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AI & IP Innovation & Creativity in an Age of Accelerated Change

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AI & IP:
INNOVATION & CREATIVITY IN AN AGE OF ACCELERATED CHANGE

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ABSTRACT

From a glimmer in the eye of a Victorian woman ahead of her time, AI has become a cornerstone of innovation that "will be the defining technology of our time." Around 2016, the convergence of computing power, funding, data, and open-source platforms tipped us into an AI-driven 4IR. AI can make a difference in accelerating disruptive innovation by bringing a data-driven approach to invention and creation. To do so, the law must embrace change and innovation as an imperative in a journey towards an ever-shifting horizon. In the creative arts, the work for hire doctrine provides a pragmatic legal vehicle for interests to vest and negotiated by the commercial interests best placed to encourage investment in both the technology and its downstream uses. Like human-generated work, AI-generated work is an amalgam of mimicry mined from our own learning and experience. The training data it draws upon, both for expressive and non-expressive sues, are merely grist for AI's mill. Consequently, fair use must be liberally applied to prevent holdup by copyright owners and stifle transformative uses enabled by AI. AI can also be used to decipher complex copyright infringement cases such as those involving musical compositions. In the technological arts, the controversy will revolve around who owns innovative breakthroughs primarily or totally attributed to AI. How should these breakthroughs affect the regard for the notion of PHOSITA? How does AI change the equation when it comes to infringement? And how can AI help save the patent system from obsolescence? In these, AI both enables and challenges how we reward individuals whose ingenuity, industry, and determination overcame the frailty of the human condition to offer us inventions that make our lives more efficient and pleasurable. It will take a clear-eyed view to ensure that copyright and patent laws do not impede the very progress they were designed to promote.

I. INTRODUCTION

Artificial intelligence (AI) has rapidly achieved one milestone after another. The ones we hear about have to do with machines surpassing our human champions, such as Deep Blue's win over Chess champion Garry Kasparov, IBM Watson's *Jeopardy* win over human trivia kings, and Google DeepMind's Go-playing bot's win against Korean grandmaster

Lee Sedol.[1] On the other side are examples of machines working with humans: augmenting clinicians' ability to diagnose diseases,[2] big data analytics empowering content producers to produce music,[3] and even formulating new varieties of perfume.[4]

These stories are stunning from a technical perspective. As the engine powering the Fourth Industrial Revolution (4IR),[5] AI is a worthy successor to mechanization, mass production, and automation; each one has propelled us through the three earlier industrial revolutions.[6] From an economic perspective, PricewaterhouseCoopers estimates that AI will add $15.7 trillion to the global economy by 2030, with the United States (U.S.) seeing a 14.5% increase in gross domestic product from AI alone.[7] From a legal perspective, AI has already begun to challenge fundamental notions underlying how and why we incentivize creation and innovation.[8]

In October 2018, Christie's auctioned its first work of art generated by an algorithm called a generative adversarial network (GAN) that was fed 15,000 portraits painted between the 14th and 20th century.[9] The

1. Jane C. Ginsburg & Luke Ali Budiardjo, *Authors and Machines*, 34 BERKELEY TECH. L.J. (forthcoming 2019).

2. *See, e.g.*, Aaron Gin, *FDA Permits Marketing of First AI-based Medical Device; Signals Fast Track Approach to Artificial Intelligence*, PATENT DOCS (Apr. 11, 2018), https://www.patentdocs.org/2018/04/fda-permits-marketing-of-first-ai-based-medical-device-signals-fast-track-approach-to-artificial-int.html [https://perma.cc/4U9Y-X5EU] (describing how IDx-DR screens patients for diabetic retinopathy, which can lead to vision impairment and blindness, using deep learning algorithms. The screening uses standard retinal imaging, takes less than a minute, and can be performed without a clinician's interpreting images or results. IDx-DR's accuracy is about 88%.).

3. Dani Deahl, *How AI-generated Music is Changing the Way Hits are Made*, VERGE (Aug. 31, 2018), https://www.theverge.com/2018/8/31/17777008/artificial-intelligence-taryn-southern-amper-music [https://perma.cc/FJ2Q-4MS6].

4. Chavie Lieber, *Christie's just sold an AI-generated painting for $432,500. It's already controversial*, VOX (Oct. 29, 2018), https://www.vox.com/the-goods/2018/10/29/18038946/art-algorithm [https://perma.cc/AP4S-275G].

5. Klaus Schwab, *The Fourth Industrial Revolution: What it Means, how to respond*, WORLD ECON. FORUM (Jan. 14, 2016), https://www.weforum.org/agenda/2016/01/the-fourth-industrial-revolution-what-it-means-and-how-to-respond/ [https://perma.cc/A92J-WH83].

6. *Id.* (describing how water and steam technology enabled mechanized production during in the First Industrial Revolution. Electric power enabled mass production in the Second Industrial Revolution. Electronics and information technology automated production in the Third Industrial Revolution.).

7. PricewaterhouseCoopers, *Global Artificial Intelligence Study: Exploiting the AI Revolution 4* (2017), https://www.pwc.com/gx/en/issues/analytics/assets/pwc-ai-analysis-sizing-the-prize-report.pdf [https://perma.cc/69DE-LLKC].

8. *See infra* Parts III and IV.

9. The genetic adversarial network (GAN) was described in the following way:

> The algorithm is composed of two parts," says Caselles-Dupré. "On one side is the Generator, on the other the Discriminator. We fed the system with a data set of 15,000 portraits painted between the 14th century to the 20th. The Generator makes a new image

portrait was created by one computer network (the generating computer) attempting to convince a second computer (the discriminating computer) that the image it generated should pass as real art. The discriminating computer is trained with a myriad of portraits to teach it to discern what a good portrait looks like so it can play the referee. The generating computer's task is to create convincing art through a feedback loop, which improves both their capabilities over time.[10]

The portrait, titled "Edmond de Belamy" from *La Famille de Belamy*, depicts a rotund man in a dark coat with a white collar. His face is a blur, as if the algorithm is implying that all humans look alike.[11] In this regard, GAN references the past but does so in a way that appears new. The Belamy portrait forces us to confront the legal implications of an increasingly thin divide between those algorithms that augment human endeavors in both the creative arts and technological innovation, and those that displace them.[12]

It will take a clear-eyed view to ensure that copyright and patent laws do not impede the very progress they were designed to promote.[13] There may be a temptation to cling to romantic notions of creativity and innovation, praising human genius that created *real art* in a way we never do if we realized that they were created by an AI like GAN. People will nitpick whether the AI that produced a song or drug shows anything more than derivative creativity or inventiveness honed on human experience and guided by human programmed code, while ignoring that human

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> based on the set, then the Discriminator tries to spot the difference between a human-made image and one created by the Generator. The aim is to fool the Discriminator into thinking that the new images are real-life portraits. Then we have a result.

Jonathan Bastable, *Is artificial intelligence set to become art's next medium?*, CHRISTIE'S (Aug. 20, 2018), https://www.christies.com/features/A-collaboration-between-two-artists-one-human-one-a-machine-9332-1.aspx [https://perma.cc/4TDN-W9BR].

10. Meagan Flynn, *A 19-year-old developed the code for the AI portrait that sold for $432,000 at Christie's*, WASH. POST (Oct. 26, 2018), https://www.washingtonpost.com/nation/2018/10/26/year-old-developed-code-ai-portrait-that-sold-christies/?utm_term=.d9a77d1d99e6 [https://perma.cc/LRY2-4V6C].

11. Mallory Locklear, *Christie's will Auction AI-generated Art for the First Time*, ENGADGET (Aug. 22, 2018), https://engt.co/2wPuhbk [https://perma.cc/P3KB-Y3QD].

12. *See also* Camilla Hrdy, *Intellectual Property and the End of Work*, FLA. L. REV. (forthcoming 2019).

13. *See, e.g.*, Ian Hargreaves, *Digital Opportunity: A Review of Intellectual Property and Growth* 1 (2011), https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/32563/ipreview-finalreport.pdf [https://perma.cc/S98S-8GG6] ("Could it be true that laws designed more than three centuries ago with the express purpose of creating economic incentives for innovation by protecting creators' rights are today obstructing innovation and economic growth?"); *infra* Parts III and IV; *see* Elizabeth Rocha, *Sophia: Exploring the Ways AI May Change Intellectual Property Protections*, 28 DEPAUL J. ART, TECH. & INTELL. PROP. L. 126 (2018) (discussing trademarks and AI).

authors and inventors do precisely the same thing.[14] This double standard will be a sticking point in the 4IR. If a Luddite view prevails, we risk destabilizing the very foundation of investment, risk-taking, and entrepreneurship that has propelled the "Progress of Science and the useful Arts"[15] through liberal encouragement.

This article presents a fresh manifesto on how copyright and patent law and policy should respond to the wave of AI developments cresting upon us.[16] Part II provides an overview of AI—how AI evolved from a glimmer in the eye of a Victorian noblewoman centuries ahead of her time to reach a tipping point around the year 2016, propelled by a confluence of computational advancements, investments, open-source platforms, and a deluge of data. AI birthed from this tipping point has profoundly augmented and disrupted how we create and invent. Part III addresses copyright issues in AI and explains the importance of a pragmatic application of the work for hire (WFH) doctrine as well as the fair use defense to training data used in machine learning.[17] It concludes by touching on how AI can be used in copyright enforcement.

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14. *See, e.g.*, David Streitfeld, *Computer Stories: A.I. Is Beginning to Assist Novelists*, N.Y. TIMES (Oct. 18, 2018), https://www.nytimes.com/2018/10/18/technology/ai-is-beginning-to-assist-novelists.html [https://perma.cc/GS2Q-WA3M] ("Writers are readers, after all. 'I have read some uncounted number of books and words over the years that all went into my brain and stewed together in unknown and unpredictable ways, and then certain things come out,' Mr. Sloan said. 'The output can't be anything but a function of the input.'").

15. U.S. CONST. art. I, § 8, cl. 8.

16. The impact of AI goes far beyond copyright and patent law. *See, e.g.*, Peter Georg Picht and Benedikt Freund, *Competition (law) in the Era of Algorithms*, MAX PLANCK INST. FOR INNOVATION & COMPETITION, https://www.ius.uzh.ch/dam/jcr:e020bc78-45b4-4e27-a08d-87a5a0ac902b/Picht%20Freund__Competition%20law%20in%20the%20era%20of%20algorithms__MPI%20Research%20Paper%20no%2018-10__SSRN-id3180550.pdf [https://perma.cc/9N6F-7FJR] (discussing how AI can be used to facilitate collusion by monitoring rival behavior or used to signal unilateral pricing intentions); Privacy International & Article 19, *Privacy and Freedom of Expression in the Age of Artificial Intelligence*, PRIVACY INTERNATIONAL (Apr. 2018), https://privacyinternational.org/sites/default/files/2018-04/Privacy%20and%20Freedom%20of%20Expression%20%20In%20the%20Age%20of%20Artificial%20Intelligence.pdf [https://perma.cc/4BNP-GCR6] (highlighting the need to safeguard the right to freedom of expression and the right to privacy, as well as ensure accountability and transparency of AI); s*ee* Mark Lemley and Bryan Casey, *Remedies for Robots*, U. CHI. L. REV. (forthcoming 2019), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3223621 [https://perma.cc/LR2F-T82K] (discussing a system of remedies for robotic torts); Kari Paul, *Why robots should pay taxes*, MARKETWATCH (Sept. 28, 2017), https://on.mktw.net/2NlF3QO [https://perma.cc/MF2J-QTBS] (discussing whether robots should be subject to income taxes just like humans).

