Nonetheless, in the public notice, USPTO sought specific comments regarding the elements of AI invention, patent eligibility, the standard of disclosure for AI systems, and the level of skills for a person of ordinary skill in the art relating to AI.[25]

Machine learning has the greatest share in the number of AI-related patent applications.[26] As reported in WIPO Technology Trends 2019 on Artificial Intelligence, and depicted in Figure 3, machine learning applications increased by 26% annually between 2011 and 2016.[27] Therefore, for the purpose of analysis and discussion, I will use machine learning (ML) as the largest subset of artificial intelligence.

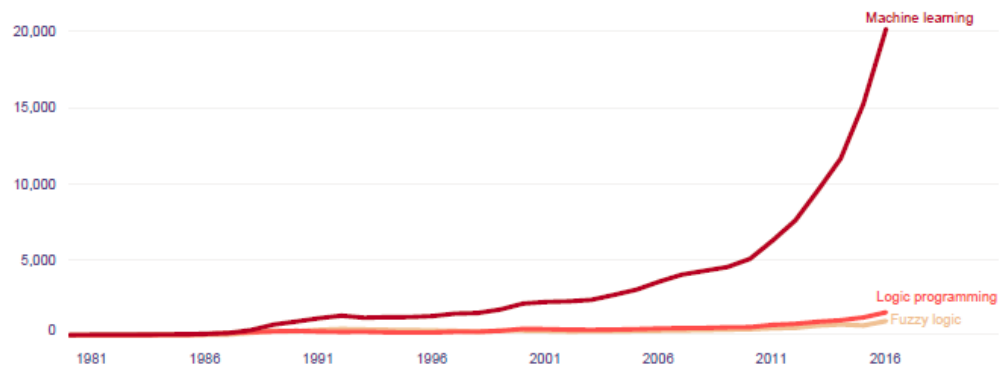

Figure 3: "top AI technologies by the earliest filing date."[28]

To date, the required written description and enablement for AI inventions, and the resulting issues, have been briefly discussed in a few articles. Yinsky discusses the black-box nature of AI systems that results in nontransparent and unexplainable features.[29] He further relates this black-box nature to the lack of clarity in the disclosure of the AI-related inventions, and he proposes a depository system as used by WIPO for microorganisms as a solution.[30] Likewise, another article, in response to the USPTO public request, briefly discusses the importance of the training dataset and the training method in machine learning algorithms and proposes that they are

[24] *See generally Id.*; *See also* Marc T. Morley, Michael T. Renaud, and Paul S. Brockland, *Recap of Federal Register Notice on Artificial Intelligence (AI) Patent Issues*, 9 NAT'L L. REV. 260 (Sep. 17, 2019), https://www.natlawreview.com/article/recap-federal-register-notice-artificial-intelligence-ai-patent-issues.

[25] *See* Request for Comments on Patenting Artificial Intelligence Inventions, 84 Fed. Reg. 44,889; *See generally* Morley et al., *supra* note 24.

[26] *See* WORLD INTELLECTUAL PROPERTY ORGANIZATION, *supra* note 16, at 14.

[27] *See id.*

[28] *See id*.

[29] *See generally* Yanisky-Ravid, Shlomit & Jin, Regina, *Summoning a New Artificial Intelligence Patent Model: In the Age of Pandemic* (June 4, 2020) https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3619069

[30] *Id.*

considered by patent examiners.[31] Decosta points out the importance of the disclosure of the training dataset, and even the topology of the neural network (NN) in NN-based machine learning.[32] Okakita points to the lack of a clear standard of disclosure for AI inventions and points out the AI-black-box problem.[33] Finally, Bruno points to the similarities between the field of biotechnology and AI, suggesting that the AI-patent issues may be resolved with the help of the well-established standards in the field of biotechnology.[34]

However, almost all of the articles lack clarity regarding the origin of the black-box nature of AI systems and how the resulting features, like nontransparency and lack of explainability, relate to a different or higher standard of disclosure. In other words, these articles do not explain which subelements of an AI invention cannot be sufficiently disclosed. Additionally, given the well-established case law regarding software patents, prior studies have not discussed the importance of the significant similarity between AI systems and conventional software patents.

Therefore, in this article, I first provide a short definition and background of AI algorithms, big data, neural networks, deep learning, and their similarities with conventional software. The article then explains the elements of conventional software and an AI system in order to clarify the fundamental differences between them—differences that typically originate from the core of an AI system or the model itself and the training method.

Part II discusses the standard of disclosure for conventional software patents, briefly exploring the background and history of the required disclosure. Specifically, the legal standards for enablement and written description are presented. I also point out the significance of the disclosure of the algorithm as the most important part of the conventional software compared to the minimal value of the underlying code.

In Part III, which is based on the foundation laid out in Parts I and II, I discuss the technology-specific considerations concerning AI patents. Part III explains that the model in a machine learning algorithm, as a black-box-like system, learns the rules that govern the relationships in the input data in a nondeterministic manner,

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31 Internet Association, et al., Response to Request for Comments on Patenting Artificial Intelligence Inventions 14 (Nov. 8, 2019), https://www.uspto.gov/sites/default/files/documents/Internet%20Association_RFC-84-FR-44889.pdf.

32 See generally Frank A. DeCosta & Aliza G. Carrano, *Intellectual Property Protection for Artificial Intelligence*, FINNEGAN (Aug. 30, 2017), https://www.finnegan.com/en/insights/articles/intellectual-property-protection-for-artificial-intelligence.html.

33 Yuhei Okakita, PATENT EXAMINATION PRACTICES REGARDING AI-RELATED INVENTIONS: COMPARISON IN THE EPO, USPTO AND JPO (2019), https://ssrn.com/abstract=3652173.

34 Enrica Bruno & Brian Cash, *Answers to AI Patent Questions May Be Found in Biotech*, LAW360 (April 19, 2019), https://www.law360.com/articles/1151883; *see also* Harm van der Heijden, *AI inventions and sufficiency of disclosure – when enough is enough*, IAM (Oct. 3, 2019), https://www.iam-media.com/ai-inventions-and-sufficiency-disclosure-when-enough-enough.

and in contrast, in conventional software, the programmer implements a set of rules that maps input data to the output. Part III further explains the dependency of an AI model on big data and points out the relationship of patent disclosure with the costly data collection methods that affect and transfer learning. Additionally, I discuss the AI algorithm as a nontransparent, black-box-like algorithm, pointing out the nondeterministic, or stochastic, nature of AI inventions and explaining how it relates to the appropriate standard of disclosure.

Finally, in Part IV, I explain why AI patents should be held to a higher standard of disclosure than conventional software patents. I also discuss whether the underlying code and the training data sets should be disclosed as part of the specification. I consider whether the disclosure of big data, or preprocessed big data, would shield the AI patent against some possible patent-invalidity challenges, or whether it would limit the scope of protection. I examine how the non-deterministic and black-box nature of AI models distinguish them from software. Next, I explain the analogy between the field of biotechnology and AI, and I discuss the predictability of a field of technology and its relationship with the required level of disclosure.

