Patentability and Inventorship of AI-Generated Inventions

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I. INTRODUCTION

Dan Brown’s mystery thriller, Origin, proposes the idea that humans and computers are evolving into one, indistinguishable species. While this may initially sound unnerving, there is truth to the idea that humans have been slowly merging with technology to attain heightened abilities. As an example, consider the degree to which people rely on smartphones and the capabilities these devices provide their users. Trends in technology, changes in behavior, and advances in medicine, which might initially seem disparate, actually appear to be converging—transforming our society and blurring our identities as humans.

Computer systems are commonly used to create inventions. For years, inventors have relied on computer systems and artificial intelligence.

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1. DAN BROWN, ORIGIN 411 (2017).

2. Neil Sahota, Human 2.0 Is Coming Faster Than You Think. Will You Evolve with the Times?, FORBES (Oct. 1, 2018, 12:57 AM), https://www.forbes.com/sites/cognitiveworld/2018/10/01/human-2-0-is-coming-faster-than-you-think-will-you-evolve-with-the-times/#68dfbc724284 [https://perma.cc/X93F-DVB4]. “In the past few years, there has been considerable discussion around the idea we are slowly merging with our technology, that we are becoming transhuman, with updated abilities, including enhanced intelligence, strength, and awareness.” Id.


“AI” as tools to assist in reducing inventions to practice. More recently, however, computers have been credited with the conception of inventions, blurring the line of inventorship for the purposes of obtaining a patent.

While the U.S. Constitution, statutes, and case law all require that a patent application name any human who contributes to the conception of an invention, it is unclear how to determine inventorship when a computer system contributes to conception. As AI becomes more commonly involved in the inventive process, patent applicants have a growing need for clear rules regarding whether the resulting inventions are patent eligible and, if they are, who should be named as an inventor.

The concept of inventorship should be analyzed along a spectrum. The process of inventing varies significantly based on the number of people involved and the degree of reliance on AI, and these variations complicate determinations of who qualifies as an inventor. Nevertheless, assuming all other patent requirements are met, involvement by AI should not impact the patentability of an invention, despite the difficulty in determining inventorship for the purposes of obtaining a patent.

Three existing doctrines can assist patent applicants in determining who should be named as an inventor. First, traditional conception analysis should continue to apply in many cases. Second, the doctrine of simultaneous conception and reduction to practice should apply to inventions created with open-ended computer programs. In order to determine which

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5. The terms artificial intelligence, AI, and computer systems are used interchangeably throughout this Note. For an explanation of the use and meaning of artificial intelligence, see infra Section II.B.
6. Abbott, supra note 4, at 1098.
7. See, e.g., Abbott, supra note 4, at 1083–91 (referring to U.S. Patent 5,852,815 for “Neural Network Based Prototyping System and Method” filed in the name of Stephen Thaler, but which Dr. Thaler attributes to his invention, the Creativity Machine); FlashPoint IP Ltd., No. 50567-3-01-US, 2020 WL 1970052 (Comm’r Pat. Apr. 22, 2020), https://www.uspto.gov/sites/default/files/documents/16524350_22apr2020.pdf [https://perma.cc/DPM7-LPUL] (outlining the response of the Commissioner for Patents to a patent application that named an AI system as the sole inventor).
8. “The term ‘inventor’ means the individual or, if a joint invention, the individuals collectively who invented or discovered the subject matter of the invention.” 35 U.S.C. § 100(f) (2018). A person cannot be an inventor unless he contributed to the conception of the invention. USPTO, MANUAL OF PATENT EXAMINING PROCEDURE § 2109(II) (9th ed., rev. 10, June 2020) [hereinafter MPEP] (citing In re Hardee, 223 USPQ 1122, 1123 (Comm’r Pat. 1984)); see discussion of conception infra Section III.B.1.
9. Within this Note, the terms “AI-generated invention” and “computer-generated invention” are used to describe inventions to which a computer system contributed to the conception. It is not necessary to distinguish between situations where a computer system partially contributed to conception, meaning one or more humans also contributed to conception, and those where a computer system wholly contributed to conception.
12. See infra Section IV.C.1.
of these doctrines applies—traditional conception analysis or the doctrine of simultaneous conception and reduction to practice—patent applicants can evaluate whether the AI system uses deterministic automation (following a rigid set of rules to reach a solution) or search automation (using trial and error to reach a solution).13

Third, the doctrine of first to recognize and appreciate should apply when an AI system operates autonomously without any human guidance.14 Although there is a natural concern that a human would receive credit for the work of a machine,15 an autonomous AI system provides no benefit without the person who recognizes the value of a particular invention. Thus, the person who performs this mental act should be recognized as an inventor.

By affirmatively acknowledging the applicability of these three approaches in the context of AI-generated inventions, the U.S. patent system can provide guidance and clarity for patent applicants.16 Additionally, because AI systems have the potential to increase the rate at which inventions are created, to produce superior inventions, or even to produce inventions that would have otherwise been impossible, it is important that the U.S. patent system recognize the patentability of AI-generated inventions in order to continue spurring innovation.

14. See infra Section IV.C.2.
16. There are several ways in which the patent system could acknowledge the patentability of AI-generated inventions and apply these three doctrines to inventorship. First, Congress could amend the Patent Act to explicitly acknowledge these concepts. Title 35 of the United States Code codifies the Patent Act, which addresses patentability and inventorship at a high level. See 35 U.S.C. §§ 101–103. Such an amendment is not necessary, however, since the patentability of AI-generated inventions and the application of the three doctrines to determine inventorship do not conflict with the Patent Act. As a second method, a court could recognize the patentability of AI-generated inventions and explain how the three doctrines can be used to determine inventorship, then proceed to apply the appropriate doctrine based on the specifics of the case. Several judicial opinions have interpreted the scope of patentability within the Patent Act. See, e.g., Diamond v. Chakrabarty, 447 U.S. 303, 309 (1980) (listing “laws of nature, physical phenomena, and abstract ideas” as exceptions to patent eligible subject matter described in 35 U.S.C. § 101). For a court to reach such a decision, however, a party must challenge the patentability and inventorship of a pertinent patent in court. As a third method, the United States Patent and Trademark Office (“USPTO”) could simply amend the Manual of Patent Examining Procedure (“MPEP”) to acknowledge these three concepts. See MPEP, supra note 8, § 2109. If a court were to recognize the patentability of AI-generated inventions and the application of these doctrines for determining inventorship, the USPTO would likely incorporate the decision into the MPEP. However, the USPTO often provides information and guidance in the MPEP independent from judicial opinions, so the USPTO would not have to wait for such a decision in order to acknowledge the patentability of AI-generated inventions and explain how the three doctrines can be used to determine inventorship.
Fourth, even without an explicit recognition by Congress, the courts, or the USPTO, patent applicants can apply these concepts to make their good faith inventorship determinations in the absence of more clear guidelines. Ultimately, the patent applicant makes the initial inventorship determination and is responsible for ensuring that the inventorship is correct when a patent issues.
To support this view, this Note considers the current patent requirements and the growing influence of AI in the inventive process. Part I provided a brief introduction. Part II explains the future of technology and the meaning of artificial intelligence, offering several real-world examples of AI-generated inventions. Part III examines the legal history relating to patents and the requirements for conception and inventorship. Part IV begins by proposing a spectrum of inventorship and arguing that patentability should be determined independently from where an inventorship scenario falls on the spectrum. It continues by offering guidance for determining who to name as an inventor and discussing the implications of granting patents for computer-generated inventions. Finally, Part V concludes this Note.

II. BACKGROUND

In order to understand the implications of granting patents for AI-generated inventions, it is first important to understand what artificial intelligence is and how the technology continues to advance. Within this Part, Section A discusses the future of technology and the approaches to AI development within the broader context. Section B addresses the use and meaning of artificial intelligence and explains the many features and types of AI. Finally, Section C focuses on the patent context and provides several examples of AI-generated inventions.

A. The Future of Technology and AI Development

Despite intellectual reservations, people continue to become more intertwined with technology.17 No one can deny that smartphones, the Internet, cloud computing, and other technological advancements have become integral components of our daily lives, changing every facet of the way we live.18 Around 2008, humankind reached a transition point where more connected devices existed than people.19 Some scholars believe that

17. Sahota, supra note 2.
people are evolving into “an updated version of humanity.” 20 This idea is referred to as transhumanism and is defined as “[t]he belief or theory that the human race can evolve beyond its current physical and mental limitations, especially by means of science and technology.” 21

Although computers have already surpassed humans in terms of algorithmic calculations, 22 it is unlikely that artificial intelligence will ever overtake humans in the sense often portrayed in science fiction stories. 23 Computer systems quickly and accurately solve problems through rational and optimal calculations. 24 If AI replicated the high-level cognition of a human, the subjective capabilities would interfere with the objective calculations, and the results of the computer system would become less accurate. 25 Therefore, from a practical perspective, artificial intelligence will likely develop through two distinct approaches. 26

The first approach to AI development is an academic approach—used for biological purposes, with a focus on understanding the human brain 27 and is independent from the creation of new inventions.  For example, one of the many forms of AI is called neural networks, 28 and it is modeled on the biological processes of the brain. 29 Scientists can use this and similar types of AI programs to better understand human consciousness and to test theories about the functions of various biological attributes. 30 However, approaches aimed at recreating human thinking will likely be limited to biological studies for purely academic use.

20. Sahota, supra note 2. “No matter the intellectual misgivings surrounding this controversial topic, the fact remains that if we view transhumanism the way it is conventionally defined, people have been evolving toward an updated version of humanity for some time.” Id.
23. See Josef Bajada, Artificial Intelligence Demystified, MEDIUM (Jan. 4, 2019), https://towardsdatascience.com/josef-bajada-demystifying-artificial-intelligence-65f7a8dd1b0 [https://perma.cc/9MT4-XJXQ]. Humans are far from developing “Artificial General Intelligence”—the technology that will enable AI systems to reason, adapt, and otherwise act independently like humans or animals. Id. This may also be described as strong AI. General AI and strong AI are contrasted with the terms narrow AI and weak AI, respectively.
25. Id.
26. Id. at 17.
27. Id.
30. Signorelli, supra note 22, at 17.
The second approach to AI development is the efficient approach, which may involve the creation of new inventions and implicate patent law. Through the efficient approach, programmers seek to develop AI systems that function more efficiently, enabling humans to perform tasks that would otherwise be impossible or making difficult tasks easier. Biological principles—such as neural networks—can still be used under the efficient approach and these biological principles may lead to the creation of inventions; however, the goal of efficient AI systems is not to achieve high-level cognition. Instead, programmers retain rational and objective logic to focus on increasing the speed and accuracy of problem solving. This objective, non-humanlike processing makes AI valuable in the context of inventing. Therefore, the benefit of AI derives not from replacing human inventors, but from assisting them.

B. The Use and Meaning of Artificial Intelligence

Many misconceptions surround AI, its meaning, and its capabilities. Artificial intelligence is, in fact, a subcategory of computer sciences that relies on mathematics, including calculus, probability and statistics, linear programming, and other numerical techniques. Particularly within the efficient approach, experts use the term “artificial intelligence” to refer to computer programs that perform analysis and make decisions based on predefined criteria. Some of the tasks appear to be intelligent because they require reasoning, comprehension, and perception when performed by a human, but these tasks can be automated through non-cognitive computational techniques that only seem to produce “intelligent” results.