17. *See* 17 U.S.C. § 201 (2018) (providing that "the employer or other person for whom the work was prepared is considered the author . . . unless the parties have expressly agreed otherwise in a written instrument signed by them" and "owns all of the rights comprised in the copyright"); *see* 17 U.S.C. § 101 (2018) (providing for "work prepared by an employee in the scope of his or her employment" and commissioned works in specified categories are considered work for hire).

Part IV addresses patent issues in AI, beginning with the observation that current rules may lead applicants into a catch-22. As the human role becomes minimal or nonexistent, an application attributing invention to a human inventor may be misleading or even fraudulent. Yet, copyright law's WFH doctrine provides a ready solution. However, the potential to upset the settled position recognizing human rather than corporate employers as inventors in non-AI inventions may prove too stubborn an obstacle to overcome.

The increasing primacy of AI's role in invention may also upend the "person having ordinary skill in the art" (PHOSITA) benchmark used in most of patent law, covering everything from patent validity to infringement.[18] Without a requirement to declare the AI's role in the invention process, applicants will unfairly be able to enjoy the benefits of coasting on the AI meta-PHOSITA's prowess while being judged by the more limited scope of what humans might find nonobvious or foreseeable under the doctrine of equivalents.

AI-generated works may infringe on other's patents rights, raising questions as to who should be liable. It also raises validity issues as to whether, and if so which, AI patents should be deemed patent-eligible subject matter. Finally, the torrential amount of prior art that examiners and patent attorneys must consider requires AI-assisted due diligence, search, and examination. Even then, the blending of software into everything, including the biopharma industry, means that litigation risk management rather than risk avoidance will increasingly become the norm. Part V concludes.

II. AI: A PRIMER

If AI had a mother, she would be Ada Lovelace. Also known as Augusta Ada King-Noel, Countess of Lovelace, Ada was the only legitimate daughter of Lord Byron.[19] Ada was also a mathematician and the world's first computer programmer.[20] Born in 1815, she died at age

18. *See, e.g.*, 35 U.S.C. § 103 (2018) (forbidding issuance of a patent when "the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art"); 35 U.S.C. § 112 (2018) (requiring that the specification describe the invention "in such full, clear, concise, and exact terms as to enable any person skilled in the art . . . to make and use the same"); Warner-Jenkinson Co. v. Hilton Davis Chem. Co., 520 U.S. 17, 36 (1997) (discussing patent infringement via the doctrine of equivalents depends on the "skilled practitioner's knowledge of interchangeability between claimed and accused elements").

19. *Ada Lovelace: Computer Programmer, Mathematician* (1815–1852), BIOGRAPHY (Apr. 2, 2014), https://www.biography.com/people/ada-lovelace-20825323 [https://perma.cc/CY34-GBR8].

20. The significance of Ada Lovelace's contributions has been summarized as the following:

36.[21] At the time, the term *computer* was coined to describe female clerical workers who operated mechanical adding machines.[22] Ironically, it was Ada who, in her short life, published the first-ever algorithm and envisioned that machines could do much more than make calculations.[23]

Yet, the literature on AI usually credits Alan Turing, born nearly a century after Lovelace, with its parentage.[24] His 1936 paper, *On Computable Numbers, with an Application to the Entscheidungsproblem*, laid the foundation for computer science by using the theoretical construct now known as a Turing Machine, a simple device that could compute anything that is computable and be modified by reading program code.[25] Turing devised a test, known as the Turing Test, where a human asks questions through a computer screen.[26] If the human cannot decide whether a human or a machine is responding to those questions, the machine would be deemed *intelligent*.[27]

> Ada described how codes could be created for the device to handle letters and symbols along with numbers. She also theorized a method for the engine to repeat a series of instructions, a process known as looping that computer programs use today. Ada also offered up other forward-thinking concepts in the article. For her work, Ada is often considered to be the first computer programmer.

Id.

21. *Id*.

22. ANNE MARIE BALSAMO, *TECHNOLOGIES OF THE GENDERED BODY: READING CYBORG WOMEN* (1995); *see also Computer*, OXFORD ENG. DICTIONARY, http://www.oed.com/view/Entry/37975?redirectedFrom=computer#eid[perma.cc/Z2KU-ZVTC [https://perma.cc/ZYR8-ABWR] (defining "computer" as "a person who makes calculations or computations; a calculator, a reckoner; spec. a person employed to make calculations in an observatory, in surveying, etc.").

23. Ada Lovelace's understanding as expressed in her 1843 paper has been described as

> What Lovelace saw—what Ada Byron saw—was that number could represent entities other than quantity. So once you had a machine for manipulating numbers, if those numbers represented other things, letters, musical notes, then the machine could manipulate symbols of which number was one instance, according to rules. It is this fundamental transition from a machine which is a number cruncher to a machine for manipulating symbols according to rules that is the fundamental transition from calculation to computation—to general-purpose computation—and looking back from the present high ground of modern computing, if we are looking and sifting history for that transition, then that transition was made explicitly by Ada in that 1843 paper.

J. Fuegi and J. Francis, *Lovelace & Babbage and the creation of the 1843 'notes*,*'* 25 IEEE ANNALS HIST. COMPUTING 16 (2003), https://ieeexplore.ieee.org/document/1253887 [https://perma.cc/ZGV6-CWEJ].

24. Nathan Zeldes, *Alan Turing: The father of Artificial Intelligence – and much more*, KNOWMAIL (June 7, 2018), https://www.knowmail.me/blog/alan-turing-father-artificial-intelligence/ [https://perma.cc/C7EH-C26M].

25. *Entscheidungsproblem*, WIKIPEDIA, https://en.wikipedia.org/wiki/Entscheidungsproblem [https://perma.cc/4JJW-WCB6].

26. A.M. Turing, *Computing Machinery and Intelligence*, 59 MIND 433, 433 (1950), https://www.csee.umbc.edu/courses/471/papers/turing.pdf [https://perma.cc/9MZN-FJHR].

27. *Turing Test*, WIKIPEDIA, https://en.wikipedia.org/wiki/Turing_test [https://perma.cc/4WV2-4BJR].

Two years after Turing's death, Stanford University professor John McCarthy coined the term *artificial intelligence*, which he defined as "the science and engineering of making intelligent machines."[28] At its simplest, AI is a compilation of *if-then* statements—rules programmed by humans. But McCarthy had an unshakeable optimism that machines would someday think autonomously, noting that:

> The speed and memory capacity of today's computers may be insufficient to stimulate many of the more complex functions of the human brain, but the main obstacle is not the lack of capacity of the machines, but our inability to write programs that take full advantage of what we have.[29]

McCarthy's words were prescient and came to fruition in our lifetimes.[30]

A. Machine Learning

AI can simulate physical human processes through machines, making routine tasks more efficient, such as attaching the front bumper of a car in an assembly line.[31] AI can also enable "large-scale automation of entire groups of tasks, including repetitive intellectual tasks previously performed by human beings."[32] More than just mimicking the physical aspects of humans, AI simulates and surpasses human mental processes.

For instance, Kewpie, a food manufacturing company, trained its AI to sort through more than a million diced potatoes daily, using 18,000 pictures of diced potatoes, doubling its productivity.[33] Similarly, an AI

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28. Beatriz Guillen Tores, *The True Father of Artificial Intelligence,* OPENMIND (Sept. 4, 2016), https://www.bbvaopenmind.com/en/the-true-father-of-artificial-intelligence/ [https://perma.cc/X35T-6SH7] (defining AI as the science and engineering of making intelligent machines on the basis that "every aspect of learning or feature of intelligence can, in principle, be described so accurately that you can create a machine that simulates them").

29. *Id.* (citations omitted).

30. *See infra* Part II.B.

31. *See generally*, Michael Copeland, *What's the Difference Between Artificial Intelligence, Machine Learning, and Deep Learning?*, NVIDIA BLOG (July 29, 2016), https://blogs.nvidia.com/blog/2016/07/29/whats-difference-artificial-intelligence-machine-learning-deep-learning-ai [https://perma.cc/JW5W-SWVC].

32. Yann Ménière & Ilja Rudyk, *The Fourth Industrial Revolution from the European Patent Office Perspective*, *in* INTELLECTUAL PROPERTY AND DIGITAL TRADE IN THE AGE OF ARTIFICIAL INTELLIGENCE AND BIG DATA 31, 31 (Xavier Seuba, Christophe Geiger, & Julien Penin eds, June 2018), https://www.ictsd.org/sites/default/files/research/ceipi-ictsd_issue_5_final_0.pdf [https://perma.cc/G7QN-V5ZA].

33. Kewpie's operations and implementation of artificial intelligence was described in the following way:

> Traditionally, employees visually inspected more than one million diced potatoes per day for quality assurance. To streamline this time-consuming process, Kewpie used 18,000

called BioMind beat a team of top radiologists in reviewing magnetic resonance imaging (MRI) images to diagnose brain tumors quickly and accurately.[34] Cities like New York City routinely employ AI in facial recognition and license plate matching as part of video camera surveillance to look for "behavioral anomalies" that signal someone is about to commit a violent crime.[35]

All these forms of AI improve human productivity, stability, and reliability while mimicking human problem-solving capabilities.[36] AI can also improve itself by acquiring skills through machine learning and use iteration, in which data is repetitively fed into an algorithm to improve outputs, enabling it to accomplish its tasks with limited or no instructions.[37] In 1959, Arthur Samuel, a pioneer of machine learning, described AI as a "field of study that gives computers the ability to learn without being explicitly programmed."[38] Machine learning may be *supervised*, with the algorithm fed labelled data to train it to successfully differentiate between images.[39] Machine learning may be *semi-supervised*, where the algorithm guesses which categories are unlabeled

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pictures of diced potatoes to teach an artificial intelligence system what quality potatoes look like. The system was thus trained to recognize high-quality potatoes automatically.

Mizuki Hashiguchi, *The Global Artificial Intelligence Revolution Challenges Patent Eligibility Laws*, 13 J. BUS. & TECH. L. 1, 2 (2017).

34. The human team took 30 minutes and correctly diagnosed 65% of the time. BioMind took half that time and was correct in nearly the 90% of cases. David Alayon, *BioMind, Artificial intelligence that defeats doctors in tumour diagnosis*, MEDIUM (Aug. 8, 2018), https://medium.com/future-today/biomind-artificial-intelligence-that-defeats-doctors-in-tumour-diagnosis-5f8ec97298b2 [https://perma.cc/BUT6-3F5Z].

35. John R. Quain, *Crime-predicting A.I. isn't science fiction. It's about to roll out in India*, DIGITAL TRENDS (Apr. 11, 2018), https://www.digitaltrends.com/cool-tech/could-ai-based-surveillance-predict-crime-before-it-happens/ [https://perma.cc/2UU3-377Y].

