Boston College Law Review

Volume 57 | Issue 4 Article 2

9-28-2016

I Think, Therefore I Invent: Creative Computers and the Future of Patent Law

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I THINK, THEREFORE I INVENT: CREATIVE COMPUTERS AND THE FUTURE OF PATENT LAW

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Abstract: Artificial intelligence has been generating inventive output for decades, and now the continued and exponential growth in computing power is poised to take creative machines from novelties to major drivers of economic growth. In some cases, a computer's output constitutes patentable subject matter, and the computer rather than a person meets the requirements for inventorship. Despite this, and despite the fact that the Patent Office has already granted patents for inventions by computers, the issue of computer inventorship has never been explicitly considered by the courts, Congress, or the Patent Office. Drawing on dynamic principles of statutory interpretation and taking analogies from the copyright context, this Article argues that creative computers should be considered inventors under the Patent and Copyright Clause of the Constitution. Treating nonhumans as inventors would incentivize the creation of intellectual property by encouraging the development of creative computers. This Article also addresses a host of challenges that would result from computer inventorship, including the ownership of computer-based inventions, the displacement of human inventors, and the need for consumer protection policies. This analysis applies broadly to nonhuman creators of intellectual property, and explains why the Copyright Office came to the wrong conclusion with its Human Authorship Requirement. Finally, this Article addresses how computer inventorship provides insight into other areas of patent law. For instance, computers could replace the hypothetical skilled person that courts use to judge inventiveness. Creative computers may require a rethinking of the baseline standard for inventiveness, and potentially of the entire patent system.

INTRODUCTION

An innovation revolution is on the horizon.[1] Artificial intelligence ("AI") has been generating inventive output for decades, and now the contin-

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[1] *See, e.g.*, JAMES MANYIKA ET AL., DISRUPTIVE TECHNOLOGIES: ADVANCES THAT WILL TRANSFORM LIFE, BUSINESS, AND THE GLOBAL ECONOMY 40 (2013) (predicting that the automation

ued and exponential growth in computing power is poised to take creative machines from novelties to major drivers of economic growth.[2] A creative singularity in which computers overtake human inventors as the primary source of new discoveries is foreseeable.

This phenomenon poses new challenges to the traditional paradigm of patentability. Computers already are generating patentable subject matter under circumstances in which the computer, rather than a human inventor, meets the requirements to qualify as an inventor (a phenomenon that this Article refers to as "computational invention").[3] Yet, it is not clear that a computer could be an inventor or even that a computer's invention could be patentable.[4] There is no statute addressing computational invention, no case law directly on the subject, and no pertinent Patent Office policy.[5]

These are important issues to resolve. Inventors have ownership rights in their patents, and failure to list an inventor can result in a patent being held invalid or unenforceable. Moreover, government policies encouraging or inhibiting the development of creative machines will play a critical role in the evolution of computer science and the structure of the research and development ("R&D") enterprise.[6] Soon computers will be routinely inventing, and it may only be a matter of time until computers are responsible for most innovation.

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of knowledge work "could have as much as $5.2 trillion to $6.7 trillion in economic impact annually by 2025").

[2] *See infra* notes 275–278 and accompanying text.

[3] *See infra* notes 28–99 and accompanying text*; see also* Ryan Abbott, *Hal the Inventor: Big Data and Its Use by Artificial Intelligence*, *in* BIG DATA IS NOT A MONOLITH (Cassidy R. Sugimoto, Hamid R. Ekbia & Michael Mattioli eds., forthcoming Oct. 2016) (discussing computational invention in an essay originally posted online on February 19, 2015).

[4] *See*, *e.g.*, Ralph D. Clifford, *Intellectual Property in the Era of the Creative Computer Program: Will the True Creator Please Stand Up*?, 71 TUL. L. REV. 1675, 1681, 1702–03 (1997) (arguing the output of creative computers cannot and should not be protected by federal intellectual property laws and that such results enter the public domain); *see also* Pamela Samuelson, *Allocating Ownership Rights in Computer-Generated Works*, 47 U. PITT. L. REV. 1185, 1199–1200 (1986) (arguing that computers cannot be authors because they do not need incentives to generate output). Pamela Samuelson, arguing against considering computers to be authors, states that, "[o]nly those stuck in the doctrinal mud could even think that computers could be 'authors.'" *Id.* at 1200.

[5] *See* Ben Hattenbach & Joshua Glucoft, *Patents in an Era of Infinite Monkeys and Artificial Intelligence*, 19 STAN. TECH. L. REV. 32, 44 & n.70 (2015) (noting no pertinent results from "a search for patent cases discussing genetic programming or computer-aided drug discovery (perhaps the two most common means of computerized inventive activity)" and that "[o]f a sampling of issued patents that were conceived wholly or in part by computers, none have ever been subject to litigation."); *see also* ROBERT PLOTKIN, THE GENIE IN THE MACHINE 60 (2009). "Patent Office" refers to the U.S. Patent and Trademark Office ("USPTO"), the federal agency responsible for granting patents and registering trademarks. *See About Us*, USPTO, http://www.uspto.gov/about-us [https://perma.cc/6HZY-V9NU] (last visited Jan. 27, 2016).

[6] *See generally* Michael Kremer & Heidi Williams, *Incentivizing Innovation: Adding to the Tool Kit*, 10 INNOVATION POL'Y & ECON. 1 (2010) (discussing the importance of intellectual property rights for promoting innovation).

This Article addresses whether a computer could and should be an inventor for the purposes of patent law as well as whether computational inventions could and should be patentable.[7] It argues that computers can be inventors because although AI would not be motivated to invent by the prospect of a patent, computer inventorship would incentivize the development of creative machines.[8] In turn, this would lead to new scientific advances.

Beyond inventorship concerns, such machines present fascinating questions: Are computers thinking entities? Who should own the rights to a computer's invention? How do animal artists differ from artificial intelligence? What would be the societal implications of a world in which most inventions were created by computers? Do creative computers challenge established norms in other areas of patent law? This Article attempts to resolve these questions as well as some of the other philosophical, societal, and even apocalyptic concerns related to creative computers.[9]

This Article is divided into three parts.[10] Part I examines instances in which AI has created patentable inventions.[11] It finds that machines have been autonomously generating patentable results for at least twenty years and that the pace of such invention is likely increasing.[12] It proceeds to discuss the criteria for inventorship and to examine the roles of humans and computers in the inventive process. It concludes that statutory language requiring inventors to be individuals and judicial characterization of invention as a "mental act" present barriers to computer inventorship, but that otherwise computers independently meet the requirements for inventorship. Finally, Part I notes that applicants seem not to be disclosing the role of creative computers to the Patent Office—likely as a result of uncertainty over whether a computer inventor would render an invention unpatentable. Applicants may also be able to legally circumvent such disclosure by being the first human to discover a computer's patentable result, but this Article will discuss how that approach is unfair, inefficient, and logistically problematic.

Part II examines the jurisprudence related to nonhuman authorship of copyrightable material in the absence of law on the subject of computer inventorship.[13] It discusses the history of the Copyright Office's Human Authorship

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[7] *See infra* notes 23–138 and accompanying text.

[8] *See infra* notes 139–239 and accompanying text.

[9] *See infra* notes 230–313 and accompanying text.

[10] *See infra* notes 23–138, 139–239, and 240–312 and accompanying text.

[11] *See infra* notes 23–138 and accompanying text.

[12] *See, e.g.*, John R. Koza, *Human-Competitive Results Produced by Genetic Programming*, *in* 11 GENETIC PROGRAMMING & EVOLVABLE MACHINES 251, 251 (2010) [hereinafter Koza, *Human-Competitive Results*] ("[T]he increased availability of computing power (through both parallel computing and Moore's law) should result in the production, in the future, of an increasing flow of human-competitive results, as well as more intricate and impressive results.").

[13] *See infra* notes 139–239 and accompanying text.

Requirement,[14] and scrutinizes case law interpreting the Patent and Copyright Clause.[15] On the basis of this analysis, and based on principles of dynamic statutory interpretation,[16] it argues that computers should qualify as legal inventors.

This would incentivize the development of creative machines consistent with the purpose and intent of the Founders and Congress. The requirement that inventors be individuals was designed to prevent corporate ownership,[17] and so computer inventorship should not be prohibited on this basis. Also, there should be no requirement for a mental act because patent law is concerned with the creativity of an invention itself rather than the subjective mental process by which an invention may have been achieved.[18] This Part concludes by addressing objections to computer inventorship including arguments that computational inventions would develop in the absence of patent protection at non-monopoly prices.

Finally, Part III addresses challenges posed by computer inventorship, and generalizes the analysis of earlier sections.[19] It finds that a computer's owner should be the default assignee of any invention, both because this is most consistent with the rules governing ownership of property, and because it would most incentivize innovation. Where a computer's owner, developer, and user are different entities, such parties could negotiate alternative arrangements by contract. Computer ownership here generally refers to software ownership, although there may be instances in which it is difficult to distinguish between hardware and software, or even to identify a software "owner."[20] This Part also examines the phenomenon of automation and the displacement of human inventors by computers. It finds that computational invention remains beneficial despite legitimate concerns and that for the foreseeable future computers are likely to refocus human inventors rather than replace them.

Part IV concludes by finding the arguments in support of computer inventorship apply with equal force to nonhuman authors. Allowing animals to create copyrightable material would result in more socially valuable art by creating new incentives for people to facilitate animal creativity.[21] It would also

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[14] *See* U.S. COPYRIGHT OFFICE, COMPENDIUM OF U.S. COPYRIGHT OFFICE PRACTICES § 306 (3d ed. 2014).

[15] *See* U.S. CONST. art. I, § 8, cl. 8.

[16] *See generally* William N. Eskridge, Jr., *Dynamic Statutory Interpretation*, 135 U. PA. L. REV. 1479 (1987) (identifying principles of dynamic statutory interpretation).

[17] *See infra* notes 122–132 and accompanying text.

[18] *See, e.g.*, *The "Flash of Genius" Standard of Patentable Invention*, 13 FORDHAM L. REV. 84, 85–86 (1944).

[19] *See infra* notes 240–312 and accompanying text.

[20] *See generally* GOVERNMENT OFFICE FOR SCIENCE, DISTRIBUTED LEDGER TECHNOLOGY: BEYOND BLOCK CHAIN (describing algorithmic technologies and distributed ledgers as examples of new and disruptive computational paradigms).

[21] *See infra* notes 279–287 and accompanying text.

provide incentives for environmental conservation.[22] Lastly, this Article examines some of the implications of computer inventorship for other areas of patent law. Computers are a natural substitute for the person having ordinary skill in the art ("PHOSITA" or, simply, the "skilled person") used to judge a patent's inventiveness. The skilled person is presumed to know of all the prior art (what came before an invention) in a particular field—a legal fiction that could be accurate in the case of a computer. Substituting a computer for the skilled person also suggests a need to expand the scope of prior art, given that computers are not limited by human distinctions of scientific fields. This would make it more challenging for inventions to be held nonobvious, particularly in the case of inventions that merely combine existing elements in a new configuration (combination patents). That would be a desirable outcome, although the new test would create new challenges.

I. CREATIVE COMPUTERS AND PATENT LAW

This Part investigates instances when AI has created patentable inventions.[23] It finds that machines have been autonomously generating patentable results for at least twenty years and that the pace of such invention is likely increasing.[24] This Part proceeds to discuss the criteria for inventorship and to examine the roles of humans and computers in the inventive process.[25] It concludes that statutory language requiring inventors to be individuals and judicial characterizations of invention as a "mental act" present barriers to computer inventorship, but that computers independently meet the requirements for inventorship otherwise.[26] Finally, this Part notes that applicants seem not to be disclosing the role of creative computers to the Patent Office—likely as a result of uncertainty over whether a computer inventor would render an invention unpatentable.[27]

A. Computers Independently Generate Patentable Results

1. Example One: The Creativity Machine

Computers have been autonomously creating inventions since the twentieth century. In 1994, computer scientist Stephen Thaler disclosed an invention

[22] *See infra* notes 279–287 and accompanying text.
[23] *See infra* notes 23–138 and accompanying text.
[24] *See, e.g.*, Koza, *Human-Competitive Results*, *supra* note 12, at 251 ("[T]he increased availability of computing power (through both parallel computing and Moore's law) should result in the production, in the future, of an increasing flow of human-competitive results, as well as more intricate and impressive results.").
[25] *See infra* notes 100–121 and accompanying text.
[26] *See infra* notes 122–132 and accompanying text.
[27] *See infra* notes 133–138 and accompanying text.

he called the "Creativity Machine," a computational paradigm that "came the closest yet to emulating the fundamental mechanisms responsible for idea formation."[28] The Creativity Machine is able to generate novel ideas through the use of a software concept referred to as artificial neural networks—essentially, collections of on/off switches that automatically connect themselves to form software without human intervention.[29]

At its most basic level, the Creativity Machine combines an artificial neural network that generates output in response to self-stimulation of the network's connections together with another network that perceives value in the stream of output.[30] This results in an AI that "brainstorms" new and creative ideas after it alters (perturbs) the connections within its neural network.[31] An example of this phenomenon occurred after Dr. Thaler exposed the Creativity Machine to some of his favorite music, and the machine proceeded to write eleven thousand new songs in a single weekend.[32]

Dr. Thaler compares the Creativity Machine and its processes to the human brain and consciousness.[33] The two artificial neural networks mimic the human brain's major cognitive circuit: the thalamo-cortical loop.[34] In a simplified model of the human brain, the cortex generates a stream of output (or consciousness), and the thalamus brings attention (or awareness) to ideas that are of interest.[35] Like the human brain, the Creativity Machine is capable of generating novel patterns of information rather than simply associating patterns, and it is capable of adapting to new scenarios without additional human input.[36] Also like the human brain, the AI's software is not written by human beings—

[28] *See What Is the Ultimate Idea?*, IMAGINATION ENGINES INC., http://www.imagination-engines.com [https://perma.cc/P877-F33B] (last visited Jan. 25, 2016).

[29] The architecture for the Creativity Machine is discussed in greater detail in several publications. *See, e.g.*, Stephen L. Thaler, *Synaptic Perturbation and Consciousness*, 6 INT'L J. MACHINE CONSCIOUSNESS 75 (2014) [hereinafter Thaler, *Synaptic Perturbation and Consciousness*]; Stephen Thaler, *Creativity Machine® Paradigm*, *in* ENCYCLOPEDIA OF CREATIVITY, INVENTION, INNOVATION, AND ENTREPRENEURSHIP 451 (Elias G. Carayannis ed., 2013) [hereinafter Thaler, *Creativity Machine® Paradigm*]; S.L. Thaler, *A Proposed Symbolism for Network-Implemented Discovery Processes*, WORLD CONGRESS ON NEURAL NETWORKS '96, SAN DIEGO 1265 (Int'l Neural Network Soc'y 1996) [hereinafter, Thaler, *A Proposed Symbolism*].

[30] *See* Aaron M. Cohen, *Stephen Thaler's Imagination Machines*, THE FUTURIST, July–Aug. 2009, at 28, 28–29.

[31] *See* Thaler, *A Proposed Symbolism*, *supra* note 29, at 1265–68.

[32] *See* Tina Hesman, *Stephen Thaler's Computer Creativity Machine Simulates the Human Brain*, ST. LOUIS POST-DISPATCH, Jan. 24, 2004, *available at* http://www.mindfully.org/Technology/2004/Creativity-Machine-Thaler24jan04.htm [https://perma.cc/T8HS-C2TB].

[33] Thaler, *Creativity Machine® Paradigm*, *supra* note 29, at 447.

[34] *Id.*

[35] *Id.*

[36] *See Artificial Neural Networks*, IMAGINATION ENGINES INC., http://imagination-engines.com/iei_ann.php [https://perma.cc/BB8K-G3FH] (last visited Jan. 25, 2016); *IEI's Patented Creativity Machine® Paradigm*, IMAGINATION ENGINES INC., http://imagination-engines.com/iei_cm.php [https://perma.cc/4A8A-6H3Y] (last visited Jan. 25, 2016).

it is self-assembling.[37] Dr. Thaler argues his AI is very different from a software program that simply generates a spectrum of possible solutions to a problem combined with an algorithm to filter for the best ideas generated.[38] He notes that such a software program would be another method for having an AI developing novel ideas.[39]

Dr. Thaler invented the Creativity Machine, and the machine was the subject of his first patent, titled "Device for the Autonomous Generation of Useful Information."[40] The second patent filed in Dr. Thaler's name was "Neural Network Based Prototyping System and Method."[41] Dr. Thaler is listed as the patent's inventor, but he states that the Creativity Machine invented the patent's subject matter (the "Creativity Machine's Patent").[42] The Creativity Machine's Patent application was first filed on January 26, 1996, and granted on December 22, 1998.[43]

As one of Dr. Thaler's associates observed in response to the Creativity Machine's Patent, "Patent Number Two was invented by Patent Number One. Think about that. Patent Number Two was invented by Patent Number One!"[44] Aside from the Creativity Machine's Patent, the machine is credited with numerous 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.[45]

The Creativity Machine's Patent is interesting for a number of reasons. If Dr. Thaler's claims are accurate, then the Patent Office has already granted, without knowing it has done so, a patent for an invention created by a non-human inventor—and as early as 1998. Also, the Patent Office apparently had no idea it was doing so. Dr. Thaler listed himself as the inventor on the patent

[37] *See* Cohen, *supra* note 29.