Ultimately, I conclude that AI requires an elevated level of disclosure compared to conventional software inventions, and I suggest complementary incentives to balance the proposed heightened standard of disclosure concerning AI patents.

I. A Brief Description of AI Systems

A. What Is AI?

The term "artificial intelligence" was first introduced by John McCarthy in 1956; he allegedly chose this term in contrast with an older term called "thinking machine."[35] McCarthy used the term in conjunction with a research study regarding the simulation of the learning procedure and the features of human intelligence.[36] Typically, artificial intelligence is considered a subfield of computer science that enables machines to mimic human intelligence.[37] Britannica Encyclopedia defines AI as "the ability of a digital computer-controlled robot" to simulate human intelligence, including reasoning, generalizing, and learning from the past.[38] In sum, artificial intelligence is an algorithm,[39] a system,[40] or a mechanism[41] that models or simulates human intelligent behavior.[42] AI algorithms enable machines to learn from the input data and to find the unknown rule, the target function, that approximates the relationship between the input data and the corresponding output of the

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35 *See generally* Bernard Marr, *The Key Definitions of Artificial Intelligence (AI) That Explain Its Importance*, FORBES (Feb 14, 2018), https://www.forbes.com/sites/bernardmarr/2018/02/14/the-key-definitions-of-artificial-intelligence-ai-that-explain-its-importance/#6c6ed64e4f5d.

36 *Id.*

37 *Artificial intelligence, supra* note 3.

38 *See* Copeland, *supra* note 5.

39 *See* Pridmore, *supra* note 4.

40 *See* Copeland, *supra* note 5.

41 *See generally* Evans, *supra* note 6.

42 *See generally* Frankenfield, *supra* note 7.

AI system.[43] Furthermore, AI can learn, find, and discover the anomalies and hidden patterns in the data.[44]

B. Big Data and Data Collection

Gartner defines big data (BD) as "data that contains greater variety arriving in increasing volumes and with ever-higher velocity."[45] In simple terms, big data is a complex, large volume of data that typically can be collected by modern methods of data collection from new sources.[46] Big data plays a crucial role in developing an artificial-intelligence system.[47] An AI system digests and processes the big data, and subsequently, the underlying AI model learns the rules and relationships, and surfaces hidden patterns. The computing power of computers and parallel processing have enabled AI systems to analyze and learn from a huge, complex volume of data.[48] Hence, the methods of data collection and the methods of data engineering and data analysis are significant parts of an AI system.

C. Learning and Neural Networks

To explain how an AI system learns from the big data, I briefly discuss two types of machine learning methods: supervised and unsupervised learning.[49] In supervised learning, the algorithm learns the relationship between the input data and the associated output data;[50] subsequently, the deployed trained model can be used to make decisions and do predictions in response to new sample data in the execution stage. In unsupervised learning, the algorithm learns from the input dataset, and it does not require associated output.[51] In other words, in unsupervised learning, an AI algorithm can use the input data and can learn, surface, and discover data patterns[52] and anomalies in the data. Additionally, unsupervised learning, by restructuring the data and splitting it into different classes, may give the user insights to better understand the nature of the input dataset and to find out a better strategy to be used

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43 *See generally* Jason Brownlee, *How Machine Learning Algorithms Work (they learn a mapping of input to output)*, Machine Learning Mastery (Mar. 11, 2016), https://machinelearningmastery.com/how-machine-learning-algorithms-work.

44 *See generally* Vegard Flovik, *how to use machine learning for anomaly detection and condition monitoring*, Towards data science (Dec. 31, 2018), https://towardsdatascience.com/how-to-use-machine-learning-for-anomaly-detection-and-condition-monitoring-6742f82900d7.

45 *See What is big data?*, ORACLE, https://www.oracle.com/big-data/guide/what-is-big-data.html (last visited Dec. 23, 2019).

46 *Id*.

47 *See generally* Bernard Marr, *Why AI Would Be Nothing Without Big Data*, FORBES (Jun. 9, 2017), https://www.forbes.com/sites/bernardmarr/2017/06/09/why-ai-would-be-nothing-without-big-data/#10494a364f6d.

48 *See generally* Tiernan Ray, *AI is changing the entire nature of compute*, ZDNet (Jun. 30, 2019), https://www.zdnet.com/article/ai-is-changing-the-entire-nature-of-compute.

49 *See generally* JOHN PAUL MUELLER & LUCA MASSARON, ARTIFICIAL INTELLIGENCE FOR DUMMIES 133 (2018);

50 *See generally Id.*; *See generally* Aidan Wilson, *A Brief Introduction to Supervised Learning*, TOWARDS DATA SCIENCE (Sep. 29, 2019), https://towardsdatascience.com/a-brief-introduction-to-supervised-learning-54a3e3932590.

51 *See generally* MUELLER, *supra* note 49, at 133–34.

52 *See Id.* at 134.

in the supervised learning method.[53]

D. Elements of Conventional Software Inventions

There are different types of categorization regarding software development and computer technology. WIPO has introduced three general types of inventions concerning computer technology: (1) improving the computing functions of computers, (2) machines or devices that use computers to run a particular function, and (3) the use of computers in creating inventions in various fields of technology.[54]

Typically, in conventional software development, an algorithm, as a multi-step procedure of problem-solving, can be considered as the starting point of the process that can be implemented in a form of software or code utilizing various types of programming languages.[55] The software program can then be executed on a system that meets the minimum requirements to run the software such as a processing unit, memory, and an operating system.[56] In traditional programming, a person develops a software program based on pre-determined rules that maps the input to the desired output. However, in machine learning, the underlying learning algorithm discovers and formulates the rules in the model, based on the input data and the corresponding output.[57] Thus, in conventional software patents, the algorithm is the most important part that should be disclosed and claimed.[58]

E. Elements of AI Inventions

AI-based systems include various submodules that are used in the training phase of the AI model, after which the trained model is deployed to be used in the execution phase.[59] In AI inventions, we must first determine which part or parts of the AI system will be claimed. Generally, an AI system can be divided into (1) data collection techniques and what kind of data should be collected for a specific purpose or an improvement thereof, (2) the preprocessing step of feeding the data to the model and the feature extraction, (3) learning methods and the process of iterated

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53 *See Id.*

54 Standing Comm. on the Law of Patents, Background Document on Patents and Emerging Technologies 12, U.N. Doc. E/SCP/30/5 (2019).

55 *See generally* Aishwarya Verma, *Difference between Algorithm, Pseudocode and Program*, GeeksforGeeks (Dec. 21, 2018), https://www.geeksforgeeks.org/difference-between-algorithm-pseudocode-and-program.

56 *See generally System Requirements, TechTerms,* https://techterms.com/definition/system_requirements (last visited Jan. 5, 2021).