36. Sean Illing, *Why not all forms of artificial intelligence are equally scary*, VOX (Mar. 8, 2017), https://www.vox.com/science-and-health/2017/3/8/14830108/artificial-intelligence-science-technology-robots-singularity-bostrom [https://perma.cc/M2P8-BF6G].

37. Ian Sample, *Google's DeepMind makes AI program that can learn like a human*, GUARDIAN, (Mar. 14, 2017), https://www.theguardian.com/global/2017/mar/14/googles-deepmind-makes-ai-program-that-can-learn-like-a-human [https://perma.cc/7AMS-F5NP]; *see also*, Michael Borella, *The Subject Matter Eligibility of Machine Learning: An Early Take*, PATENT DOCS (Sept. 23, 2018), http://www.patentdocs.org/2018/09/the-subject-matter-eligibility-of-machine-learning-an-early-take.html [https://perma.cc/MG4S-SQPT] ("Machine learning is more than just a buzzword. It represents a fundamental shift in how problems are solved across industries and lines of business.").

38. *Artificial Inteligence (AI) vs. Machine Learning vs. Deep Learning*, SKYMIND, https://skymind.ai/wiki/ai-vs-machine-learning-vs-deep-learning [https://perma.cc/UG7F-AD2M] ("Samuel taught a computer program to play checkers. His goal was to teach it to play checkers better than himself, which is obviously not something he could program explicitly. He succeeded, and in 1962 his program beat the checkers champion of the state of Connecticut.").

39. ROBERT PLOTKIN, THE GENIE IN THE MACHINE: HOW COMPUTER-AUTOMATED INVENTING IS REVOLUTIONIZING LAW AND BUSINESS 61 (2009).

images and the results are fed back as training data. Machine learning also may be *unsupervised*, where the algorithm can differentiate without a pre-programmed dataset by clustering data based on characteristics. While human input is needed to specify the seed solutions, fitness measures, and termination criteria, no human intervention is required during the program's execution.

This sort of *unsupervised* or *deep learning* brings machine learning to the next level by mimicking how the human brain works. It does not break problems down into parts to solve individually. Rather, it solves the problem from end to end by repeating each generation of solutions until the algorithm converges on offspring that solve the problem, similar to what humans do when we learn from experience.[40] This so-called *deep learning* powers chatbots like Alexa, Cortana, and Siri, as well as real-time natural language translators.[41] Associated Press uses deep learning in its Wordsmith AI to generate millions of news stories for financial services and sports, outpacing the output of all major media companies combined.[42] It plans to offer medium-specific stories, such as those published online and read on air by newscasters; publication-specific stories separately tailored for publications like the *New York Times* and *Buzzfeed*; and customizable stories for individual households by integrating with other AIs like Amazon's Alexa.[43]

40. Deep learning has been described in the following way:

> Deep is a technical term. It refers to the number of layers in a neural network. A shallow network has one so-called hidden layer, and a deep network has more than one. Multiple hidden layers allow deep neural networks to learn features of the data in a so-called feature hierarchy, because simple features (e.g. two pixels) recombine from one layer to the next, to form more complex features (e.g. a line). Nets with many layers pass input data (features) through more mathematical operations than nets with few layers, and are therefore more computationally intensive to train. Computational intensity is one of the hallmarks of deep learning, and it is one reason why GPUs are in demand to train deep-learning models.

Chris Zhou, *How does the complexity of Go compare with Chess?*, QUORA, https://www.quora.com/How-does-the-complexity-of-Go-compare-with-Chess [https://perma.cc/HNU7-BNLW].

41. Will Knight, *A plan to advance AI by exploring the minds of children*, MIT TECH. REV. (Sept. 12, 2018), https://www.technologyreview.com/s/612002/a-plan-to-advance-ai-by-exploring-the-minds-of-children/ [https://perma.cc/D633-RMNF] ("Deep learning has, for instance, given computers the ability to recognize words in speech and faces in images as accurately as a person can. Deep learning also underpins spectacular progress in game-playing programs, including DeepMind's AlphaGo, and it has contributed to improvements in self-driving vehicles and robotics.").

42. *The Associated Press uses NLG to transform raw earnings data into thousands of publishable stories, covering hundreds more quarterly earnings stories than previous manual efforts*, AUTOMATED INSIGHTS (Feb. 12, 2018), https://automatedinsights.com/customer-stories/associated-press/ [https://perma.cc/N9JY-JH9R].

43. *Id.*

AI can also suggest designs that are structurally unusual and possess significant functional advantages over the prior art. For instance, the National Aeronautics and Space Administration (NASA) used its AI to optimize pre-existing inventions. This is particularly useful where interrelationships between variables are poorly understood or unknown or where improvements can produce significant results. NASA designed miniature satellites used in its Space Technology 5 mission by focusing the AI on developing antenna designs that met the predefined mission requirements.[44] Similarly, deep-learning AI helped Hitachi design a nose cone for the Japanese bullet train, which improved aerodynamic performance and reduced cabin noise levels.[45] Oral-B devised the cross-bristle design of its CrossAction toothbrush using AI, which removed plaque better than other toothbrush designs.[46] GlaxoSmithKline (GSK) applied AI to predict molecule behavior and determine if its drugs would be beneficial, reducing the cost and time of discovery by 75%.[47] All this happened because four factors converged around 2015–2016 that tipped and accelerated the AI wave powering the 4IR.

B. *Tipping Point and Acceleration*

Around 2015–2016, the AI revolution reached a tipping point. In 2015, Microsoft Research's AI surpassed human performance in a test to identify objects in digital images. AI excelled at "fine-grained recognition," which might be a category of expertise beyond the average person's abilities but is trivial for massive computer archives of data.[48] For instance, humans can easily recognize a bird but may not be able to identify their species. ImageNet has run the competition annually since 2010, and in 2015, a computer took the crown from the best human score

44. Erica Fraser, *Computers as Inventors – Legal and Policy Implications of Artificial Intelligence on Patent Law*, 13 SCRIPTED 305 (2016), https://script-ed.org/?p=3195 [https://perma.cc/3MNW-PWFN] ("This exemplifies that using AI to explore a wide range of possibilities without the limitations of human preconceptions can produce results with previously unachievable levels of performance.").

45. Plotkin, *supra* note 39.

46. Ryan Abbott, *I Think, Therefore I Invent: Creative Computers and the Future of Patent Law*, 57 B.C. L. REV. 1079, 1083–85 (2016).

47. *See* Ben Hirschler, *Big Pharma Turns to AI to Speed Drug Discovery, GSK Signs Deal*, REUTERS (July 1, 2017), https://reut.rs/2x0d1Rs [https://perma.cc/4G8D-83VF].

48. Michael Thomsen, *Microsoft's Deep Learning Project Outperforms Humans in Image Recognition*, FORBES (Feb. 19, 2015), https://www.forbes.com/sites/michaelthomsen/2015/02/19/microsofts-deep-learning-project-outperforms-humans-in-image-recognition/#267efbe5740b [https://perma.cc/6ZM3-RBLN].

for the first time. Microsoft's deep-learning AI won by beating the human benchmark of 5.1% errors with 4.94% errors.[49]

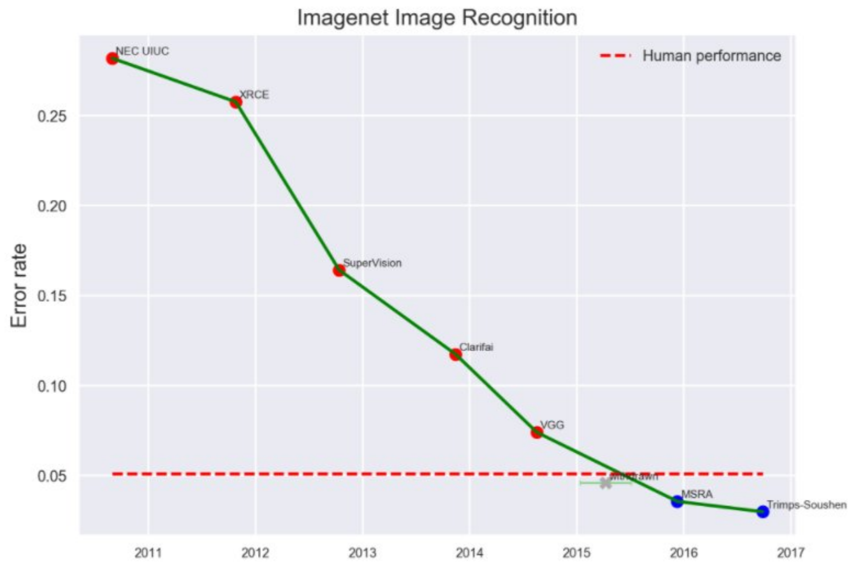

Figure 1. Imagenet Image Recognition.[50]

In 2016, Next Rembrandt, a group of museums and researchers in the Netherlands, unveiled a painting created by AI that mimicked the subject matter and style of the artist almost indistinguishably. It analyzed thousands of works by a 17th century Dutch artist and broke them down into 168,263 fragments before using them to create the painting.[51] Similarly, computer scientists in Tübingen, Germany, trained an AI robot to paint in Picasso's signature style.[52] French computer scientists wrote an algorithm using Bach's style to compose music so well that half of the

49. R. Colin Johnson, *Microsoft, Google Beat Humans at Image Recognition*, EE TIMES (Feb. 18, 2015), https://www.eetimes.com/document.asp?doc_id=1325712 [https://perma.cc/P8YN-VPLU] (attributing its breakthrough to being able to "make [neural] units smarter by allowing them to take a more flexible form," where "the particular form of each unit is learned by end-to-end training").

50. *AI Progress Measurement*, ELECTRONIC FRONTIER FOUND., http://www.eff.org/ai/metrics [https://perma.cc/3GEG-YLUZ].

51. Andres Guadamuz, *Artificial Intelligence and Copyright*, WIPO MAG. (Oct. 2017), http://www.wipo.int/wipo_magazine/en/2017/05/article_0003.html [https://perma.cc/SD4Q-KE9E].

52. Hashiguchi, *supra* note 33 ("When a user provides this artificial intelligence 'maestro' with a scenic photograph of Tübingen, with its light pink, yellow, and sky-blue houses facing the Neckar River, the artificial intelligence produces a painting of this scenery that creates the impression that it was actually painted by Pablo Picasso.").

over 1,200 people who listened to it believed that it was composed by Bach himself.[53]

Also in 2016, a short novel written by a Japanese AI "author" reached the second round of a national literary prize;[54] DeepMind's AI generated music by listening to recordings;[55] and Tesla began rolling out its new Autopilot hardware for its cars.[56] In 2016, the Committee on Legal Affairs of the European Parliament pushed for protection of AI-generated creations, "obviously perceiving a competitive advantage in extending the copyright framework to machine creation."[57] And that year, the White House released, for the first time, two reports detailing how AI would transform the American economy[58]

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53. Gaëtan Hadjeres, François Pachet & Frank Nielson, *DeepBach: A Steerable Model for Bach Chorales Generation*, 70 PROC. MACHINE LEARNING RES. 1362–71 (2017), http://proceedings.mlr.press/v70/hadjeres17a/hadjeres17a.pdf [https://perma.cc/5YFM-ZWBR].