[38] *See* Telephone Interview with Stephen Thaler, President and CEO, Imagination Engines, Inc. (Jan. 10, 2016) [hereinafter Thaler, Telephone Interview].

[39] *See id.*

[40] *See* U.S. Patent No. 5,659,666 (filed Oct. 13, 1994).

[41] *See* U.S. Patent No. 5,852,815 (filed May 15, 1998).

[42] *See Patent Listing*, IMAGINATION ENGINES INC., http://imagination-engines.com/iei_ip.php [https://perma.cc/N79N-NWEF] (last visited Jan. 25, 2016).

[43] U.S. Patent No. 5,852,815 (filed May 15, 1998). This application is a divisional of application with serial number 08/592,767 filed Jan. 26, 1996. This means the patent was invented sometime before January 26, 1996. Patent applications require an inventor to actually or constructively possess the invention at the time an application is filed to meet enablement and written description requirements. *See* U.S. PATENT & TRADEMARK OFFICE, MANUAL OF PATENT EXAMINING PROCEDURE § 2164 (9th ed. Rev 7, Nov. 2015) [hereinafter MPEP].

[44] Hesman, *supra* note 32 (quoting Rusty Miller).

[45] Thaler, *Creativity Machine® Paradigm*, *supra* note 29, at 451. Table 1 contains a list of Creativity Machine accomplishments. *Id.*

and did not disclose the Creativity Machine's involvement to the Patent Office. The patent's prosecution history contains no mention of a computer inventor.[46]

2. Example Two: The Invention Machine

The Creativity Machine has not been the only source of computational invention.[47] Software modeled after the process of biological evolution, known as Genetic Programming ("GP"), has succeeded in independently generating patentable results. [48] Evolution is a creative process that relies on a few simple processes: "mutation, sexual recombination, and natural selection."[49] GP emulates these same methods digitally to achieve machine intelligence.[50] It delivers human-competitive intelligence with a minimum amount of human involvement.[51]

As early as 1996, GP succeeded in independently generating results that were the subject of past patents.[52] By 2010, there were at least thirty-one instances in which GP generated a result that duplicated a previously patented invention, infringed a previously issued patent, or created a patentable new invention.[53] In seven of those instances, GP infringed or duplicated the functionality of a twenty-first century invention.[54] Some of those inventions were on the cutting edge of research in their respective fields.[55] In two instances, GP may have created patentable new inventions.[56]

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[46] The file history for this patent is available from a search of the USPTO's website. *Patent Application Information Retrieval*, USPTO, http://portal.uspto.gov/pair/PublicPair [https://perma.cc/7PAM-3EG7] (last visited Jan. 27, 2016). Patent applicants have a duty of candor and good faith in dealing with the Office, which includes a duty to disclose to the Office all information known to be material to patentability. 37 C.F.R. § 1.56 (2012). Indeed, Dr. Thaler completed an inventor's oath or declaration stating that he disclosed to the Office all information known to be material to patentability including the identity of all inventors. *See* 35 U.S.C. § 115 (2012); MPEP, *supra* note 43, § 602.01(b) (listing the standard for patents filed before September 16, 2012). Such oaths are made under penalty of fine or imprisonment, and willful false statements may jeopardize the validity of an application and any future patents. 35 U.S.C. § 115; MPEP, *supra* note 43, § 602.01(a)–(b).

[47] *See generally* Jon Rowe & Derek Partridge, *Creativity: A Survey of AI Approaches*, 7 ARTIFICIAL INTELLIGENCE REV. 43 (1993) (detailing sources of computational inventions).

[48] Koza, *Human-Competitive Results*, *supra* note 12, at 265. Alan Turing identified GP as a method of creating machine intelligence in his 1950 report *Intelligent Machinery*. A.M. TURING, INTELLIGENT MACHINERY 18 (1948) ("[T]he genetical or evolutionary search by which a combination of genes is looked for, the criterion being the survival value.").

[49] John R. Koza et al., *Evolving Inventions*, SCI. AM., Feb. 2003, at 52.

[50] *See id.*

[51] *See id.*

[52] *See* Koza, *Human-Competitive Results*, *supra* note 12, at 255–56, 265.

[53] *See id.*

[54] *See id.*

[55] *See* Koza et al., *Evolving Inventions*, *supra* note 49, at 52.

[56] Koza, *Human-Competitive Results*, *supra* note 12, at 265. These two instances are the inventive act described in U.S. Patent No. 6,847,851 (filed July 12, 2002) and JOHN R. KOZA ET AL., GENETIC PROGRAMMING IV: ROUTING HUMAN-COMPETITIVE MACHINE INTELLIGENCE 102–04 (2003).

The Patent Office granted another patent for a computational invention on January 25, 2005.[57] That invention was created by the "Invention Machine"—the moniker for a GP-based AI developed by John Koza.[58] Dr. Koza is a computer scientist and pioneer in the field of GP, and he claims the Invention Machine has created multiple "patentable new invention[s]."[59] A 2006 article in *Popular Science* about Dr. Koza and the Invention Machine claimed that the AI "has even earned a U.S. patent for developing a system to make factories more efficient, one of the first intellectual-property protections ever granted to a nonhuman designer."[60] The article refers to a patent titled "Apparatus for Improved General-Purpose PID and non-PID Controllers" (the "Invention Machine's Patent").[61] The Invention Machine generated the content of the patent without human intervention and in a single pass.[62] It did so without a database of expert knowledge and without any knowledge about existing controllers.[63] It simply required information about basic components (such as resistors and diodes) and specifications for a desired result (performance measures such as voltage and frequency).[64] With this information, the Invention Machine proceeded to generate different outputs that were measured for fitness (whether an output met performance measures).[65]

Once again, the Patent Office seems to have had no idea of the AI's role in the Invention Machine's Patent.[66] The *Popular Science* article states that Dr. Koza did not disclose the Invention Machine's involvement, and the patent's

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[57] Jonathon Keats, *John Koza Has Built an Invention Machine*, POPULAR SCI. (Apr. 18, 2006), http://www.popsci.com/scitech/article/2006-04/john-koza-has-built-invention-machine [https://web.archive.org/web/20150218225133/http://www.popsci.com/scitech/article/2006-04/john-koza-has-built-invention-machine].

[58] Dr. Koza was also the inventor of the scratch-off lottery ticket in the 1970s. *See Home Page of John R. Koza*, GENETIC PROGRAMMING, http://www.genetic-programming.com/johnkoza.html [https://perma.cc/H77Y-XM4T] (last visited Aug. 8, 2016).

[59] *See* Koza, *Human-Competitive Results*, *supra* note 12, at 265.

[60] Keats, *supra* note 57.

[61] *See id*; U.S. Patent No. '851 (filed July 12, 2002). Although the article does not specifically identify the patent it is referring to, a search of USPTO records reveals only one patent with Dr. Koza listed as an inventor and with a grant date of January 25, 2005. In addition, in 2010, Dr. Koza subsequently identified the 851 Patent as one of two examples in which GP created a patentable new invention. *See* Koza, *Human-Competitive Results*, *supra* note 12, at 265.

[62] KOZA ET AL., GENETIC PROGRAMMING IV, *supra* note 56, at 102–04.

[63] Telephone Interview with John Koza, President, Genetic Programming Inc. (Jan. 22, 2016) [hereinafter Koza, Telephone Interview].

[64] *Id*.

[65] Thus, the GP algorithm is domain independent. Unlike human inventors who often have extensive knowledge of prior inventions and who proceed to build on earlier work, the GP algorithm generated a new controller without any reliance on prior art.

[66] "If the Turing test had been to fool a patent examiner instead of a conversationalist, then January 25, 2005 would have been a date for the history books." PEDRO DOMINGOS, THE MASTER ALGORITHM: HOW THE QUEST FOR THE ULTIMATE LEARNING MACHINE WILL REMAKE OUR WORLD 133–34 (2015).

prosecution history contains no mention of a computer inventor.[67] Dr. Koza states that his legal counsel advised him at the time that his team should consider themselves inventors despite the fact that "the whole invention was created by a computer."[68]

Dr. Koza reports that his agenda in having the Invention Machine recreate previously patented results was to prove that computers could be made to solve problems automatically.[69] He believed that focusing on patentable results would produce compelling evidence that computers were producing something valuable.[70] For that reason, he focused on recreating or inventing patentable subject matter that represented significant scientific advances.[71] For instance, the Invention Machine's Patent was for an improved version of a landmark controller built in 1995.[72]

3. Example Three: Watson

The Creativity Machine and the Invention Machine may be the earliest examples of computer inventors, but others exist.[73] Moreover, the exponential growth in computing power over the past dozen years combined with the increasing sophistication of software should have led to an explosion in the

[67] Indeed, all three of the inventors on the '851 patent, including Dr. Koza, completed an inventor's oath or declaration stating that they disclosed to the Office all information known to be material to patentability including the identity of all inventors.

[68] Koza, Telephone Interview, *supra* note 63.

[69] *Id.*

[70] *Id.*

[71] *Id.* Generating these results *de novo* thus represented a test with an external measure of difficulty, in contrast to other AI researchers who were training computers to complete academic exercises.

[72] *See generally* KARL J. ASTROM & TORE HAGGLUND, PID CONTROLLERS: THEORY, DESIGN, AND TUNING (2d ed. 1995) (detailing original version of the controller for which the Invention Machine created an improved, patentable version).

[73] *E.g.*, Matrix Advanced Solutions used AI to develop a new anticoagulant. *See* Daniel Riester et al., *Thrombin Inhibitors Identified by Computer-Assisted Multiparameter Design*, 102 PROC. NAT'L ACAD. SCI. USA 8597, 8597–602 (2005). Maxygen Inc. used GP to develop a novel Hepatitis C treatment. *See Maxygen's Next-Generation Interferon Alpha Enters Phase Ia Clinical Trial*, MAXYGEN (Nov. 7, 2006), *available at* http://www.prnewswire.com/news-releases/maxygens-next-generation-interferon-alpha-enters-phase-ia-clinical-trial-56073027.html [https://perma.cc/Y9LD-B9EL]. In fact, there is an annual competition for computers producing human-competitive results by genetic and evolutionary computation. *See Humies Awards*, SIGEVO-GECCO, http://sig.sigevo.org/index.html/tiki-index.php?page=Humies+Awards [https://perma.cc/XMG2-DAGY] (last visited Aug. 9, 2016). Dr. Koza states that competition participants have gone on to patent their results. Koza, Telephone Interview, *supra* note 63. For additional examples of "Artificial Inventions," see Plotkin, *supra* note 5, at 61. In his book, Dr. Plotkin uses the metaphor of a genie to argue that AI will change the dynamics of human-computer collaborations. He suggests that humans will write "wishes" (an abstract description of a machine or a set of instructions for creating a machine) for AI to "grant" (by producing the design for a machine or an actual machine). He further argues that fear of invention automation is unnecessary, and that individuals will become more sophisticated at "writing wishes" (defining problems) for AI to solve. He suggests this will result in more skilled inventors and non-inventors becoming inventors with the help of machines. *Id.* at 1–11.

number of computational inventions.[74] Indeed, it is likely that computers are inventing more than ever before.[75] Consider, for instance, the results produced by IBM's AI "Watson" of *Jeopardy!* fame.[76] Watson is a computer system developed by IBM to compete on the game show *Jeopardy!*[77] In 2011, it beat former *Jeopardy!* winners Ken Jennings and Brad Rutter on the show, earning a million dollars in the process.[78]

IBM describes Watson as one of a new generation of machines capable of "computational creativity."[79] IBM uses that term to describe machines that can generate "ideas the world has never imagined before."[80] Watson "generates millions of ideas out of the quintillions of possibilities, and then predicts which ones are [best], applying big data in new ways."[81] This is a fundamentally different type of AI than the Creativity Machine or the Invention Machine; Watson utilizes a more conventional architecture of logical deduction combined with access to massive databases containing accumulated human knowledge and expertise.[82] Although Watson is not modeled after the human brain or evo-

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[74] *See, e.g.*, *50 Years of Moore's Law*, INTEL, http://www.intel.com/content/www/us/en/silicon-innovations/moores-law-technology.html [https://perma.cc/PMN9-XJ2L] (last visited Jan. 26, 2016). In 1965, Gordon Moore, co-founder of Intel and Fairchild Semiconductor, published a paper in which he noted a doubling every year in the number of components in an integrated circuit. Based on this and his subsequent observations, "Moore's Law" became the "golden rule for the electronics industry," predicting that overall processing power for computers will double every eighteen months. *See id*.

[75] *See, e.g.*, Koza, *Human-Competitive Results*, *supra* note 12, at 251 (stating that "the increased availability of computing power (through both parallel computing and Moore's Law) should result in the production, in the future, of an increasing flow of human-competitive results, as well as more intricate and impressive results").

[76] *See* Jo Best, *IBM Watson*, TECHREPUBLIC, http://www.techrepublic.com/article/ibm-watson-the-inside-story-of-how-the-jeopardy-winning-supercomputer-was-born-and-what-it-wants-to-do-next/ [https://perma.cc/BQ4V-Q48F] (last visited Jan. 17, 2016).

[77] *See id.*

[78] *See id.*

[79] *See Computational Creativity*, IBM, http://www.research.ibm.com/cognitive-computing/computational-creativity.shtml#fbid=kwG0oXrjBHY [https://perma.cc/6FK4-WTL3] (last visited Jan. 25, 2016).

[80] *What Is Watson?*, IBM, http://www.ibm.com/smarterplanet/us/en/ibmwatson/what-is-watson.html [https://perma.cc/8KM3-LLSG] (last visited Jan. 25, 2016). Watson is a cognitive commuting system with the extraordinary ability to analyze natural language processing, generate and evaluate hypotheses based on the available data then store and learn from the information. In other words, Watson essentially mirrors the human learning process by getting "smarter [through] tracking feedback from its users and learning from both successes and failures." *Id*. Watson made its notable debut on the game show Jeopardy, where it defeated Brad Rutter and Ken Jennings using only stored data by comparing potential answers and ranking confidence in accuracy at the rate of approximately three seconds per question. *Id*.

[81] *Computational Creativity*, *supra* note 79.

[82] *See, e.g.*, David Ferrucci et al., *Building Watson: An Overview of the DeepQA Project*, AI MAG., Fall 2010, at 59, 68–69; *IBM Watson: Beyond Jeopardy! Q&A*, ACM, http://learning.acm.org/webinar/lally.cfm [https://perma.cc/JA3N-J6HG] (last visited Jan. 25, 2016).

lutionary processes, it is also capable of generating novel, nonobvious, and useful ideas.

Watson's *Jeopardy!* career was short and sweet, and by 2014, it was being applied to more pragmatic challenges, such as running a food truck.[83] IBM developed new algorithms for Watson and incorporated a database with information about nutrition, flavor compounds, the molecular structure of foods, and tens of thousands of existing recipes.[84] This new design permits Watson to generate recipes in response to users inputting a few parameters such as ingredients, dish (e.g., burgers or burritos), and style (e.g., British or dairy-free).[85] On the basis of this user input, Watson proceeds to generate a staggeringly large number of potential food combinations.[86] It then evaluates these preliminary results based on novelty and predicted quality to generate a final output.[87]

It is likely that some of Watson's discoveries in food science are patentable.[88] Patents may be granted for any "new and useful process, machine, manufacture, or composition of matter, or any new and useful improvement thereof."[89] Food recipes can qualify as patentable subject matter on this basis because lists of ingredients combine to form new compositions of matter or manufacture and the steps involved in creating food may be considered a process.[90] To be patentable, however, an invention must not only contain patentable subject matter; it must also be novel, nonobvious, and useful.[91] That may be challenging to achieve in the case of food recipes given that there is a finite number of ingredients and people have been combining ingredients together for a

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[83] *See* Maanvi Singh, *Our Supercomputer Overlord Is Now Running a Food Truck*, NPR (Mar. 4, 2014), http://www.npr.org/blogs/thesalt/2014/03/03/285326611/our-supercomputer-overlord-is-now-running-a-food-truck [https://perma.cc/V7KM-X8P5]; *Chef Watson*, IBM, https://www.ibmchef watson.com/community [https://perma.cc/2D54-UURY] (last visited Jan. 17, 2016); *Under the Hood*, IBM, http://www.ibm.com/smarterplanet/us/en/cognitivecooking/tech.html [https://perma.cc/HWQ8-SEFE] (last visited Jan. 17, 2016).

[84] *See Under the Hood*, *supra* note 83.

[85] *See Watson Cooks Up Computational Creativity*, IBM, http://www.ibm.com/smarterplanet/us/en/innovation_explanations/article/florian_pinel.html [https://perma.cc/GGV7-NHT4] (last visited Jan. 17, 2016).

[86] *See id.*

[87] *See id.*

[88] *See Can Recipes Be Patented?*, INVENTORS EYE (June 2013), http://www.uspto.gov/inventors/independent/eye/201306/ADVICE.jsp [https://perma.cc/EN3V-9DY4]; *see also* Diamond v. Chakrabarty, 447 U.S. 303, 308– 09 (1980) (noting that patentable subject matter "include[s] anything under the sun that is made by man" (quoting S. REP. NO. 82-1979, at 5 (1952); H.R. REP. NO. 82-1923, at 6 (1952))) (internal quotation marks omitted).