31. Id.
32. Id.
33. Id.
34. Id.
35. Dan Robitzski, You Have No Idea What Artificial Intelligence Really Does, FUTURISM (Oct. 16, 2018), https://futurism.com/artificial-intelligence-hype [https://perma.cc/ZC36-FM2X]. “People think AI is a smart robot that can do things a very smart person would – a robot that knows everything and can answer any question.” . . . But this is not what experts really mean when they talk about AI. “In general, AI refers to computer programs that can complete various analyses and use some predefined criteria to make decisions.”
36. Bajada, supra note 23.
37. Robitzski, supra note 35.
38. Harry Surden, Machine Learning and Law, 89 WASH. L. REV. 87, 95 (2014). [R]esearchers have achieved success in automating complex tasks by focusing not upon the intelligence of the automated processes themselves, but upon the results that automated processes produce. Under this alternative view, if a computer system is able to produce outputs that people would consider to be accurate, appropriate, helpful, and useful, such results can be considered “intelligent”—even if they did not come about through artificial versions of human cognitive processes.
Id. at 98–99 (footnote omitted).
Definitions of artificial intelligence fail to truly capture the meaning and breadth of the term.39 John McCarthy, an inventor and computer scientist, first used the term “artificial intelligence” in 1955.40 He later defined AI as “the science and engineering of making intelligent machines, especially intelligent computer programs.”41 However, there is no consensus among AI researchers42 and, therefore, no single definition of artificial intelligence. Rather, the definitions tend to emphasize particular aspects of AI.43

The definitions for artificial intelligence have become so extensive that nearly any computer program that performs something automatically can be referred to as AI.44 AI can include any combination of eight key features: creativity,45 unpredictability,46 independence and autonomy,47 rational intelligence,48 evolution,49 capability of data collection and communication,50 efficiency and accuracy,51 and free choice among alternative options.52 Any particular technique or branch of AI may contain some or
all of these features, each to varying degrees, making it difficult to establish a universal definition.  

An AI system is the tangible technology that consists of both hardware and software. Thus, the term “artificial intelligence system” includes robots, programs running on either a single computer or a network of computers, and any other arrangement of components that host AI.  

Throughout its history, artificial intelligence experienced long periods of unpopularity resulting from over-ambitious promises, but it has regained popularity in recent years. This is not a result of new techniques; rather, it is the result of an advanced technological environment, with cloud-based infrastructure and availability of massive data sets.  

In terms of artificial intelligence algorithms, the media tends to focus on refined versions of techniques developed in the 1950s and 60s. Within the efficient approach, some of the many branches of artificial intelligence include logical AI, search, pattern recognition, representation, inference common sense knowledge and reasoning, learning from experience (including machine learning and neural networks), planning, epistemology, ontology, heuristics, and genetic programming.  

53. Id. at 2224.  
55. Id.  
56. Bajada, supra note 23.  
57. Id.  
58. Bajada, supra note 23.  
60. Id. Logical AI programs use sentences of mathematical logical language to represent general facts about the world, specific facts about a situation, and the ultimate goal(s). Id. In order to make decisions, a logical AI program infers that certain actions will allow it to achieve a goal. Id.  
61. Id. Search programs examine a large number of possibilities and continually discover how to do so more efficiently. Id.  
62. Id. Pattern recognition programs make observations of some kind and compare it to a pattern. Id.  
63. Id. Genetic programming systems solve a task by combining—or “mating”—random options and selecting the best fit from millions of generations. Id. at 10. Genetic Programming is based on genetic algorithms, relying on selection, mutation, and crossover to generate possibilities and an artificial “survival of the fittest” to refine the solution. Guirong Dong, Xiaozhe Wang & Dianzi Liu, Metaheuristic Approaches to Solve Complex Aircraft Performance Optimization Problem, APPLIED SCIS., July 25, 2019, at 4, https://www.mdpi.com/2076-3417/9/15/2979/pdf [https://perma.cc/U7UD-8TSY]. Genetic algorithms can also be referred to as evolutionary algorithms. See GREGORY S.
In addition to these concepts, other unidentified concepts or techniques likely exist.64

Learning from experience is the largest branch of AI, and these programs take several forms.65 The foundation for most efficient AI is machine learning.66 However, it is misleading to say a computer system is learning.67 Describing it in this way is projecting a human trait to a machine that operates in a very different manner than the manner in which the human brain operates.68 The process of machine learning relies on algorithms to enable the computer to recognize patterns in large data sets, thereby allowing the computer system to direct actions or draw conclusions without the need for rule-based programming.69 In this way, the computer systems are not being programmed as much as they are being trained.70 Rather than providing rules to follow, the computer is given labeled data from which the computer essentially establishes its own rules.71

C. Examples of AI-Generated Inventions

It might be easy to discount the need for clear guidance regarding patent eligibility and inventorship for AI-generated inventions, believing it is a problem for the future; however, patent applicants have been submitting applications for computer-generated inventions for more than twenty years.72 The United States Patent and Trademark Office (“USPTO”) began granting patents for computer-generated inventions without realizing it was doing so.73 By 1998, the USPTO had granted a patent for an invention that was—at least in part—generated by a computer.74 Stephen Thaler invented a “device for the autonomous generation of useful information”—called the
Creativity Machine\textsuperscript{75}—which he credits as the true inventor of his subsequent patented invention, a “neural network based prototyping system and method.”\textsuperscript{76}

When considering inventorship, examples of AI-generated inventions provide context and insight into some of the scientific fields in which AI is commonly used.\textsuperscript{77} For many years, inventors in the fields of chemistry and biology have used computer systems to develop new compounds that have desirable properties.\textsuperscript{78} Additionally, genetic algorithms are commonly used in the design of aircraft wings and other applications involving aerodynamics.\textsuperscript{79} The remainder of this Section provides four particular examples, which demonstrate the variety of inventorship arrangements and the related interactions with artificial intelligence.

First, a man interacting with an AI system, which he independently developed and trained, produced a new toothbrush design.\textsuperscript{80} Dr. Stephen Thaler credits the Creativity Machine with inventing the cross-bristle arrangement of the Oral-B CrossAction toothbrush.\textsuperscript{81} In developing the new design, Dr. Thaler did not specifically program the Creativity Machine to invent a toothbrush with crossing bristles.\textsuperscript{82} Rather, he provided the

\begin{footnotesize}
\begin{enumerate}
    \item U.S. Patent No. 5,659,666 (filed Oct. 13, 1994) (issued Aug. 19, 1997). Stephen Thaler received a patent for a “device for the autonomous generation of useful information” in 1997. \textit{Id.} Dr. Thaler called the system the Creativity Machine, and he credits it with the conception of other inventions: “the cross-bristle design of the Oral-B CrossAction toothbrush, new super-strong materials, and devices that search the Internet for messages from terrorists, among others.” Abbott, \textit{supra} note 4, at 1085. “The Creativity Machine itself consists of two neural networks that work together. The first network, the source machine, is responsible for ‘producing a stream of [possibilities],’ each of which the second network, the evaluation machine, examines to find if it matches the discovery criteria of interest.” Ralph D. Clifford, \textit{Intellectual Property in the Era of the Creative Computer Program: Will the True Creator Please Stand Up?}, 71 TUL. L. REV. 1675, 1679 (1997) (footnotes omitted).
    \item The following examples were not all developed in the United States nor did they all lead to a U.S. patent application or issued patent.
    \item Ben Hattenbach & Joshua Glucoft, \textit{Patents in an Era of Infinite Monkeys and Artificial Intelligence}, 19 STAN. TECH. L. REV. 32, 43 (2015) (citing Daniel Riester et al., \textit{Thrombin Inhibitors Identified by Computer-Assisted Multiparameter Design}, 102 PROCS. NAT’L ACAD. SCI. 8597 (2005)). For example, a series of thrombin inhibitors—a class of medications that act as an anticoagulant by inhibiting the thrombin enzyme—was generated by a multiparameter optimization process, which began with a set of random molecules and resulted in compounds exhibiting a favorable profile and a number of preferable traits. Rister et al., \textit{supra}, at 8597.
    \item \textit{Takenori Wajima, Masakazu Matsumoto & Shinichi Sekino, Latest System Technologies for Railway Electric Cars} 164 (2005), https://www.hitachi.com/rev/pdf/2005/r2005_04_102.pdf [https://perma.cc/CNF4-SJZX]; see also Dong et al., \textit{supra} note 63, at 2. The design of aircraft requires a multidisciplinary, iterative effort and often results in a tedious and computationally expensive multidisciplinary analysis and optimization. Faculty members from various universities used genetic programming to simultaneously consider requirements of various disciplines, thereby increasing the efficiency and accuracy of the analysis while optimizing the geometry of the aircraft wing and minimizing wing stiffness based on aerodynamic and stability constraints. \textit{Id.}
    \item PLOTKIN, \textit{supra} note 13, at 1.
    \item \textit{Id.}
    \item \textit{Id. at} 2.
\end{enumerate}
\end{footnotesize}
computer system with information about existing toothbrush designs and how effectively they perform. The Creativity Machine determined what aspects made one toothbrush better than another and produced a toothbrush to optimize teeth cleaning based on the given criteria and, ultimately, Dr. Thaler was surprised with the result.

Next, a computer system and humans learned from each other and created an optimized antenna design as the result of a feedback loop. Gregory Hornby and his team at the NASA Ames Research Center developed a small antenna using evolutionary algorithms. Hornby claims that no human would have thought to design such a strange-looking antenna but explained that it works better than previous human-created designs. In the early designs, the NASA team recognized that the strength of the antenna signal varied over time at a given elevation. The team used this information to adjust the fitness requirement to favor antennas with a steady signal strength and ran the program again to produce a better result.

Third, the founders of a start-up custom car company, the members of a multinational software corporation, and an AI system created an optimized car chassis. The founders of Hackrod collaborated with the software company Autodesk “to create visually striking new cars with high-performance properties.” Their goal was to provide an AI system—called Dreamcatcher—with an enormous amount of real-world data to create the ideal vehicle. The team began by driving an existing car design, fitted with dozens of wireless sensors, through the desert. Then, the team allowed Dreamcatcher to analyze the information—a set of four billion data points collected by the sensors, which represented the structure of the car

83. Id.
84. Id. at 54. “Probably the best evidence that he didn’t design the physical structure of the CrossAction toothbrush is that when the Creativity Machine presented its creation, he himself was surprised by the results.” Id.
85. Id. at 89.
86. HORNBY ET AL., supra note 63, at 1.
87. PLOTKIN, supra note 13, at 1. Because artificial intelligence systems do not have preconceived notions or human biases, they are able to create solutions that seem to violate conventional design wisdom. Id. at 4.
88. Id. at 89.
89. Id.
90. Stuart Nathan, Generating a New Drive for Speed in the Desert, ENG’r (Mar. 26, 2019, 8:30 AM), https://www.theengineer.co.uk/generative-design/ [https://perma.cc/VY7H-MP46].
91. Id.
93. Nathan, supra note 90.
and the forces acting on it—and output a design based on the given constraints.\textsuperscript{94} Humans could never have designed the resulting chassis due to the sheer volume of data that Dreamcatcher analyzed.\textsuperscript{95}

Finally, a team of scientists and lawyers, which comprise the Artificial Inventor Project (“AIP”), submitted the first-ever U.S. patent application naming an AI system as the sole inventor in July 2019.\textsuperscript{96} The team credited an algorithm—called DABUS\textsuperscript{97}—with designing “interlocking food containers that are easy for robots to grasp and a warning light that flashes in a rhythm that is hard to ignore.”\textsuperscript{98} The AIP acknowledged that, in most cases, artificial intelligence is merely a tool used in the inventive process, but the team members believed DABUS fell outside the norm since it had not been trained to solve particular problems, and instead, it sought to devise and develop new ideas.\textsuperscript{99} After initial proceedings in the Patent Office, the USPTO issued a formal public decision in April 2020, rejecting the AIP’s arguments for allowing an AI system to be named as an inventor, and instead ruled that an inventor “must be a natural person.”\textsuperscript{100} The AIP—which was formed specifically to explore the patentability of inventions generated entirely by AI\textsuperscript{101}—expected this result and recognized that it may take years to resolve this complex legal matter.\textsuperscript{102}


\textsuperscript{95} Terdiman, supra note 92.