57 *See generally* Sriram Parthasarathy, *Machine Learning vs. Traditional Programming*, LogiAnalytics (Sep. 16, 2020), https://www.logianalytics.com/predictive-analytics/machine-learning-vs-traditional-programming.

58 *See* Fonar Corp. v. Gen. Elec. Co., 107 F.3d 1543, 1549 (Fed. Cir. 1997) (stating that the description of a software patent relies on "what the software has to do" and "providing the functions of the software [i]s more important than providing the computer code").

59 *See generally* Michael Borella, *How to Draft Patent Claims for Machine Learning Inventions*, PATENT DOCS (Nov. 25, 2018), https://www.patentdocs.org/2018/11/how-to-draft-patent-claims-for-machine-learning-inventions.html (stating that once an AI "model is sufficiently accurate on test data, it can be deployed for production use").

feeding inputs to the model, (4) the model itself, its structure, weights, coefficients, specific features, and connections in detail, (5) customizing and improving the existing models, and (6) post-processing and interpretation of the output of the model. Therefore, AI inventions may include one or many of the mentioned parts.[60]

Most of the differences between AI and conventional software are related to the core of an AI system, which is the learning algorithm and the resulting model.[61] Therefore, an inventor may claim a model itself, or he can claim an improvement to the model. There are several types of models that include the most popular machine learning algorithms, such as linear regression, logistic regression, linear discriminant analysis, decision trees, Naive Bayes, K-Nearest Neighbors, learning vector quantization, support vector machines, bagging and random forest, and deep neural networks.[62]

In sum, as discussed above, according to the wide range of AI algorithms and models, we must determine which part of an AI system would be claimed. In this paper, I typically assume that the claimed invention relates to the model, the learning algorithm, or a trained model; to avoid complexity, most of the explanations and examples will be provided based on machine learning, neural networks, and deep learning algorithms.

II. What Is The Standard of Disclosure Regarding Conventional Software

Under 35 U.S.C. § 112(a), "The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same, and shall set forth the best mode contemplated by the inventor or joint inventor of carrying out the invention."[63] In this section, the article separately examines the written description and enablement requirement, as required in the statute. In this article, the main issue is what should be disclosed concerning AI inventions, not how to disclose it. Subsequently, other subsections of 35 U.S.C. § 112, like subsection (f) regarding functional claims, will not be discussed. Nonetheless, it is notable that other relevant factors can affect the outcome of litigations concerning section 112 of the Patent Act, including the place of the decision, the Federal Circuit or the district court, whether the claim is drafted under Section 112(f), and whether the is-

[60] Christopher J. White & Hamid R. Piroozi, *Drafting Patent Applications Covering Artificial Intelligence Systems*, ABA, https://www.americanbar.org/groups/intellectual_property_law/publications/landslide/2018-19/january-february/drafting-patent-applications-covering-artificial-intelligence-systems/#11 (last visited Dec. 23, 2019).

[61] *See generally* Oleksii Kharkovyna, *Machine Learning vs Traditional Programming, towards data science* (Apr. 22, 2019), https://towardsdatascience.com/machine-learning-vs-traditional-programming-c066e39b5b17.

[62] Vladimir Fedak, *Top 10 Most Popular AI Models*, DZone (Nov. 8, 2018), https://dzone.com/articles/top-10-most-popular-ai-models.

[63] 35 U.S.C. § 112(a).

sue was resolved after the Markman hearing.[64]

A. Written Description

The required level of written description depends on the level of skill of a person having ordinary skill in the art, nature of the claimed invention, and the complexity and predictability of the technology.[65] As the Federal Circuit stated in *Ariad* and *Vasudevan*, to assess the adequacy of the written description, we must consider "whether the disclosure of the application relied upon reasonably conveys to those skilled in the art that the inventor had possession of the claimed subject matter as of the filing date."[66] However, an inventor cannot meet the required disclosure by merely giving the "desired result."[67] In some fields of technology, there is an "inverse correlation" between the level of knowledge of a skilled person in the art and the level of required written description.[68]

Regarding software patents, the implementation of the underlying code of the software can normally be done by a skilled person in the art without undue experimentation.[69] Therefore, the disclosure of the function of the software may adequately meet the required standard of written description.[70]

B. Enablement

A claim must enable a person of ordinary skill in the art to make and use the same invention without undue experimentation.[71] The enablement requirement is different than the written description, and it must be satisfied separately.[72] The written description is broader than merely enabling a skilled person in the relevant art to make and use the claimed invention.[73]

The "undue experimentation" requirement depends on the field of art.[74] Typically, when a field of art involves complex experimentation, then the complexity of the experimentation in the art does not make it undue.[75] In *Vasudevan,*[76] the Federal Circuit stated that "a claim is sufficiently enabled even if a considerable amount of experimentation is necessary, so long as the experimentation is merely routine, or if the specification in question provides a reasonable amount of guidance with respect

64 John R. Allison & Lisa Larrimore Ouellette, *How Courts Adjudicate Patent Definiteness and Disclosure*, 65 DUKE L.J. 609, 610 (2019).
65 Ariad Pharm., Inc. v. Eli Lilly & Co., 598 F.3d 1336, 1351 (Fed. Cir. 2010).
66 Vasudevan Software, Inc. v. MicroStrategy, Inc., 782 F.3d 671, 682 (Fed. Cir. 2015); *Ariad Pharm.*, 598 F.3d at 1351.
67 *Vasudevan Software*, 782 F.3d at 682.
68 U.S. PATENT & TRADEMARK OFFICE, MANUAL OF PATENT EXAMINING PROCEDURE § 2163 (9th ed. 2014, rev. ed. 2020)
69 *Fonar*, 107 F.3d at 1549 .
70 *Id.* at 1549.
71 *See In re* Wands, 858 F.2d 731, 737 (Fed. Cir. 1988).
72 Vas-Cath Inc. v. Mahurkar, 935 F.2d 1555, 1563 (Fed. Cir. 1991).
73 *Id.*
74 *In re* Certain Limited-Charge Cell Culture Microcarriers, 5 ITRD 2302 (1983).
75 *Id.*
76 *Vasudevan Software*, 782 F.3d at 684.

to the direction in which the experimentation should proceed."[77] In *Wands*,[78] concerning the "undue experimentation," the Federal Circuit pointed out eight factors:

> (1) the quantity of experimentation necessary, (2) the amount of direction or guidance presented, (3) the presence or absence of working examples, (4) the nature of the invention, (5) the state of the prior art, (6) the relative skill of those in the art, (7) the predictability or unpredictability of the art, and (8) the breadth of the claims.[79]

According to the Federal Circuit in *Everlight,*[80] the disclosure of "every possible iteration" of a claimed process is not required to enable a person skilled in the art to practice the full scope of the claim.[81] However, an inventor is not required to disclose what is "well known in art."[82] Additionally, an inventor may rely on the abilities of the skilled person in the art to satisfy the enablement standard; nevertheless, he cannot do the same for novel aspects of the invention.