[89] 35 U.S.C. § 101 (1952).

[90] *See Can Recipes Be Patented?*, *supra* note 88.

[91] *See General Information Concerning Patents*, USPTO, http://www.uspto.gov/patents-getting-started/general-information-concerning-patents [https://perma.cc/J88J-YUVA] (Oct. 2014).

very long time.[92] Not only would Watson have to create a recipe that no one had previously created, but it could not be an obvious variation on an existing recipe. Still, people do obtain patents on new food recipes.[93] The fact that some of Watson's results have been surprising to its developers and to human chefs is encouraging[94] in this regard[95] because unexpected results are one of the factors considered in determining whether an invention is nonobvious.[96]

Watson is not limited to competing on *Jeopardy!* or to developing new food recipes.[97] IBM has made Watson broadly available to software application providers, enabling them to create services with Watson's capabilities.[98] Watson is now assisting with financial planning, helping clinicians to develop treatment plans for cancer patients, identifying potential research study participants, distinguishing genetic profiles that might respond well to certain drugs, and acting as a personal travel concierge.[99]

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[92] *See* Therese Oneill, *7 of the World's Oldest Foods Discovered by Archeologists*, MENTAL FLOSS (Oct. 8, 2015), http://mentalfloss.com/article/49610/7-world%E2%80%99s-oldest-food-finds [https://perma.cc/Y9C5-DRGP].

[93] *See, e.g.*, U.S. Patent No. 8,354,134 (filed Dec. 22, 2005).

[94] Which is not to say that patents on recipes are a social good. *See generally* KAL RAUSTIALA & CHRISTOPHER SPRIGMAN, THE KNOCKOFF ECONOMY: HOW IMITATION SPARKS INNOVATION (2012) (discussing social ills that can arise from patents).

[95] *See, e.g.*, Rochelle Bilow, *How IBM's Chef Watson Actually Works*, BON APPÉTIT (June 30, 2014), http://www.bonappetit.com/entertaining-style/trends-news/article/how-ibm-chef-watson-works [https://perma.cc/5UAB-VAGW].

[96] MPEP, *supra* note 43, § 716.02(a).

[97] IBM has even worked with food magazine *Bon Appétit* to develop a recipe app called Chef Watson to allow the general public to enlist Watson's help in making new recipes. Rochelle Bilow, *We Spent a Year Cooking with the World's Smartest Computer—and Now You Can, Too*, BON APPÉTIT (June 23, 2015), http://www.bonappetit.com/entertaining-style/trends-news/article/chef-watson-app [https://perma.cc/HF7Q-C9FM]. Chef Watson can be accessed online at https://www.ibmchef watson.com/community [https://perma.cc/2D54-UURY]. For the less technologically inclined who still wish to sample machine cooking, IBM has published a book of Watson's recipes. *See generally* IBM & THE INST. OF CULINARY EDUC., COGNITIVE COOKING WITH CHEF WATSON: RECIPES FOR INNOVATION FROM IBM & THE INSTITUTE OF CULINARY EDUCATION (2015) (detailing recipes created by Watson).

[98] *Watson Cooks Up Computational Creativity*, *supra* note 85.

[99] Anna Edney, *Doctor Watson Will See You Now, if IBM Wins in Congress*, BLOOMBERG BNA HEALTH IT LAW & INDUSTRY REPORT (Jan. 29, 2015), *available at* http://www.post-gazette.com/frontpage/2015/01/29/Doctor-Watson-will-see-you-now-if-IBM-wins-in-Congress/stories/201501290332 [https://perma.cc/4BHU-VJXU]; Thor Olavsrud, *10 IBM Watson-Powered Apps That Are Changing Our World*, CIO (Nov. 6, 2014), http://www.cio.com/article/2843710/big-data/10-ibm-watson-powered-apps-that-are-changing-our-world.html#slide11 [https://perma.cc/NPY7-DDMA].

B. Human and Computer Involvement in Computational Inventions

1. Requirements for Inventorship

All patent applications require one or more named inventors who must be "individuals," a legal entity such as a corporation cannot be an inventor.[100] Inventors own their patents as a form of personal property that they may transfer by "assignment" of their rights to another entity.[101] A patent grants its owner "the right to exclude others from making, using, offering for sale, or selling the invention throughout the United States or importing the invention into the United States."[102] If a patent has multiple owners, each owner may independently exploit the patent without the consent of the others (absent a conflicting contractual obligation).[103] This makes the issue of whether a computer can be an inventor one of practical as well as theoretical interest because inventors have ownership rights in their patents, and failure to list an inventor can result in a patent being held invalid or unenforceable.[104]

For a person to be an inventor, the person must contribute to an invention's "conception."[105] Conception refers to, "the formation in the mind of the inventor of a definite and permanent idea of the complete and operative invention as it is thereafter to be applied in practice."[106] It is "the complete perfor-

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[100] *See* 35 U.S.C. § 100(f) (1952) "The term 'inventor' means the individual or, if a joint invention, the individuals collectively who invented or discovered the subject matter of the invention." *See id*. The same issues surrounding computer inventorship may not exist outside of the U.S. where applications do not require a named inventor. *See* MPEP, *supra* note 43, § 2137.01 ("The requirement that the applicant for a patent in an application filed before September 16, 2012 be the inventor(s) . . . and that the inventor . . . be identified in applications filed on or after September 16, 2012, are characteristics of U.S. patent law not generally shared by other countries."). For example, a patent application at the European Patent Office may be filed by "any body equivalent to a legal person by virtue of the law governing it." Convention on the Grant of European Patents art. 58, Oct. 5, 1973, 1065 U.N.T.S. 199. Under the U.S. Patent Act, only individuals can invent, not corporations. *See* 35 U.S.C. §§ 115–116.

[101] *See* MPEP, *supra* note 43, § 300. About ninety-three percent of patents are assigned to organizations (rather than individuals). *See Patenting by Organizations (Utility Patents)*, USPTO, http://www.uspto.gov/web/offices/ac/ido/oeip/taf/topo_13.htm#PartA1_1b [https://perma.cc/VF56-GFVT] (last modified Jan. 25, 2016). For example, it is common for scientific and technical workers to preemptively assign their patent rights to employers as a condition of employment. Most, but not all, inventions can be placed under an obligation of assignment in employment contracts. For example, in California, employees are permitted to retain ownership of inventions that are developed entirely on their own time without using their employer's equipment, supplies, facilities, or trade secret information except for inventions that either: related, at the time of conception or reduction to practice of the invention, to the employer's business; actual or demonstrably anticipated research or development of the employer; or resulted from any work performed by the employee for the employer. CAL. LAB. CODE § 2872(a) (West 1979).

[102] 35 U.S.C. § 154.

[103] *See* MPEP, *supra* note 43, § 2137.

[104] *See, e.g.*, Advanced Magnetic Closures, Inc. v. Rome Fastener Corp., 607 F.3d 817, 829 (Fed. Cir. 2010).

[105] MPEP, *supra* note 43, § 2137.01(II).

[106] Townsend v. Smith, 36 F.2d 292, 295 (C.C.P.A. 1929).

mance of the mental part of the inventive act."[107] After conception, someone with ordinary skill in the invention's subject matter (e.g., a chemist if the invention is a new chemical compound) should be able to "reduce the invention to practice."[108] That is to say, they should be able to make and use an invention from a description without extensive experimentation or additional inventive skill.[109] Individuals who simply reduce an invention to practice, by describing an already conceived invention in writing or by building a working model from a description for example, do not qualify as inventors.[110]

2. The Role of Computers in Inventive Activity

The requirement that an inventor participate in the conception of an invention creates barriers to inventorship for computers as well as people. Although computers are commonly involved in the inventive process, in most cases, computers are essentially working as sophisticated (or not-so-sophisticated) tools. One example occurs when a computer is functioning as a calculator or storing information. In these instances, a computer may assist a human inventor to reduce an invention to practice, but the computer is not participating in the invention's *conception*. Even when computers play a more substantive role in the inventive process, such as by analyzing data in an auto-

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[107] *Id.*

[108] Reduction to practice refers to either actual reduction—where it can be demonstrated the claimed invention works for its intended purpose (for example, with a working model)—or to constructive reduction—where an invention is described in writing in such a way that it teaches a person of ordinary skill in the subject matter to make and use the invention (as in a patent application). *See In re* Hardee, 223 U.S.P.Q. (BNA) 1122, 1123 (Com'r Pat. & Trademarks Apr. 3, 1984); *see also* Bd. of Educ. *ex rel.* Bd. of Trs. of Fla. State Univ. v. Am. Bioscience, Inc., 333 F.3d 1330, 1340 (Fed. Cir. 2003) ("Invention requires conception."). With regard to the inventorship of chemical compounds, an inventor must have a conception of the specific compounds being claimed. *See Am. Bioscience*, 333 F.3d at 1340 ("[G]eneral knowledge regarding the anticipated biological properties of groups of complex chemical compounds is insufficient to confer inventorship status with respect to specifically claimed compounds."); *see also Ex parte* Smernoff, 215 U.S.P.Q 545, 547 (Pat. & Tr. Office Bd.App. Aug. 17,1982) ("[O]ne who suggests an idea of a result to be accomplished, rather than the means of accomplishing it, is not a coinventor."). Actual reduction to practice "requires that the claimed invention work for its intended purpose." Brunswick Corp. v. United States, 34 Fed. Cl. 532, 584 (1995) (quotations omitted) (quoting Hybritech Inc. v. Monoclonal Antibodies, Inc., 802 F.2d 1367, 1376 (Fed. Cir. 1986). Constructive reduction to practice "occurs upon the filing of a patent application on the claimed invention." *Id.* The written description requirement is "to ensure that the inventor had possession, as of the filing date of the application relied on, of the specific subject matter later claimed by him." *Application of* Edwards, 568 F.2d 1349, 1351 (C.C.P.A. 1978).

[109] "[C]onception is established when the invention is made sufficiently clear to enable one skilled in the art to reduce it to practice without the exercise of extensive experimentation or the exercise of inventive skill." Hiatt v. Ziegler & Kilgour , 179 U.S.P.Q. 757, 763 (Bd. Pat. Interferences Apr. 3, 1973). Conception has been defined as a disclosure of an idea that allows a person skilled in the art to reduce the idea to a practical form without "exercise of the inventive faculty." Gunter v. Stream, 573 F.2d 77, 79 (C.C.P.A. 1978).

[110] *See* De Solms v. Schoenwald, 15 U.S.P.Q. 2d 1507, 1510 (Bd.Pat.App.& Interferences. Feb. 22, 1990).

mated fashion, retrieving stored knowledge, or by recognizing patterns of information, the computer still may fail to contribute to conception. Computer involvement might be conceptualized on a spectrum: on one end, a computer is simply a tool assisting a human inventor; on the other end, the computer independently meets the requirements for inventorship. AI capable of acting autonomously such as the Creativity Machine and the Invention Machine fall on the latter end of the spectrum.

3. The Role of Humans in Inventive Activity

Just as computers can be involved in the inventive process without contributing to conception, so can humans. For now, at least, computers do not entirely undertake tasks on their own accord. Computers require some amount of human input to generate creative output.

For example, before the Creativity Machine composed music, Dr. Thaler exposed it to existing music and instructed it to create something new.[111] Yet, simply providing a computer with a task and starting materials would not make a human an inventor.[112] Imagine Friend *A* tells Friend *B*, who is an engineer, that *A* would like *B* to develop an iPhone battery with twice the standard battery life and *A* gives *B* some publically available battery schematics. If *B* then succeeds in developing such a battery, *A* would not qualify as an inventor of the battery by virtue of having instructed *B* to create a result.[113] This scenario essentially occurred in the case of the Creativity Machine's toothbrush invention: Dr. Thaler provided the Creativity Machine information on existing toothbrush designs along with data on each brush's effectiveness.[114] Solely from this information, the Creativity Machine produced the first ever crossed-bristle design.[115] This does not make Dr. Thaler an inventor. In the case of the Creativity Machine, the creative act is the result of random or chaotic perturbations in the machine's existing connections that produce new results which, in turn, are judged by the machine for value.[116]

Humans are also necessarily involved in the creative process because computers do not arise from a void; in other words, humans have to create computers.[117] Once again, that should not prevent computer inventorship. No

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[111] Thaler, Telephone Interview, *supra* note 38.

[112] *Ex parte* Smernoff, 215 U.S.P.Q. at 547 ("[O]ne who suggests an idea of a result to be accomplished, rather than the means of accomplishing it, is not a coinventor.").

[113] *See id.*

[114] Thaler, Telephone Interview, *supra* note 38.

[115] *Id.*

[116] *See* Thaler, *Creativity Machine® Paradigm*, *supra* note 29, at 449.

[117] This will be the case until computers start designing other computers or engaging in reflection. Reflection is a software concept that refers to a computer program that can examine itself and modify its own behavior (and even its own code). J. Malenfant et al., *A Tutorial on Behavioral Reflection and Its Implementation*, *in* PROCEEDINGS OF THE FIRST INTERNATIONAL CONFERENCE REFLECTION 1, 1–

one would exist without their parents contributing to their conception (pun intended), but that does not make parents inventors on their child's patents. If a computer scientist creates an AI to autonomously develop useful information and the AI creates a patentable result in an area not foreseen by the inventor, there would be no reason for the scientist to qualify as an inventor on the AI's result. An inventor must have formed a "definite and permanent idea of the complete and operative invention" to establish conception.[118] The scientist might have a claim to inventorship if he developed the AI to solve a particular problem, and it was foreseeable that the AI would produce a particular result.[119]

4. Combining Human and Computer Creativity

A computer may not be a sole inventor; the inventive process can be a collaborative process between human and machine. If the process of developing the Creativity Machine's Patent had been a back-and-forth process with both the AI and Dr. Thaler contributing to conception, then both might qualify as inventors.[120] By means of illustration, suppose a human engineer provides a machine with basic information and a task. The engineer might learn from the machine's initial output, then alter the information that he or she provides to the machine to improve its subsequent output. After several iterations, the machine might produce a final output that the human engineer might directly alter to create a patentable result. In such a case, both the engineer and the machine might have played a role in conception. Leaving AI aside, invention is rarely occurs in a vacuum, and there are often joint inventors on patents.[121] In some of these instances, if a computer were human, it would be an inventor. Yet, computers are not human, and, as such, they face unique barriers to qualifying as inventors.

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20 (1996), *available at* http://www2.parc.com/csl/groups/sda/projects/reflection96/docs/malenfant/malenfant.pdf [https://perma.cc/7EKK-7BJT].

[118] *Townsend*, 36 F.2d at 295.

[119] *See generally* Shyamkrishna Balganesh, *Foreseeability and Copyright Incentives*, 122 HARV. L. REV. 1569 (2009) (discussing foreseeability in the patent context).

[120] What is required is some "quantum of collaboration or connection." Kimberly-Clark Corp. v. Procter & Gamble Distrib. Co., 973 F.2d 911, 917 (Fed. Cir. 1992). For joint inventorship, "there must be some element of joint behavior, such as collaboration or working under common direction, one inventor seeing a relevant report and building upon it or hearing another's suggestion at a meeting." *Id.*; *see also* Moler & Adams v. Purdy, 131 U.S.P.Q. 276, 279 (Bd. Pat. Interferences 1960) ("[I]t is not necessary that the inventive concept come to both [joint inventors] at the same time.").

[121] *See* Prerna Wardhan & Padmavati Manchikanti, *A Relook at Inventors' Rights*, 18 J. INTELL. PROP. RIGHTS 168, 169 (2013).

C. Barriers to Computer Inventorship

1. The Legal Landscape

Congress is empowered to grant patents on the basis of the Patent and Copyright Clause of the Constitution.[122] That clause enables Congress "[t]o 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."[123] It also provides an explicit rationale for granting patent and copyright protection, namely to encourage innovation under an incentive theory.[124] The theory goes that people will be more inclined to invent things (i.e., promote the progress of science) if they can receive government-sanctioned monopolies (i.e., patents) to exploit commercial embodiments of their inventions. Having the exclusive right to sell an invention can be tremendously lucrative.[125]

The Patent Act, which here refers to United States patent law as a whole, provides at least a couple of challenges to computers qualifying as inventors under the Patent and Copyright Clause.[126] First, as previously mentioned, the Patent Act requires that inventors be "individuals."[127] This language has been in place since at least the passage of legislation in 1952 that established the basic structure of modern patent law.[128] The "individual" requirement likely was included to reflect the constitutional language that specifically gives "in-

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[122] U.S. CONST. art. I, § 8, cl. 8. This clause is also sometimes referred to as the "Patent Clause" or the "Copyright Clause."

[123] *Id.*

[124] *See* Mark A. Lemley, *Ex Ante Versus Ex Post Justifications for Intellectual Property*, 71 U. CHI. L. REV. 129, 129 (2004) ("The standard justification for intellectual property is ex ante . . . . It is the prospect of the intellectual property right that spurs creative incentives.").