54. *Id.*

55. Paul Ratner, *Listen to New Google AI Program Talk Like a Human and Write Music*, BIG THINK (Sept. 11, 2016), https://bigthink.com/paul-ratner/listen-to-new-google-ai-program-talk-like-a-human-and-write-music [https://perma.cc/4J2C-75MH]. One way that DeepMind is different than traditional methods was described in the following way:

> Most research projects train a system by converting the raw sound waves into MIDI files, which the neural network is expected to recreate. This, it seems, strips away the details and nuances that are important when it comes to crafting music that sounds realistic. So instead, the DeepMind gang trained their model directly from raw audio waves, teaching it to produce raw audio waves – a move other teams are also starting to consider.

Katyanna Quach, *Here's why AI can't make a catchier tune than the worst pop song in the charts right now*, REGISTER (July 24, 2018), https://www.theregister.co.uk/2018/07/24/deepmind_ai_music/ [https://perma.cc/8XJW-AD5N].

56. Cadie Thompson, *Elon Musk says Tesla will launch its cross-country road trip in a self-driving car in 3 to 6 months*, BUS. INSIDER (Feb. 7, 2018), https://www.businessinsider.com/elon-musk-tesla-road-trip-in-autonomous-car-mid-2018-2018-2 [https://perma.cc/7SCH-ZFYG]. This technology has become so advanced that today, traditional carmakers like Audi, Cadillac, and Volvo are developing advanced self-driving technology capable of safely shuttling passengers without driver input. By 2040, one in four vehicles sold are expected to be autonomous. *See* Jonathan Long, *10 Artificial Intelligence Trends to Watch in 2018*, ENTREPRENEUR (Jan. 18, 2018), https://www.entrepreneur.com/article/307589 [https://perma.cc/M729-UZAY]; Chris Neiger, *How to Make Money in Self-Driving Cars*, MOTLEY FOOL (Apr. 13, 2018), https://www.fool.com/investing/2018/04/13/how-to-make-money-in-self-driving-cars.aspx [https://perma.cc/8JH9-554F].

57. Daniel Schönberger, *Deep Copyright: Up - and Downstream Questions Related to Artificial Intelligence (AI) and Machine Learning (ML)*, *in* DROIT D'AUTEUR 4.0 / COPYRIGHT 4.0 145–73 (2018).

58. Executive Office of the President, The National Science and Technology Council, Committee on Technology, *Preparing for the Future of Artificial Intelligence* (Oct. 2016), https://obamawhitehouse.archives.gov/sites/default/files/whitehouse_files/microsites/ostp/NSTC/preparing_for_the_future_of_ai.pdf [https://perma.cc/4Y3C-MKGU]; Executive Office of the President, *Artificial Intelligence, Automation, and the Economy* (Dec. 2016), https://obamawhitehouse.archives.gov/sites/whitehouse.gov/files/documents/Artificial-Intelligence-Automation-Economy.PDF [https://perma.cc/Z66K-MG7R].

One report noted that "[i]n 2016, applicants filed 9,605 AI-related patent applications in the U.S., a decade-over-decade increase of almost 500%."[59] Combined, the U.S., China, and Japan account for 74% of the total AI patents published, with China leading the pack.[60] China also had half the number of AI-focused companies than the U.S.[61] AI-related patent application filings in China began outpacing those of the U.S., Patent Cooperation Treaty (PCT), Europe, Japan, and Korea in 2016.[62]

The U.S. excels at visionary research and moonshot projects thanks to its vibrant intellectual environment, unparalleled network of research universities, and openness to immigration.[63] AI implementation, however, requires both the ability to adapt public infrastructure to fit AI-innovations and a private sector that can successfully commercialize AI into viable products.[64] If AI is to transform the way we innovate and create, then we will need to embrace the businesses that will invest in the necessary digital and physical infrastructure. The bottleneck for the U.S. will not be in major improvements in core algorithms but rather in the policy adaptation needed to implement such algorithms in commercially viable products and services to mesh with new technology in public infrastructure and public institutions.

In the past, the traditional levers of production were capital investment and labor. These levers, however, had little impact on raising economic growth recently.[65] Businesses must find new paths to create growth and value with AI as the primary driver.[66] AI will create jobs in

59. Aaron V. Gin & Michael Krasniansky, *Claiming Artificial Intelligence: AI-related Patent Filing Trends and Practice Tips*, MBHB SNIPPETS (2018), https://www.mbhb.com/intelligence/snippets/claiming-artificial-intelligence-ai-related-patent-filing-trends-and-practice-tips [https://perma.cc/E8LQ-7DG4].

60. AFD China Intellectual Property, *China Busy in Mapping AI Patents*, MONDAQ (Aug. 31, 2018), http://www.mondaq.com/china/x/732208/Patent/Government+to+Ramp+up+Crackdown+on+Counterfeit+Goods [https://perma.cc/GXS7-C84P].

61. *Id.*

62. Gin & Krasniansky, *supra* note 59; *see* AFD China Intellectual Property, *supra* note 62 (China's strength is in the application of AI, but it currently trails the U.S. in areas such as hardware and algorithms).

63. Kai-Fu Lee, *What China Can Teach the US About Artificial Intelligence*, N.Y. TIMES (Sept. 26, 2018), https://www.nytimes.com/2018/09/22/opinion/sunday/ai-china-united-states.html [https://perma.cc/4RGG-97WE].

64. *Id*.

65. The Economist Intelligence Unit, *Intelligent Economies: AI's Transformation of Industries and Society*, ECONOMIST (2018), https://perspectives.eiu.com/sites/default/files/EIU_Microsoft%20-%20Intelligent%20Economies_AI%27s%20transformation%20of%20industries%20and%20society.pdf [https://perma.cc/DG75-7UEM] [hereinafter "Intelligent Economies"].

66. *Id.* at 6–7 (reporting that 94% of respondents describe AI as important to solving their organizational strategic challenges and 84% expect it to have a positive impact on innovation).

the innovative and creative sectors that patent and copyright stakeholders care about. But it will also cause other individuals to lose work.[67] It is futile for Luddites to fight over obsolete technologies and yesterday's jobs. Enlighted policymakers in the U.S. will take advantage of the new opportunities AI offers and *upskill* to harness the jobs of the future.[68]

The tipping point in 2016 results from the convergence of four factors. First, computer processors attained the miniaturization, sophistication, and power needed for AI to take off.[69] Coding is typically labor-intensive, making computing expensive and slow. Computing, however, has become so cheap that it is more efficient for a computer to write a program. Equipped with different data sets, software can solve different problems. In 2016, *Wired* reported that tech giants like Google, Facebook, Microsoft, Amazon, and Baidu would replace central processing units (CPUs) with graphics processing units (GPUs) as the main means of computing.[70] The next year, Intel, the world's largest chipmaker, announced its ambitions to make AI "available for all" by building AI capabilities into its chips.[71] Apple is using its Bionic chip inside iPhones to enable faster on-device AI compared to devices requiring the cloud to perform AI-based tasks.[72] A smart camera system running on CUDA cores and DGX-1 box by Nvidia can spot guns in video footage with 99% accuracy.[73] Using this technology, cameras can

67. *The Future of Jobs 2018*, WORLD ECON. FORUM (2018), http://reports.weforum.org/future-of-jobs-2018/ [https://perma.cc/J7TQ-V7T8] (estimating that by 2025 machines will take over 75 million jobs, or about the half current global workforce, while creating 133 million jobs).

68. Will Knight, *MIT has just announced a $1 billion plan to create a new college for AI*, TECH. REV. (Oct. 15, 2018), https://www.technologyreview.com/the-download/612293/mit-has-just-announced-a-1-billion-plan-to-create-a-new-college-for-ai/ [https://perma.cc/6HPU-P93G] ("With $1 billion in funding, MIT will create a new college that combines AI, machine learning, and data science with other academic disciplines. It is the largest financial investment in AI by any US academic institution to date.").

69. Ryan Calo, *Artificial Intelligence Policy: A Primer and Roadmap*, 51 U.C. DAVIS L. REV. 399, 402 (2017) ("A vast increase in computational power and access to training data has led to practical breakthroughs in machine learning, a singularly important branch of AI.").

70. Cade Metz, *How AI Is Shaking Up the Chip Market*, WIRED (Oct. 28, 2016), https://www.wired.com/2016/10/ai-changing-market-computer-chips/ [https://perma.cc/B98R-CFDF].

71. Angela Scott-Briggs, *Latest Trends in Artificial Intelligence*, TECH BULLION (Feb. 2, 2017), https://www.techbullion.com/latest-trends-artificial-intelligence/ [https://perma.cc/A6CS-FD3Q].

72. Emrah Gultekin, *The AI bubble won't burst anytime soon, but change is on the horizon*, VENTUREBEAT (July 1, 2018), https://venturebeat.com/2018/07/01/the-ai-bubble-wont-burst-anytime-soon-but-change-is-on-the-horizon/ [https://perma.cc/GM9D-PJPP].

73. Luke Dormehl, *A.I. security camera can identify guns with 99 percent accuracy*, DIGITAL TRENDS (Sept. 28, 2018), https://www.digitaltrends.com/cool-tech/ai-camera-spots-guns-in-video/ [https://perma.cc/7DV5-MW2Z].

automatically alert law enforcement to the presence of guns, potentially saving lives in the process. These technologies are among the fastest GPUs currently on the market.[74]

The second factor was the development of open-source frameworks, which allowed developers to work synergistically on the same platforms to build the infrastructure needed for AI-enabled devices to interoperate.[75] Interconnected computer processors performing parallel processing are formed by artificial neural networks. These networks can learn from historical data and known patterns and apply them in clinical diagnosis and image analysis.[76] Peer-to-peer networks, such as those used by cryptocurrencies, empower even small entities to run "advanced AI programs by harnessing the collective power of networked personal computers."[77] GAN was an example of open source sharing that facilitated the creation of the Bellamy portrait.[78]

An open-source architecture, however, brings its share of challenges, particularly to patents covering AI technology. AI patents may be helpful to attract investment, build a defensive portfolio, or secure a licensing stream.[79] However, if AI using open-source software is subject to an open-source license itself, the license terms may preclude patenting improvements to the open-source code, require improvements to be freely distributed, or force patents to be licensed at no cost to third parties.[80] One way around this is to carve out a set of standards or protocols for patenting but leave elements of it as open-source.[81]

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74. *Id.*

75. Gultekin, *supra* note 72.

76. Susan Y. Tull, *Patenting the Future of Medicine: The Intersection of Patent Law and Artificial Intelligence in Medicine*, 10 LANDSLIDE 40, 41 (2018) ("Neural networks have been used for diagnosing prostates as benign or malignant, cervical screening, and imaging analysis (including radiographs, ultrasounds, CTs, and MRIs), as well as for analyzing heart waveforms to diagnose conditions such as atrial fibrillation and ventricular arrhythmias.").