As explained in the preceding sections regarding the elements of a software invention, the algorithm is the most important part of the conventional software invention that should be disclosed in order to enable a skilled person in the art to make and use the claimed invention.[83] In *Sherwood*,[84] the Court of Customs and Patent Appeals for the first time addressed this issue. The court found that:

> "writing a computer program may be a task requiring the most sublime of the inventive faculty, or it may require only the droning use of a clerical skill. The difference between the two extremes lies in the creation of mathematical methodology to bridge the gap between the information one starts with (the 'input') and the information that is desired (the 'output'). If these bridge-gapping tools are disclosed, there would seem to be no cogent reason to require disclosure of the menial tools known to all who practice this art."[85]

Therefore, in *Sherwood*, the court lowered the standard of disclosure concerning software inventions by limiting the required disclosure to the methodology and steps, which maps the input to the desired output. The court pointed out that the underlying code or implementation of the algorithm is like clerical task that is known to a person having ordinary skill in the art and can be done without undue experimentation.[86] Furthermore, the court analogized a computer coder with a translator; the court explained that coding in different programming languages is similar to writing in different spoken languages, which can be translated to other languages by

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77 *Id.*; *In re* Wands, 858 F.2d 731, 737, 8 USPQ2d 1400, 1404 (Fed. Cir. 1988).
78 *In re* Wands, 858 F.2d at 737.
79 *Id.*; *Vasudevan Software*, 782 F.3d at 671.
80 Trustees of Bos. Univ. v. Everlight Elecs. Co., 896 F.3d 1357 (Fed. Cir. 2018).
81 *Id.* at 1364.
82 *Id.*
83 *See supra* Part I.D.
84 *In re* Application of Sherwood, 613 F.2d 809 (C.C.P.A. 1980).
85 *Id.* at 816–17.
86 *Id.* at 819 n. 6.

a translator.[87]

III. Technology-specific Considerations Regarding the Disclosure of ai Inventions

As discussed in Part II, a claim must enable a person having ordinary skill in the art (PHOSITA) to make and use the same invention.[88] The level of skill of a PHOSITA depends on several factors, including "sophistication of the technology[,] and educational level of active workers in the field."[89] Regarding deep machine learning algorithms, although a deep neural network is a simple and generic principle, new AI-related inventions require a broader knowledge than neural networks that may include (1) training dataset, data reduction, and preprocessing, (2) computational power, hardware requirements, and software optimization, (3) different structures of neural networks, and (4) robustness, including long-term reliability and safety.[90] For example, in a neural network learning algorithm that is used in the field of image recognition and security systems, a PHOSITA is a person who is familiar with the field of artificial intelligence, image recognition, and security systems.[91] Therefore, this complexity involved in the field of artificial intelligence requires a level of skill that is commensurate with the technology. This higher level of skills of a PHOSITA may affect and reduce the level of disclosure by an inventor. Nevertheless, it is notable that a skilled person in the art must still be able to make and use the full scope of the claimed invention.[92]

Concerning AI-related patents, an inventor may claim the entire pipeline[93], any of the underlying components which may "run asynchronously,"[94] or any combination of the components. An AI pipeline may have different components, including data collection, data preparation and preprocessing, learning algorithm or model selection, training methods, post-processing and candidate model validation, and deployment of the trained model.[95] Although most of the components of a machine learning pipeline are algorithms, and they are implemented by conventional software,[96] typically, the model or the learning algorithm has certain distinct characteristics. In a machine learning algorithm, the model learns the rules that govern the

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87 *Id*.
88 *See supra* Part II.B.
89 *In re* GPAC Inc., 57 F.3d 1573, 1579 (Fed. Cir. 1995).
90 *See* Standing Committee on the Law of Patents, *supra* note 54, at 11.
91 *See id.* at 18.
92 *Trustees of Bos. Univ.*, 896 F.3d at 1364.
93 *See* Aurelien Geron, *Hands-On Machine Learning with Scikit-Learn & TensorFlow* 36 (2017) ("A sequence of data processing components is called a pipeline. Pipelines are very common in Machine Learning systems, since there is a lot of data to manipulate and many data transformations to apply.").
94 *Id.*
95 *See generally What are Azure Machine Learning pipelines*, MICROSOFT (Nov. 6, 2019), https://docs.microsoft.com/en-us/azure/machine-learning/concept-ml-pipelines; *See generally* Semi Koen, *Architecting a Machine Learning Pipeline*, TOWARDS DATA SCIENCE (Apr. 5, 2019), https://towardsdatascience.com/architecting-a-machine-learning-pipeline-a847f094d1c7.
96 *See generally* Standing Committee on the Law of Patents, *supra* note 54, at 13.

relationships in the input data in a nondeterministic manner.[97] Unlike conventional software in which the programmer implements a set of rules that maps input data to the output, in machine learning AI systems, a black-box learning algorithm discovers the rules and surfaces hidden patterns.[98]

For instance, in a deep learning neural network, explaining the internal process of learning and generating the model might be an issue[99] because the results are the product of a non-deterministic,[100] black-box-like model that is generated with minimal transparency.[101] Therefore, we must examine how this difference distinguishes AI from software, and whether the disclosure of the big data and the details of weight initialization may solve this issue.

A. AI Systems, Conventional Software, and Biotechnology

The software, compared to biotechnology, has been held to a lower standard of written description and enablement.[102] Biological product, "natural process product," can be evolved, changed, and reproduced without further interference by its inventor or creator.[103] So, when a biological product is patented according to its features and characteristics in one moment, there might be a dispute concerning the self-created changes in the future without the intervention of its inventor. This specific feature has been addressed in the field of biotechnology and related patents.[104] As discussed in the preceding sections, and as will be discussed further in the next sections, AI has similar stochastic, or non-deterministic, characteristics as exists in the field of biotechnology. For example, in a deep neural network machine learning algorithm, we may have several candidates for the deployment of the model.[105] The trained model may differ depending on several factors that are determined by random processes.[106] The training process may involve a random selection of the training data set in different iterations, and it may be affected by the methods of random weight initialization.[107]

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97 *See generally supra* Part I.A.
98 *See generally supra* Part I.E; *see generally supra*, Part I.A.
99 *See generally* Standing Committee on the Law of Patents, *supra* note 54, at 9.
100 *See infra* Part III.D.
101 *See infra* Part III.C.
102 Ajeet P. Pai, *The Low Written Description Bar for Software Inventions*, 94 VA. L. REV. 457, 479 (2008); John R. Allison & Lisa Larrimore Ouellette, *How Courts Adjudicate Patent Definiteness and Disclosure*, 65 DUKE L.J. 609, 624 (2016).
103 *See generally* Carly Klein, *The Complications Around Patenting Biotechnology*, LABIOTECH.EU (Aug. 1, 2019), https://www.labiotech.eu/features/biotechnology-patents-intellectual-property; *see also* Bruno & Cash, *supra* note 34.
104 *Id.*
105 *See generally* Jason Brownlee, *A Gentle Introduction to Model Selection for Machine Learning*, MACHINE LEARNING MASTERY (Dec. 2, 2019), https://machinelearningmastery.com/a-gentle-introduction-to-model-selection-for-machine-learning.
106 *See generally* Jason Brownlee, *What Does Stochastic Mean in Machine Learning?*, MACHINE LEARNING MASTERY (Nov. 18, 2019), https://machinelearningmastery.com/stochastic-in-machine-learning.
107 *See generally id.*

Therefore, in an AI claim that includes the model, we must consider whether the claim encompasses all variations of the proposed deep neural network learning model or if it only includes that particular disclosed embodiment of the model. This might subject AI inventions to similar standards of disclosure as used in biotechnological products, and consequently, it may impose a higher standard of disclosure on model-related AI claims.