[125] *See* JOHN STUART MILL, PRINCIPLES OF POLITICAL ECONOMY WITH SOME OF THEIR APPLICATIONS TO SOCIAL PHILOSOPHY 563 (Prometheus Books 2004) (1872) (noting that under a patent system, "the greater the usefulness, the greater the reward").

[126] Legislation pertaining to patents is found under Title 35 of the United States Code. The Patent Act may also be used to refer to specific pieces of legislation ranging from the Patent Act of 1790, the first patent law passed by the federal government, to the Patent Act of 1952. Pub. L. No. 82-593, 66 Stat. 792 (1952).

[127] *E.g.*, 35 U.S.C. § 100(f) ("The term 'inventor' means the individual or, if a joint invention, the individuals collectively who invented or discovered the subject matter of the invention."). The same issues surrounding computer inventorship may not exist outside of the U.S. where applications do not require a named inventor. *See* MPEP, *supra* note 43, § 2137.01 ("The requirement that the applicant for a patent in an application filed before September 16, 2012 be the inventor(s), . . . and that the inventor . . . be identified in applications filed on or after September 16, 2012, are characteristics of U.S. patent law not generally shared by other countries."). For example, a patent application at the European Patent Office may be filed by "any body equivalent to a legal person by virtue of the law governing it." Convention on the Grant of European Patents, *supra* note 100, at art. 58; *see also* 35 U.S.C. §§ 115–116.

[128] Pub. L. No. 82-593, 66 Stat. 792 (1952); *see also* Gregory Dolin, *Dubious Patent Reform*, 56 B.C. L. REV. 881, 889 (2015) (discussing aims of 1952 Patent Act).

ventors" the right to their discoveries as opposed to other legal entities that might assert ownership rights.[129] Such language would help to ensure that patent rights were more likely to go to individual inventors than to corporate entities where ownership was disputed.[130] Legislators were not thinking about computational inventions in 1952.[131] Second, patent law jurisprudence requires that inventions be the result of a "mental act."[132] So, because computers are not individuals and it is questionable that they engage in a mental act, it is unclear whether a computer autonomously conceiving of a patentable invention could legally be an inventor.

2. Avoiding Disclosure of Artificially Intelligent Inventors

Given that computers are functioning as inventors, and likely inventing at an escalating rate, it would seem that the Patent Office should be receiving an increasing number of applications claiming computers as inventors. That the Patent Office has not suggests that applicants are choosing not to disclose the role of AI in the inventive process.[133] That may be due to legal uncertainties about whether an AI inventor would render an invention unpatentable.[134]

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[129] In the words of the United States Court of Appeals for the Federal Circuit, "people conceive, not companies." New Idea Farm Equip. Corp. v. Sperry Corp., 916 F.2d 1561, 1566 n.4 (Fed. Cir. 1990).

[130] Now under the America Invents Act ("AIA"), a corporate entity can apply for a patent on behalf of an inventor who is under an assignment obligation. MPEP, *supra* note 43, § 325.

[131] *See* Karl F. Milde, Jr., *Can a Computer Be an "Author" or an "Inventor"?*, 51 J. PAT. OFF. SOC'Y 378, 379 (1969). As one commentator notes:

> The closest that the Patent Statute comes to requiring that a patentee be an actual person is in the use, in Section 101, of the term "whoever." Here too, it is clear from the absence of any further qualifying statements that the Congress, in considering the statute in 1952, simply overlooked the possibility that a machine could ever become an inventor.

Id.; *see also, e.g.*, A.M. Turing, *Computing Machinery and Intelligence*, 59 MIND 433, 433–51 (1950) [hereinafter Turing, *Computing Machinery and Intelligence*].

[132] Conception has been defined as "the complete performance of the mental part of the inventive art," and it is "the formation in the mind of the inventor of a definite and permanent idea of the complete and operative invention as it is thereafter to be applied in practice." *Townsend*, 36 F.2d at 295.

[133] *See supra* note 5 and accompanying text. The discussion in note 5 infers that the Patent Office has not received applications claiming computers as inventors because they have no policy or guidance on the subject, they do not seem to have ever addressed the issue in any publication, and because computer inventorship does not seem to have been at issue in any patent litigation.

[134] *See, e.g.*, Dane E. Johnson, *Statute of Anne-imals: Should Copyright Protect Sentient Nonhuman Creators?*, 15 ANIMAL L. 15, 23 (2008) (quoting one Copyright Office employee who explained that "[as] a practical matter[,] the Copyright Office would not register [a computer's own] work if its origins were accurately represented on the copyright application. The computer program itself would be registerable if it met the normal standards for computer programs, but not the computer-generated literary work.") Despite this policy and the Copyright Office's Compendium guidelines, numerous computer-authored works have been registered. *See, e.g.*, William T. Ralston, *Copyright in Computer-Composed Music: Hal Meets Handel*, 52 J. COPYRIGHT SOC'Y OF THE U.S.A. 281, 283 (2004) (noting

Without a legal inventor, new inventions would not be eligible for patent protection and would enter the public domain after being disclosed.[135]

There is another reason why computers might not be acknowledged: a person can qualify as an inventor simply by being the first individual to recognize and appreciate an existing invention.[136] That is to say, someone can discover rather than create an invention. Uncertainty (and accident) is often part of the inventive process.[137] In such cases, an individual need only understand the importance of an invention to qualify as its inventor.[138] For the purposes of this Article, assuming 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. So, it may be the case that computational inventions are only patentable when an individual subsequently discovers them.

II. IN SUPPORT OF COMPUTER INVENTORS

This Part examines the law regarding non-human authorship of copyrightable material.[139] It discusses the history of the Copyright Office's Human Authorship Requirement.[140] This Part also scrutinizes case law interpreting the Patent and Copyright Clause.[141] On the basis of this analysis and principles of dynamic statutory interpretation, this Part argues that computers should qualify as legal inventors.[142] This would incentivize the development of creative ma-

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one computer-authored volume of poetry registered to a computer author, "Racter," but still not explicitly disclosed to be a computer). In 1993, Scott French programmed a computer to write in the style of a famous author, and the resulting work was registered as an "original and computer aided text." Tal Vigderson, Comment, *Hamlet II: The Sequel? The Rights of Authors vs. Computer-Generated "Read-Alike" Works*, 28 LOY. L.A. L. REV. 401, 402–03 (1994). The novel was apparently terrible. *See* Patricia Holt, *Sunday Review*, S.F. CHRON., Aug. 15, 1993, B4 ("[t]he result is a mitigated disaster").

[135] *See* MPEP, *supra* note 43, § 2137.

[136] Conception requires contemporaneous recognition and appreciation of the invention. *See* Invitrogen Corp. v. Clontech Labs., Inc., 429 F.3d 1052, 1064 (Fed. Cir. 2005) (noting that the inventor must have actually made the invention and understood the invention to have the features that comprise the inventive subject matter at issue); *see also, e.g.*, Silvestri v. Grant, 496 F.2d 593, 597 (C.C.P.A. 1974) ("[A]n accidental and unappreciated duplication of an invention does not defeat the patent right of one who, though later in time, was the first to recognize that which constitutes the inventive subject matter.").

[137] For instance, Alexander Fleming discovered penicillin in a mold that had contaminated his samples of Staphylococcus. Howard Markel, *The Real Story Behind Penicillin*, PBS (Sep. 27, 2013), http://www.pbs.org/newshour/rundown/the-real-story-behind-the-worlds-first-antibiotic/ [https://perma.cc/V6SM-2QJL].

[138] *See Silvestri*, 496 F.2d at 597.

[139] *See infra* notes 139–239 and accompanying text.

[140] COMPENDIUM OF U.S. COPYRIGHT OFFICE PRACTICES, *supra* note 14, § 306.

[141] U.S. CONST. art. I, § 8, cl. 8.

[142] *See generally* Eskridge, *Dynamic Statutory Interpretation*, *supra* note 16 (discussing canons of statutory interpretation).

chines consistent with the purpose and intent of the Founders and Congress. The requirement that inventors be individuals was designed to prevent corporate ownership, and, therefore, computer inventorship should not be prohibited on this basis.[143] Also, there should be no requirement for a mental act because patent law is concerned with the nature of an invention itself rather than the subjective mental process by which an invention may have been achieved.[144] This Part concludes by addressing objections to computer inventorship including arguments that computational inventions would develop in the absence of patent protection at non-monopoly prices.[145]

A. Nonhuman Authors of Copyrightable Material

The Patent Act does not directly address the issue of a computer inventor. The Patent Office has never issued guidance addressing the subject, and there appears to be no case law on the issue of whether a computer could be an inventor. That is the case despite the fact that the Patent Office appears to have already granted patents for inventions by computers but, as previously discussed, did so unknowingly.

There is, however, guidance available from the related issue of nonhuman authorship of copyrightable works.[146] Nonhuman authorship is not governed by statute, but there is interesting case law on the subject. Also, since at least 1984 the Copyright Office has conditioned copyright registration on human authorship.[147] In its 2014 compendium, the Copyright Office published an updated "Human Authorship Requirement" which states that:

> To qualify as a work of "authorship" a work must be created by a human being. . . . The Office will not register works produced by nature, animals, or plants. . . . Similarly, the Office will not register

[143] *See infra* notes 206–208 and accompanying text.

[144] *See, e.g.*, *The "Flash of Genius" Standard of Patentable Invention*, *supra* note 18, at 86.

[145] *See* notes 189–239 and accompanying text.

[146] The issue of computer authorship (and inventorship) has been considered "since the 1960s when people began thinking about the impact of computers on copyright." Arthur R. Miller, *Copyright Protection for Computer Programs, Databases, and Computer-Generated Works: Is Anything New Since CONTU?*, 106 HARV. L. REV. 977, 1043 (1993). Most of the literature related to computer generated works has focused on copyright rather than patent protection. "In the secondary literature on copyright, rivers of ink are spilt on" whether computers can be considered authors. MELVILLE B. NIMMER & DAVID NIMMER, NIMMER ON COPYRIGHT § 5.01[A] (LexisNexis 2015).

[147] COMPENDIUM OF U.S. COPYRIGHT OFFICE PRACTICES, *supra* note 14, § 202.02(b). The *Compendium of U.S. Copyright Office Practices* elaborates on the "human authorship" requirement by stating: "The term 'authorship' implies that, for a work to be copyrightable, it must owe its origin to a human being. Materials produced solely by nature, by plants, or by animals are not copyrightable." *Id.* It further elaborates on the phrase "[w]orks not originated by a human author" by stating: "In order to be entitled to copyright registration, a work must be the product of human authorship. Works produced by mechanical processes or random selection without any contribution by a human author are not registrable." *Id.* § 503.03(a).

> works produced by a machine or mere mechanical process that operates randomly or automatically without any creative input or intervention from a human author.[148]

This policy was the result of many years of debate within the Copyright Office.[149]

The requirement is based on jurisprudence that dates long before the invention of modern computers to the *In re Trade-Mark Cases* in 1879, in which the U.S. Supreme Court interpreted the Patent and Copyright Clause to exclude the power to regulate trademarks.[150] In interpreting this clause, the Court stated, in dicta, that the term "writings" may be construed liberally but noted that only writings that are "original, and are founded in the creative powers of the mind" may be protected.[151]

The issue of computer authorship was implicit in the Court's celebrated case of *Burrow-Giles Lithographic Co. v. Sarony* in 1884.[152] In that case, a lithographic company argued that a photograph of Oscar Wilde did not qualify as a "writing" or as the work of an "author."[153] The company further argued that even if a visual work could be copyrighted, that a photograph should not qualify for protection because it was just a mechanical reproduction of a natural phenomenon and thus could not embody the intellectual conception of its author.[154] The Court disagreed, noting that all forms of writing "by which the ideas in the mind of the author are given visible expression" were eligible for copyright protection.[155] The Court stated that although ordinary photographs might not embody an author's "idea," in this particular instance, the photographer had exercised enough control over the subject matter that it qualified as an original work of art.[156] Therefore, the case explicitly addressed whether the camera's involvement negated human authorship, and it implicitly dealt with

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[148] *Id.* § 313.2.

[149] *See, e.g.*, U.S. COPYRIGHT OFFICE, EIGHTY-SECOND ANNUAL REPORT OF THE REGISTER OF COPYRIGHTS 18 (1979) (discussing issues related to computer authorship).

[150] *See generally In re* Trade-Mark Cases, 100 U.S. 82 (1879) (finding that the Patent and Copyright Clause excludes regulating trademarks). Congress, which does indeed enjoy the ability to regulate trademarks, passed the Trade Mark Act of 1881 two years after this case was decided. That Act gave Congress the authority to regulate trademarks on the basis of the Commerce Clause.

[151] *Id.* at 94. The Court in this case held that only original works of art, which are the "fruits of intellectual labor," may be protected under copyright law. *Id.* (emphasis omitted).

[152] *See* Burrow-Giles Lithographic Co. v. Sarony, 111 U.S. 53, 56 (1884).

[153] *Id.*

[154] *Id.* at 58–59.

[155] *Id.* at 58.

[156] *Id.* at 54–55. Protections for all photographs was eventually made a part of the statutory scheme for copyright protection. 17 U.S.C. § 106A (2012). In the words of Judge Learned Hand, "no photograph, however simple, can be unaffected by the personal influence of the author, and no two will be absolutely alike." Jewelers' Circular Pub. Co. v. Keystone Pub. Co., 274 F. 932, 934 (S.D.N.Y. 1921), *aff'd*, 281 F. 83 (2d Cir. 1922).

the question of whether a camera could be considered an author. Though it seems unwise to put much emphasis on dicta from more than a century ago to resolve the question of whether nonhumans could be authors, the Copyright Office cites *Burrow-Giles* in support of its Human Authorship Requirement.[157]

The Copyright Office first addressed the issue of computer authors in 1966 when the Register of Copyrights, Abraham Kaminstein, questioned whether computer-generated works should be copyrightable.[158] Mr. Kaminstein reported that, in 1965, the Copyright Office had received applications for computer-generated works including: an abstract drawing, a musical composition, and compilations that were, at least partly, the work of computers.[159] Mr. Kaminstein did not announce a policy for dealing with such applications but suggested the relevant issue should be whether a computer was merely an assisting instrument (as with the camera in *Burrow-Giles*) or whether a computer conceived and executed the traditional elements of authorship.[160]

In the following years, the Copyright Office struggled with how to deal with computers more broadly.[161] At that time, copyright law did not even address the issue of whether computer software should be copyrightable—a far more urgent and financially important problem.[162]

In 1974, Congress created the Commission on New Technological Uses of Copyrighted Works ("CONTU") to study issues related to copyright and computer-related works.[163] With regards to computer authorship, CONTU wrote in 1979 that there was no need for special treatment of computer-generated works because computers were not autonomously generating creative results without human intervention; computers were simply functioning as tools to assist human authors.[164] CONTU also declared that autonomously creative AI was not immediately foreseeable.[165] The Commission unanimously concluded that "[w]orks created by the use of computers should be afforded copyright protection if they are original works of authorship within the Act of 1976."[166] According to the Commission, "the author is [the] one who employs

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[157] *See* COMPENDIUM OF U.S. COPYRIGHT OFFICE PRACTICES, *supra* note 14, § 306.

[158] *See* U.S. COPYRIGHT OFFICE, SIXTY-EIGHTH ANN. REP. REG. COPYRIGHTS 4–5 (1966).

[159] *Id.*

[160] *See id.*

[161] *See* Act of Dec. 31, 1974, Pub. L. No. 93-573, § 201, 88 Stat. 1873, 1873–74; *see also* H.R. REP. NO. 1476, 94th Cong., 2d Sess. 116 (1976), *reprinted in* 1976 U.S.C.C.A.N. 5731, 5731 (discussing issues regarding computers and copyrights). These issues had not been addressed in the 1974 Copyright Act. Pub. L. No. 94-553, § 117, 90 Stat. 2565 (1976), *repealed by* Computer Software Protection Act, Pub. L. No. 96-517, § 117, 94 Stat. 3028 (1980) (codified at 17 U.S.C. § 117 (1988)).

[162] *See* Act of Dec. 31, 1974 § 201.

[163] *Id.* § 201(a)–(b).

[164] *See* NAT'L COMM'N ON NEW TECH. USES OF COPYRIGHTED WORKS, FINAL REPORT ON NEW TECHNOLOGICAL USES OF COPYRIGHTED WORKS 44 (1979).

[165] *See id.*

[166] *Id.* at 1.

the computer."[167] Former CONTU Commissioner Arthur Miller explained that "CONTU did not attempt to determine whether a computer work generated with little or no human involvement is copyrightable."[168] Congress subsequently codified CONTU's recommendations.[169]

Nearly a decade later, in 1986, advances in computing prompted the U.S. Congress's Office of Technology Assessment ("OTA") to issue a report arguing that CONTU's approach was too simplistic and computer programs were more than "inert tools of creation."[170] The OTA report contended that, in many cases, computers were at least "co-creators."[171] The OTA did not dispute that computer-generated works should be copyrightable, but it did foresee problems with determining authorship.[172]

The 2014 iteration of the Human Authorship Requirement was partially the result of a prominent public discourse about nonhuman authorship stemming from the "Monkey Selfies."[173] The Monkey Selfies are a series of images that a Celebes crested macaque took of itself in 2011 using equipment belonging to the nature photographer David Slater.[174] Mr. Slater reports that he staged the photographs by setting up a camera on a tripod and leaving a remote trigger for the macaque to use.[175] He subsequently licensed the photographs,

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[167] *Id*. at 45. This rule is largely similar in British law: "In the case of a literary, dramatic, musical or artistic work which is computer-generated, the author shall be taken to be the person by whom the arrangements necessary for the creation of the work are undertaken." Copyright, Designs and Patent Act 1988, c. 48 § 9(3) (UK). "'Computer-generated,' in relation to a work, means that the work is generated by computer in circumstances such that there is no human author of the work." *Id.* § 178.