77. Long, *supra* note 54.

78. James Vincent, *How three French students used borrowed code to put the first AI portrait in Christie's*, VERGE (Oct. 23, 2018), https://www.theverge.com/2018/10/23/18013190/ai-art-portrait-auction-christies-belamy-obvious-robbie-barrat-gans [https://perma.cc/VV9V-KXUL] ("Insiders say the code used to generate these prints is mostly the work of another artist and programmer: 19-year-old Robbie Barrat, a recent high school graduate who shared his algorithms online via an open-source license.").

79. *See generally, e.g.*, Robert Stoll, *Alternative Routes to Protection of Innovation*, IPWATCHDOG (June 18, 2018), https://www.ipwatchdog.com/2018/06/13/alternative-routes-to-protection-of-innovation/id=98373/ [https://perma.cc/5JQY-86KE].

80. *See generally, e.g.*, Leslie M. Spencer & Marta Belcher, *Blockchain Intellectual Property Considerations for Innovators and Investors*, LEXOLOGY (June 21, 2018), https://www.lexology.com/library/detail.aspx?g=7bf415ff-c423-46ef-b88a-660a3e7e303a [https://perma.cc/VKZ9-BLJ9].

81. *Id.*

Third, enough data now exists to meaningfully run AI algorithms. AI systems need to be trained using vast amounts of data for pattern-recognition and predictive analytics.[82] Machine learning is a resource-hungry endeavor, requiring considerable data. Because AI uses probabilities to determine decisions, more data empowers it to become better at making predictions.[83] This refers not merely to the number of users and ability to access the data contributed by those users but also to the depth of data on each user in the form of their real-world activities to give a multidimensional picture of each user so AI companies can better tailor their services. That data allows search engines and online retailers to predict what consumers are interested in purchasing.[84]

The Third Industrial Revolution brought with it massive amounts of data (2.6 quintillion bytes daily)[85] and the torrent is increasing at an accelerated rate to feed deep-learning algorithms in every sphere of creativity and innovation.[86] Banks, insurance companies, and government agencies have collected data for archival purposes for a long time. Now they realize they are sitting on gold mines. *The Economist* boldly declared that in the 4IR, "[t]he world's most valuable resource is no longer oil, but data."[87]

Fourth, investment in AI projects was sufficiently plentiful. The McKinsey Global Institute's report estimated that firms spent between

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82. Amanda Levendowski, *How Copyright Law Can Fix Artificial Intelligence's Implicit Bias Problem*, 93 WASH. L. REV. 579, 591 (2018) ("Most AI systems require exposure to significant amounts of data to automatically improve at a task. These data are referred to as 'training data.'"); Benjamin L. W. Sobel, *Artificial Intelligence's Fair Use Crisis*, 41 COLUM. J.L. & ARTS 45, 58 (2017) ("These methodologies encourage and reward the acquisition of large amounts of data.").

83. Long, *supra* note 56.

84. Sam Baxter, *Nothing Artificial About This Intelligence: AI Meets IP*, IP.COM (Dec. 18, 2017), https://ip.com/blog/nothing-artificial-intelligence-ai-meets-ip/ [https://perma.cc/AG5Q-P5UU].

85. Christophe Geiger, Giancarlo Frosio & Oleksandr Bulayenko, *Crafting a Text and Data Mining Exception for Machine Learning and Big Data in the Digital Single Market*, *in* GLOBAL PERSPECTIVES AND CHALLENGES FOR THE INTELLECTUAL PROPERTY SYSTEM 95, 97 (2018).

86. Claudia Jamin, *Managing Big Data in the Digital Age: An Industry Perspective*, *in* GLOBAL PERSPECTIVES AND CHALLENGES FOR THE INTELLECTUAL PROPERTY SYSTEM 149, 151(2018) ("While less than 10 zettabytes of data were created in 2015, according to the market intelligence company IDC, expectations go as high as 180 zettabytes of data (or 180 trillion gigabytes) in 2025."); *see also* Bernard Marr, *What Is Deep Learning AI? A Simple Guide With 8 Practical Examples*, FORBES (Oct. 1, 2018), https://www.forbes.com/sites/bernardmarr/2018/10/01/what-is-deep-learning-ai-a-simple-guide-with-8-practical-examples/ [https://perma.cc/7BYY-9VFB] ("Since deep-learning algorithms require a ton of data to learn from, this increase in data creation is one reason that deep learning capabilities have grown in recent years.").

87. *The world's most valuable resource is no longer oil, but data*, ECONOMIST (May 6, 2017), https://www.economist.com/leaders/2017/05/06/the-worlds-most-valuable-resource-is-no-longer-oil-but-data [https://perma.cc/SE79-XQ98].

$18 billion and $27 billion on AI-related projects, including acquisitions in 2016.[88] Between 2017 and 2025, market revenue is expected to more than double from $33.5 billion to $88.5 billion.[89] The investment also comes in the form of corporate restructuring. Microsoft created the Cloud and AI Platform to complement its AI and Research group, which it set up in 2016 to accelerate the adoption. As its CEO noted, "We will continue to drive investments in A.I.+R across research and A.I. breakthroughs that are key to [Microsoft's] long-term success."[90] Today, Microsoft has 8,000 workers in those departments.[91]

The convergence of these four factors—computing power, open source platforms, data, and financing—supercharged AI breakthroughs at an accelerated pace. In 1997, IBM's Deep Blue defeated Gary Kasparov in chess, a game with 10^{120} possible moves, more than the number of atoms in the universe.[92] In 2016, Google's AlphaGo defeated world champion Lee Sedol in Go, a game with 10^{174} moves—"1 million trillion trillion trillion trillion more configurations than chess."[93] In 2003, the human genome took ten years to sequence at a cost of three billion dollars. In 2013, it took one week and one thousand dollars. As 2017 dawned, Illumina was poised to do so in one hour at a cost as low as one hundred dollars.[94] As AI has accelerated toward the tipping point, its development and dissemination has augmented and disrupted how we create and invent.

88. *Tech Platforms Weekly: A Closer Look at Amazon's Conduct in the Book Market; More Claims of Search Bias; Facebook, Apple, and Net Neutrality Updates; The Myspace Myth*, CAPITOL FORUM (Jan. 20, 2017), http://thecapitolforum.cmail2.com/t/ViewEmail/j/91CFEB1924D56C52/45A74A929A973E10E663AB054A538FBA [https://perma.cc/CL58-AK79] (noting how firms spent $2 to $3 billion on AI-related M&A in 2016); Robert Seamans, *Artificial Intelligence Is On The March. But Is Government Ready?*, FORBE (Sept. 5, 2018), https://www.forbes.com/sites/washingtonbytes/2018/09/05/artificial-intelligence-is-on-the-march-but-is-government-ready/#6b6faaaa218b [https://perma.cc/AQS8-AYMR].

89. *Big data market size revenue forcast worldwide from 2011 to 2027 (in billion U.S. dollars)*, STATISTA, https://www.statista.com/statistics/254266/global-big-data-market-forecast/ [https://perma.cc/TG25-G2RZ].

90. Kevin Parrish, *Microsoft 'excited' about its secret hardware built for artificial intelligence*, DIGITAL TRENDS (Apr. 4, 2018), https://www.digitaltrends.com/computing/microsoft-harry-shum-excited-ai-driven-hardware/ [https://perma.cc/MAY2-4XMF].

91. *Id.*

92. Curiosity Staff, *There Are More Games of Chess Possible Than Atoms in The Universe*, CURIOSITY (June 16, 2016), https://curiosity.com/topics/there-are-more-games-of-chess-possible-than-atoms-in-the-universe-curiosity/ [https://perma.cc/9UNA-LEEF].

93. Zhou, *supra* note 40.

94. Sarah Buhr, *Illumina wants to sequence your whole genome for $100*, TECHCRUNCH (2016), https://techcrunch.com/2017/01/10/illumina-wants-to-sequence-your-whole-genome-for-100/ [https://perma.cc/ZLM7-SMGP].

C. Augmentation & Disruption

AI augments what authors and inventors can do. Just as calculators make advanced mathematics more accessible without innate talent at arithmetic, AI makes creation and innovation more accessible to a wider range of people by simplifying tasks and freeing up human experts for what they do best.[95] Artists today work with a dazzling array of media, from "fluorescence microscopy, 3-dimensional bioprinting, and mixed reality, further stretching the possibilities of self-expression and investigation."[96] For instance, Wibbitz offers a platform for publishers to turn written content into video content through AI video production,[97] and See Sound translates the human voice into digital sculptures, the material, orientation, shape, and volume of which are defined by the timbre, pitch, and volume of the artist's voice.[98]

Similarly, AI can accompany a performance or give creative inspiration to power-through a writer's block.[99] It can enable services that deep-dive into the music catalogue and find what traits hit songs share such as "melodies, pitch, tempo, octave, beat, rhythm, fullness of sound, chord progression and brilliance."[100] This information in turn can help record companies determine which songs to promote as singles and which to include in an album.[101]

While such AI technology assists artists in giving form to their expression, artists wield them while continuing to express their own intelligence, insight, and inspiration through the creative processes. These AI-augmented innovations and creative works are examples of a technology progressing linearly within the intellectual property (IP) framework. Even though the AI exercises a degree of autonomy in generating the work, human input is still necessary for AI to express

95. Guadamuz, *supra* note 51 ("Since the 1970s computers have been producing crude works of art, and these efforts continue today. Most of these computer-generated works of art relied heavily on the creative input of the programmer; the machine was at most an instrument or a tool very much like a brush or canvas.").

96. Rama Allen, *AI will be the art movement of the 21st century*, QUARTZ (Mar. 5, 2018), https://qz.com/1023493/ai-will-be-the-art-movement-of-the-21st-century/ [https://perma.cc/NR46-YVS6].

97. Long, *supra* note 56.

98. Millchannel, *Mill Move Me, See Sound Voice-Driven Sound Sculptures*, YOUTUBE (July 20, 2017), https://www.youtube.com/watch?v=LIctf06yIDk [https://perma.cc/FX6V-K4SF].

99. Stuart Dredge, *RoboPop: How will AI and machine learning affect the music industry?*, MUSICALLY (Apr. 20, 2018), https://musically.com/2018/04/20/robopop-ai-machine-learning-music/ [https://perma.cc/2XGF-HW8N].

100. *The beat goes on*, ECONOMIST (July 9, 2004), https://www.economist.com/news/2004/07/09/the-beat-goes-on [https://perma.cc/VN8A-T755].

101. *Id.*

creativity and may be analogized to a tool that augments human creativity.[102] There is no collaboration as such.

With advances in machine learning, the interaction between algorithms and the creative process is changing. AI now allows artists to find unexpected beauty in chaos and complexity that exceeds the human grasp, providing humans with the systematic analysis they need to make the novel leap into something wholly new.[103] These new forms of AI can interact with artists in a fashion like improvisational jazz, where musicians feed off cues from each other in a creative feedback loop.