In the field of biotechnology, when a molecule, amino acid, or protein is invented, the inventor may disclose the relevant DNA sequence or part of the sequence as part of the disclosure.[108] Subsequently, the patent office uses the disclosed sequence for the purpose of prior art searches.[109] Likewise, in the field of AI, an inventor may need to disclose the training dataset or several sample datasets[110] that enable a person skilled in the art to train a similar learning algorithm that leads to desired candidate models. The inventor may disclose a different initialization of the weights and the required methods of initialization to enable a skilled person to make and use the claimed model, and the said model must produce the desired results at the time of execution with acceptable accuracy. Typically, the dataset or the big data used for training the model is kept as a trade secret by AI inventive entities.[111]

As indicated in *Myriad*, a strand of complementary DNA (cDNA) may be patented.[112] cDNA is a synthesized sequence of codons[113] which lacks introns[114][115] There are synonymous codons that make the same amino acid or protein;[116] therefore, as a simple example, different stands of cDNA may exist with synonymous codons that may generate the same amino acid or protein. In other words, some structurally different cDNAs may be used for the same purpose, to make the same protein, and to be used to cure the same disease. Likewise, a candidate AI model with different weights and hyperparameters, and even minor topological difference, that has been trained with the same set of data for a particular purpose may substan-

108 *See generally* Bruno & Cash, *supra* note 34.
109 *See id.*
110 *See generally id.*
111 *See infra* Part III.B.
112 Alex Harding, *Shedding Light on the Obviousness of Gene Patents*, JOLT DIGEST (Jan. 16, 2018), https://jolt.law.harvard.edu/digest/obviousness-gene-patents; *see generally* Ass'n for Molecular Pathology v. Myriad Genetics, Inc., 569 U.S. 576 (2013).
113 *See* Codon, NATURE EDUCATION, https://www.nature.com/scitable/definition/codon-155/ (last visited July 26, 2020) ("A codon is a sequence of three DNA or RNA nucleotides that corresponds with a specific amino acid or stop signal during protein synthesis.").
114 *See* Intron/Introns, NATURE EDUCATION, https://www.nature.com/scitable/definition/intron-introns-67/ (last visited July 26, 2020) ("In some genes, not all of the DNA sequence is used to make protein. Introns are noncoding sections of an RNA transcript, or the DNA encoding it, that are spliced out before the RNA molecule is translated into a protein.").
115 *See generally* John W. Pelley, *Recombinant DNA and Biotechnology*, SCIENCEDIRECT, *available at* https://www.sciencedirect.com/topics/medicine-and-dentistry/complementary-dna (last visited July 26, 2020).
116 *See generally* Melissa Phillips, *Different codons, same amino acid*, THESCIENTIST (Aug. 16, 2004), https://www.the-scientist.com/research-round-up/different-codons-same-amino-acid-49688.

tially function in the same way and may generate the desired output with high accuracy for a single problem.[117]

Adaption of a patented cDNA is another example that can be used in other parts of the body to cure a target disease.[118] Even though this process needs difficult experimentation and involves substantial uncertainty, it could not have been done without the use of the available, patented cDNA.[119] Likewise, in the field of AI, by utilizing transfer learning methods, a pre-existing trained model can be adapted to be reused to improve a related task.[120] Considering the aforementioned examples, the analogy between the field of biotechnology and AI will be further discussed in the last chapter of this article.

B. The Dependency of an AI Model on Big Data, Costly Data Collection Methods, and Transfer Learning

The model as a component of an AI system can be claimed separately or can be claimed in connection with other components of the system.[121] For example, in a deep neural network learning algorithm, a model or a structural improvement can be claimed as a learning algorithm and it may be defined by its structure, the number of layers and neurons,[122] and the internal connections between them; alternatively, the model can be claimed as a trained, deployed model in the execution phase[123] with all known and adjusted weights. The mere disclosure of the structure of a known model would not enable a person of ordinary skill in the art to use the proposed model in practice. Therefore, an inventor must disclose the weights and coefficients of the network, or he may disclose the training dataset and provide the method of training to enable a skilled person to train the learning algorithm and deploy the model.[124]

Nonetheless, it is notable that disclosing a training dataset that has been obtained by costly data collection processes might be a serious issue for inventive entities.[125] In deep learning networks, a large amount of data is required to enable the pretrained model to find the relationship between the inputs and outputs with high accuracy.[126] Collecting large data samples would be costly because, depending on

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117 *See generally infra*, Part III.
118 *See generally* Harding, *supra* note 112.
119 *See generally id.*
120 *See generally* Alexandre Gonfalonieri, *Dealing with the Lack of Data in Machine Learning*, MEDIUM (May 17, 2019), https://medium.com/predict/dealing-with-the-lack-of-data-in-machine-learning-725f2abd2b92 ("Transfer learning uses knowledge from a learned task to improve the performance on a related task, typically reducing the amount of required training data.").
121 *See supra* Part I.E.
122 *See generally* Borella, *supra* note 59. ("Claim the structure of the model.").
123 *See generally Id*. ("Do not mix the training phase and the execution phase in the same claim.").
124 *See generally Id.*
125 *See generally* Volha Litskevich, *How Much Does Artificial Intelligence (AI) Cost in 2019*, AZATI (Jan. 23, 2019), https://azati.ai/how-much-does-it-cost-to-utilize-machine-learning-artificial-intelligence.
126 *See generally* Jason Brownlee, *Impact of Dataset Size on Deep Learning Model Skill And Performance Estimates*, MACHINE LEARNING MASTERY (Jan. 2, 2019),

the type of AI project, some sorts of data are not freely and easily available. For some specific projects, the model needs a long history of previously collected data.[127] Additionally, the process of cleaning and extracting valuable data requires specific knowledge and techniques that could add to the cost of data collection.[128] Thus, AI-based entities do not want to release this valuable data, and they prefer to keep it as a trade secret.