[168] Miller, *supra* note 146, at 1070. Professor Miller continued to argue in 1993 that "computer science does not appear to have reached a point at which a machine can be considered so 'intelligent' that it truly is creating a copyrightable work." *Id*. at 1073. Rather, "for the foreseeable future, the copyrightability of otherwise eligible computer-generated works can be sustained because of the significant human element in their creation, even though there may be some difficulty is assigning authorship." *Id.*

[169] *See* 17 U.S.C. § 117.

[170] *See* U.S. CONGRESS, OFFICE OF TECH. ASSESSMENT, INTELLECTUAL PROPERTY RIGHTS IN AN AGE OF ELECTRONICS AND INFORMATION 70–73 (1986). As stated by the OTA:

> Courts will then be left with little guidance, and even less expertise, to solve these highly complex conceptual and technological issues. . . . [E]ither the legislature or the courts will have to confront some questions that will be very difficult to resolve under the present system. These include: . . . What of originality in works that are predominately automated? Who is the author? Providing answers to these questions will become more urgent as creative activities continue to fuse with machine intelligence.

Id. at 71–73.

[171] *Id*. at 72.

[172] *Id*. at 73.

[173] *See* Naruto v. Slater, No. 3:2015-cv-04324, 2016 WL 362231, *1 (N.D. Cal. Jan. 23, 2016).

[174] *Id*. at *1.

[175] *See Sulawesi Macaques*, DJS PHOTOGRAPHY, http://www.djsphotography.co.uk/original_story.html [https://perma.cc/H93K-8CB9] (last visited Jan. 26, 2016) (showing Mr. Slater's photographs and providing an overview of how he staged them). The claim by Mr. Slater that he engineered the shoot is controversial based on his earlier reports of the event in question. *See* Mike Masnick,

claiming he owned their copyright.[176] Other parties then reposted the photographs without his permission and over his objections, asserting that he could not copyright the images without having taken them directly.[177] On December 22, 2014, the Copyright Office published its Human Authorship Requirement, which specifically lists the example of a photograph taken by a monkey as something not protectable.[178]

In September 2015, People for the Ethical Treatment of Animals ("PETA") filed a copyright infringement suit against Mr. Slater on behalf of Naruto, the monkey it purports took the Monkey Selfies, asserting that Naruto was entitled to copyright ownership.[179] On January 28, 2016, U.S. District Judge William H. Orrick III dismissed PETA's lawsuit against Slater.[180] Judge Orrick reasoned that the issue of the ability for animals to obtain a copyright is "an issue for Congress and the President."[181] The case is currently under appeal in the Ninth Circuit.[182]

B. Computers Should Qualify as Legal Inventors

1. Arguments Supporting Computer Inventors

Preventing patents on computational inventions by prohibiting computer inventors, or allowing such patents only by permitting humans who have discovered the work of creative machines to be inventors, is not an optimal system. In the latter case, AI may be functioning more or less independently, and it is only sometimes the case that substantial insight is needed to identify and understand a computational invention. Imagine that Person *C* instructs their AI to develop an iPhone battery with twice the standard battery life and gives it some publically available battery schematics. The AI could produce results in the form of a report titled "Design for Improved iPhone Battery"—complete with schematics and potentially even pre-formatted as a patent application. It seems inefficient and unfair to reward *C* for recognizing the AI's invention when *C* has not contributed significantly to the innovative process.

Photographer David Slater Claims That Because He Thought Monkeys Might Take Pictures, Copyright Is His, TECHDIRT (July 15, 2011), https://www.techdirt.com/articles/20110714/16440915097/photographer-david-slater-claims-that-because-he-thought-monkeys-might-take-pictures-copyright-is-his.shtml [https://perma.cc/MA7S-PFJ9].

[176] *See Naruto*, 2016 WL 362231, at *1.

[177] *See* Masnick, *supra* note 175.

[178] COMPENDIUM OF U.S. COPYRIGHT OFFICE PRACTICES, *supra* note 14, § 313.2.

[179] *See Naruto*, 2016 WL 362231, at *1.

[180] *Id.*

[181] *See id.*; Beth Winegarner, *'Monkey Selfie' Judge Says Animals Can't Sue Over Copyright*, LAW 360 (Jan. 6, 2016), https://www.cooley.com/files/'MonkeySelfie'JudgeSaysAnimalsCan'tSueOverCopyright.pdf [https://perma.cc/2CUG-2JDT].

[182] *See generally* Opening Brief of Plaintiff-Appellant, Naruto v. Slater, No. 3:15-cv-04324 (9th Cir. July 28, 2016) (arguing for the appeal of the district court's decision).

Such a system might also create logistical problems. If *C* had created an improved iPhone battery as a human inventor, *C* would be its inventor regardless of whether anyone subsequently understood or recognized the invention. If *C* instructed *C*'s AI to develop an improved iPhone battery, the first person to notice and appreciate the AI's result could become its inventor (and prevent *C* from being an inventor). 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.

More ambitiously, treating computational inventions as patentable and recognizing creative computers as inventors would be consistent with the Constitutional rationale for patent protection.[183] It would encourage innovation under an incentive theory. Patents on computational inventions would have substantial value independent of the value of creative computers; allowing computers to be listed as inventors would reward human creative activity upstream from the computer's inventive act. Although AI would not be motivated to invent by the prospect of a patent, it would motivate computer scientists to develop creative machines. Financial incentives may be particularly important for the development of creative computers because producing such software is resource intensive.[184] Though the impetus to develop creative AI might still exist if computational inventions were considered patentable but computers could not be inventors, the incentives would be weaker owing to the logistical, fairness, and efficiency problems such a situation would create.

There are other benefits to patents beyond providing an *ex ante* innovation incentive. Permitting computer inventors and patents on computational inventions might also promote disclosure and commercialization.[185] Without the ability to obtain patent protection, owners of creative computers might choose to protect patentable inventions as trade secrets without any public dis-

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[183] *See* U.S. CONST. art. I, § 8, cl. 8. Among those addressing the patentability implications of computational invention, Ralph Clifford has argued that works generated autonomously by computers should remain in the public domain unless AI develops a consciousness that allows it to respond to the Copyright Act's incentives. *See* Clifford, *supra* note 4, at 1702–03; *see also* Liza Vertinsky & Todd M. Rice, *Thinking About Thinking Machines: Implications of Machine Inventors for Patent Law*, 8 B.U. J. SCI. & TECH. L. 574, 581 (2002). Colin R. Davies has argued more recently that a computer should be given legal recognition as an individual under UK law to allow proper attribution of authorship and to allow respective claims to be negotiated through contract. *See generally* Colin R. Davies, *An Evolutionary Step in Intellectual Property Rights—Artificial Intelligence and Intellectual Property*, 27 COMPUT. L. & SEC. REV. 601 (2011).

[184] *See, e.g.*, Ferrucci et al., *supra* note 82, at 59 (stating that Watson's creation required "three years of intense research and development by a core team of about 20 researchers").

[185] *See, e.g.*, *Innovation's Golden Goose*, THE ECONOMIST, Dec. 12, 2002, at 3 (discussing the increase in innovation after the Bayh-Dole Act of 1980 because the legislation providing inventors an incentive to disclose and commercialize their ideas).

closure.[186] Likewise, businesses might be unable to develop patentable inventions into commercial products without patent protection.[187] In the pharmaceutical and biotechnology industries, for example, the vast majority of expense in commercializing a new product is incurred after the product is invented during the clinical testing process required to obtain regulatory approval for marketing.[188]

2. Arguments Against Computer Inventors

Those arguments reflect the dominant narrative justifying the grant of intellectual property protection.[189] That account, however, has been criticized, particularly by academics.[190] Patents result in significant social costs by establishing monopolies.[191] Patents also can stifle entry by new ventures by creating barriers to subsequent research.[192] Whether the benefit of patents as an innovation incentive outweighs their anti-competitive costs, or for that matter, whether patents even have a net positive effect on innovation, likely varies between industries, areas of scientific research, and inventive entities.[193]

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[186] *See, e.g.*, Festo Corp. v. Shoketsu Kinzoku Kogyo Kabushiki Co., 535 U.S. 722, 736 (2002) ("[E]xclusive patent rights are given in exchange for disclosing the invention to the public.").

[187] Commercialization theory holds that patents are important in providing incentives for investment in increasing the value of a patented technology. *See* Edmund W. Kitch, *The Nature and Function of the Patent System*, 20 J.L. & ECON. 265, 276–77 (1977).

[188] *See* TUFTS CTR. FOR THE STUDY OF DRUG DEV., *Briefing: Cost of Developing a New Drug* (Nov. 18, 2014), http://csdd.tufts.edu/files/uploads/Tufts_CSDD_briefing_on_RD_cost_study_-_Nov_18,_2014..pdf (estimating that pre-human expenditures are 30.8% of costs per approved compound, and estimating average pre-tax industry cost per new prescription drug approval [inclusive of failures and capital costs] is $2.55 billion). The cost of new prescription drug approval is hotly contested. *See, e.g.*, Roger Collier, *Drug Development Cost Estimates Hard to Swallow*, 180 CANADIAN MED. ASS'N J. 279, 279 (2009).

[189] *See* Jeanne C. Fromer, *Expressive Incentive in Intellectual Property*, 98 VA. L. REV. 1745, 1746 (2012).

[190] *See generally, e.g.*, Frederick M. Abbott, *The Doha Declaration on the TRIPS Agreement and Public Health: Lighting a Dark Corner at the WTO*, 5 J. INT'L ECON L. 469 (2002) (discussing problems with a pure incentive theory for patents in the medicines context).

[191] *See* Daniel J. Hemel & Lisa Larrimore Ouellette, *Beyond the Patents–Prizes Debate*, 92 TEX. L. REV. 303, 314–15 (2013) (discussing the deadweight loss of monopoly).

[192] *See* Lisa Larrimore Ouellette, *Access to Bio-Knowledge: From Gene Patents to Biomedical Materials*, 2010 STAN. TECH. L. REV. 48, 3 at n. 1 (considering effects of patents on entry to the biomedical products market); Arti Kaur Rai, *Regulating Scientific Research: Intellectual Property Rights and the Norms of Science*, 94 NW. U. L. REV. 77, 133 (1999); *see also* Bhaven Sampat & Heidi L. Williams, How Do Patents Affect Follow-on Innovation? Evidence from the Human Genome 15 (Oct. 13, 2015) (unpublished manuscript), *available at* http://economics.mit.edu/files/10782 [https://perma.cc/5K7N-89C4] (discussing patents to entry created by patents).

[193] As discussed above, the need for patent incentives is particularly compelling in the pharmaceutical context where large investments in clinical research over several years are typically needed to commercialize products that often are inexpensive for competitors to replicate. *See* Benjamin N. Roin, *Unpatentable Drugs and the Standards of Patentability*, 87 TEX. L. REV. 503, 545–47 (2009).

For instance, commentators such as Judge Richard Posner have argued that patents may not be needed to incentivize R&D in the software industry.[194] Software innovation is often relatively inexpensive, incremental, quickly superseded, produced without patent incentives, protected by other forms of intellectual property, and associated with a significant first mover advantage.[195] Likewise, patents may be unnecessary to spur innovation in university settings where inventors are motivated to publish their results for prestige and the prospect of academic advancement.[196]

Computational inventions may develop due to non-patent incentives. Software developers have all sorts of non-economic motivations to build creative computers: for example, to enhance their reputations, satisfy scientific curiosity, or collaborate with peers.[197] Business ventures might find the value of computational inventions exceeds the cost of developing creative computers even in the absence of patent protection. Of course, computational invention patents may not be an all-or-nothing proposition; they may further encourage activities that would have otherwise occurred on a smaller scale over a longer timeframe. If patents are not needed to incentivize the development of creative computers, it may be justifiable to treat computational inventions as unpatentable and failing to recognize computer inventors. Yet, whether patents produce a net benefit as an empirical matter is difficult to determine *a priori*. Even though individuals and businesses do not always behave as rational economic actors, in the aggregate, it is likely that providing additional financial incentives to spur the development of creative computers will produce a net benefit.[198]

Patents for computational inventions might also be opposed on the grounds that they would chill future human innovation, reward human inven-

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[194] *See* WILLIAM M. LANDES & RICHARD A. POSNER, THE ECONOMIC STRUCTURE OF INTELLECTUAL PROPERTY LAW 312–13 (2003).

[195] *See id.*; *see also* Eric Goldman, *The Problems with Software Patents*, FORBES (Nov. 28, 2012), http://www.forbes.com/sites/ericgoldman/2012/11/28/the-problems-with-software-patents/#234ba3d66545 [https://web.archive.org/web/20160412114510/http://www.forbes.com/sites/ericgoldman/2012/11/28/the-problems-with-software-patents/#41a0c38b2a70] (discussing in a three-part series why patents may be unnecessary for software, challenges to fixing the problems, and exploring possible fixes).

[196] *See* Mark A. Lemley, *Are Universities Patent Trolls?*, 18 FORDHAM INTELL. PROP. MEDIA & ENT. L.J. 611, 621 (2008).

[197] *See* YOCHAI BENKLER, THE WEALTH OF NETWORKS 65 (2006). Further, behavior law and economics posits that actual people do not act in accordance with standard economic principles because they have limited rationality, willpower, and self-interest. *See* Christine Jolls, Cass R. Sunstein, & Richard Thaler, *A Behavioral Approach to Law and Economics*, 50 STAN. L. REV. 1471, 1476 (1998).

[198] *See, e.g.*, GARY S. BECKER, THE ECONOMIC APPROACH TO HUMAN BEHAVIOR 14 (1978) ("[A]ll human behavior can be viewed as involving participants who [1] maximize their utility [2] from a stable set of preferences and [3] accumulate an optimal amount of information and other inputs in a variety of markets.").

tors who failed to contribute to the inventive process, and result in further consolidation of intellectual property in the hands of big business (assuming that businesses such as IBM will be the most likely to own creative computers).[199]

Other non-utilitarian patent policies do not appear to support computer inventorship. For example, courts have justified granting patent monopolies on the basis of Labor Theory, which holds that a person has a natural right to the fruits of their work.[200] Labor Theory may support giving a patent to someone who has worked for years to invent a new device so that they can profit from their invention, but it does not apply to computers because computers cannot own property. All computer work is appropriated. Similarly, Personality Theory, which holds that innovation is performed to fulfill a human need, would not apply to AI.[201] Creative computers invent because they are instructed to invent, and a machine would not be offended by the manner in which its inventions were used. AI might even be a concerning recipient for inventorship under Social Planning Theory, which holds that patent rights should be utilized to promote cultural goals.[202] An AI could develop immoral new technologies.[203] Submissions, however, are no longer rejected by the Patent Office for being "deceitful" or "immoral," and, to the extent this is a concern, there would be opportunities for a person to judge the morality of an application before it is granted.[204]

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[199] *See generally* Jamie Carter, *The Most Powerful Supercomputers in the World—and What They Do*, TECHRADAR (Dec. 13, 2014), http://www.techradar.com/us/news/computing/the-most-powerful-supercomputers-in-the-world-and-what-they-do-1276865 [https://perma.cc/AZ94-H3B2] (noting that most advanced computer systems are owned by governments and large businesses).

[200] *See* William Fisher, *Theories of Intellectual Property*, *in* NEW ESSAYS IN THE LEGAL AND POLITICAL THEORY OF PROPERTY 173–74 (Stephen Munzer ed., 2001).

[201] Tom G. Palmer, *Are Patents and Copyrights Morally Justified? The Philosophy of Property Rights and Ideal Objects*, 13 HARV. J.L. & PUB. POL'Y 817, 835–36 (1990).

[202] Mohammad Amin Naser, *Computer Software: Copyrights v. Patents*, 8 LOY. L. & TECH. ANN. 37, 41–42 (2009).

[203] Beneficial utility was once required for patent grant such that "deceitful" or "immoral" inventions would not qualify. In 1999, The United States Court of Appeals for the Federal Circuit in *Juicy Whip, Inc. v. Orange Bang, Inc.*, stated:

> [Y]ears ago courts invalidated patents on gambling devices on the ground that they were immoral, . . . but that is no longer the law . . . . "Congress never intended that the patent laws should displace the police powers of the States, meaning by that term those powers by which the health, good order, peace and general welfare of the community are promoted". . . . [W]e find no basis in section 101 to hold that inventions can be ruled unpatentable for lack of utility simply because they have the capacity to fool some members of the public.

185 F.3d 1364, 1367–68 (Fed. Cir. 1999) (quoting Webber v. Virginia, 103 U.S. 344, 347–48 (1880))

[204] *See id. See generally* Cynthia M. Ho, *Splicing Morality and Patent Law: Issues Arising from Mixing Mice and Men*, 2 WASH. U. J.L. & POL'Y 247, 247–85 (2000) (discussing Social Planning theory).