For instance, "generative artists" compose algorithmically or remove their own personalities from the creative process altogether by ceding control to self-executing algorithms.[104] By reacting to the AI's output, they provide another input to the system, which distills the essence of the artist's expression to reach a new paradigm of creativity.[105] Artist Sougwen Chung trains her AI DOUG with her style of drawing and learns how it translates her drawing, in turn affecting her own drawing behaviors in a real-time duet.[106] AI can even be trained to beatbox live with a human by "parsing his voice, intonation, and rhythms to create new rhythmic accompaniments and melodies."[107]

Beyond the duet, AI is evolving into autonomous systems that can learn and produce works that are specifically programmed.[108] The Belamy portrait exists on a different scale from filters on smartphone apps that make summer selfies look like a Monet or Picasso. GAN crunches data about how art has changed over time and generates a work that looks

102. This relationship has been described in the following way:

> [T]he scope of that discretion is limited to the operation of programming created by the human inventors. The significance of this from the copyright perspective is that human input is still necessary, not only for a work to be produced, but for it to have any sort of creative content. An expert system has become a tool for human creativity.

Shlomit Yanisky-Ravid, *Generating Rembrandt: Artificial Intelligence, Copyright, and Accountability in the 3A Era–the Human-Like Authors Are Already Here–A New Model*, 2017 MICH. ST. L. REV. 659, 674 (2017).

103. Allen, *supra* note 96.

104. Annemarie Bridy, *The Evolution of Authorship: Work Made by Code*, 39 COLUM. J.L. & ARTS 395, 397 (2016).

105. Allen, *supra* note 96 ("The output of this expression differs categorically from all art previously made by humans through history, and this intelligent contribution inspires deeper investigations of the meanings of authorship, creativity, and art.").

106. Jack Cote, *Drawing Operations Unit: Generation 2 (Memory)*, DIGITAL ART (May 23, 2017), http://www.digiart21.org/art/drawing-operations-unit-generation-2-memory [https://perma.cc/UTL3-28KS].

107. Allen, *supra* note 96.

108. Guadamuz, *supra* note 51.

simultaneously ancient and modern.[109] It learns from the training data and makes independent decisions throughout the process to determine what the new work should look like.

Similarly, AI like Google's Magenta composes music without the aid of specific algorithms or human intervention, and Google's DeepMind generates novel music and artworks by listening to other music or analyzing existing work online.[110] GAN, Magenta, and DeepMind usher us into an age where the AI, and not its human partner, is a collaborator, if not the primary actor, contributing the skill and labor of an artistic kind.[111] These AI developments tease a future where scientific discovery and creative expression take place autonomously and humans are only secondarily responsible.

An artist's spark of genius dictates his brushstrokes. The spark is inchoate and cannot be downloaded and decoded, and it is this spark that has fueled the utilitarian underpinnings of copyright protection. Christie's estimated the Belamy portrait to sell for about $10,000.[112] It sold for $432,000, over 43 times higher than Christie's own estimate.[113] That sale raises the stakes in providing answers to fundamental copyright questions arising from AI technology: Can there be copyright in an AI-created portrait, even one indistinguishable from those done by humans? Who is the author and owner—the software's user, the software's creator, or someone else? Who can copy the portrait? With the rapid development of content creating AI like GAN, these questions must be answered, and courts will have to grapple with them sooner rather than later.

A similar revolution is happening with inventions. Deep learning can sift through stockpiles of previously out-of-reach data.[114] These could be notes buried in old charts or records and tracing data points that led it to its conclusions. AI-powered diagnostics might use a patient's medical record as a baseline to measure deviations and alert their physician of a

109. *See* Alexander Mordvintsev et al., *Inceptionism: Going Deeper into Neural Networks*, GOOGLE RESEARCH BLOG (June 17, 2015), https://ai.googleblog.com/2015/06/inceptionism-going-deeper-into-neural.html [https://perma.cc/QHG8-TV7M] (describing Google's DeepDream, an AI that can detect and enhance similar patterns in unrelated images).

110. Matt McFarland, *Google's computers are creating songs. Making music may never be the same*, WASH. POST (June 6, 2016), https://www.washingtonpost.com/news/innovations/wp/2016/06/06/googles-computers-are-creating-songs-making-music-may-never-be-the-same/?utm_term=.55226125405c [https://perma.cc/4389-VN6N].

111. Schönberger, *supra* note 57, at 145–73.

112. Flynn, *supra* note 10.

113. Flynn, *supra* note 10.

114. Marr, *supra* note 84 (Deep-learning "allows machines to solve complex problems even when using a data set that is very diverse, unstructured and inter-connected.").

need to follow up.[115] As in the creative arts, the use of AI in medicine has evolved from augmenting processes to work more fluidly and efficiently, to clinical detection systems to analyze scans, medical records, electrocardiograms and the like using coded datasets, to AIs that identify connections in clinical development and commercialization by asking the right questions.[116] As one commentator noted, "AI can identify connections that were previously loosely associated by normalizing unrelated contexts. This is disruptive because it allows us to simultaneously generate and test novel hypotheses for a variety of life-science use cases."[117]

AI screens, compounds, and automates the design of new classes of drugs, finding new uses for them.[118] "Robot Eve," an AI, is used in drug development to fight drug-resistant malaria.[119] It devises hypotheses, designs experiments, employs automated laboratory equipment to run experiments, and even interprets the results. The growing role of AI in drug innovation helps prioritize experiments and substantially reduces the necessity for experimental work.[120] It could also steer drug companies toward diagnoses and treatment plans they might not have otherwise considered.[121]

Incentivizing AI-generated work will facilitate a creative renaissance. AI does not suffer from perceptual limitations the way that humans do. An example may be seen in the case of patients in Beijing that doctors said had "no hope" of regaining consciousness.[122] The hospital

115. Intelligent Economies, *supra* note 65, at 5.

116. Gunjan Bhardwaj, *Understanding the Third Wave of AI in Healthcare and Life Sciences*, TECH EMERGENCE (Jan. 30, 2018), https://www.techemergence.com/understanding-the-third-wave-of-ai-in-healthcare-and-life-sciences/ [https://perma.cc/78FT-KACL].

117. *Id.*

118. *Id.*

119. Robot Eve's performance has been described in the following way, "Given a set of 5000 molecules, Robot Eve determined the characteristics of the most effective molecules, then screened only those remaining members of the set that it predicted would be most effective. Through this process, Robot Eve 'discovered' a new anti-malarial use for an existing drug that was previously known only as cancer inhibitor." Fraser, *supra* note 44.

120. Fraser, *supra* note 44 ("The benefits of employing deep neural networks are particularly acute when screening against multi-target profiles, which is otherwise extremely difficult and time-consuming, and sometimes even impossible.").

121. *See, e.g.*, Mark Bergen, *Google Is Training Machines to Predict When a Patient Will Die*, BLOOMBERG (June 18, 2018), https://www.bloomberg.com/news/articles/2018-06-18/google-is-training-machines-to-predict-when-a-patient-will-die [https://perma.cc/PH8G-AK6R] ("Google researcher said existing models miss obvious medical events, including whether a patient had prior surgery.").

122. Stephen Chen, *Doctors said the coma patients would never wake. AI said they would–and they did*, S. CHINA MORNING POST (Sept. 8, 2018), https://www.scmp.com/news/

used an AI system to read the patients' MRI images and predicted they would wake up in a year. Nine in ten did. The AI was able to do this because "neural activities are too numerous and sophisticated to be directly visible to doctors but the AI, equipped with machine-learning algorithms, is able to scrutinise these changing details and discover previously unknown patterns from past cases."[123] The augmentation and disruption brought on by AI in how we create and invent raise interesting and important issues in copyright and patent laws.

III. AI & COPYRIGHT

The source code of AI may be protected as literary works under copyright law.[124] Software protection extends to the original expression but not to its functional aspects such as formatting, logic, or system design.[125] It must be *original* in the sense that authors must create the work through their own skill, judgement and effort.[126] Neither conception nor execution alone suffices. Authors must clothe their expressions in a tangible medium.[127] Assistants executing assigned tasks within the intended scope of instruction create works, the authorship of which remains with the ones who instructed them.[128]

Copyright law vests rights in an *author* without defining the term. With each iteration of technology, courts must determine if a copyright

china/science/article/2163298/doctors-said-coma-patients-would-never-wake-ai-said-they-would [https://perma.cc/T28Q-UWVC].

123. The article further describes:

> For instance, the machine can look into regions in charge of different functions – including motion control, verbal capability, hearing and vision – to see how they interact with one another after suffering physical damage.

Some patients might have an active mind, but their communication with the outside world is temporarily blocked. Their state is more likely to be misjudged by conventional evaluation methods, which are usually based on operationally defined behavioural responses to specific sensory stimulation.

Id.

124. *See* Library of Congress, *Copyright Registration of Computer Programs*, U.S. COPYRIGHT OFF., https://www.copyright.gov/circs/circ61.pdf [https://perma.cc/FC6Y-KFUR].

125. Andrea W. Jeffries et al., *Protecting Artificial Intelligence IP: Patents, Trade Secrets, or Copyrights*?, JONES DAY (Jan. 2018), https://www.jonesday.com/protecting-artificial-intelligence-ip-patents-trade-secrets-or-copyrights-01-09-2018/ [https://perma.cc/PWY3-XXSY].

126. Feist Publ'ns, Inc. v. Rural Tel. Serv. Co., 499 U.S. 340, 345 (1991) ("To qualify for copyright protection, a work must be original to the author," which means that the work must be "independently created by the author" and it must possess "at least some minimal degree of creativity.").

127. 17 U.S.C. § 102(a) (2018).

128. Andrien v. S. Ocean Cty. Chamber of Commerce, 927 F.2d 132, 135 (3d Cir. 1991) ("[W]riters are entitled to copyright protection even if they do not perform with their own hands the mechanical tasks of putting the material into the form distributed to the public.").

exists and if so, who owns the work.[129] Printmakers who engraved copper plates to print copies of the Bible authored a copyrighted work in their engravings as much as those who use their laptops to type out their selection of Beyoncé's hit music.[130] In each case, there is some modicum of originality in design, arrangement, selection, or ornamentation. Similarly, creators who use AI to augment their work can claim authorship over the resulting work.[131] The outcome becomes less clear when AI like GAN generates the work with little or no direct guidance from humans, but the need to ensure that the rules are clear are no less important.

A. AI as Authors

One possibility is to treat AI as a co-author or even a sole author. Copyright law confers co-authorship on assistants who contribute in elaborating the concepts of their collaborators.[132] The law confers sole authorship if the instructions were merely general ideas and the assistant ably devises their own plans.[133] Skepticism arises in treating AI-generated works the same way as works of human authorship because algorithms "cannot themselves formulate creative plans or 'conceptions' to inform their execution of expressive works."[134] According to this reasoning, the spark of creativity the AI displays simply flows from a faithful adherence to the code simulating human creative genius, which falls short of authorship required by the law.[135]

The U.S. Copyright Office (Copyright Office) determined that it will register only those works "created by a human being,"[136] while excluding "works produced by a machine or mere mechanical process that operates

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129. Sobel, *supra* note 84, at 50 ("When novel technologies emerge, society often doubts their ability to facilitate human expression, particularly when those technologies mediate between a human subject and the expressive output she creates.").