This begs the question of whether an AI system should be protected by obtaining a patent or should be kept as a trade secret. On one hand, if an inventor decides to obtain a patent, and later, a court finds the patent invalid for the lack of sufficient disclosure of the sample training dataset, neither the patent protection nor the trade secret benefits would be available. On the other hand, if the inventor decides to keep the entire invented AI system, including the training dataset, as a trade secret, he will not have the opportunity to prevent competitors from making and using a similar invention.

In the absence of sufficient data, pre-existing data sets and models in the related field of technology can be used to remedy the deficiency of the available small data.[129] This might cause another issue regarding the required disclosure when an entity uses a model or data set, which has been previously claimed by another inventive entity, to supplement its own small dataset and build working models for other relevant tasks.[130] For example, to develop a learning algorithm for autonomous driving, we can start from costly data collection to train a new image recognition model from scratch; alternatively, we can use a pre-trained model that can be found on Google and has been trained based on an ImageNet dataset.[131] Therefore, another inventive entity may take advantage of the existing, invented, disclosed model and dataset.

This begs the question of whether the patent protection of the preexisting model or the disclosed model can be extended to these new variations of the model and whether the disclosed dataset can be used for developing new models in the relevant tasks. The answer to this question determines whether, and to what extent, the inventor should disclose the detail of the model and the training dataset.

Consequently, an inventor may extend the scope of the claim to encompass other relevant tasks by disclosing the underlying datasets and explaining the methods of "transfer learning."[132] We should particularly determine to what extent our

https://machinelearningmastery.com/impact-of-dataset-size-on-deep-learning-model-skill-and-performance-estimates.

[127] *See generally* Litskevich, *supra* note 125.

[128] *See generally Id.*

[129] *See generally* Gonfalonieri, *supra* note 120.

[130] *See generally id.*

[131] *See generally* Dishashree Gupta, *Transfer learning and the art of using Pre-trained Models in Deep Learning*, ANALYTICS YIDHYA (Jun. 1, 2017), https://www.analyticsvidhya.com/blog/2017/06/transfer-learning-the-art-of-fine-tuning-a-pre-trained-model.

[132] *See generally Id.*; *see generally* MUELLER, *supra* note 50, at 165.

AI claim depends on a specific data set, and to what extent that specific data set can limit the functionality of the claimed invention. Then, an inventor may go further and disclose supplemental datasets and explain how a skilled person may modify and tune the model and use it to develop new models to be used in relevant tasks.

Nonetheless, the disclosure of a training dataset may limit the claim to a specifically disclosed dataset. Additionally, disclosing similar types of datasets may not provide broader protection because arguably, a different dataset may generate a completely different model, even with minor differences in the generated results. Thus, if an inventor could not show that different disclosed datasets will generate a model that produces substantially similar results in practice, the scope of the claim would be limited to the disclosed dataset.[133]

C. AI Algorithm as a Non-transparent Black-Box-like Algorithm

Typically, in conventional software, the rule of decision is created and developed by humans.[134] Then, a programmer implements the governing rule or the algorithm; the generated program is capable of mapping the input data to the outputs as determined by the governing rules.[135] In contrast, the rule of decision in an AI model is formed as a result of the training process in which the learning model learns and develops the underlying rules from the dataset.[136] A programmer or an AI inventor has a minimal effect on extracting and discerning the rules. Next, the trained AI model can be used to generate results or outputs in response to new inputs according to the rule of decision that had been shaped and formed in the learning phase.[137]

In a deep neural network learning algorithm, the black-box-like[138] model learns the correlations and the relationship between the input and output data, at which point the model approximates the complex, governing function that maps the inputs to the desired output.[139] There is no clear explanation of the manner of decision-making of the trained model,[140] and the approximation of the complex, governing function cannot be clearly interpreted and explained. This lack of transparency would be reflected in the written description of an AI-based model invention, which may be cured by a higher level of disclosure of the detail of an AI system.

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[133] *See generally Artificial Intelligence (AI) Patents*, PATENT ATTORNEYS https://www.techlaw.attorney/artificial-intelligence-ai-patents (last visited Mar. 9, 2019).

[134] *See generally supra* Part I.D.

[135] *See generally id.*

[136] *See generally supra* Part I.A.

[137] Arti K. Rai, *Machine Learning at the Patent Office: Lessons for Patents and Administrative Law*, 104 Iowa L. Rev. 2617, 2625 (2019).

[138] *See generally* Standing Committee on the Law of Patents, *supra* note 54, at 9; *see generally* Ariel Bleicher, *Demystifying the Black Box That Is AI*, SCIENTIFIC AMERICAN (Aug. 9, 2017), https://www.scientificamerican.com/article/demystifying-the-black-box-that-is-ai.

[139] *See generally supra* Part I.A.

[140] *See generally* Standing Committee on the Law of Patents, *supra,* note 54, at 9.

D. Nondeterministic or Stochastic Nature of AI Inventions

The initialization of the weights of a pretrained model is an important step in a deep neural network learning algorithm.[141] In the initialization step, we might specify the initial value of the weights by randomization, and the final value of the weights will be adjusted later in the learning process. The initial values are not predetermined and can be defined in many ways, including randomization.[142] Even by using the same model with the same structure or architecture and the same training dataset, different weight initializations may lead to different candidate models.[143]

Although the difference in the results of the candidate models could be minor, this minimal difference may nevertheless become an issue in defining the scope of the invention and in determining whether an inventor had the possession of the claimed model and its minimal variations as of the effective filing date. This nondeterministic characteristic of an AI model may change the required standard of disclosure, and it may impose a higher standard of disclosure on model-related AI inventions.

IV. AI Patents Should Be Held To a Higher Standard of Disclosure

As discussed in the previous sections, there exists no separate specific standard of disclosure for software-related patents. Under 35 U.S.C. § 112(a), an inventor must separately satisfy the required written description as well as the enablement standard. For written description, the inventor must "convince" a skilled person in the art that he had the possession of the claimed invention at the time of effective filing date.[144] Furthermore, "the description requirement of the patent statute requires a description of an invention, not an indication of a result that one might achieve if one made that invention,"[145] and mere disclosure of the "desired result" does not satisfy Section 112 written-description requirements.[146]

Consequently, because of the black-box-like and non-deterministic characteristics of the model, a disclosure for a model-related claim may be found as mere disclosure of the "desired results," which leads to the insufficiency of the required disclosure .[147] An inventor may avoid this issue by disclosing several working examples of the model that produce substantially similar results. Additionally, the inventor may disclose sample datasets with adequate description regarding the training process and the weight initialization method to enable a skilled person in the art

[141] *See generally* Kian Katanforoosh & Daniel Kunin, *Initializing neural networks*, DEEPLEARNING.AI, https://www.deeplearning.ai/ai-notes/initialization (last visited Mar. 26, 2019).
[142] *See generally id.*; *see generally* Jason Brownlee, *Why Initialize a Neural Network with Random Weights*, MACHINE LEARNING MASTERY (Aug. 1, 2018), https://machinelearningmastery.com/why-initialize-a-neural-network-with-random-weights.
[143] See generally Standing Committee on the Law of Patents, *supra,* note 54.
[144] *Ariad Pharm.*, 598 F.3d at 1349; LizardTech, Inc. v. Earth Res. Mapping, Inc., 424 F.3d 1336, 1345 (Fed. Cir. 2005).
[145] Regents of the Univ. of California v. Eli Lilly & Co., 119 F.3d 1559, 1568 (Fed. Cir. 1997).
[146] *Vasudevan Software*, 782 F.3d at 682.
[147] *Id.*

to make a substantially similar model that generates the desired results and is capable of doing similar tasks.