\textsuperscript{96} Application No. 16/524,350 was filed on July 29, 2019 for “Devices and Methods for Attracting Enhanced Attention.” Flashpoint IP Ltd., No. 50567-3-01-US, 2020 WL 1970052 (Comm’r Pat. Apr. 22, 2020). The associated Application Data Sheet (“ADS”) listed a single inventor, specifying the given name as “[DABUS]” and the family name as “(Invention generated by artificial intelligence),” with “Stephen L. Thaler” as the assignee. Id. In lieu of the required inventor’s oath, the applicant filed a substitute statement under 37 C.F.R. § 1.64. Id.


\textsuperscript{99} Id. In the Inventorship Statement attached to the warning light application, the team asserted that “DABUS was not created to solve any particular problem, and it was not trained on any special data relevant to the instant invention. Instead, it was the machine, not a person, which recognized the novelty and salience of the instant invention.” Flashpoint IP Ltd., No. 50567-3-01-US, 2020 WL 1970052 (Comm’r Pat. Apr. 22, 2020) (footnotes omitted).


III. LEGAL HISTORY

The patent rights established in the Constitution and rooted in the early American understanding of the nature and role of intellectual property are important for the economic future of America.103 In an effort to protect the economic incentives for innovation, inventions must meet the requirements stated in the Patent Act.104 Within this Part, Section A explains the justifications of the patent system and the requirements for patentability.

Anyone who contributes to the conception of an invention must be named as an inventor on the patent application.105 Section B discusses conception and how it relates to the process of inventing. In practice, identifying conception and, therefore, determining inventorship can be difficult.106 However, the determination is important because a valid patent must correctly identify the inventors107 and, as a default, inventorship determines ownership.108 Section C examines the human inventor requirement, joint inventorship, and the importance of correct inventorship.

A. Background on Patents

The Patent and Copyright Clause of the U.S. Constitution grants Congress power to “promote the Progress of Science and useful Arts, by securing for limited Times to Authors and Inventors the exclusive Right to their respective Writings and Discoveries.”109 In accordance with this power, the Patent Act states: “Whoever invents or discovers any new and useful process, machine, manufacture, or composition of matter, or any new and useful improvement thereof, may obtain a patent therefor, subject to the conditions and requirements of this title.”110 However, the constitutional foundation does not address concerns about how Congress should administer patents today and whether or how Congress should limit the rights.111

105. MPEP, supra note 8, § 2109.
108. MPEP, supra note 8, § 301; 37 C.F.R. § 3.73(a) (2020).
111. ABBOTT, supra note 103, at 2.
1. Justifications of the Patent System

When analyzing inventorship and the effects of AI-generated inventions, it is important to consider the original justifications of the patent system to ensure these goals continue to be met. The Supreme Court “has consistently held that the primary purpose of our patent laws is not the creation of private fortunes for the owners of patents, but is ‘to promote the progress of science and the useful arts[,]’”112 The Framers of the Constitution recognized the value of robust patent rights, which are also limited in time, so the information ultimately becomes available to the public and is able to serve a greater purpose.113 In the United States, the justifications of intellectual property laws rest on three distinct theories: Lockean labor theory, personhood perspective, and economic incentive or utilitarian approach.114

The first justification for patent law is the Lockean labor theory.115 The Framers of the Constitution did not view intellectual property rights as a special privilege conveyed by the government, but rather as a fundamental natural property right similar to the rights in tangible property.116 The understanding of natural rights expressed by John Locke provides the foundation for this thinking.117 Accordingly, “an inventor has an inherent right to the fruits of his labor as he does to the fruits of his mind and soul.”118 With respect to inventorship analysis, the Lockean labor theory recognizes that inventors should be rewarded for their labor.119 In the context of AI-generated inventions, an AI system does not need recognition, but a person who creates AI or who works in conjunction with AI should be rewarded for his labor.

114. Ravid & Liu, supra note 43, at 2237.
115. Id. at 2242.
116. ABBOTT, supra note 103, at 2. Having a natural right does not necessarily mean a person has an enforceable right; however, the fact that the Framers explicitly recognized intellectual property rights in the Constitution indicates their strong belief in the importance of intellectual property rights. Id. at 3–4.
117. Id. at 2–3. This theory recognizes two limitations on acquiring property rights: (1) a person may acquire rights only “where there is enough, and as good, left in common for others,” and (2) a person may acquire rights only to satisfy one’s needs and no more. JOHN LOCKE, THE SECOND TREATISE ON CIVIL GOVERNMENT 20–21 (Prometheus Books 1986) (1690). Both of these requirements are fundamentally at odds with the grant of exclusive, albeit temporary, monopolies. Ravid & Liu, supra note 43, at 2242.
118. Ravid & Liu, supra note 43, at 2242.
119. Id. at 2243.
The second justification for patent law is the personhood or personality perspective.120 The personhood perspective is based on G.W.F. Hegel’s philosophy that an individual’s personality is developed and realized through the granting of property rights.121 Hegel proposed that “an idea belongs to its creator because the idea is a manifestation of the creator’s personality or self.”122 Therefore, the personhood perspective does not support naming AI as an inventor;123 however, a person who creates AI or works in conjunction with AI should receive a property right as recognition of his personality developed through his ideas.

The third justification is the economic incentive or utilitarian approach to property rights, which is the dominant theory in the U.S.124 This theory recognizes that inventions are costly to develop, but once an invention is released, competition is difficult to control.125 The resulting “free rider” problem occurs when a person copies an invention and enjoys the benefits without incurring any of the development cost.126 In accordance with the utilitarian theory, patent law provides a temporary monopoly as a market-driven incentive for people and entities to create, develop, and market new products.127

Although it may seem counterintuitive, the granting of temporary monopolies and the resulting reduction in competition, can spur increased innovation.128 Government-granted monopolies reduce imitation-based competition, but they encourage innovation-based competition.129 Additionally, the property rights conferred through a patent encourage the patentee to further invest in the property by efficiently and beneficially using, improving, and commercializing the patented technology.130

Under the economic incentive theory, the patent system attempts to maximize the total economic and social welfare of the public.131 Granting

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120. Id. at 2244.
123. Ravid & Liu, supra note 43, at 2244. “[A]n AI system cannot be entitled to patent rights to its creations and inventions because personality is exclusively attributed to human beings.” Id.
124. Id. at 2237–38.
127. I Menell et al., supra note 125, at 167.
129. Id.
130. Kesan, supra note 128, at 902.

Patents reduce transaction costs, help convert inventions into transferable assets, promote disclosure, provide a system of certification and standardization, and allow greater divisibility of technology. They also support cooperation and collaboration between innovators, and signal to investors, collaborators, and adopters important information about the technology
too many or too few patents can impede innovation rather than stimulate it.\textsuperscript{132} Therefore, policymakers must balance factors such as the nature of the rights granted, the duration of the patent term, and the patent requirements in order to establish the proper economic incentives.\textsuperscript{133}

2. Patent Requirements

The U.S. patent requirements seek to balance the interests of both the inventor and the public, while optimizing innovation under the economic incentive theory. The Patent Act identifies five requirements for patentability: (1) patent eligible subject matter,\textsuperscript{134} (2) novelty,\textsuperscript{135} (3) nonobviousness,\textsuperscript{136} (4) utility,\textsuperscript{137} and (5) disclosure.\textsuperscript{138} These requirements, particularly nonobviousness and disclosure, can be difficult to establish, creating a high threshold for patentability and reinforcing the economic justifications of the U.S. patent system.\textsuperscript{139} When considering whether to grant patents for AI-generated inventions, it is important to remember that these five requirements determine whether an invention is worthy of a patent.

The nonobviousness requirement plays an important role in maintaining the economic justifications of the patent system by ensuring that only nontrivial advances receive patents.\textsuperscript{140} Nonobviousness has been characterized as the “ultimate condition of patentability.”\textsuperscript{141} To be patentable, an
invention cannot be an obvious modification of an existing invention\textsuperscript{142} as judged by a hypothetical “person having ordinary skill in the art.”\textsuperscript{143} The purpose of this requirement is to reward substantial steps in the invention process, rather than minor or incremental improvements that would have occurred regardless of the existence of the patent system.\textsuperscript{144}

The disclosure requirement also reinforces the economic incentives of the patent system. “The requirement for an adequate disclosure ensures that the public receives something in return for the exclusionary rights that are granted to the inventor by a patent.”\textsuperscript{145} “[T]he ultimate goal of the patent system is to bring new designs and technologies into the public domain through disclosure.”\textsuperscript{146} To fulfill this goal, a patent application requires a specification that “enables” a person having ordinary skill in the art to “reduce the invention to practice” without undue experimentation or the exercise of inventive skill.\textsuperscript{147}

Ultimately, patentability should be based on these five requirements and the invention itself, not the means by which it was invented.\textsuperscript{148} Congress reached this conclusion when it eliminated the Flash of Genius test in 1952.\textsuperscript{149} The decision was based on the recommendation of the National Patent Planning Commission, which reported that “patentability

\textsuperscript{142} 35 U.S.C. § 103. A patent for a claimed invention may not be obtained, notwithstanding that the claimed invention is not identically disclosed as set forth in [35 U.S.C. § 102], if the differences between the claimed invention and the prior art are such that the claimed invention as a whole would have been obvious before the effective filing date of the claimed invention to a person having ordinary skill in the art to which the claimed invention pertains. Patentability shall not be negated by the manner in which the invention was made.

\textsuperscript{143} Id. The standard for the person having ordinary skill in the art (“PHOSITA”) can naturally adjust as AI-generated inventions become more common. \textsc{Ryan Abbott}, \textit{The Reasonable Robot} 12 (2020) (“[T]he skilled person should become the skilled person using AI. This should raise the bar to patentability because AI augmentation will make average workers more sophisticated and knowledgeable—making more inventions obvious.”).

\textsuperscript{144} \textsc{See} \textit{KSR Int’l Co. v. Teleflex Inc.}, 550 U.S. 398, 419 (2007) (“Granting patent protection to advances that would occur in the ordinary course without real innovation retards progress . . . .”).