130. James Grimmelmann, *There's No Such Thing as a Computer-Authored Work–And It's a Good Thing, Too,* 39 COLUM. J.L. & ARTS 403, 408 (2016) ("[T]o complain that these steps are too mechanical to support a copyright is to go looking for authorship in all the wrong places.").

131. *See* Burrow-Giles Lithographic Co. v. Sarony, 111 U.S. 53 (1884).

132. 17 U.S.C. § 101 (2018) (defining joint authorship as "a work prepared by two or more authors with the intention that their contributions be merged into inseparable or interdependent parts of a unitary whole").

133. *See, e.g.*, Childress v. Taylor, 945 F.2d 500, 507 (2d Cir. 1991) (noting a concern about "spurious claims by those who might otherwise try to share the fruits of the efforts of a sole author of a copyrightable work").

134. Ginsburg & Budiardjo, *supra* note 1.

135. SELMER BRINGSJORD & DAVID FERRUCCI, ARTIFICIAL INTELLIGENCE AND LITERARY CREATIVITY: INSIDE THE MIND OF BRUTUS, A STORYTELLING MACHINE xvi (1999) (describing it as an "attempt to reduce creativity to computation").

136. U.S. Copyright Office, *Compendium of U.S. Copyright Office Practices* § 313.2 (3d ed. 2017).

randomly or automatically without any creative input or intervention from a human author."[137] When Klein and Bolitho attempted in 1956 to register a computer-generated song, the Copyright Office rejected it.[138] In a 1973 compendium, the Copyright Office memorialized that copyrightable works must owe their origin to a "human agent."[139] One example given by the Copyright Office is a "weaving process that randomly produces irregular shapes in the fabric without any discernible pattern."[140] Since the programmer of the weaving algorithm is not directly responsible for the resulting work, it would not be protected by U.S. copyright. This remains the practice of the Copyright Office today.[141]

Whether AI-generated works lie beyond the scope of copyright protection, however, should be a conclusion, not–as the Copyright Office suggests–its starting point. This conclusion should flow from a careful weighing of the merits of protecting it to advance artistic progress. If the progress of creative output depends on incentivizing its creation, then it is incumbent on the law to find the proper vehicle to attribute the work's expressive value, whether that vehicle is the AI, a human, or a corporation.

In determining the status of AI-generated works under copyright law, "a page of history is worth a volume of logic."[142] From the founding of the United States, the States granted Congress the power to protect the *Writings* of *Authors*.[143] These terms "have not been construed in their narrow literal sense but, rather, with the reach necessary to reflect the broad scope of constitutional principles."[144] The term *Author* means "he to whom anything owes its origin; originator."[145] Similarly, the term *Writings* includes "any physical rendering of the fruits of creative intellectual or aesthetic labor."[146] Congress foresaw that new and

137. U.S. Copyright Office, *Compendium of U.S. Copyright Office Practices* § 313.2 (3d ed. 2017).

138. Bridy, *supra* note 104 ("The rejection, for which the Office didn't offer–and couldn't have offered–any statutory basis, revealed a deep-seated if unspoken assumption that authors are necessarily human").

139. *See* U.S. Copyright Office, *Compendium of U.S. Copyright Office Practices* § 2.8.3 (1st ed. 1973) (stating works are not copyrightable if they do not "owe their origin to a human agent").

140. U.S. Copyright Office, *Chapter 300: Copyrightable Authorship: What Can Be Registered*, COPYRIGHT COMPENDIUM III 2014 WL 7749578, at *18.

141. U.S. Copyright Office, *Compendium of U.S. Copyright Office Practices* § 313.2 (3d ed. 2017) (The Copyright Office "will not register works produced by a machine or mere mechanical process that operates randomly or automatically without any creative input or intervention from a human author.").

142. N.Y. Tr. Co. v. Eisner, 256 U.S. 345, 349 (1921).

143. U.S. CONST. art. I, § 8, cl. 8.

144. Goldstein v. California, 412 U.S. 546, 561 (1973).

145. Burrow-Giles Lithographic Co. v. Sarony, 111 U.S. 53, 58 (1884).

146. *Goldstein*, 412 U.S. at 561.

unforeseeable technologies would be used to create works of authorship.[147] Two factors were key in determining what could be protected: the character of the writing and its commercial importance.[148]

As to the first factor, unlike patent law, there is no explicit requirement that an author be human.[149] U.S. Copyright law confers protection to "the fruits of intellectual labor . . . founded in the creative powers of the mind."[150] The threshold for originality required in those fruits is low. The law does not arbitrate artistic merit of the work.[151] Thus, "[a] copyist's bad eyesight or defective musculature, or a shock caused by a clap of thunder, may yield sufficiently distinguishable variations. [Yet], [h]aving hit upon such a variation unintentionally, the 'author' may adopt it as his and copyright it."[152] It is the author's "personal reaction . . . upon nature" that renders the work copyrightable.[153]

When asked whether photographs were copyrightable in 1884, the Supreme Court noted that while the "ordinary production of a photograph" was "merely mechanical, with no place for novelty, invention or originality," the "existence of those facts of originality, of intellectual production, of thought, and conception on the part of the author" endowed the photograph with copyright protection.[154] It was the photographer's "mental conception" in selecting and arranging the subject's costume, determining the lighting, and arranging the scene that conferred the creativity sufficient for authorship.[155]

147. 17 U.S.C. § 101 (2018) (defining a copy as a work "fixed by any method now known or later developed" and a "'device,' 'machine,' or 'process'" as "one now known or later developed.").

148. *Goldstein* discussed factors relevant to protected writings:

> The history of federal copyright statutes indicates that the congressional determination to consider specific classes of writings is dependent, not only on the character of the writing, but also on the commercial importance of the product to the national economy. As our technology has expanded the means available for creative activity and has provided economical means for reproducing manifestations of such activity, new areas of federal protection have been initiated.

Goldstein, 412 U.S. at 562.

149. *See infra* Part IV.

150. *In re* Trade-Mark Cases, 100 U.S. 82, 94 (1879).

151. Bleistein v. Donaldson Lithographic Co., 188 U.S. 239 (1903) (finding that chromolithographed advertisements for a circus qualified).

152. Alfred Bell & Co. v. Catalda Fine Arts, Inc. 191 F.2d 99, 105 (2d Cir. 1951).

153. Mazer v. Stein, 347 U.S. 201, 208 (1954) ("Personality always contains something unique. It expresses its singularity even in handwriting, and a very modest grade of art has in it something irreducible, which is one man's alone. That something he may copyright unless there is a restriction in the words of the act.").

154. Burrow-Giles Lithographic Co. v. Sarony, 111 U.S. 53, 59 (1884).

155. *Id.* at 54–55, 60.

Telephone directory listings are too "mechanical or routine,"[156] and animal selfies lack the human origin required to support statutory standing to sue for copyright infringement.[157] A stick-man sketch by a human hand has more worth in the eyes of copyright law than the product of the Next Rembrandt.[158] Some element of human creativity must have occurred regardless of how the work is done.[159] As one commentator put it, "the original purpose of IP protection was about promoting sciences and useful arts [by incentivizing creativity]. Absent this rationale of promotion and incentive which clearly does not apply to machines, there is no need to award IP protection to the 'creator' of said IP subject matter."[160]

The first possibility, then, is that no AI-generated work is copyrightable. The primacy of human direction is what infuses copyrightable subject matter with their "original intellectual conceptions."[161] It is not technological wizardry that copyright law

156. *Id.* at 55.

157. Naruto v. Slater, 888 F.3d 418, 420 (9th Cir. 2018).

158. The historical conception of authorship has been described in the following way:

> Congress has constitutional authority to create exclusive rights in the writings of authors. And historically, courts have construed these words liberally, but always with reference to human genius or intellect. Going back to the early cases, we get the image of the author as maker or originator in *Burrow-Giles Lithographic Co. v. Sarony. In Bleistein v. Donaldson Lithographing Co*., the author is figured as the embodiment of a unique personality that mystically passes into a work as it is created.

Bridy, *supra* note 102, at 398. James Grimmelmann, *Copyright for Literate Robots*, 101 IOWA L. REV. 657, 658 (2016) ("[T]he sort of creativity copyright concerns itself with is the product of a specific human mind.").

159. Naruto v. Slater, No. 15-CV-04324-WHO, 2016 WL 362231, at *3 (N.D. Cal. Jan. 28, 2016) ("The Supreme Court and Ninth Circuit have repeatedly referred to 'persons' or 'human beings' when analyzing authorship under the Act."); Naruto v. Slater, 888 F.3d 418, 420 (9th Cir. 2018) (noting that only humans have standing to sue for copyright infringement); Bridy, *supra* note 104, at 399 ("[T]here seems to be an assumption, maybe driven by practical and historical considerations, that authorship means human authorship."); Russ Pearlman, *Recognizing Artificial Intelligence (AI) as Authors and Inventors Under U.S. Intellectual Property Law*, 24 RICH. J.L. & TECH. 2, 16 (2018) (noting that both the 1965 Register of Copyrights Annual Report and the 1978 National Commission on New Technological Uses of Copyrighted Works (CONTU) stated that while human generated works are copyrightable, machine generated works are not. "These conclusions seem to be based on the same reasoning that the courts applied generally to copyright: the 'inventive spark' required for copyright was fundamentally missing from computer systems, and such capabilities are unique to humans.").

160. Amir H. Khoury, *Intellectual Property Rights for "Hubots": On the Legal Implications of Human-Like Robots as Innovators and Creators*, 35 CARDOZO ARTS & ENT. L.J. 635, 656 (2017) ("IP rights granted to Hubots for creation derogates from the collective content with no payoff to the creator who does not need incentives to function and/or create new content.").

161. *Burrow-Giles Lithographic Co.*, 111 U.S. at 58.

protects but conception by a human being that has been fixed in a tangible medium of expression. Nothing more is needed. Nothing less will do.[162]

There is some support for this view. The length of copyright protection typically is pegged to the life of the author or joint authors.[163] Moreover, machines are not incentivized by IP.[164] Therefore, arguably, no IP is needed. If the work falls immediately into the public domain as a result, it provides fertilizer "to give birth to new artistic genres and whole new areas of innovation, where humans could build freely upon initial machine-output[.]"[165] That result is also good for *ontological* reasons, argue its advocates:

> Artists enjoy the admiration of us fellow humans because given their talent and efforts they create original works others are not capable of. It is this ability to vanquish mediocrity that deserves protection and economic reward. . . .Why should anyone still care to create and undergo all the pains and existential insecurities a creative process entails, if a machine – that naturally cannot know similar troubles – was treated the same? Would art not degenerate to a mere commodity, producible and consumable upon pushing a button?[166]

The problem with this view is that it ignores the second basis for determining what works should be protected. Authorship was meant to be entrepreneurial rather than an exercise in self-aggrandizement. The question is not whether machines need incentives—they clearly do not. The Supreme Court ruled that the limited benefits associated with copyright ownership are "intended to motivate the creative activity of authors and inventors by the provision of a special reward, and allow the public access to the products of their genius after the limited period of exclusive control has expired."[167] The question therefore is whether denying copyright protection incentivizes the kind of utilitarian creativity that results in the public dissemination of the fruits of those activities.