Ultimately, despite concerns, computer inventorship remains a desirable outcome. The financial motivation it will provide to build creative computers is likely to result in a net increase in the number of patentable inventions produced. Particularly, while quantitative evidence is lacking about the effects of computational invention patents, courts and policy makers should be guided first and foremost by the explicit constitutional rationale for granting patents.[205] Further, allowing patents on computational inventions as well as computer inventors would do away with what is essentially a legal fiction—the idea that only a human can be the inventor of the autonomous output of a creative computer—resulting in fairer and more effective incentives.

C. It Does Not Matter Whether Computers Think

1. The Questionable Mental Act Requirement

The judicial doctrine that invention involves a mental act should not prevent computer inventorship. The Patent Act does not mention a mental act, and courts have discussed mental activity largely from the standpoint of determining when an invention is actually made not whether it is inventive. In any case, whether or not creative computers "think" or have something analogous to consciousness should be irrelevant with regards to inventorship criteria.[206]

To begin, the precise nature of a "mental act requirement" is unclear. Courts associating inventive activity with cognition have not been using terms precisely or meaningfully in the context of computational inventions. It is unclear whether computers would have to engage in a process that results in creative output—which they do—or whether, and to what extent, they would need to mimic human thought. If the latter, it is unclear what the purpose of such a requirement would be except to exclude nonhumans (for which a convoluted test is unnecessary). Dr. Thaler has argued eloquently that the Creativity Machine closely imitates the architecture of the human brain.[207] Should that mean that the Creativity Machine's inventions should receive patents while Watson's do not? There is a slippery slope in determining what constitutes a "thinking" computer system even leaving aside deficits in our understanding of the structure and function of the human brain. Perhaps the Creativity Machine still is not engaging in mental activity—would a computer scientist have to design a completely digitized version of the human brain? Even if designing a completely digitized version of the human brain was possible, it might not be the

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[205] *See* United States v. Line Material Co., 333 U.S. 287, 316 (1948) (Douglas, J., concurring) (noting "the reward to inventors is wholly secondary" to the reward to society); *see also* THE FEDERALIST NO. 43 (James Madison) (stating that social benefit arises from patents to inventors).

[206] Though, it is surely a fascinating topic deserving of its own treatise.

[207] Thaler, *Synaptic Perturbation and Consciousness*, *supra* note 29.

most effective way to structure a creative computer.[208] On top of that, it would be difficult or impossible for the Patent Office and the courts to distinguish between different computers' architectures.

2. The Turing Test and a Functionalist Approach

The problem of speaking precisely about thought with regards to computers was identified by Alan Turing, one of the founders of computer science, who in 1950 considered the question, "Can machines think?"[209] He found the question to be ambiguous, and the term "think" to be unscientific in its colloquial usage.[210] Turing decided the better question to address was whether an individual could tell the difference between responses from a computer and an individual; rather than asking whether machines "think," he asked whether machines could perform in the same manner as thinking entities.[211] Dr. Turing referred to his test as the "Imitation Game" though it has come to be known as the "Turing test."[212]

Although the Turing test has been the subject of criticism by some computer scientists, Turing's analysis from more than sixty years ago demonstrates that a mental act requirement would be ambiguous, challenging to administer, and of uncertain utility.[213] Incidentally, it is noteworthy that the Patent Office administers a sort of Turing test, which creative computers have successfully passed. The Patent Office receives descriptions of inventions then judges whether they are nonobvious—which is a measure of creativity and ingenuity.[214] In the case of the Invention Machine's Patent, it was already noted that "January 25, 2005 looms large in the history of computer science as the day that genetic programming passed its first real Turing test: The examiner had no idea that he was looking at the intellectual property of a computer."[215] In an-

[208] This is analogous to one of the criticisms of the Turing test. Namely, that mimicking human responses may not be the best test of intelligence given that not all human responses are intelligent. *See* Editorial, *Artificial Stupidity*, THE ECONOMIST, Aug. 1, 1992, at 14.

[209] Turing, *Computing Machinery and Intelligence*, *supra* note 131, at 433. "Nobody so far has been able to give a precise, verifiable definition of what general intelligence or thinking is. The only definition I know that, though limited, can be practically used is Alan Turing's. With his test, Turing provided an operational definition of a specific form of thinking—human intelligence." Tomaso Poggio, "*Turing+" Questions*, *in* WHAT TO THINK ABOUT MACHINES THAT THINK 48 (John Brockman ed., 2015).

[210] *See* Turing, *Computing Machinery and Intelligence*, *supra* note 131, at 433.

[211] *See id.* at 433–34.

[212] *See id.* at 433.

[213] *See, e.g.*, Jose Hernandez-Orallo, *Beyond the Turing Test*, 9 J. LOGIC LANGUAGE & INFO. 447, 447 (2000).

[214] *See* Koza et al., *Evolving Inventions*, *supra* note 49, at 59. The Patent Office "receives written descriptions of inventions and then judges whether they are nonobvious," which is a measure of creativity and ingenuity. *See id.*

[215] Keats, *John Koza Has Built an Invention Machine*, *supra* note 57.

other sense, GP had already also passed the test by independently recreating previously patented inventions: because the original human invention received a patent, the AI's invention should have received a patent as well, leaving aside that the original patent would be prior art not relied upon by the GP.[216]

3. The Invention Matters, Not the Inventor's Mental Process

The primary reason a mental act requirement should not prevent computer inventorship is that the patent system should be indifferent to the means by which invention comes about.

Congress came to this conclusion in 1952 when it abolished the Flash of Genius doctrine.[217] That doctrine had been used by the Federal Courts as a test for patentability for over a decade.[218] It held that in order to be patentable, a new device, "however useful it may be, must reveal the flash of creative genius, not merely the skill of the calling."[219] The doctrine was interpreted to mean that an invention must come into the mind of an inventor in a "flash of genius" rather than as a "result of long toil and experimentation."[220] As a commentator at the time noted, "the standard of patentable invention represented by [the Flash of Genius doctrine] is apparently based upon the nature of the mental processes of the patentee-inventor by which he achieved the advancement in the art claimed in his patent, rather than solely upon the objective nature of the advancement itself."[221]

The Flash of Genius test was an unhelpful doctrine because it was vague, difficult for lower courts to interpret, involved judges making subjective decisions about a patentee's state of mind, and made it substantially more difficult

[216] *See id.*

[217] *See* 35 U.S.C. § 103 (2012).

[218] *See, e.g.*, Hamilton Standard Propeller Co. v. Fay-Egan Mfg. Co., 101 F.2d 614, 617 (6th Cir. 1939) ("The patentee did not display any flash of genius, inspiration or imagination . . . ."). The doctrine was formalized by the Supreme Court in 1941 in *Cuno Engineering Corp. v. Automatic Devices Corp.* 314 U.S. 84, 91 (1941). It was reaffirmed by the Court in 1950 in *Great Atlantic & Pacific Tea Co. v. Supermarket Equipment Corp.*, 340 U.S. 147, 154 (1950) (Douglas, J., concurring).

[219] *Cuno Eng'g Corp.*, 314 U.S. at 91.

[220] The Supreme Court later claimed the "Flash of Creative Genius" language was just a rhetorical embellishment and that requirement concerned the device not the manner of invention. Graham v. John Deere Co. of Kan. City, 383 U.S. 1, 15 n.7, 16 n.8 (1966). That was not, however, how the test was interpreted. *See* P.J. Federico, *Origins of Section 103*, 5 APLA Q.J. 87, 97 n.5 (1977) (noting the test led to a higher standard of invention in the lower courts). When Congress abolished the test, Congress noted it should be immaterial whether invention was made "from long toil and experimentation or from a flash of genius." 35 U.S.C. § 103. Further, the Court stated in 1966 in *Graham* that "[t]he second sentence states that patentability as to this requirement is not to be negatived by the manner in which the invention was made, that is, it is immaterial whether it resulted from long toil and experimentation or from a flash of genius." *Graham*, 383 U.S. at 16 n.8.

[221] *The "Flash of Genius" Standard of Patentable Invention*, *supra* note 18, at 87.

to obtain a patent.[222] The test was part of a general hostility toward patents exhibited by mid-twentieth century courts, a hostility that caused United States Supreme Court Justice Robert Jackson to note in a dissent that "the only patent that is valid is one which this Court has not been able to get its hands on."[223]

Criticism of this state of affairs led President Roosevelt to establish a National Patent Planning Commission to study the patent system and to make recommendations for its improvement.[224] In 1943, the Commission reported with regard to the Flash of Genius doctrine that "patentability 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."[225] Adopting this recommendation, the Patent Act of 1952 legislatively disavowed the Flash of Genius test.[226] In the same manner, patentability of computational inventions should be based on the inventiveness of a computer's output rather than on a clumsy anthropomorphism because, like Turing, patent law should be interested in a functionalist solution.

4. A Biological Requirement Would Be a Poor Test

Incidentally, even a requirement for biological intelligence might be a bad way to distinguish between computer and human inventors. Although functioning biological computers do not yet exist, all of the necessary building blocks have been created.[227] In 2013, a team of Stanford University engineers created

[222] *See* DePaul College of Law, *Patent Law—"Flash of Genius" Test for Invention Rejected*, 5 DEPAUL L. REV. 144, 146 (1955); Stephen G. Kalinchak, *Obviousness and the Doctrine of Equivalents in Patent Law: Striving for Objective Criteria*, 43 CATH. U. L. REV. 577, 586 (1994).

[223] Jungersen v. Ostby & Barton Co., 335 U.S. 560, 572 (1949) (Jackson, J., dissenting).

[224] *See* William Jarratt, *U.S. National Patent Planning Commission*, 153 NATURE 12, 14 (1944).

[225] *The "Flash of Genius" Standard of Patentable Invention*, *supra* note 18, at 85 (internal quotation marks omitted).

[226] *See* 35 U.S.C. § 103 (2012). Further, in *Graham*, the Supreme Court noted that "[i]t . . . seems apparent that Congress intended by the last sentence of § 103 to abolish the test it believed this Court announced in the controversial phrase 'flash of creative genius,' used in *Cuno Engineering*." *Graham*, 383 U.S. at 15.

[227] *See* Sebastian Anthony, *Stanford Creates Biological Transistors, the Final Step Towards Computers Inside Living Cells*, EXTREMETECH (Mar. 29, 2013), http://www.extremetech.com/extreme/152074-stanford-creates-biological-transistors-the-final-step-towards-computers-inside-living-cells [https://perma.cc/ENX4-WZKA] (noting that, in addition to biological transistors, a method for data storage and a means of connecting transcriptors with memory would be necessary to create a biological computer and stating that "[f]ortunately, as we've covered a few times before, numerous research groups have successfully stored data in DNA—and Stanford has already developed an ingenious method of using the M13 virus to transmit strands of DNA between cells"); *see also* Monica E. Ortiz & Drew Endy, *Engineered Cell-Cell Communication via DNA Messaging*, J. BIOLOGICAL ENGINEERING (Dec. 1, 2012), https://jbioleng.biomedcentral.com/articles/10.1186/1754-1611-6-16 [https://perma.cc/6BWZ-GUUP]; Katherine Deria, *Biological Supercomputer Can Solve Complex Problems Using Less* Energy, TECH TIMES (Feb. 27, 2016), http://www.techtimes.com/articles/137017/20160227/biological-supercomputer-can-solve-complex-problems-using- less-energy.htm [https://perma.cc/A75T-3TVV] (describing a new biological supercomputer model powered by a biochemical that facilitates energy transfer among cells).

a biological version of an electrical transistor. Mechanical computers use numerous silicon transistors to control the flow of electrons along a circuit to create binary code.[228] The Stanford group created a biological version with the same functionality by using enzymes to control the flow of RNA proteins along a strand of DNA.[229] Envisioning a not-too-distant future in which computers can be entirely biological, there seems to be no principled reason why a biological, but not a mechanical version, of Watson should qualify as an inventor. In the event that policymakers decide computers should not be inventors, a rule explicitly barring nonhuman inventorship would be a better way to achieve that result.

D. Computer Inventors Are Permitted Under a Dynamic Interpretation of Current Law

Whether a computer can be an inventor in a constitutional sense is a question of first impression. If creative computers should be inventors, as this Article has argued, then a dynamic interpretation of the law should allow computer inventorship.[230] Such an approach would be consistent with the Founders' intent in enacting the Patent and Copyright Clause, and it would interpret the Patent Act to further that purpose.[231] Nor would such an interpretation run afoul of the chief objection to dynamic statutory interpretation, namely that it interferes with reliance and predictability and the ability of citizens "to be able to read the statute books and know their rights and duties."[232] That is because a dynamic interpretation would not upset an existing policy; permitting computer inventors would allow additional patent applications rather than retroactively invalidate previously granted patents, and there is naturally less reliance and predictability in patent law than in many other fields given that it is a highly dynamic subject area that struggles to adapt to constantly changing technologies.[233]

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[228] *See* Anthony, *supra* note 227.

[229] *See id.*

[230] *See* William N. Eskridge, Jr. & Philip P. Frickey, *Statutory Interpretation as Practical Reasoning*, 42 STAN. L. REV. 321, 324 (1990).

[231] *See* HENRY M. HART, JR. & ALBERT M. SACKS, THE LEGAL PROCESS: BASIC PROBLEMS IN THE MAKING AND APPLICATION OF LAW 1124 (1994); *see also* Abbe R. Gluck, *The States as Laboratories of Statutory Interpretation: Methodological Consensus and the New Modified Textualism*, 119 YALE L.J. 1750, 1764(2010) (noting that purposivists subscribe to dynamic methods of statutory interpretation).

[232] *See* Eskridge, Jr. & Frickey, *supra* note 230, at 340.

[233] *See* William C. Rooklidge & W. Gerard von Hoffmann, III, *Reduction to Practice, Experimental Use, and the "On Sale" and "Public Use" Bars to Patentability*, 63 ST. JOHN'S L. REV. 1, 49–50 (1988).

Other areas of patent law have been the subject of dynamic interpretation.[234] For example, in the landmark 1980 case of *Diamond v. Chakrabarty*, the Supreme Court was charged with deciding whether genetically modified organisms could be patented.[235] It held that a categorical rule denying patent protection for "inventions in areas not contemplated by Congress . . . would frustrate the purposes of the patent law."[236] The court noted that Congress chose expansive language to protect a broad range of patentable subject matter.[237]

Under that reasoning, computer inventorship should not be prohibited based on statutory text designed to favor individuals over corporations. It would be particularly unwise to prohibit computer inventors on the basis of literal interpretations of texts written when computational inventions were unforeseeable. If computer inventorship is to be prohibited, it should only be on the basis of sound public policy. Drawing another analogy from the copyright context, just as the terms "Writings" and "Authors" have been construed flexibly in interpreting the Patent and Copyright Clause, so too should the term "Inventors" be afforded the flexibility needed to effectuate constitutional purposes.[238] Computational inventions may even be especially deserving of protection because computational creativity may be the only means of achieving certain discoveries that require the use of tremendous amounts of data or that deviate from conventional design wisdom.[239]

III. Implications of Computer Inventorship

This Part finds that a computer's owner should be the default assignee of any invention because this is most consistent with the rules governing owner-

[234] The Supreme Court has called the section of the U.S. Code relating to patentable subject matter a "dynamic provision designed to encompass new and unforeseen inventions." J.E.M. AG Supply, Inc. v. Pioneer Hi-Bred Int'l, Inc., 534 U. S. 124, 135 (2001). The Court noted in *Bilski v. Kappos* that "it was once forcefully argued that until recent times, 'well- established principles of patent law probably would have prevented the issuance of a valid patent on almost any conceivable computer program.'" 561 U.S. 593, 605 (2010) (quoting Diamond v. Diehr, 450 U.S 175, 195 (1981) (Stevens, J., dissenting)). The Court, however, went on to state that "this fact does not mean that unforeseen innovations such as computer programs are always unpatentable." *Id.* (citing *Diehr*, 450 U.S at 192–93 (Stevens, J., dissenting)).

[235] *See* Diamond v. Chakrabarty, 447 U. S. 303, 317 (1980).

[236] *Id*. at 315.

[237] *See id*. at 316.

[238] In 1973, the Supreme Court in *Goldstein v. California* noted that the terms "Writings" and "Authors," have "not been construed in their narrow literal sense but, rather, with the reach necessary to reflect the broad scope of constitutional principles." 412 U.S. 546, 561 (1973).