\textsuperscript{145} MPEP, supra note 8, § 608.


\textsuperscript{147} MPEP, supra note 8, § 608.01 (citing 35 U.S.C. § 112 and 37 C.F.R. § 1.71); id. § 608.01(g). Reliance on AI during the inventive process could make it more difficult for patent applicants to adequately disclose an invention due to lack of transparency—both from inscrutability and a lack of explainability. \textsc{See} Tabrez Y. Ebrahim, \textit{Artificial Intelligence Inventions & Patent Disclosure}, 125 Penn St. L. Rev. 147, 172 (2020). “Inscrutability refers to defying practical inspection and resisting comprehension due to the underlying complex and numerous calculations in the AI context.” Id. at 179. “AI explainability refers to the difficulty of making plain or comprehensible the inner workings of an algorithm to humans.” Id. at 178–79.

\textsuperscript{148} Abbott, supra note 4, at 1110.

\textsuperscript{149} Id. The Flash of Genius doctrine was a subjective determination of patentability: “[i]f the inventor made his advance by purposeful experimentation, it is not invention; but if he arrived at it by a flash of genius, or a flash of thought, he may be rewarded with a patent.” \textsc{The “Flash of Genius” Standard of Patentable Invention}, 13 \textit{Fordham L. Rev.} 84, 88 (1944), https://ir.lawnet.fordham.edu/cgi/viewcontent.cgi?article=1269&context=flr [https://perma.cc/FUL9-96RE].
shall be determined objectively by the nature of the contribution to the advancement of the art, and not subjectively by the nature of the process by which the invention may have been accomplished.\(^\text{150}\) Additionally, the statute relating to nonobviousness states, “Patentability shall not be negated by the manner in which the invention was made.”\(^\text{151}\) Thus, patent eligibility rests on the five patent requirements, independent from inventorship determinations and involvement by AI.

### B. Conception and the Process of Inventing

To qualify as an inventor, a person must contribute to the conception of the invention.\(^\text{152}\) Therefore, the meaning of conception and when it occurs governs inventorship determinations. In practice, conception is hard to identify.\(^\text{153}\) Moreover, advancements in technology have made it possible for computer systems to contribute to conception, thereby casting doubt as to who—or what—is responsible for conception. Additionally, the involvement of multiple stakeholders, particularly in the context of AI, complicates the analysis.

#### 1. Conception Requirement

For the sake of obtaining a patent, an invention must be conceived, as well as reduced to practice.\(^\text{154}\) The U.S. Court of Appeals for the Federal Circuit described conception as “the ‘formation, in the mind of the inventor, of a definite and permanent idea of a complete and operative invention,’ [while] reduction to practice ‘requires that the claimed invention work for its intended purpose.’”\(^\text{155}\) When determining inventorship, “reduction to practice, \textit{per se}, is irrelevant.”\(^\text{156}\) Therefore, traditional conception analysis

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\(^{150}\) The “Flash of Genius” Standard of Patentable Invention, supra note 149, at 85 (internal quotation marks omitted) (quoting H.R. Doc. No. 78-239, at V A (1943)).

\(^{151}\) 35 U.S.C. § 103.

\(^{152}\) MPEP, \textit{supra} note 8, § 2109.

\(^{153}\) \textit{Reid A. Baldwin, Appreciating the Invention: A Proposal to Reform Claim Amendment Practice} 7 (2013), https://www.law.msu.edu/king/2012-2013/Baldwin.pdf [https://perma.cc/33HY-8VT5]. The requirement of conception implies that invention is an event which occurs at a particular point in time (or at least is completed at a particular point in time).\(^\text{Id.}\)

\(^{154}\) Solvay S.A. v. Honeywell Int’l, 742 F.3d 998, 1000 (Fed. Cir. 2014).

\(^{155}\) \textit{Id.} (quoting Solvay S.A. v. Honeywell Int’l, Inc., 622 F.3d 1367, 1376 (Fed. Cir. 2010)).

\(^{156}\) MPEP, \textit{supra} note 8, § 2109 (quoting \textit{In re Hardee}, 223 USPQ 1122, 1123 (Comm’r Pat. 1984)). “Reduction to practice may be an actual reduction or a constructive reduction to practice which occurs when a patent application on the claimed invention is filed.”\(^\text{Id.}\) § 2138.05. “[P]roof of actual reduction to practice requires a showing that ‘the embodiment . . . actually worked for its intended purpose.’” DSL Dynamic Scis. Ltd. v. Union Switch & Signal, Inc., 928 F.2d 1122, 1125 (Fed. Cir. 1991) (quoting Newkirk v. Lulejian, 825 F.2d 1581, 1582 (Fed. Cir. 1987)). “A process is reduced to practice when it is successfully performed. A machine is reduced to practice when it is assembled, adjusted, and used. A manufacture is reduced to practice when it is completely manufactured. A
considers conception independently from reduction to practice. The threshold question “is who conceived the invention,” and a person cannot be an inventor unless he contributed to conception.157

Conception is “the complete performance of the mental part of the inventive act.”158 Under traditional conception analysis, “[a]n inventor need not know that his invention will work for conception to be complete. He need only show that he had the complete mental picture and could describe it with particularity . . . .”159 Conception may be complete even though additional experimentation is required to reduce the invention to practice; however, the idea must be more than a desirable result.160 Conception is complete when a person having ordinary skill in the art is able to reduce the invention to practice without undue research or experimentation.161

In some cases, it can be difficult to draw a line between true contributions to conception and other contributions that do not rise to the level of conception, and therefore, do not make the contributor an inventor.162 However, this Note proposes that two existing doctrines should be used to supplement traditional conception analysis: the doctrine of simultaneous conception and reduction to practice, as well as the doctrine of first to recognize and appreciate.

The doctrine of simultaneous conception and reduction to practice163 provides an alternative to traditional conception analysis in cases where conception cannot be completed without also reducing the invention to composition of matter is reduced to practice when it is completely composed.” Corona Cord Tire Co. v. Dovan Chem. Corp., 276 U.S. 358, 383 (1928).

157. MPEP, supra note 8, § 2109 (citing In re Hardee, 223 USPQ at 1123).
158. Townsend v. Smith, 36 F.2d 292, 295 (C.C.P.A. 1929) (emphasis added). This is referred to as traditional conception analysis within this Note.
159. Univ. of Pittsburgh v. Hedrick, 573 F.3d 1290, 1298 (Fed. Cir. 2009) (internal citations omitted).
160. 3A DONALD S. CHISUM, CHISUM ON PATENTS § 10.04(3)(b) (2021). “It is not sufficient that the result to be obtained be conceived, but it is required that there be conceived and disclosed the means provided to accomplish that result.” Field v. Knowles, 183 F.2d 593, 611 (C.C.P.A. 1950) (emphasis in original).
162. MPEP, supra note 8, § 2109.

Difficulties arise in separating members of a team effort, where each member of the team has contributed something, into those members that actually contributed to the conception of the invention, such as the physical structure or operative steps, from those members that merely acted under the direction and supervision of the conceivers. Id. (citing Fritsch v. Lin, 21 USPQ 2d 1737 (B.P.A.I. 1991); see also Eli Lilly & Co. v. Aradigm Corp., 376 F.3d 1352, 1359 (Fed. Cir. 2004) (“The line between actual contributions to conception and the remaining, more prosaic contributions to the inventive process that do not render the contributor a co-inventor is sometimes a difficult one to draw.”). 163. MacMillan v. Moffett, 432 F.2d 1237, 1240 (C.C.P.A. 1970).
practice.\textsuperscript{164} In these situations, conception occurs simultaneously with reduction to practice when the invention is shown to “work for its intended purpose.”\textsuperscript{165} Historically, courts have rarely applied the doctrine, typically limiting its use to areas of chemistry and biology.\textsuperscript{166} However, this Note proposes that the doctrine should also apply to inventorship analysis for AI-generated inventions, such as when an open-ended AI system is used to create an invention through trial and error.\textsuperscript{167}

The doctrine of first to recognize and appreciate is another alternative to traditional conception analysis.\textsuperscript{168} Although conception does not require that an inventor know an invention will work or appreciate its patentability,\textsuperscript{169} it does require “a contemporaneous recognition and appreciation of the invention.”\textsuperscript{170} The doctrine of appreciation is typically used to date conception for purposes of determining prior art,\textsuperscript{171} but the same analysis can also support the identification of a human inventor for AI-generated inventions.\textsuperscript{172} Under this doctrine, “there is no conception or reduction to practice where there has been no recognition or appreciation of the existence of the new form.”\textsuperscript{173} Thus, if an AI system is solely responsible for conceiv-

\textsuperscript{164} MPEP, supra note 8, § 2138.04.
\textsuperscript{166} MPEP, supra note 8, § 2138.04; MacMillan, 432 F.2d at 1240; Alpert v. Slatin, 305 F.2d 891, 894 (C.C.P.A. 1962).
\textsuperscript{167} See infra Section IV.C.1.
\textsuperscript{168} See Abbott, supra note 4, at 1098.
\textsuperscript{169} MacMillan, 432 F.2d at 1239.
\textsuperscript{170} We do not think that the concealer must know the unexpected properties associated with the conceived invention, nor even that the conceived subject matter is new. These facts are of course relevant to patentability, but there is no requirement in the law that a concealer be aware of the facts which render the conceived subject matter patentable. The “appreciation” requirement is no more than a recognition requirement applied in cases wherein the invention is produced unintentionally.
\textsuperscript{171} Id. (internal citation omitted).
\textsuperscript{172} See Abbott, supra note 4, at 1098 (“[A]ssuming that a computer cannot be an inventor, individuals who subsequently ‘discover’ computational inventions by mentally recognizing and appreciating their significance would likely qualify as inventors.”).
\textsuperscript{173} Silvestri, 496 F.2d at 597; see also Heard v. Burton, 333 F.2d 239, 243 (C.C.P.A. 1964). To clarify, Heard and Silvestri establish that
ing of an invention, the first person to recognize and appreciate the invention should qualify as the inventor because an AI system is incapable of performing the requisite mental act of recognizing and appreciating inventive subject matter. Accordingly, this Note proposes that the doctrine of first to recognize and appreciate should apply when an AI system independently generates an invention.174

2. Use of Tools During the Inventive Process

Inventors commonly use tools throughout the inventive process, and historically, reliance on tools has not impacted the patentability of the resulting inventions.175 Tools are valuable extensions of human ability and promote innovation by assisting humans in understanding and improving their inventions in a more effective way than would otherwise be possible.176 For thousands of years, calculation devices—from the abacus to advanced computers—have enabled inventors to make predictions and determinations about their inventions.177 Today, inventors commonly rely on computer systems during the inventive process.178

Computer systems are often used to assist inventors to reduce their inventions to practice; however, it is becoming increasingly common for computers to contribute to conception, as well.179 If a person clearly defines a problem through the rules and boundaries of a computer program, and the computer simply calculates the solution, the person qualifies as an inventor, and the computer system is merely a tool. However, whether a person can be considered an inventor becomes less clear as the computer system performs more of the substantive work.180

The USPTO has not clearly established whether a human qualifies as an inventor when the person creates an extremely open-ended program and

174. See infra Section IV.C.2.
175. PLOTKIN, supra note 13, at 87–90.
176. Id. at 87–88.
177. Id. at 87.
178. Abbott, supra note 4, at 1094.
179. Id.
180. See id. at 1080.
the computer generates a result that is unexpected and not understood. 181 Some argue that using a computer program to reach such a result via brute force trial-and-error is not inventing. 182 However, brute force trial-and-error constitutes a well-known technique used for inventing, even outside the context of AI. 183 For example, in selecting the best candidate for the light bulb filament, Thomas Edison hired people to search the world and test more than 6,000 potential options. 184 Although Edison did not use a computer system, he hired people to perform an enormous number of discrete tasks in order to reach the ideal solution in the same way that a computer program operates.