Regarding the required enablement standard, an inventor must sufficiently disclose his invention to enable a person of ordinary skill in the art to make and use the claimed invention without undue experimentation.[148] The architecture of the pretrained or the trained model may be claimed separately or as a part of a pipeline in an AI system.[149] For example, in a machine learning algorithm that uses deep neural networks, an inventor may disclose the architecture or the structure of the network as part of the claim.[150] Nonetheless, nondisclosure of specific information regarding the initialization of the pretrained model or the sample training datasets may require an "extended period of experimentation," or undue experimentation.[151]

However, the required extended time is not determinative regarding the enablement standard because an inventor need not enable a skilled person in the art to make a "perfected, commercially viable embodiment" of the claimed invention.[152] In machine learning neural networks, different methods of initialization and the training method will result in a different model with different weights, and this results in a different performance of the model that might be important in some applications.[153] Regarding conventional software patents, an inventor may obtain a valid patent while retaining viable commercial know-how, like the underlying software codes, as a trade secret.[154]

In contrast, regarding AI inventions that include the pretrained or the trained model, like the deep neural network machine learning models, disclosure of sample datasets and the weights or the accurate initialization values might be an essential part of the patent description. Consequently, although AI inventors desire to disclose minimally, specifically regarding the training dataset, they might be required to comply with a higher standard of disclosure.

Regarding conventional software patents, the Federal Circuit, in *Sherwood*,[155] stated that the mere disclosure of the functions, methods, and steps that generate the desired output would suffice and implementing the source code is clerical work.[156] In contrast, in *Lilly*[157], the Federal Circuit held that the biotechnological inventions should satisfy a higher standard of disclosure, and the Federal Circuit required a

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148 *See generally supra* Part II.B.
149 *See generally supra* Part I.E.
150 *See generally id.*
151 *Vasudevan Software*, 782 F.3d at 683.
152 CFMT, Inc. v. YieldUp Int'l Corp., 349 F.3d 1333, 1338 (Fed.Cir.2003); *see Vasudevan Software*, 782 F.3d at 684.
153 *See* Jason Brownlee, *How to Improve Deep Learning Performance*, MACHINE LEARNING MASTERY (Sep. 21, 2016), https://machinelearningmastery.com/improve-deep-learning-performance.
154 Ted Sichelman, *Commercialization Patents*, 62 Stan. L. Rev. 341, 355–56 (2010).
155 *See In re* Application of Sherwood, 613 F.2d 809, 816 (C.C.P.A. 1980).
156 *See id.* at 816–17.
157 *See generally Regents of the Univ. of California*, 119 F.3d at 1568–69.

"precise definition"[158] for a claimed DNA. In *Moba*,[159] Judge Rader, in the concurrence, explained that as a result of the *Lily's* decision, the disclosure of DNA-related discoveries has been held to a higher standard of disclosure, a "super-enablement rule,"[160] and the mere disclosure of the function of the sequence would not suffice.[161]

Judge Rader further stated that DNA is a sequence of amino acids, and the "functional properties" of the claimed DNA will not be altered by the substitution of some parts of the sequence.[162] Moreover, he pointed out that this elevated standard of disclosure "is tantamount to requiring disclosure, for a new software invention, of the entire source code, symbol by symbol, including all source code permutations that would not alter the function of the software."[163] In *Enzo,*[164] the Federal Circuit commingled the matter of written description and the enablement standard and remanded the case. In the remand, the court instructed the lower court to consider whether a person having ordinary skills in the art—by considering the information from the written description and the claimed, sequences deposits—can demonstrate that the inventor had the possession of "the generic scope of the claims" at the time of the invention.[165]

Therefore, as explained in the preceding paragraph, this technology-specific requirement distinguishes software inventions from the field of biotechnology, and it may clarify the standard of disclosure regarding AI inventions. In machine learning algorithms, like the claims directed to DNA in the field of biotechnology, several candidate models may have similar functional properties with different precision and recall.[166] Different weight initialization methods,[167] different model hyperparameters,[168] preprocessing of the dataset, randomization of the dataset in each iteration, and the method of training may lead to a different candidate model. Nonethe-

158 *See* Moba, B.V. v. Diamond Automation, Inc., 325 F.3d 1306, 1325 (Fed. Cir. 2003).
159 *See id.*
160 *See* Moba, 325 F.3d at 1325.
161 *Id*.
162 *Id.*
163 *Id*.
164 Enzo Biochem, Inc. v. Gen-Probe Inc., 323 F.3d 956 (Fed. Cir. 2002).
165 *See* Moba at 1320; *See generally* Enzo 323 F.3d at 966.
166 *See generally* Will Koehrsen, Modeling: *Teaching a Machine Learning Algorithm to Deliver Business Value*, TOWARDS DATA SCIENCE (Nov. 15, 2018), https://towardsdatascience.com/modeling-teaching-a-machine-learning-algorithm-to-deliver-business-value-ad0205ca4c86; *see generally* Jason Brownlee, *A Gentle Introduction to Model Selection for Machine Learning*, TOWARDS DATA SCIENCE (Dec. 2, 2019), https://machinelearningmastery.com/a-gentle-introduction-to-model-selection-for-machine-learning ("Model selection is a process that can be applied both across different types of models (e.g. logistic regression, SVM, KNN, etc.) and across models of the same type configured with different model hyperparameters.").
167 *See generally* Brownlee, *How to Improve Deep Learning Performance*, *supra* note 153 ("The weights are the actual parameters of your model that you are trying to find. . . . Remember, changing the weight initialization method is closely tied with the activation function and even the optimization function.").
168 *See generally Id.* ("You may need to train a given "configuration" of your network . . . to get a good estimate of the performance of the configuration.").

less, the different generated models, candidate models, may generate different results with different precisions, and they can be tuned by "transfer learning"[169] to be used in similar tasks, or can be updated using "online learning"[170] methods. Therefore, in addition to the disclosure of the model selection process[171] and model assessment[172] methods, this issue may be solved by having a depository of sample datasets, different initialization values, different hyperparameters, different variations of the model, and candidate models.