[239] *See* Jason D. Lohn, *Evolvable Systems for Space Application*, NASA (Nov. 24, 2003), http://www.genetic-programming.com/c2003jasonlohn20031124talk.pdf [https://perma.cc/BWC7-UPJK]; Adam Frank, *The Infinite Monkey Theorem Comes to Life*, NPR (Dec. 10, 2013), http://www.npr.org/blogs/13.7/2013/12/10/249726951/the-infinite-monkey-theorem-comes-to-life [https://perma.cc/PT5R-53GS].

ship of property and it would most incentivize innovation.[240] Additionally, this Part suggests that where a computer's owner, developer, and user are different entities, such parties could negotiate alternative arrangements by contract.[241] Computer ownership here generally refers to software ownership, although there may be instances in which it is difficult to distinguish between hardware and software, or even to identify a software "owner."[242] This Part also examines the phenomenon of automation and the displacement of human inventors by computers and finds that computational invention remains beneficial despite legitimate concerns.[243]

This Part concludes by finding that the arguments in support of computer inventorship apply with equal force to non-human authors.[244] Allowing animals to create copyrightable material would result in more socially valuable art by creating new incentives for people to facilitate animal creativity.[245] It would also provide incentives for environmental conservation.[246] Lastly, this Part examines some of the implications of computer inventorship for other areas of patent law.[247]

A. Computational Invention Ownership

1. Options for Default Assignment Rules

In the event that computers are recognized as patent inventors, there still remains the question of who would own these patents. Computers cannot own property, and it is safe to assume that "computer personhood" is not on the horizon.[248] This presents a number of options for patent ownership (assignment) such as a computer's owner (the person who owns the AI as a chattel), developer (the person who programmed the AI's software), or user (the person giving the AI tasks).[249] The developer, user, and owner may be the same person, or they may be different entities.

Ownership rights to computational inventions should vest in a computer's owner because it would be most consistent with the way personal property (in-

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[240] *See infra* notes 240–312 and accompanying text.
[241] *See infra* notes 248–255 and accompanying text.
[242] *See generally* GOVERNMENT OFFICE FOR SCIENCE, *supra* note 20.
[243] *See infra* notes 256–278 and accompanying text.
[244] *See infra* notes 279–312 and accompanying text.
[245] *See infra* notes 279–287 and accompanying text.
[246] *See infra* notes 279–287 and accompanying text.
[247] *See infra* notes 288–313 and accompanying text.
[248] *See generally* Adam Winkler, *Corporate Personhood and the Rights of Corporate Speech*, 30 SEATTLE U. L. REV. 863, 863 (2007) (describing the phenomenon of "corporate personhood").
[249] There are other, less conventional, options. For instance, even if legally listed as an inventor, it might be the case that no one could own a computer's invention and that computational inventions would automatically become part of the public domain. New legislation could also establish that ownership rights to computational inventions automatically vest in a government agency.

cluding both computers and patents) is treated in the United States and it would most incentivize computational invention.[250] Assignment of computational inventions to a computer's owner could be taken as a starting point although parties would be able to contract around this default, and as computational inventions become more common, negotiations over these inventions may become a standard part of contract negotiations.[251]

2. Owner vs. User Assignment

To see why it would be problematic to have patent ownership rights vest in a computer's user, consider the fact that IBM has made Watson available to numerous developers without transferring Watson's ownership.[252] To the extent that Watson creates patentable results as a product of its interactions with users, promoting user access should result in more innovation.

There is theoretically no limit to the number of users that Watson, as a cloneable software program, could interact with at once. If Watson invents while under the control of a non-IBM user, and the "default rule" assigns the invention to the user, IBM might be encouraged to restrict user access; in contrast, assigning the invention to IBM would be expected to motivate IBM to further promote access. If IBM and a user were negotiating for a license to Watson, the default rule might result in a user paying IBM an additional fee for the ability to patent results or receiving a discount by sticking with the default. It may also be the case that Watson co-invents along with a user; in which case, a system of default assignment to a computer's owner would result in both IBM and the user co-owning the resulting patent. Where creative computers are not owned by large enterprises with sophisticated attorneys, it is more likely the default rule will govern the final outcome.[253]

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[250] *See* Annemarie Bridy, *Coding Creativity: Copyright and the Artificially Intelligent Author*, 2012 STAN. TECH. L. REV. 1, 1–28 (arguing that "AI authorship is readily assimilable to the current copyright framework through the work made for hire doctrine, which is a mechanism for vesting copyright directly in a legal person who is acknowledged *not* to be the author-in-fact of the work in question").

[251] *See generally* Ian Ayres & Robert Gertner, *Filling Gaps in Incomplete Contracts: An Economic Theory of Default Rules*, 99 YALE L.J. 87 (1990) (discussing default rules and how they are formed in the context of contract law).

[252] Bruce Upbin, *IBM Opens Up Its Watson Cognitive Computer for Developers Everywhere*, FORBES (Nov. 14, 2013), http://www.forbes.com/sites/bruceupbin/2013/11/14/ibm-opens-up-watson-as-a-web-service/ [https://web.archive.org/web/20160310124933/http://www.forbes.com/sites/bruceupbin/2013/11/14/ibm-opens-up-watson-as-a-web-service/#1ccc9051d0ee].

[253] *See, e.g.*, Daniel D. Barnhizer, *Power, Inequality and the Bargain: The Role of Bargaining Power in the Law of Contract—Symposium Introduction*, 2006 MICH. ST. L. REV. 841, 842 (describing various approaches to dealing with bargaining power asymmetries).

3. Owner vs. Developer Assignment

Likewise, patent ownership rights should vest in a computer's owner rather than its developer. Owner assignment would provide a direct economic incentive for developers in the form of increased consumer demand for creative computers. Having assignment default to developers would interfere with the transfer of personal property in the form of computers, and it would be logistically challenging for developers to monitor computational inventions made by machines they no longer own.

In some instances, however, owner assignment of intellectual property (IP) rights might produce unfair results. In the movie *Her*, the protagonist (who is a writer) purchases an AI named Samantha that organizes his existing writings into a book, which it then submits to be published.[254] It is possible that Samantha would own the copyright in the selection and arrangement of his writings and would thus have a copyright interest in the book.[255] Here, owner assignment of intellectual property rights seems unappealing if there is a minimal role played by the consumer/owner. The consumer's role in the process might be limited to simply purchasing a creative computer and asking it to do something (where the owner is the user) or purchasing a computer and then licensing it to someone else to use creatively. Further, assigning computer inventions to owners might impede the development or sharing of creative machines because the machine developers might want to retain the rights to the computational inventions their computers produce.

These problems are more easily resolved than problems associated with assigning intellectual property rights to developers by default. Developers could either require owners to pay them the value of a creative machine, taking into account the likelihood of those machines engaging in computational invention, or avoid the problem by licensing rather than selling creative computers. In the case of licensing, the developer remains the owner, and the consumer is simply a user. One might imagine a creative computer, such as the AI in *Her*, coming with a license agreement under which consumers prospectively assign any inventions made by the system to the licensor.

This analysis also reveals an important reason why computational invention works best when the computer is the legal inventor. If computational inventions were treated as patentable but computers could not be inventors, then presumably the first person to recognize a computer's invention would be the legal inventor and patent owner. That means that the computer's user, rather than its developer or owner, would likely be the patentee as the person in a position to first recognize a computational invention. To the extent this is an un-

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[254] HER (Annapurna Pictures 2013).

[255] *See* RONALD B. STANDLER, COPYRIGHT FOR COMPILATIONS IN THE USA 22 (2013).

desirable outcome, as this Article has argued, then the best solution is to permit computer inventorship.

In sum, assigning a computer's invention by default to the computer's owner seems the preferred outcome, and computer owners would still be free to negotiate alternate arrangements with developers and users by contract.

B. Coexistence and Competition

1. Computers and People Will Compete in Creative Fields

> *"IBM has bragged to the media that Watson's question-answering skills are good for more than annoying Alex Trebek. The company sees a future in which fields like medical diagnosis, business analytics, and tech support are automated by question-answering software like Watson. Just as factory jobs were eliminated in the 20th century by new assembly-line robots, [Watson's Jeopardy competitors] were the first knowledge-industry workers put out of work by the new generation of 'thinking' machines. 'Quiz show contestant' may be the first job made redundant by Watson, but I'm sure it won't be the last."*[256]

With the expansion of computers into creative domains previously occupied only by people, machines threaten to displace human inventors. To better understand this phenomenon, consider the following hypothetical example involving the field of antibody therapy.

Antibodies are small proteins made naturally by the immune system, primarily to identify and neutralize pathogens such as bacteria and viruses.[257] They are Y-shaped proteins that are largely similar to one another in structure although antibodies contain an extremely variable region which binds to target structures.[258] Differences in that region are the reason different antibodies bind to different targets—for example the reason why one antibody binds to a cancer cell while another binds to the common cold virus.[259] The body generates antibody diversity in part by harnessing the power of random gene recombinations and mutations (much as GP does), and then it selects for antibodies with a desired binding (much as GP does).[260] Following the discovery of antibody structure and the development of technologies to manufacture antibodies in the 1970s, human researchers began to create antibodies for diagnostic and thera-

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[256] Ken Jennings, *My Puny Human Brain*, SLATE (Feb 16, 2011), http://primary.slate.com/articles/arts/culturebox/2011/02/my_puny_human_brain.html [https://perma.cc/BE9X-NUNX].

[257] *See* Janice M. Reichert, *Marketed Therapeutic Antibodies Compendium*, 4 MABS 413, 413 (2012).

[258] *See* Neil S. Lipman et al., *Monoclonal Versus Polyclonal Antibodies: Distinguishing Characteristics, Applications, and Information Resources*, 46 ILAR J. 258, 258 (2005).

[259] *See id.* at 258–59.

[260] *See id.* at 259.

peutic purposes.[261] Therapeutic antibodies can block cell functions, modulate signal pathways, and target cancer cells among other functions.[262] There are now dozens of artificially manufactured antibodies approved to treat a variety of medical conditions.[263]

One of the interesting things about antibodies from a computational invention perspective is that a finite number of antibodies exist. There are, at least, billions of possible antibodies, which is enough natural diversity for the human immune system to function and to keep human researchers active for the foreseeable future.[264] Even so, there are only so many possible combinations of amino acids (the building blocks of proteins) that the body can string together to generate an antibody.[265] It is not hard to imagine that, with enough computing power, an AI could sequence every possible antibody that could ever be created. Even if that was trillions of antibodies, the task would be relatively simple for a powerful enough computer but impossible for even the largest team of human researchers without computer assistance.

Generating the entire universe of antibody sequences would not reveal all of the possible functions of those antibodies; so, a computer's owner could not obtain patents for all of the sequences on this basis alone because usefulness (utility) of the invention must be disclosed in addition to the sequence itself.[266] The computer could, however, prevent any future patents on the structure of new antibodies (assuming the sequence data is considered an anticipatory disclosure).[267] If this occurred, a computer would have preempted human invention in an entire scientific field.[268]

2. Computers May Refocus Human Activity

In the hypothetical scenario above, society would gain access to all possible future knowledge about antibody structure at once rather than waiting decades or centuries for individuals to discover these sequences. Early access to antibody sequences could prove a tremendous boon to public health if it led to

[261] *See* Reichert, *Marketed Therapeutic Antibodies Compendium*, *supra* note 257, at 413.

[262] *See id.*

[263] *See id.*

[264] *See* Lipman, *supra* note 258, at 258.

[265] *See, e.g.*, U.S. Patent No. 8,008,449 (filed May 2, 2006) (disclosing antibodies to the protein Programmed Death 1 ("PD-1") by virtue of publishing their amino acid sequences).

[266] *See In re* Fisher, 421 F.3d 1365, 1370 (Fed. Cir. 2005).

[267] *See* MPEP, *supra* note 43, § 2131.

[268] Along similar lines, projects such as "All Prior Art" and "All the Claims" are attempting to use machines to create and publish vast amounts of information to prevent other parties from obtaining patents. *See* ALL PRIOR ART, allpriorart.com/about/ [https://perma.cc/3XJR-2FF5] (last visited Jul. 10, 2016); ALL THE CLAIMS, alltheclaims.com/about/ [https://perma.cc/QDE2-5J49] (last visited Jul. 10, 2016); *see also* Hattenbach & Glucoft, *supra* note 5, at 35–36 (describing the efforts of a company, Cloem, which is mechanically publishing possible patent claims to prevent others from obtaining patents).

the discovery of new drugs. Some antibody sequences might never be identified without creative computers.

Creative computers may simply refocus, rather than inhibit, human creativity. In the short term, scientists who were working on developing new antibody structures might shift to studying how the new antibodies work, or finding new medical applications for those antibodies, or perhaps move on to studying more complex proteins beyond the capability of AI to comprehensively sequence. For the foreseeable future, there will be plenty of room for human inventors—all with net gains to innovation.

Antibody therapies are just one example of how AI could preempt invention in a field. A sophisticated enough computer could do something similar in the field of genetic engineering by creating random sequences of DNA. Living organisms are a great deal more complex than antibodies, but the same fundamental principles would apply. Given enough computing power, an AI could model quintillions of different DNA sequences, inventing new life forms in the process. In fact, on a smaller scale, this is something GP already does.[269] Although results have been limited by the computationally intense nature of the process, that will change as computers continue to improve.[270] By creating novel DNA sequences, GP would be performing the same function as non-digital GP—natural evolution!

3. Dealing with Industry Consolidation

It will probably be the case that creative computers result in greater consolidation of intellectual property in the hands of large corporations such as IBM. Such businesses may be the most likely to own creative computers owing to their generally resource intense development.[271] As previously discussed, the benefits, however, may outweigh the costs of such an outcome. Imagine that Watson was the hypothetical AI that sequenced every conceivable antibody and, further, that Watson could analyze a human cancer and match it with an antibody from its library to effectively treat the cancer. Essentially, this could allow IBM to patent the cure for cancer.

Though this would be profoundly disruptive to the medical industry and might lead to market abuses, it is not a reason to bar computational invention. Society would obtain the cure for cancer, and IBM would obtain a twenty-year monopoly (the term of a patent) in return for publically disclosing the infor-

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[269] *See, e.g.*, Tim Stefanini, *The Genetic Coding of Behavioral Attributes in Cellular Automata*, *in* ARTIFICIAL LIFE AT STANFORD 172–80 (John R. Koza ed., 1994); W.B. Langdon & B.F. Buxton, *Genetic Programming for Mining DNA Chip Data from Cancer Patients*, 5 GENETIC PROGRAMMING AND EVOLVABLE MACHINES 251, 251 (2004).

[270] *See* Stefanini, *supra* note 269, at 172–80.

[271] *See* Carter, *supra* note 199 (noting that most advanced computer systems are owned by governments and large businesses).

mation a competitor would need to duplicate Watson's invention.[272] In the absence of creative computers, such an invention might never come about.

To the extent that price gouging and supply shortages are a concern, protections are built into patent law to protect consumers against such problems.[273] For example, the government could exercise its march in rights or issue compulsory licenses.[274]

4. The Creative Singularity and Beyond

As creative computers become more and more sophisticated, at some point in the future, it is possible that they could have a very disruptive effect on human creativity. In recent years, a number of prominent scientists and entrepreneurs such as Bill Gates, Stephen Hawking, and Elon Musk have expressed concern about the "singularity"—a point in the future when machines outperform humans.[275] Likewise, a "creative singularity" in which computers overtake people as the primary source of innovation may be inevitable. Taken to its logical extreme and given that there is really no limit to the number of computers that could be built or their capabilities, it is not especially improbable to imagine that computers could eventually preempt much or all human inven-

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[272] *See* MPEP, *supra* note 43, § 2164.

[273] See the case of Martin Shkreli, who has been pilloried for price gouging by drastically increasing the price of an old drug, Daraprim. *See* Andrew Pollack & Julie Creswell, *Martin Shkreli, the Mercurial Man Behind the Drug Price Increase That Went Viral*, N.Y. TIMES (Sept. 22, 2015), http://www.nytimes.com/2015/09/23/business/big-price-increase-for-an-old-drug-will-be-rolled-back-turing-chief-says.html?r_=0 [https://perma.cc/Q3Q3-95CS]. In this particular case, the monopoly was due to lack of competition, but the same economic principles apply to patent monopolies. *See* Ryan Abbott, *Balancing Access and Innovation in India's Shifting IP Regime, Remarks*, 35 WHITTIER L. REV. 341, 344 (2014) (discussing patent law protections against practices including "evergreening").

[274] *See, e.g.*, Abbott, *supra* note 273, at 345 (explaining India's issuance of a compulsory license).

[275] Of perhaps greater concern than automation displacing human workers, a number of prominent scientists are concerned about the implications of machines outperforming people. Professor Stephen Hawking has warned that self-improving computers could threaten the very existence of humanity. Rory Cellan-Jones, *Stephen Hawking Warns Artificial Intelligence Could End Mankind*, BBC (Dec. 2, 2014), http://www.bbc.com/news/technology-30290540 [https://perma.cc/2NWE-D8MB]. Elon Musk recently donated ten million dollars to an institute focused on threats posed by advances in AI. *See* Chris Isidore, *Elon Musk Gives $10M to Fight Killer Robots*, CNN MONEY (Jan. 16, 2015), http://money.cnn.com/2015/01/15/technology/musk-artificial-intelligence/ [https://perma.cc/6N3U-WTWF]; *see also* Dylan Love, *Scientists Are Afraid to Talk About the Robot Apocalypse, and That's a Problem*, BUSINESS INSIDER (July 18, 2014), http://www.businessinsider.com/robot-apocalypse-2014-7#ixzz3QQpLJ0Jj [https://perma.cc/AH5J-5G34] (noting that robots may pose a "real risk" to humanity); Kevin Rawlinson, *Microsoft's Bill Gates Insists AI Is a Threat*, BBC (Jan. 29, 2015), http://www.bbc.com/news/31047780 [https://perma.cc/9MXD-TQ68] (expressing Bill Gates's concerns about advanced AI). Concerns about the threat posed by advanced AI are nothing new. *See, e.g.*, Irving J. Good, *Speculations Concerning the First Ultraintelligent Machine*, 6 ADVANCES IN COMPUTERS 31, 31–88 (1966). As an aside, the date the patent for the Creativity Machine issued is the same date as "Judgment Day" from the original Terminator movie, August 29, 1997.

tion.[276] The future may involve iPads in place of fast food cashiers,[277] robots empathizing with hospital patients,[278] and AI responsible for research. For now, this is a distant possibility.