Inventions can be created in an endless number of ways, and the complexity and variability of the inventive process makes it difficult to establish universal guidelines for determining conception. For example, many well-known inventions were made by mistake. 185 At the same time, many inventions result from a methodical engineering approach. 186 In practice, most design processes are non-linear and cyclical, meaning the steps of the process are repeated several times to reach a solution or to improve upon it. 188 As AI advances, this feedback loop 189 requires less human intervention because a computer is able to internally generate, simulate, test, and

181. Id.
182. PLOTKIN, supra note 13, at 82–83.
183. Id. at 83.
184. Id. (citing FRANK LEWIS DYER & THOMAS COMMERFORD MARTIN, EDISON, HIS LIFE AND INVENTIONS 234–66 (1929)).
185. Alyson Krueger, 15 Life-Changing Inventions That Were Created by Mistake, BUS. INSIDER (Nov. 16, 2010, 9:01 AM), https://www.businessinsider.com/these-10-inventions-were-made-by-mistake-2010-11 [https://perma.cc/H9WJ-ZA4W] (naming fifteen inventions that were created by mistake, including the pacemaker, microwave ovens, Post-it Notes, and x-rays).
186. See PLOTKIN, supra note 13, at 62–63 (citing John F. Jacobs, Lincoln Laboratory, The Romance of Programming, Nov. 8, 1956). There are a number of models for engineering design, one of which is the “Waterfall Model.” Id. at 62. It is comprised of six steps that can be used to solve a problem or create an invention: (1) problem definition, (2) requirements analysis, (3) functional design, (4) physical design, (5) construction, and (6) use. Id. at 63. It is helpful to be aware of the general stages of the design process because, as AI improves, it is becoming increasingly involved in the design process and has begun performing steps that previously could only be performed by humans. Id. at 64–66.
187. The design process can be non-linear, meaning that some of the steps may be skipped or performed out of order.
189. The term “feedback loop” describes an iterative process where the output is used as an input to refine the result. Feedback loop is defined as “the path by which some of the output of a circuit, system, or device is returned to the input.” Feedback Loop, DICTIONARY.COM, https://www.dictionary.com/browse/feedback-loop [https://perma.cc/6WE2-KGUM] (last visited Mar. 4, 2021). Although the term is commonly used within the context of computer programming, inventors use feedback loops when they create a design, build a prototype, test the prototype, and make changes to the design based on the results of the testing. See, e.g., PLOTKIN, supra note 13, at 89; see also supra Section II.C. (providing the NASA antenna as an example of an invention resulting from a feedback loop).
refine potential solutions.\textsuperscript{190} Improvements in computational ability, coupled with the complexity of the inventive process, make drawing the line between artificial intelligence and human contributions to conception increasingly difficult.

3. Stakeholders in Artificial Intelligence

The development of artificial intelligence often requires input from multiple people,\textsuperscript{191} which further complicates determinations of when conception occurs and who contributed to it. If a single person programs, trains, and operates an AI system, conception and inventorship determinations are less difficult. In most cases, however, there are multiple stakeholders with varying interests.\textsuperscript{192}

At least seven entities could have a partial stake in an AI system.\textsuperscript{193} These entities include software programmers, data suppliers, trainers or feedback suppliers, operators of the AI systems, owners of the AI systems, investors, and the AI system itself.\textsuperscript{194} In some cases, these categories overlap—for example, the programmer can also be the owner of the AI—and in other cases, they remain separate and distinct.\textsuperscript{195}

Initially, software programmers develop an AI system as a software program.\textsuperscript{196} A program consists of a “set of instructions, or a set of modules or procedures, that allow for a certain type of computer operation.”\textsuperscript{197} Next, data suppliers typically provide information from which the AI system can “learn.”\textsuperscript{198} Trainers or feedback suppliers then review the results of the AI system and correct them, as necessary, to improve the accuracy of the system.\textsuperscript{199} Ultimately, the operator uses the AI system.\textsuperscript{200} For large-scale AI systems, hundreds or even thousands of people could be involved.\textsuperscript{201} Additional stakeholders include the owners of the AI system and the investors, who provide the financial backing to develop the system.\textsuperscript{202} While the owners and investors, within those discrete roles, are unlikely to

\textsuperscript{190} Plotkin, supra note 13, at 91--92.
\textsuperscript{191} Ravid & Liu, supra note 43, at 2232.
\textsuperscript{192} Id.
\textsuperscript{193} See id. at 2232--33.
\textsuperscript{194} See id.
\textsuperscript{195} Id. at 2232.
\textsuperscript{196} Id.
\textsuperscript{198} Ravid & Liu, supra note 43, at 2232.
\textsuperscript{199} Id. at 2233.
\textsuperscript{200} Id.
\textsuperscript{201} Benjamin McDermott, Will AI Take Over the Process of Invention?, DOGTOWN MEDIA (Feb. 3, 2020), https://www.dogtownmedia.com/will-ai-take-over-the-process-of-invention/ [https://perma.cc/F6TL-KA5T] (providing IBM’s super computer, Watson, as an example).
\textsuperscript{202} Ravid & Liu, supra note 43, at 2233.
contribute to the conception of an invention, they are likely to be interested in the ownership of a patent.

Each of these seven stakeholders is integral in developing an AI system capable of contributing to the conception of an invention. Within their discrete roles—and depending on the type of AI system and the circumstances of inventing—a software programmer, data supplier, trainer or feedback supplier, or operator of an AI system might also take actions that constitute contributions to the conception of an invention. As a result, identifying conception, and therefore determining inventorship, is complicated in the context of AI by the involvement of multiple stakeholders.

C. Inventorship

Inventorship is one of the fundamental concepts specific to U.S. patent law. However, inventorship is not always an easy or uncomplicated determination. Despite changes under the Leahy-Smith America Invents Act (“AIA”), which no longer require the inventor to be the patent applicant, the actual inventor or joint inventors of the claimed subject matter must still be correctly named on a patent application. While it seems impossible to create by natural persons as private individuals.

203. The MPEP recognizes “[t]he requirement that the applicant for a patent . . . be the inventor(s) . . . and that the inventor or each joint inventor be identified . . . are characteristics of U.S. patent law not generally shared by other countries.” MPEP, supra note 8, § 2109; see also Rosa Maria Ballardini, Kan He & Teemu Roos, AI-Generated Content: Authorship and Inventorship in the Age of Artificial Intelligence, in ONLINE DISTRIBUTION OF CONTENT IN THE EU 126 (Taina Pihlajarinne, Juha Vesala & Olli Honkilä eds., 2019), https://www.elgaronline.com/view/edcoll/9781788119894/9781788119894.00015.xml [https://perma.cc/MK65-6SWJ]. The European Patent Convention (“EPC”) requires that applicants name the inventors on the patent application, and the failure to name an inventor is grounds for rejecting the application. Id. However, this requirement simply fulfills a formality because, in practice, the European Patent Office (“EPO”) never verifies that the named inventor is the true inventor. Id. The EPC and its associated case law do not explicitly define an inventor; rather, it is left to the law of each country. Id. at 126–27. The presumption, however, is that inventions can only be created by natural persons as private individuals. Id. at 127.


205. MPEP, supra note 8, § 605. The Leahy-Smith America Invents Act (“AIA”) allows assignees to file patent applications on behalf of the inventors, rather than requiring the inventors to file the application. Id.

Effective September 16, 2012, the Office revised the rules of practice to permit a person to whom the inventor has assigned or is under an obligation to assign an invention to file and prosecute an application for patent as the applicant, and to permit a person who otherwise shows sufficient proprietary interest in the matter to file and prosecute an application for patent as the applicant on behalf of the inventor.

Id.


Some may think that, because § 102(f) has been repealed, there is no longer any legal requirement that a patent for an invention be obtained by the inventor. Not so. Both the
clear that inventors must be human,207 the parameters of joint inventorship have been difficult to establish and, as a result, inventorship is ultimately a case-by-case determination.208 The determination is significant, however, because “a valid patent requires correct inventorship,”209 and as a default, inventorship determines ownership.210

1. Human Inventor Requirement

Under current interpretations of the Constitution, statutory provisions, and decisions of the Federal Circuit Court of Appeals, only a human can be named an inventor. The Patent Act defines an inventor as the individual, or the collective group of individuals in the case of joint inventorship, “who invented or discovered the subject matter of the invention.”211 According to the Dictionary Act, “[i]n determining the meaning of any Act of Congress . . . the words ‘person’ . . . and ‘individual,’ shall include every infant member of the species homo sapiens who is born alive at any stage of development.”212

Congress has described patentable subject matter as “anything under the sun that is made by man.”213 In holding that an entity cannot be named as an inventor, the Federal Circuit Court of Appeals explicitly stated “only natural persons can be ‘inventors.’”214 Additionally, when referring to conception, the Federal Circuit Court of Appeals held that “[t]o perform this mental act, inventors must be natural persons and cannot be corporations or sovereigns.”215 Finally, in a decision released by the USPTO in 2020—in
response to the AIP’s patent application on behalf of DABUS—

the Commissioner of Patents explained that “interpreting ‘inventor’ broadly to encompass machines would contradict the plain reading of the patent statutes that refer to persons and individuals.” Thus, an AI system cannot be named as an inventor. However, it is not clear whether involvement by AI precludes patentability.

2. Joint Inventorship

Setting aside the complexity in the AI context, the process of inventing rarely occurs in a vacuum and, as a result, several people often contribute to a single invention. The Patent Act states that, if an invention is made jointly by two or more people, they must apply for a patent jointly and each must make the required oath. However, courts have struggled to define the exact parameters that constitute joint inventorship, explaining that “[i]t is one of the muddiest concepts in the muddy metaphysics of the patent law.”

Congress seems reluctant to create specific joint inventorship standards for fear of precluding the identification of a bona fide inventor on the basis of a rigid statutory requirement. In 1984, Congress significantly modified the statute in an effort to accommodate the team approach to research and development common among corporations, universities, and other large organizations. Such team approaches involve multiple people, potentially spread over many years. The legislative changes “lowered the bar for joint inventorship status but did not clarify any of the inherent uncertainty in joint inventorship status.”

Despite the difficulty in forming a definition, one of the primary goals of joint inventorship rules is to provide clarity and predictability in application. The rules for joint inventorship seek to promote “equity, ease of

216. See supra Section II.C.
218. Abbott, supra note 4, at 1095.
219. 35 U.S.C. §§ 115, 116 (2018); 37 C.F.R. § 1.63 (2020). The requirements of the inventor’s oath, including that it “[i]dentify the inventor or joint inventor executing the oath or declaration by his or her legal name” and “[i]nclude a statement that the person executing the oath or declaration believes the named inventor or joint inventor to be the original inventor or an original joint inventor of a claimed invention in the application for which the oath or declaration is being submitted” can only be fulfilled by humans. Id. § 1.63(a).
222. Id. at 254 (citing 35 U.S.C. § 116).
223. Id.
224. Id. at 246.
225. Id. at 279.
administration, and promotion of collegial and collaborative team research.”