In *Spectra-Physics*,[173] the Federal Circuit held that "if an invention pertains to an art where the results are predictable, . . . a broad claim can be enabled by disclosure of a single embodiment."[174] There are many cases, including cases in the field of biotechnology, that have satisfied the enablement standard with disclosure of a single embodiment. However, the level of predictability in a field of art is still a challenge for the required level of written description and enablement concerning the standard of disclosure.[175]

Therefore, one of the distinguishing characteristics of the standard of disclosure of software from that of biotechnology is the level of the predictability of the results related to the field of art that encompasses the claimed invention.[176] If a field of technology is highly predictable, a person of skill in the art in that field would be able to discern the precise meaning of the claimed invention with fewer efforts and would be able to extend the claimed invention to other predictable embodiments. Application of this rule in the field of software and biotechnology can explain the elevated required level of disclosure for the field of biotechnology compared to software.

Like the field of biotechnology, the non-deterministic and black-box-like nature of the AI model may result in a higher level of uncertainty and unpredictability. Subsequently, AI inventions may be held to an elevated standard of enablement and written description. Therefore, inventors in the field of artificial intelligence may be required to disclose more details including multiple embodiments of the claimed model, the precise structure of the model, sample datasets, the method of weight ini-

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169 *See generally* Mueller, *supra* note 50, at 165.
170 *Id.*
171 *See generally* Brownlee, *What Does Stochastic Mean in Deep Learning?*, *supra* note 106 ("Stochastic gradient boosting is an ensemble of decision trees algorithms. The stochastic aspect refers to the random subset of rows chosen from the training dataset used to construct trees, specifically the split points of trees.").
172 *Id.*
173 Spectra-Physics, Inc. v. Coherent, Inc., 827 F.2d 1524, 1533 (Fed. Cir. 1987).
174 *Id.*
175 *See generally* Michele C. Bosch & Denise Main, *Unpredictability: Understanding the U.S. Enablement Requirement*, FINNEGAN (Mar 2012), https://www.finnegan.com/en/insights/unpredictability-understanding-the-u-s-enablement-requirement.html ("The question of whether a person skilled in the art could practice the claimed invention without undue burden, however, especially in unpredictable fields such as the biotechnology arts, cannot be easily answered and is determined on a case-by-case basis.").
176 *See* Pai, *supra,* note 102, at 487.

tialization, and sample initial weight values to show that they had the possession of the full scope of the claimed invention at the time of the effective filing date, and to enable a person of ordinary skill in the art to make and use the full breadth of the claim without undue experimentation.

However, one of the main goals of the patent system is to promote invention;[177] and patents, indeed, help high-tech startups, specifically in the fields of biotechnology and medical devices, compete in the market through their technological inventions.[178] This begs the question of whether the enhanced level of disclosure of AI systems would contradict with promoting invention or would undermine the competitive advantage of high-tech startups.

As discussed in the preceding sections, the enhanced level of disclosure for AI patents may require the disclosure of the training dataset or the big data that has been obtained by costly processes.[179] In deep learning algorithms, a large amount of data is required to achieve high accuracy.[180] Some sorts of data are not freely and easily available and the process of cleaning and extracting valuable data requires specific knowledge and techniques that increase the cost of data collection.[181] Additionally, the disclosed valuable dataset may be used by competitors in developing new AI models for other purposes and in other fields of technology.[182] Thus, AI-based entities do not desire to patent at the expense of releasing their costly and valuable collected big data. However, this deficiency may be resolved by other incentives like governmental funds, tax credits, sale tax cuts, grants, and supplements as complementary incentives to balance the elevated standard of disclosure concerning AI patents.[183]

Conclusion

In sum, non-transparent black-box-like AI models that utilize stochastic opti-

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[177] FEDERAL TRADE COMMISSION, TO PROMOTE INNOVATION: THE PROPER BALANCE OF COMPETITION AND PATENT LAW AND POLICY 4–17 (2003), http://www.ftc.gov/opa/2003/10/cpreport.htm.; *see also generally* Stuart J.H. Graham, et. al., *High Technology Entrepreneurs and the Patent System: Results of the 2008 Berkeley Patent Survey*, 24 Berkeley Tech. L.J. 1255, 1255 (2009) ("Our results show that entrepreneurs have varied and subtle reasons for using the patent system, many of which diverge from the traditional theory that patents provide an 'incentive to invent.'").

[178] *See* Graham, et. al., *supra* note 177, at 1288.

[179] *See generally supra* Part III.B ("Therefore, an inventor must disclose the weights and coefficients of the network, or he may disclose the training dataset and provide the method of training to enable a skilled person to train the learning algorithm and deploy the model.").

[180] *See generally* Jason Brownlee, *Impact of Dataset Size on Deep Learning Model Skill And Performance Estimates*, *supra* note 126.

[181] *See generally id.* ("The results highlight how important cross-validation methods such as leave-one-out cross-validation are, allowing the model to make a test prediction for each example in the dataset, yet come at such a great computational cost, requiring almost one model to be trained for each example in the dataset.").

[182] *See generally supra* Part III.B ("Therefore, another inventive entity may take advantage of the existing, invented, disclosed model and dataset.").

[183] *See* Ted M. Sichelman, *Patents, Prizes, and Property*, 30 Harv. J.L. & Tech. 279, 280–81 (2017).

mization methods and behave nondeterministically may require an elevated level of disclosure to satisfy the written description requirement and enablement standard compared to conventional software inventions. Typically, a machine learning model has a nontransparent-rule-of-decision-making mechanism in which the inventor does not have the insight into the process of learning and extracting the governing rules that approximate the existing, complex function that maps the inputs to the outputs in an AI system. In contrast, in conventional software, a programmer can determine the governing rule of the system and implement the algorithm accordingly.

Many of the machine learning systems use randomness in the process of model training, hyperparameter adjustment, and weight initialization. This may cause uncertainty in the outcome and may generate different candidate models. Furthermore, data collection and preprocessing of the data is a costly process, which is the prerequisite of training a machine learning algorithm. In some specific problems and claims, big data is an important part that may be required to be disclosed to enable a skilled person to make and use the claimed invention without undue experimentation.

To overcome these issues, according to the similarities between biotechnology and model-related AI inventions, reviewing the policies and the laws concerning biotechnology patents would be helpful. Biotechnology patents like DNA-related claims share similar black-box-like and stochastic behaviors with model-related AI inventions that may impose a higher standard of disclosure on AI inventions. Consequently, to avoid invalidity challenges under Section 112(a) of the Patent Act, an AI system inventor may be required to disclose a higher level of detail, which may include multiple embodiments of the claimed AI model, the structure of the model, sample datasets, methods of transfer learning and online learning, methods of weight initialization and hyperparameter adjustment, sample initial weight values and the method of initialization, and sample implementations of the underlying code.

This heightened standard of the disclosure may undermine the goal of the patent system, which is to promote inventions. However, this deficiency may be resolved by other complementary regulatory incentives like governmental funds, tax credits, sale tax cuts, grants, and supplements.