Moreover, patents on computational inventions would not prevent this outcome. If creative computers ever come to substantially outperform human inventors, they still will replace people—just without the ability to receive patents.

C. Lessons for Copyright Law

1. Promoting the Useful Arts and Environmental Conservation

The need for computer inventorship also explains why the Copyright Office's Human Authorship Requirement is misguided. Nonhumans should be allowed to qualify as authors because doing so would incentivize the creation of new and valuable creative output. In the case of the Monkey Selfies, Mr. Slater, a photographer familiar with macaques, reported that he carefully staged the environment in such a way that Naruto would be likely to take his own photograph.[279] If accurate, he probably did so in part due to an expectation of selling the resulting photographs.[280] Had Mr. Slater known in advance that the images would pass into the public domain, he might never have taken the photographs. Although an owner default assignment rule would give copyright ownership of the Monkey Selfies to Naruto's owner[281] rather than to Mr. Slater, he could have contracted with Naruto's owner to purchase or license the photographs. Certainly in the aggregate, fewer photographers will engage in such activities without the prospect of copyright protection, and although animal selfies are not the cure for cancer, they have societal value as does any other form of art.[282]

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[276] *See* Brian Christian, *Mind vs. Machine*, THE ATLANTIC (Mar. 2011), http://www.theatlantic.com/magazine/archive/2011/03/mind-vs-machine/308386/ [https://perma.cc/7CMT-DAEZ].

[277] *See* Victoria Taft, *Protesters Aren't Going to Like How McDonald's Is Reacting to Their Minimum Wage Concerns*, INDEP. J. REV. (May 26, 2015), http://ijr.com/2015/05/330129-guy-wont-taking-mickey-ds-order-much-longer-might-surprised-reasons/ [https://perma.cc/AZH6-GWXC].

[278] *See* Bertalan Mesko, *Will Robots Take Over Our Jobs in Healthcare?*, *in* MY HEALTH UPGRADED: REVOLUTIONARY TECHNOLOGIES TO BRING A HEALTHIER FUTURE 80, 80–83 (Richard E. Cytowic ed. 2015).

[279] *See Photographer 'Lost £10,000' in Wikipedia Monkey 'Selfie' Row*, BBC (Aug. 7, 2014), http://www.bbc.com/news/uk-england-gloucestershire-28674167 [https://perma.cc/WQF8-KNYL].

[280] *See* Complaint, Naruto v. Slater, 2016 WL 362231 (No. 3:15-cv-04324) at *1, *9 (noting his sale of copies of the Monkey Selfies).

[281] Here that might be the government of Indonesia or the Tangkoko Reserve (Naruto's home) depending on Indonesian law and the reserve's structure. *See* Complaint, *Naruto*, 2016 WL 362231 (No. 3:15-cv-04324) at *1.

[282] *See* Johnson, *supra* note 134, at 16 (describing the sale of works of art created by a chimpanzee whose "fans may have included . . . Pablo Picasso" and works created by seven Asian elephants) (internal quotation marks omitted). Alternatively, in the words of Justice Holmes:

Animal authorship might also have some ancillary conservation benefits. Continuing with the case of the Monkey Selfies, Naruto is a member of a critically endangered species with a total population of between four and six thousand macaques.[283] The species' "numbers have decreased by approximately ninety percent (90%) over the last twenty-five years due to human population encroachment, being killed by humans in retribution for foraging on crops, and being trapped and slaughtered for bush meat."[284] Permitting Naruto's activities to have a new source of value would be another economic incentive for private and public landowners to conserve biodiversity.[285] Naruto lives in a reserve in Indonesia, but the United States also continues to suffer significant biodiversity loss.[286] Some environmentalist groups argue this is because conservation efforts are chronically underfunded.[287] Nonhuman authorship might be an additional policy lever to reverse this trend.

D. Rethinking the Ultimate Test of Patentability

Considering the case for creative computers provides insight into other areas of patent law. Take, for instance, the nonobviousness requirement for grant of a patent.[288] When Congress did away with the Flash of Genius doctrine, it replaced that test with the current requirement for nonobviousness.[289] Part of the requirement's evaluation involves employing the legal fiction of a "person having ordinary skill in the art" ("PHOSITA" or simply the "skilled person") who serves as a reference for determining whether an invention is nonobvious.[290] Essentially, an applicant cannot obtain a patent if the skilled person would have found the difference between a new invention and the prior

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> It would be a dangerous undertaking for persons trained only to the law to constitute themselves final judges of the worth of pictorial illustrations, outside the narrowest and most obvious limits. At the one extreme some works of genius would be sure to miss appreciation. . . . At the other end, copyright would be denied to pictures which appealed to a public less educated than the judge.

Bleistein v. Donaldson Lithographing Co., 188 U.S. 239, 251–52 (1903).

[283] *See* Complaint, *Naruto*, 2016 WL 362231 (No. 3:15-cv-04324), at *3.

[284] *Id.*

[285] For a discussion of existing economic incentives for landowners to conserve biodiversity, see generally Frank Casey et al., *Incentives for Biodiversity Conservation: An Ecological Is Economic Assessment*, DEFENDERS OF WILDLIFE (2006), http://www.defenders.org/publications/incentives_for_biodiversity_conservation.pdf [https://perma.cc/LEM8-SPYC].

[286] *See id.* at 7.

[287] *Id.* at 8.

[288] *See* 35 U.S.C. § 103 (2012).

[289] *See id.*

[290] Actually, the skilled person is relevant to many areas of patent law including claim construction, best mode, definiteness, enablement, and the doctrine of equivalents. *See* Dan L. Burk & Mark A. Lemley, *Is Patent Law Technology-Specific?*, 17 BERKELEY TECH. L.J. 1155, 1186–87 (2002).

art (what came before the invention) obvious.[291] The test presumes that the skilled person is selectively omniscient, having read, understood, and remembered every existing reference from the prior art in the relevant field of invention (analogous art).[292] A federal judge explained that the way to apply the obviousness test is to "first picture the inventor as working in his shop with the prior art references, which he is presumed to know, hanging on the walls around him."[293]

Needless to say, no actual person could have such knowledge, but the standard helps avoid difficult issues of proof related to an inventor's actual knowledge; also, it prevents obvious variations of publically disclosed inventions from being patented.[294] Stopping obvious variations from being patented is important because that prevents the removal of knowledge from the public domain.[295] Inventions which would have been obvious to skilled persons are already within reach of the public.[296] This raises the bar to obtaining a patent—a result that is desirable because patents should not be granted lightly given their anticompetitive effects.[297] At the same time, creating too high a bar to patentability is undesirable because then patents would fail to adequately incentivize researchers. A balance is needed.[298] Ideally, the system would only issue patents for inventions that would not have been created but for the expectation of obtaining a patent.[299] The importance of the nonobvious requirement to patentability has led to its characterization as the "ultimate condition of pa-

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[291] *See* 35 U.S.C. § 103(a).

[292] *See* Standard Oil Co. v. Am. Cyanamid Co., 774 F.2d 448, 454 (Fed. Cir. 1985). *See generally* Lance Leonard Barry, *Cézanne and Renoir: Analogous Art in Patent Law*, 13 TEX. INTELL. PROP. L.J. 243 (2005) (discussing analogous art).

[293] *Application of* Winslow, 365 F.2d 1017, 1020 (C.C.P.A. 1966).

[294] *See* Jonathan J. Darrow, *The Neglected Dimension of Patent Law's PHOSITA Standard*, 23 HARV. J.L. & TECH. 227, 228 (2009); Daralyn J. Durie & Mark A. Lemley, *A Realistic Approach to the Obviousness of Inventions*, 50 WM. & MARY L. REV. 989, 991–92, 1017 (2008).

[295] *See* Sakraida v. Ag Pro, Inc., 425 U.S. 273, 281 (1976) ("A patent . . . which only unites old elements with no change in their respective functions . . . obviously withdraws what already is known into the field of its monopoly and diminishes the resources available to skillful men . . . .") (internal quotation marks omitted) (quoting Great Atl. & Pac. Tea Co. v. Supermarket Equip. Corp., 340 U.S. 147, 152–53 (1950))

[296] *See id.*

[297] *See* Eldred v. Ashcroft, 537 U.S. 186, 246 (2003) (Breyer, J., dissenting) (discussing the views of Madison, Jefferson "and others in the founding generation, [who] warned against the dangers of monopolies").

[298] *See* Edmund W. Kitch, Graham v. John Deere Co.*: New Standards for Patents*, 1966 SUP. CT. REV. 293, 301 ("The non-obviousness test makes an effort, necessarily an awkward one, to sort out those innovations that would not be developed absent a patent system.").

[299] Graham v. John Deere Co., 383 U.S. 1, 11 (1965) ("The inherent problem was to develop some means of weeding out those inventions which would not be disclosed or devised but for the inducement of a patent.").

tentability."[300] The idea of a PHOSITA understanding all of the prior art in her field was always fictional,[301] but now it is possible for a skilled entity, in the form of a computer, to possess such knowledge. For example, Watson's database could be populated with every published food recipe available to the Patent Office. This makes the skilled computer a natural substitute for the hypothetical skilled person. The standard would require a skilled computer rather than a creative computer for the same reason that the skilled person is not an inventive person.[302] PHOSITA has traditionally been characterized as skilled at repetitive processes that produce expected results.[303] If the skilled person were capable of inventive activity, then inventive patent applications would appear obvious.[304]

Replacing the skilled person with the skilled computer suggests a change to the nonobviousness test. At present, the test takes into account the skilled person's knowledge of the prior art. Decreasing the universe of prior art makes it easier to get a patent because, with less background knowledge, a new invention is more likely to appear inventive.[305] Likewise, expanding the universe of prior art would raise the patentability bar.[306] Yet although it may be unrealistic

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[300] *See* NONOBVIOUSNESS—THE ULTIMATE CONDITION OF PATENTABILITY 23 (John Witherspoon ed., 1980) (commemorating the twenty-fifth anniversary of the passage of 35 U.S.C. § 103 (2012)).

[301] *See* Dan L. Burk, *The Role of Patent Law in Knowledge Codification*, 23 BERKELEY TECH. L.J. 1009, 1025 (2008) ("[T]he PHOSITA is a fictional composite, a conceptual construct imagined for the purpose of assessing the claimed invention against its technological antecedents."); Cyril A. Soans, *Some Absurd Presumptions in Patent Cases*, 10 PAT. TRADEMARK & COPY. J. RES. & ED. 433, 438–39 (1967) (railing against the judicially created "superhuman Frankenstein monster Mr. Phosita").

[302] Factors to consider in determining the level of ordinary skill in the art include: (1) "type of problems encountered in the art"; (2) "prior art solutions to those problems"; (3) "rapidity with which innovations are made"; (4) "sophistication of the technology"; and (5) "educational level of active workers in the field." *In re* GPAC Inc., 57 F.3d 1573, 1579 (Fed. Cir. 1995). The U.S. Court of Appeals for the Federal Circuit has acknowledges that "[i]n a given case, every factor may not be present, and one or more factors may predominate." *See id.*; *see also* Custom Accessories, Inc. v. Jeffrey-Allan Indus., Inc., 807 F.2d 955, 962–63 (Fed. Cir. 1986) (discussing PHOSITA); Envtl. Designs, Ltd. v. Union Oil Co. of Cal., 713 F.2d 693, 696–97 (Fed. Cir. 1983) (providing precedent upon which Federal Circuit Court of Appeals in *GPAC, Inc.* relied).

[303] Hotchkiss v. Greenwood, 52 U.S. (11 How.) 248, 253 (1850) (noting patentability requires more "ingenuity or skill" than would be possessed by "an ordinary mechanic acquainted with the business"). The Court noted in 2007 in *KSR International Co. v. Teleflex Inc.* that "[a] person of ordinary skill is also a person of ordinary creativity, not an automaton." 550 U.S. 398, 421, 424 (2007) (referring to PHOSITA as a "pedal designer of ordinary skill" in a case involving pedal design).

[304] *See KSR International Co.*, 550 U.S. at 424.

[305] *See In re* Clay, 966 F.2d 656, 658 (Fed. Cir. 1992) (noting that "the scope and content of the prior art" is relevant to a determination of obviousness).

[306] *See id.*; *see also* Brenda M. Simon, *The Implications of Technological Advancement for Obviousness*, 19 MICH. TELECOMM. & TECH. L. REV. 331, 333, 350–51 (2013) (arguing that "the availability of information in a searchable form and the use of increased processing capabilities" will result in "very few" inventions being held nonobvious and that at some point AI "might become sufficiently

to expect a human inventor to have knowledge of prior art in unrelated fields, there is no reason to limit a computer's database to a particular subject matter. A human inventor may not think to combine cooking recipes with advances in medical science, but a computer would not be limited by such self-imposed restrictions. Now that humans and computers are competing creatively, the universe of prior art should be expanded.

This change would produce a positive result.[307] The PHOSITA standard has been the subject of extensive criticism, most of which has argued the criteria for assessing nonobviousness are not stringent enough and therefore too many patents of questionable inventiveness are issued.[308] Expanding the scope of prior art would make it more challenging to obtain patents, particularly combination patents.[309] The Supreme Court has particularly emphasized "the need for caution in granting a patent based on the combination of elements found in the prior art."[310] The scope of analogous prior art has consistently expanded in patent law jurisprudence, and the substitution of a skilled computer would complete that expansion.[311]

Of course, the new standard would pose new challenges. With human PHOSITAs, juries are asked to put themselves in the shoes of the skilled person and decide subjectively what that person would have considered obvious. A jury would have a difficult time deciding what a "skilled" computer would consider obvious. They could consider some of the same factors that are applied to the skilled person,[312] or perhaps the test could require a combination of

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sophisticated to ascertain what references those in the art would have actually considered at the time of invention, making the obviousness determination more predictable").

[307] *See generally* Robert P. Merges, *Uncertainty and the Standard of Patentability*, 7 HIGH TECH. L.J. 1, 14–15 (1992) (advocating for an objective PHOSITA standard). For an alternative perspective, see, for example, Durie & Lemley, *supra* note 294, at 991–92, 1017, arguing that "*KSR* overshoots the mark" in raising the patentability bar and advocating for a skilled person standard based "on what the PHOSITA and the marketplace actually know and believe."

[308] Critics have argued that the USPTO has issued too many invalid patents that unnecessarily drain consumer welfare, stunt productive research, and unreasonably extract rents from innovators. *See generally* Michael D. Frakes & Melissa F. Wasserman, *Does the U.S. Patent and Trademark Office Grant Too Many Bad Patents?: Evidence from a Quasi-Experiment*, 67 STAN. L. REV. 613 (2015) (describing the "general consensus that the [US]PTO allows too many invalid patents to issue").

[309] *See KSR Int'l Co.*, U.S. 550 at 420 (noting that "in many cases a person of ordinary skill will be able to fit the teachings of multiple patents together like pieces of a puzzle").

[310] *See id.* at 415.

[311] *See, e.g.*, George. J. Meyer Mfg. Co. v. San Marino Elec. Corp., 422 F.2d 1285, 1288 (9th Cir. 1970) (discussing the expansion of analogous art); Innovative Scuba Concepts, Inc., v. Feder Indus., Inc., 819 F. Supp. 1487, 1503 (D. Colo. 1993) (discussing the expansion of analogous art).

[312] Factors to consider in determining the level of ordinary skill in the art include: (1) "type of problems encountered in the art"; (2) "prior art solutions to those problems"; (3) "rapidity with which innovations are made"; (4) "sophistication of the technology"; and (5) "educational level of active workers in the field." *GPAC, Inc.*, 57 F.3d at 1579. "In a given case, every factor may not be present, and one or more factors may predominate." *Id.*

human and computer activity. For example, the skilled computer might be a skilled person with access to a computer's unlimited database of prior art.

CONCLUSION

It is important for policy makers to give serious consideration to the issue of computer inventorship. There is a need for the Patent Office to issue guidance in this area, for Congress to reconsider the boundaries of patentability, and for the courts to decide whether computational invention is worthy of protection. Doing so and recognizing that computers can be inventors will do more than address an academic concern; it will provide certainty to businesses, fairness to research, and promote the progress of science. In the words of Thomas Jefferson, "ingenuity should receive a liberal encouragement."[313] What could be more ingenious than creative computers?

[313] Diamond v. Chakrabarty, 447 U. S. 303, 308 (1980) (quoting 5 WRITINGS OF THOMAS JEFFERSON 75–76 (H. Washington ed. 1871)). "In choosing such expansive terms [for the language of Section 101] . . . modified by the comprehensive 'any,' Congress plainly contemplated that the patent laws would be given wide scope . . . . *Id.*