Clear rules allow applicants to assess whether a person should be named as a joint inventor, even if the applicants cannot be sure a patent will ultimately issue on the basis of the five patent requirements.

An invention is considered to be made jointly if it is the product of collaboration between two or more people who contribute to the conception of the solution to a problem. Joint invention occurs even if the inventors play different roles or one person contributes more than another, as long as each makes some original contribution to the final solution of the problem. To this end, the Patent Act states inventors may apply jointly “even though (1) they did not physically work together or at the same time, (2) each did not make the same type or amount of contribution, or (3) each did not make a contribution to the subject matter of every claim of the patent.”

An inventor “may use the services, ideas, and aid of others in the process of perfecting his invention without losing his right to a patent.” However, assisting the inventor after conception—such as assisting with subsequent reduction to practice—will not qualify a person as a joint inventor. Similarly, a person cannot become a joint inventor by merely directing the inventive activity or by approving the inventive activity after the fact.

Ultimately, inventorship determinations are fact-specific and, as a result, there are no bright-line standards that apply in every case. A person must contribute to conception in “some significant manner.”

Clear, predictable rules about the legal requirements for inventorship status allow parties to negotiate within known bounds and find agreeable terms on which to collaborate. . . . In the absence of clear rules, there is uncertainty about the potential rights accruing to a particular collaborator—this inhibits any agreement on terms of collaboration.

Id. (footnotes omitted).

226. Id. (footnotes omitted).
227. See id.
228. 2 CHISUM, supra note 160, § 2.02[2][a].
The fact that each of the inventors plays a different role and that the contribution of one may not be as great as that of another, does not detract from the fact that the invention is joint, if each makes some original contribution, though partial, to the final solution of the problem.

Id.
235. Pannu v. Iolab Corp., 155 F.3d 1344, 1351 (Fed. Cir. 1998) (citing Fina Oil, 123 F.3d at 1473; Ethicon, 135 F.3d at 1460).
contribution must not be “insignificant in quality, when that contribution is measured against the dimension of the full invention.” 236 Additionally, a joint inventor must “do more than merely explain to the real inventors well-known concepts and/or the current state of the art.” 237 However, there is no explicit lower limit to the quantity or quality of inventive contribution necessary for joint inventorship. 238

An understanding of joint inventorship is helpful for several reasons. First, joint inventorship analysis applies in many cases involving AI because of the frequent involvement by multiple stakeholders. Second, given that there is no minimum quantitative or qualitative contribution requirement, the fact that Congress made it easier for multiple team members to be named, and the fact that Congress has avoided creating a strict standard, there is a clear desire to be inclusive rather than preclude a bona fide inventor from being named. Finally, the views of Congress suggest that inventorship is an administrative requirement and not part of the threshold determination for patentability. Thus, any questions of inventorship raised by the involvement of AI should not impact patentability of the invention.

3. Importance of Correct Inventorship

Ultimately, a patent must have correct inventorship to be valid in the United States. 239 Two types of incorrect inventorship exist: misjoinder and nonjoinder. 240 Misjoinder refers to erroneously naming a person who is not an inventor, while nonjoinder refers to erroneously failing to name a person who is an inventor. 241 Either type of error can cause issues for a patentee because “a valid patent requires correct inventorship.” 242

An innocent mistake in inventorship, by itself, does not invalidate a patent. 243 Incorrect inventorship is considered a technical defect that can easily be cured. 244 In fact, inventorship often changes throughout the prosecution of a patent as patent claims are amended or cancelled to overcome the requirements of novelty and nonobviousness. 245 Therefore, applicants

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236. Id. (citing Fina Oil, 123 F.3d at 1473; Ethicon, 135 F.3d at 1460).
237. Id. (citing Fina Oil, 123 F.3d at 1473; Ethicon, 135 F.3d at 1460).
238. Fina Oil, 123 F.3d at 1473.
239. In re Verhoef, 888 F.3d 1362, 1365 (Fed. Cir. 2018) (citing Panu, 155 F.3d at 1349, 1350).
242. Verhoef, 888 F.3d at 1365.
243. Hulse, supra note 233, at 3.
244. 37 C.F.R. § 1.324 (2020) (outlining requirements to correct inventorship in an issued patent); 37 C.F.R. § 1.48 (outlining requirements to correct inventorship in a patent application); Canon Comput. Sys., Inc. v. Nu-Kote Int’l, Inc., 134 F.3d 1085, 1089 (Fed. Cir. 1998) (explaining incorrect inventorship as “a technical defect in a patent that may be easily curable”).
may correct incorrect inventorship, regardless of whether the naming was a mistake or purposeful. Additionally, as long as no fraud or deceptive intent existed, the patent remains valid and enforceable, even during the period prior to the correction. Regardless, it is best to resolve inventorship issues before filing a patent application to avoid the cost of correcting errors.

For an issued patent, the inventorship is presumed correct. The invalidation of patents simply because the inventors were incorrectly named. Anyone who challenges the inventorship on a patent must provide clear and convincing evidence of an error.

As a default, ownership of a patent vests in the inventors in equal, undivided shares. Thus, in the absence of an agreement, inventorship determines ownership. Each joint owner may “make, use, offer to sell, or sell the patent invention within the United States, or import the patented invention into the United States, without the consent of and without accounting to the other owners,” assuming there is no agreement to the contrary. Furthermore, patents “have the attributes of personal property,” which means the ownership rights may be transferred.

In practice, patents are often assigned or licensed. In employment contexts, patent ownership often vests in the employer, either because the invention results from actions employees were hired to perform or...
because the employer requires employees to sign an assignment contract as a term of employment. However, even if an employee does not obtain ownership rights in a patent, an employee still benefits from being named an inventor.258

Because inventorship rests on the nebulous definition of conception, and ultimately requires a case-by-case determination, patent applicants cannot guarantee they have correctly determined inventorship. However, in the absence of fraud or deceptive intent, errors in inventorship do not affect patent eligibility or validity. Thus, any complexity that arises from the involvement of AI should not impact whether the invention is eligible for a patent. Inventorship errors relating to the involvement of AI should be easily curable, just as for any other patent. At the same time, existing legal doctrines can provide some guidance for patent applicants making inventorship determinations, helping applicants avoid the need for corrections.259

IV. ANALYSIS

Bright-line tests do not apply to inventorship determinations; rather, inventorship must be determined on a case-by-case basis.260 Accordingly, Section A proposes that inventorship scenarios should be considered along a spectrum.261 A spectrum provides an understanding of the circumstances of inventing, as well as the relative complexity of determining inventorship. Ultimately, as argued in Section B, the location on the spectrum of an inventorship scenario should not impact the patentability of the invention. Following this premise, Section C provides guidance for determining inventorship when AI is involved. Depending on the particular circumstances, the following doctrines enable a patent applicant to determine who qualifies as an inventor: (1) traditional conception analysis, (2) the doctrine of simultaneous conception and reduction to practice, and (3) the doctrine...
of first to recognize and appreciate. Finally, Section D discusses the implications of granting patents for AI-generated inventions. Ultimately, patent applicants would have more clarity, and the justifications and economic incentives for patents would be fulfilled, if the patent system recognized these three approaches for determining inventorship.

A. The Spectrum of Inventorship

Patent law relies on many dichotomies that do not truly exist—or are hazy at best. Something is either patent-eligible, or it is not. It is either obvious or nonobvious. A person is either an inventor, or he is not. In reality, these distinctions are difficult to draw, and they often fall somewhere on a spectrum, rather than into two distinct categories.

Two spectrums comprising a two-dimensional graph can assist in understanding inventorship scenarios. The first spectrum is a range of technology used during the inventive process.262 On one end of the spectrum, some inventors create their inventions without relying on any technology. On the other end of the spectrum, inventors use advanced computer systems, relying on them entirely during the conception of their inventions. For instance, the members of AIP relied entirely on DABUS—which was neither programmed nor trained to solve any particular problem—to develop new inventions.263 Between these extremes is a range of computer involvement. For example, the Hackrod Team relied on the Autodesk Dreamcatcher system to optimize a car chassis based on an enormous set of data, but the final design was also based on specific goals and constraints provided by the team members.264 As another example, the team at NASA relied on AI to design an antenna, but the AI also relied on refined human information to produce the final result.265

Importantly, the spectrum of technology is not between man and machine.266 Despite the incredible power of computers and the many ways in which computers have surpassed human capacity, AI systems are not capable of thinking and acting as a human.267 For the foreseeable future, humans will continue to be involved in the inventive process, although a computer may also be significantly involved. Even in the case of DABUS,
a human must still recognize the creative potential in one of the randomly-outputted inventions.\textsuperscript{268} Therefore, the technology spectrum appropriately covers the range from man working independently to man “merged” with machine, such that it is difficult to determine who, or what, contributed to conception.

The second spectrum is that of inventorship, and ranges from a single human inventor to a complex arrangement of people contributing to an invention. On one end of the spectrum, a single inventor creates an invention independently. On the other end, a complex group of people from various entities collaborate to create an invention, possibly including a mix of employees from private and public organizations, multinational groups, and crowdsourcing endeavors.\textsuperscript{269} For example, in the case of Hackrod, the founders of a start-up company collaborated with members of a multinational software corporation.\textsuperscript{270} As another example, scientists developing new compounds in the fields of chemistry and biology often collaborate among universities, government organizations, and private entities.\textsuperscript{271}

Combining the two spectrums creates a two-dimensional graph, with the spectrum of technology comprising the vertical axis and the spectrum of inventorship comprising the horizontal axis. (See Figure 1.) A representation of any inventorship scenario can be plotted on this graph. Conceptualizing inventorship in this way helps in understanding inventorship determinations and when complexity arises. Moving \textit{horizontally} along the inventorship spectrum, the inventorship determinations become more difficult as more people and entities become involved. Moving \textit{vertically} along the technology spectrum, inventorship determinations become more difficult as inventors rely on more advanced computer systems and AI begins contributing to the conception of inventions. Combining the two spectrums creates a diagonal gradation where inventorship determinations are easiest at the top left corner and most difficult at the bottom right corner.\textsuperscript{272}

\textsuperscript{268} See \textit{supra} Section II.C.
\textsuperscript{270} See \textit{supra} Section II.C.
\textsuperscript{271} See, e.g., Riester et al., \textit{supra} note 78, at 8597.
\textsuperscript{272} The shading on the graph in Figure 1 illustrates the difficulty of determining inventorship. As the shading gets darker (moving from the upper left corner to the lower right corner), the difficulty of determining inventorship increases.
Despite the difficulty in identifying inventors, the patentability of an invention should not depend on the location of a particular inventorship arrangement on the spectrum. In proposing a one-dimensional spectrum consisting solely of the technology spectrum (or the involvement of AI), some commentators have suggested drawing a line, beyond which an invention is no longer patentable or, alternatively, beyond which it should be necessary to name the AI system as an inventor. On the other hand, this Note argues that an invention should be patentable regardless of involvement by AI—as long as it meets the five patent requirements—and that only human inventors should be named. This should be the case even if a scenario falls at one of the four extremes (the four corners) of the spectrum: (1) where a single inventor created the invention without the use

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273. See, e.g., Abbott, supra note 4, at 1094; McLaughlin, supra note 11, at 241–42; FlashPoint IP Ltd., No. 50567-3-01-US, 2020 WL 1970052 (Comm'r Pat. Apr. 22, 2020) (“Petitioner contends that inventorship should not be limited to natural persons and, therefore, the naming of DABUS as the inventor in the above-identified application is proper.”).
of any technology, (2) where a complex team of people worked together without the use of any technology, (3) where a single inventor relied heavily on AI, or (4) where a complex team of people relied heavily on AI.274

B. Patentability Requirements for AI-Generated Inventions

The requirements of patent-eligible subject matter, novelty, nonobviousness, utility, and adequate disclosure should be the only requirements that dictate the patentability of a particular invention.275 Inventions benefit society regardless of how they were created.276 Thus, the same requirements for patentability should apply whether or not artificial intelligence is involved in the inventive process. The current patent application process does not require inventors to reveal how an invention was created,277 and including such a requirement would only add unnecessary complexity to the application and examination processes.

If the USPTO were to require additional disclosure regarding how an invention was made, it would be difficult to establish a meaningful requirement.278 As an initial matter, assuming the new disclosure requirement did not apply broadly to all applications, patent applicants would need to know the threshold of computer involvement that triggers the requirement to disclose the inventive method. Inventors regularly rely on computers to create their inventions, but there is no clear way to determine whether a computer contributed to the conception of an invention.279 Ultimately, requiring patent applicants to reveal the AI involvement would create more uncertainty for patent applicants, not less.

Additionally, the variety of approaches to AI would make the analysis highly technical, and the inventorship determination could hinge on details

274. These four points are labeled on the four corners of the spectrum in Figure 1.
275. This is not to say these five requirements are the only requirements necessary to obtain a patent. Patent applicants must fulfill numerous requirements, but the other requirements are procedural. For example, the patent applicant must pay the application fees: filing, search, and examination fees. MPEP, supra note 8, § 607. Without paying these fees, the applicant cannot receive a patent, but this has no bearing on the patentability of the underlying invention.
276. ABBOTT, supra note 143, at 11.
277. Robert Jehan, Should an AI System Be Credited as an Inventor?, ARTIFICIAL INVENTOR PROJECT (Aug. 24, 2019), http://artificialinventor.com/should-an-ai-system-be-credited-as-an-inventor-robert-jehan/ [https://perma.cc/6QA6-VNBQ] (“There is no provision in patent law that requires the applicant or inventor to explain how the invention was arrived at.”).
278. See Ebrahim, supra note 147, at 190 (“[N]o capability exists at the USPTO to determine whether an invention is based on AI-generated output from the use of an AI-based tool.”).
279. Id. at 191 (explaining that “AI-generated inventions do not even have a visible distinction from human-generated inventions”).
of the branch of AI and how a specific system operates. These determinations could lead to inconsistent results, where a particular invention is patentable if conceived by one AI system but ineligible if conceived by another. Allowing the inconsistent granting of patents based on the method of invention contradicts the purpose of patent law—“To promote the Progress of Science and useful Arts”—which is fulfilled when new inventions are released to the public, independent of how they were developed.

Even if a meaningful requirement for revealing how an invention was made could be established, such a requirement would result in negative consequences for two primary reasons. First, requiring patent applicants to reveal their involvement with AI would have a chilling effect if would-be applicants do not want to disclose either their method of inventing or the details of their AI system. Such a requirement would undermine the economic incentives of the patent system, because the public would be receiving additional information without giving the inventor anything more in return.

Second, requiring patent applicants to identify and document their interaction with AI would likely hamper the process of inventing. The expansion of technology makes it easier to rely on computer systems, but also more difficult to recognize the use of those computer systems and to distinguish between the actions of computer systems and the humans using them. “A good tool is an invisible tool.” For example, billions of people around the world wear eyeglasses, but people rarely give conscious thought to the fact they are wearing eyeglasses. Instead, they focus on the world around them and what they see. Similarly, it would be burdensome if inventors were required to give conscious thought to their interactions with and reliance on AI, or even if they were required to document their inventive processes generally.

280. See supra Section II.B.
282. See Abbott, supra note 4, at 1097–98.
283. See Ebrahim, supra note 147, at 162, 211–12 (recommending that the patent system offer additional incentives, such as prioritized examination or reduced maintenance fees, to account for the additional disclosure).
284. See PLOTKIN, supra note 13, at 72–74.
285. Id. at 74 (“Increasingly invisible computer technology can potentially enable integration of computers into the inventive process more seamlessly than ever before.”). Even beyond the realm of inventing, humans use tools and various machines to augment and enhance their minds. Id. at 86. For example, Google is effectively external memory, helping a person to “remember” the dates of historical events he learned in high school but would otherwise be unable to recall. Id.
286. Id. at 74 (quoting Mark Weiser, The World Is Not a Desktop, 1 ACM INTERACTIONS 7–8 (Jan. 1994)).
287. Id.
288. Id.
Because patentability does not currently depend on how an invention was made, and because adding such a disclosure requirement does not make sense, patentability cannot and should not rest on the degree of involvement by AI. Thus, the point where a particular arrangement falls on the inventorship spectrum should have no effect on patentability. In the absence of fraud or deceptive intent, any errors in inventorship should continue to be recognized as technical defects and easy to correct. Relying on the five patent requirements—rather than creating a new disclosure requirement—also allows more flexibility for future adaptations as new technology emerges and as man continues to “merge” with machine.

C. Naming Inventors

The justifications of the patent system support recognizing humans for their work in developing inventions, regardless of contributions by AI. Having established that the involvement by AI in the inventive process should not preclude the granting of a valid patent, the fundamental problem of determining who should be named an inventor remains. Depending on the situation, patent applicants can use one of three existing doctrines to determine inventorship: (1) traditional conception analysis, (2) the doctrine of simultaneous conception and reduction to practice, or (3) the doctrine of first to recognize and appreciate.

1. Traditional Conception Analysis and the Doctrine of Simultaneous Conception and Reduction to Practice

Ultimately, inventorship is determined on a case-by-case basis. The specific features of an AI system, as well as the particular interactions between a person and the system, make it difficult to determine whether a person performed “the mental part of the inventive act” necessary for traditional conception analysis. The number of stakeholders involved, the enormous variety of AI systems, and the rate at which technology changes

289. Contra Ebrahim, supra note 147, at 162.
290. See supra Section II.A.
291. See supra Section III.A.1.
292. See supra Section III.B.1. Under traditional inventorship analysis, any person who contributes to the conception of the invention is an inventor. Reduction to practice is not relevant to such an inventorship determination.
293. See supra Section III.B.1. In some instances, conception cannot be completed without also reducing the invention to practice, in which case, any person who contributes to reduction to practice is an inventor.
294. See supra Section III.B.1. A person can discover—as opposed to create—an invention, in which case the first person to recognize and appreciate an invention is the inventor.
295. See supra Section III.C.2.
also contribute to the complexity of inventorship determinations. However, to guide in determining whether traditional conception analysis or simultaneous conception and reduction to practice should apply, patent applicants can categorize an AI system as one of two general types of automation: deterministic automation or search automation.297

On one hand, deterministic automation follows a rigid set of rules, with little or no room for interpretation, to transform a description into a design.298 Solutions deriving from deterministic-based programs are typically well-understood because they derive from a set of clearly defined rules.299 In these cases, because of the level of detail required to write such a program, conception occurs before the computer ever produces a result. Therefore, traditional conception analysis applies. Any associated complications in determining inventorship will result from the complexity of joint inventorship, not as a result of the involvement of AI.

On the other hand, search automation operates by generating and testing new designs, using randomness and brute force trial-and-error to “search” for an optimal design.300 Inventing through search automation requires identification of the problem to be solved and a determination of how to recognize a solution.301 However, it is not necessary to understand the form of the solution, and as a result, users do not always understand why the computer reached a particular solution.302 In such a case, it makes sense to apply the doctrine of simultaneous conception and reduction to practice. Before the computer produces a result, the idea is too abstract for the invention to be considered “conceived.” After the computer produces the result, the invention is not only conceived, but also reduced to practice.

When applying the doctrine of simultaneous conception and reduction to practice, patent applicants no longer need to distinguish between contributions to conception and reduction to practice. Both conception and reduction to practice occur simultaneously and any person who contributed to reduction to practice also contributed to conception. Accordingly, any person who made “a contribution to the claimed invention that is not insignificant in quality, when that contribution is measured against the dimension of the full invention,” is an inventor.303

297. See PLOTKIN, supra note 13, at 67.
298. Id.
299. Id. at 79.
300. Id. at 67.
301. Id. at 78. Thomas Edison, applying the search approach, had the knowledge that he needed a material that would create light in the bulb when electricity was passed through it; he did not have to understand the chemistry or physics of the materials he tested or why a particular material worked. Id. at 67, 78.
302. Id. at 79. Additionally, the programs could contain bugs or “junk” solutions, but these are hard to anticipate without understanding the program. Id.
To contextualize the analysis, consider a single person who performs the role of software programmer, data supplier, and trainer of an AI system. This person invests the time and money necessary to develop the system and is the owner of the AI. The program, written by the individual, provides the computer with a general goal: cleaner teeth. The person also supplies data, such as the effectiveness of existing toothbrush designs, to enable the AI system to determine a solution. The computer produces a result, which is expected in the sense that it is a toothbrush; however, the result is unexpected in terms of its exact form because the bristles of the toothbrush are crossing. Assume the unexpected feature makes it patentable and that it meets the requirements of patent eligible subject matter, novelty, nonobviousness, utility, and adequate disclosure—so there would be no doubt as to its patentability in the absence of involvement by AI.

If the program consists of a rigid set of rules, traditional conception analysis can be used to determine inventorship. Perhaps the person creates the program to determine the ideal toothbrush, or even the ideal orientation of bristles, for the most efficient teeth cleaning. This is an example of deterministic automation, and the creation of the program, with specific parameters that limit and direct the results, also establishes conception. This can be the case, that conception is complete by the writing of the program, even if the person is surprised by the resulting configuration of bristles. The deterministic program performs the reduction to practice, and it is not uncommon for inventors to be surprised by the results of reduction to practice, even outside the context of AI.

If, on the other hand, the program consists only of a high-level goal, the doctrine of simultaneous conception and reduction to practice should apply to determine inventorship. Perhaps the person writes an open-ended program to create a more efficient way to clean teeth without specifying anything about a toothbrush, much less with any particular goals about the configuration of a toothbrush or its bristles. After searching through various options, the computer determines that crossing the bristles on a toothbrush results in cleaner teeth. This is an example of search automation, and conception may not occur until the person runs the program and the AI system outputs the resulting toothbrush configuration, at which point the invention has also been reduced to practice.

304. These hypothetical examples are loosely based on the creation of the Oral-B CrossAction Toothbrush. See supra Section II.C.
305. In fact, a patent applicant can use evidence of unexpected results to overcome a determination of obviousness. MPEP, supra note 8, § 2141. An invention is not patentable if it would have been obvious to a person having ordinary skill in the art. Id. (citing 35 U.S.C. § 103 (2018)). To avoid or rebut a finding of obviousness, the patent applicant can provide objective evidence, sometimes referred to as “secondary considerations,” and one such consideration is unexpected results. Id.
Nevertheless, the person should be recognized and named an inventor because it is as a result of his efforts that a patentable toothbrush is created. In the given examples, the invention results from the work of only one person, so he is the sole inventor. If multiple people work together to generate the invention with the assistance of the AI system, the inventorship determination would be based on existing joint inventorship doctrines, and the involvement of AI should have no impact.

In practice, the distinction between deterministic and search automation is not always clear. There will be room for trial-and-error of potential solutions within a very rigid set of rules. Likewise, some rules will govern even the most random search-based process. The more complex the search problem, the more structure the user must provide in order to reach a computational solution within a reasonable timeframe.

As a guide for deciding which inventorship analysis to use, patent applicants can consider the impact of improved computing power. Generally, running deterministic software on a newer, faster computer will simply cause the software to run more quickly, but will not impact the end result. However, because of the way search programs are written, running a search program on a newer, faster computer will typically produce a better solution. Additionally, a single search program, written once, can potentially produce multiple inventions with no additional work. Although inventorship will ultimately be determined on a case-by-case basis, analyzing inventorship in terms of deterministic or search automation, and considering the impact of improved computing power, can provide some guidance and clarity for patent applicants.

306. PLOTKIN, supra note 13, at 67–68.
307. Id.
308. Id. at 68.
309. See id.

[A]ny computer-based search process that is used to solve a complex problem must have a heavy dose of design baked into it if it is to complete its task within the lifetime of the universe; it is not feasible to search every possible solution to real-world problems. . . . Today’s artificial invention researchers therefore spend much of their time refining genetic algorithms and other search-based techniques to search through the “space” of possible solutions as efficiently as possible.

Id. (emphasis in original).
310. Id. at 74–76.
311. Id. at 75.
312. Id.
313. Id. The effects of a search program can be improved by using a faster computer, “a better simulator, an improved genetic algorithm, or some other improved technology, all of which [may be] obtained or purchased from someone else” without requiring additional inventive effort. Id.
2. The Doctrine of First to Recognize and Appreciate

Another approach for determining inventorship also exists: the doctrine of first to recognize and appreciate.314 Currently, the well-known and widely used techniques of AI require human input, and therefore, inventorship can typically be determined under either traditional conception analysis or the doctrine of simultaneous conception and reduction to practice. However, the technology that allows an AI system to independently and autonomously create inventions will exist someday—if it does not already, as argued by the AIP team working with DABUS.315

If an AI system truly acts autonomously in creating inventions without any human guidance, the first person to recognize and appreciate the inventive subject matter should qualify as the inventor.316 Modifying the current patent system to recognize an AI system as an inventor, on the other hand, would raise additional issues.

First, as discussed, naming an AI system as an inventor violates the intent of the U.S. patent system. It conflicts with the express language of Congress and the Court of Appeals for the Federal Circuit, which both clearly require that a human inventor be named.317 Additionally, the economic justifications do not support naming an AI system as an inventor, because AI systems are not motivated by obtaining a patent in the way humans are.318

Second, there are several administrative issues with requiring that AI be listed as an inventor, such as how an AI system should be named. No system currently exists to facilitate the naming or registering of AI systems. There are also uncertainties about whether a modification to an existing AI system converts it into a different AI system requiring a different name. Arguably, it does not matter what an AI system is called or whether it is registered, but requiring patent applicants to name an AI system as an inventor implies that these details are important.319

Third, naming AI as an inventor would complicate ownership of the patent.320 The inventor, and subsequently an assignee and owner, has the

314. See Abbott, supra note 4, at 1098.
315. See supra Section II.C.
316. Joint inventorship analysis could still apply if different people recognize different features incorporated in the patent claims.
317. See supra Section III.C.1.
318. See supra Section III.A.1.
319. The naming of an AI system on a patent application seems to necessitate a system to identify and differentiate between various AI systems. Without such a system, the naming of an AI system on a patent application provides no value. As an alternative, a patent application could simply be designated as having or not having contributions from AI.
320. By default, inventors are the owners of a patent. MPEP, supra note 8, § 301; 37 C.F.R. § 3.73(a) (2020). An AI system, however, cannot be a legal owner of a patent. Abbott, supra note 4, at 1114.
ability to enter into contracts, grant licenses, and sue and be sued—none of which AI can do.\textsuperscript{321} Ultimately, no justification or incentive exists to allow naming an AI system as an inventor under the current patent system.

A natural concern is that, under the doctrine of first to recognize and appreciate, a human receives credit for the work of a machine.\textsuperscript{322} However, an autonomous AI system that independently creates inventions provides no benefit unless a person recognizes the value of a particular invention.\textsuperscript{323} A human must perform the required “mental act” in order to initiate the patent process.\textsuperscript{324} To provide an incentive for people to identify inventions and ultimately disclose them publicly through the pursuit of a patent, it makes sense that a person who performs the mental act be recognized as an inventor.\textsuperscript{325} It also fulfills the wording of the Patent Act: “Whoever invents or discovers any new and useful process, machine, manufacture, or composition of matter, or any new and useful improvement thereof, may obtain a patent therefor . . . .”\textsuperscript{326}

An otherwise-patentable invention should not become ineligible due to the method of inventing. Therefore, it must be possible to name a human inventor associated with computer-generated inventions. When traditional conception analysis and the doctrine of simultaneous conception and reduction to practice do not apply, the doctrine of first to recognize and appreciate should be used to identify the appropriate human inventor.

\textsuperscript{321} McDermott, supra note 201.

\textsuperscript{322} Abbott, supra note 10. One of the team members who filed a patent application on behalf of the AI system DABUS argued:

\begin{quote}
Allowing a person to be listed as an inventor for an AI-generated invention would not be unfair to an AI, which has no interest in being acknowledged, but allowing people to take credit for work they have not done would devalue human inventorship. It would put the work of someone who merely asks an AI to solve a problem on an equal footing with someone who is legitimately inventing something new.
\end{quote}

\textit{Id.}

\textsuperscript{323} Practically speaking, the development of such AI systems will probably be limited, because an AI system that generates random inventions is not as economically valuable as an AI system created to produce a desired result.

\textsuperscript{324} For the foreseeable future, a person must be involved in obtaining a patent even when an AI system independently creates the invention. Recently, firms have begun developing artificial intelligence to automate the patent application process, but this technology has not progressed to the point that an AI system could fully prosecute a patent for an invention it generated. See, e.g., Shawn Lillemo, \textit{Improving Speed and Quality Using Automation for Patent Application Drafting}, IP WATCHDOG (Sept. 26, 2019), https://www.ipwatchdog.com/2019/09/26/improving-speed-quality-using-automation-patent-application-drafting/id=113838/ [https://perma.cc/4XSD-ME42]. If, in the future, an AI system is able to independently create an invention, recognize the patentability of that invention, and autonomously prosecute a patent, the implications of such powerful technology would need to be addressed on a much broader scale.

\textsuperscript{325} \textit{Contra} Abbott, supra note 4, at 1104 (“One could imagine this creating a host of problems: the first person to recognize a patentable result might be an intern at a large research corporation or a visitor in someone’s home. A large number of individuals might also concurrently recognize a result if access to an AI is widespread.”).

D. Implications of Granting Patents for AI-Generated Inventions

AI systems will continue to become more and more involved in inventive processes. Without a clear direction for addressing inventorship now, the integrity of the patent system is at risk. The primary justification for granting patents for AI-generated inventions is the disclosure and commercialization of valuable new inventions.  However, people and entities may lose the incentive to disclose if it is unclear whether or how inventorship determinations will impact patentability. A would-be patent applicant may decide not to file an application in order to avoid the risk of disclosing his invention without gaining any protection.  Providing guidelines for determining inventorship will help applicants feel more confident in their patent application and could also provide guidance when inventors make decisions about assignments.

While the difficulties of distinguishing between types of AI—coupled with the complexities of patent prosecution and joint inventorship in general—make inventorship a case-by-case determination, it is important that patent eligibility is not premised on an inventorship determination. As long as the invention meets the five patent requirements and no fraud or deceptive intent exists on the part of the applicants, the invention should be eligible for a patent, and any errors in inventorship, as determined on a case-by-case basis, should be easily corrected.

Granting patents for AI-generated inventions will encourage the future creation of inventions that could not otherwise have been developed due to the complexity or the sheer volume of data involved and, ultimately, will result in more innovation. Similarly, granting patents for AI-generated inventions will provide an incentive to use AI to produce superior inventions and to produce them more quickly. Without an express acknowledgment of patentability for AI-generated inventions, entities may choose

327. See, e.g., Abbott, supra note 4, at 1104–05.
328. Id. (“Without the ability to obtain patent protection, owners of creative computers might choose to protect patentable inventions as trade secrets without any public disclosure.”).
329. ABBOTT, supra note 143, at 11.
330. See, e.g., id. at 76–77. For example, researchers at Flinders University in Australia used AI to develop a flu vaccine. Id. at 76. One AI system was used to develop trillions of potential candidates, while another AI system analyzed the candidates, evaluating effectiveness and identifying the ten most promising options. Id. This enabled the research team to develop a more effective vaccine in less time and at a lower cost. Id.
to rely on human inventors to guarantee patentability, especially for lucrative inventions.331

The primary purpose in allowing patents for AI-generated inventions is not to incentivize people to develop new AI systems or creative computers,332 although such development will be a natural byproduct. The development of new AI systems is separately motivated by the potential to obtain a patent on the system itself, so it is not necessary to grant patents for inventions generated by computers for this purpose. Still, the incentive to develop and use AI will likely be much stronger if resulting inventions are clearly patentable.333 Ultimately, granting patents for computer-generated inventions will increase innovation in a variety of ways and, therefore, will fulfill the purpose of promoting “the Progress of Science and useful Arts.”334

V. CONCLUSION

As AI continues to advance and become more involved in inventive processes, it is important to acknowledge that involvement by AI, including contributions to the conception of an invention, should not impact the patentability of resulting inventions. Society benefits from the disclosure of inventions, independent from how they were created. Thus, the requirements of patent eligible subject matter, novelty, nonobviousness, utility, and adequate disclosure—and these requirements alone—should form the basis for determining whether an invention is worthy of a patent.335 Nevertheless, patent applicants need guidance in determining who should be named as an inventor when AI contributes to an invention.

Three existing doctrines can assist patent applicants in making inventorship determinations in the context of AI-generated inventions, thereby providing clarity and advancing the fundamental ideals of the patent system. First, traditional conception analysis should continue to apply when an AI system is given a detailed definition of the problem, such that the invention is conceived before the computer produces the result. Second, when an AI system is provided with an abstract scope, the doctrine of simul-
taneous conception and reduction to practice should apply. Third, the doctrine of first to recognize and appreciate should apply if an AI system independently generates an invention. The U.S. patent system should explicitly recognize the applicability of these doctrines to inventorship determinations in the context of AI-generated inventions.