162. Khoury, *supra* note 162, at 647 ("My view is that Hubots cannot and should not qualify for IPRs no matter the degree of their independent intelligence.").

163. 17 U.S.C. § 302(a) (2018) (Copyright "endures for a term consisting of the life of the author and 70 years after the author's death."); 17 U.S.C. § 302(b) (2018) ("In the case of a joint work prepared by two or more authors who did not work for hire, the copyright endures for a term consisting of the life of the last surviving author and 70 years after such last surviving author's death.").

164. Schönberger, *supra* note 57 ("Robots do not need protection, because copyright's incentives for creativity will and naturally must remain entirely unresponded to by them.").

165. Schönberger, *supra* note 59.

166. Schönberger, *supra* note 59.

167. Sony Corp. of Am. v. Universal City Studios, Inc., 464 U.S. 417 (1984); *see also* Kalin Hristov, *Artificial Intelligence and the Copyright Dilemma*, 57 IDEA: J. FRANKLIN PIERCE FOR INTELL. PROP. 431, 438 (2017) ("Copyrighted works not only serve as an incentive to creativity, but also increase the number of works available in the public domain after their copyright expiration.").

Excluding AI-generated work for protection leaves an economic lacuna, which U.S. IP policy is loath to do.[168] Allowing AI-generated works to fall into the public domain reduces the incentive to invest in the growth of the industry.[169] As professors Kal Raustiala and Chris Sprigman observed, under this view:

> [C]reative production is by its nature a high-risk enterprise. The primary role of copyright is to protect against copying, so that the large up-front investment in creative work can be more safely made. In the absence of such protections . . . the prospect of unrestrained competition from copyists will deter investment in the production of new creative works. The result will be a persistent undersupply of new artistic and literary creativity.[170]

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168. Aversion to protection of Monsanto's AI-developed seeds was present in the following case:

> Were the matter otherwise, Monsanto's patent would provide scant benefit. After inventing the Roundup Ready trait, Monsanto would, to be sure, 'receiv[e] [its] reward' for the first seeds it sells. But in short order, other seed companies could reproduce the product and market it to growers, thus depriving Monsanto of its monopoly.

Bowman v. Monsanto Co., 569 U.S. 278, 285 (2013).

169. Hristov, *supra* note 169, at 441–42 ("As a result, an effective solution would require that both the legal status of a copyright holder and the need for incentives for AI developers are considered. These two important conditions are necessary in order to ensure the legal standing and future development of the AI sector."). These problems have been described in the following way:

> There is a considerable disadvantage to the release of independently generated AI creative works into the public domain. Without an established period of protection, there is no tangible incentive for developers of AI machines to continue creating, using, and improving their capabilities. Simply put, even if programmers and the companies for which they work have invested a substantial amount of time and money into the creation of AI machines, for the most part, they would not be able to enjoy copyright protection or the financial benefits associated with it. This trend could ultimately limit innovation by dissuading developers and companies from investing in AI research, resulting not only in the decline of AI but also in the decline of innovation across a number of related sectors.
>
> . . .
>
> Denying copyright from being issued to developers and owners of AI machines reduces their incentives to create new AI programs, and may ultimately lead to a lower number of AI generated copyrightable works and (after expiration of their copyrights) a considerable decrease in works entering the public domain. As a result, it becomes apparent that immediately releasing AI works into the public domain, as opposed to doing so after a certain period of copyright protection, significantly decreases incentives for creativity and is counterproductive to the development of AI.

Hristove, *supra* note 169, at 438–39.

170. Kal Raustiala & Chris Sprigman, *The Second Digital Disruption: Data, Algorithms & Authorship in the 21st Century*, N.Y.U. L. REV. (forthcoming 2019).

Without a legal hook, these works would fall into the public domain, which could devastate the incentives to invest in AI-generated works.[171]

The second possibility is that machines should be recognized as authors.[172] As the reasoning goes, AI using "deep-learning, neural networks, and other approaches that do not dictate the purely mechanical creation of works should be considered a potential author separate and apart from their human operator. The focus of IP law should be to recognize the contributions of the creator."[173] The problem with this view goes beyond upturning decades of settled jurisprudence, including the indeterminateness of copyright duration, rights, and liabilities.[174] It would be nonsense to talk about the life of a machine, the ability to sue a machine for infringement of derivative rights, or the right of a machine to bring a suit for infringement of its own rights.

No AI is itself the wellspring of creativity. Rather, the creativity the AI displays flows either from the algorithm used to design and train it, or from the instructions provided by the users operating it.[175] Unlike human beings, algorithms do not have the quintessential lynchpin upon which to hang creativity—free will. Machine learning allows AI to develop its own processes in ways that transcend what human programmers can manually achieve.[176] Indeed, the resulting algorithms are so complex that they become "black boxes" that elude the ability of the original programmer to understand how they work.[177] In Part IV.C, this article explains how this may result in insufficient disclosure, putting the validity of the patent right

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171. Guadamuz, *supra* note 51 ("That would be very bad news for the companies selling the works. Imagine you invest millions in a system that generates music for video games, only to find that the music is not protected by law and can be used without payment by anyone in the world.").

172. *See* Abbott, s*upra* note 46 (arguing that assigning inventorship and authorship to non-humans is an innovative new way to encourage AI growth and development).

173. Pearlman, *supra* note 159, at 36; *see also* Bridy, *supra* note 104, at 395 (noting that if creativity is not defined as a quintessentially human faculty, but could be comprehended alternatively as a set of traits or behaviors, then creativity might indeed be found in the code of machines).

174. Hristov, *supra* note 169, at 441 ("This theoretical solution, however, is controversial and could lead to an uncertain future full of legal challenges and systemic abuse. . . . Redefining copyright authorship to include non-human authors would undermine the current U.S. legal system, creating further uncertainty by raising more questions than answers.").

175. Ginsburg & Budiardjo, *supra* note 1 ("Every unanticipated machine output arises directly from some human instruction programmed into the machine. . . . Machines are, in essence, perfect agents of the humans who design and use them.").

176. Ginsburg & Budiardjo, *supra* note 1.

177. *See* Michael L. Rich, *Machine Learning, Automated Suspicion Algorithms, and the Fourth Amendment*, 164 U. PA. L. REV. 871, 886 (2016) ("[M]achine learning tends to create models that are so complex that they become 'black boxes,' where even the original programmers of the algorithm have little idea exactly how or why the generated model creates accurate predictions."). These "learning" techniques depart from other AI techniques sometimes referred to as "expert system" development.

itself at risk. With copyright law, however, authors need neither understand nor explain how the tools they use—cameras, computers, or AI—render their works of authorship. The touchstone is instead control.[178]

In the case of AI-augmented works, the task in determining copyright ownership is to distribute rights between two or more contributors.[179] With AI-generated works, AI is simply a means by which one human creates in a way specified by another. In the analog world, Spirographs, recipes, and blueprints allow us to create according to another's specified instructions. The author for copyright purposes depends on his or her contribution to the final work. For instance, architects own the copyright to the buildings they design, not the contractors building them.[180] In contrast, each child who fills in paint-by-number canvases owns the copyright to its creation even as the designer owns the copyright to the template.[181] Autonomous AI-generated work could fall into either category.

The third possibility is that one legal fiction can be considered both owner and author of another. A tech company that builds and trains the AI-generated work is more akin to the architect. In this case, AI-generated works will be owned by the corporate entity that enables the work to be created in the first place, a WFH.[182] WFH recognizes the employer or other person for whom the work was prepared as the initial owner of the copyright unless both parties sign a written agreement to the contrary.[183] The WFH doctrine intends to incentivize employers to provide tools and direction, and to undertake the risk for work.[184] It operates to vest

178. The issue of control as it relates to authorship was described in the following way. "Artificially intelligent machines, therefore, do not usurp human authorship as long as humans sufficiently 'control' them. Since we have posited that computers cannot run off on a 'frolic of their own,' some humans will wield the requisite control; the question is whether the reins are in the hands of the machine's designers or its users." Ginsburg & Budiardjo, *supra* note 1.

179. Grimmelmann, *supra* note 130, at 411 ("The problem of allocating ownership between programmers and users is just a special case of this more general and very familiar problem.").

180. Grimmelmann, *supra* note 130, at 411 ("Sometimes, the author of the instructions is regarded as the sole author of the output; architects own copyright in built buildings, not the contractors who actually do the construction work.").

181. Grimmelmann, *supra* note 130, at 411 ("[I]f a 'distinguishable variation' is enough for a copyright in a work created to the plan of another, I own the paint-by-numbers canvas I fill in, even if I only color inside the lines.").

182. Yanisky-Ravid, *supra* note 102 ("I suggest the adoption of the [WFH] doctrine for AI systems, which considers the system to be the creative employee or creative independent contractor, thus entitling the rights to another entity to be responsible for the outcomes of the AI system.").

183. 17 U.S.C. § 201(b) (2018).

184. The policy underlying the WFH doctrine has been described in the following way:

> The policy rationale for this doctrine is to incentivize the employer or primary contractor

copyright to the AI-generated work in a corporation in the first instance, without the operation of law.[185] The WFH doctrine recognizes the corporate employer or the individual commissioning the work as the legal author of the work and the employee or contractor as the author-in-fact.[186] Granting copyright to the person who made the AI possible seems to be the most sensible approach. As one commentator noted, "[s]uch an approach will ensure that companies keep investing in the technology, safe in the knowledge that they will get a return on their investment."[187]

A multitude of stakeholders contribute to creating, designing, developing and producing AI systems. These include data suppliers, trainers, feedback suppliers, and system operators. The corporation provides a vehicle to exploit the rights and accept responsibility for liabilities, and a commercially expedient alternative to human authorship, with its messy web of potential ownership claims.[188] WFH imposes accountability on corporations for criminal violations, infringement, and other tortious acts[189] while synchronizing the promotion of technological

> at whose instance, direction, use, commercial purposes or risk the work is prepared, as well as to give them control over the commercial force regarding the work. The idea and the outcome is that the employer or primary contractor, rather than the creator (who is an employee or sub-contractor), has the responsibility for and the accountability over the actions of the creator in regards to, inter alia, infringements of the law and harm caused by the work.

Yanisky-Ravid, *supra* note 102, at 711. Yanisky-Ravid, *supra* note 100, at 711 ("The justification for giving the entitlement of ownership to economic entities is rooted in the incentive theory as well. This legally sanctioned monopoly allows the users to use, sell, or distribute the works more efficiently, as well as to be accountable for avoiding infringements and counterfeits.").

185. 17 U.S.C. § 201 (2018) (Ownership "vest initially in the author or authors of the work."); Bridy, *supra* note 104, at 400 ("[by] operation of law from an employee-author to her corporate employer, thus maintaining in principle a human monopoly on authorship, but it wasn't.").

186. The relationship between the WFH doctrine and the rest of copyright law has been described in the following way.

> The [WFH] rule is thus an exception to the general principle of copyright ownership. Usually, the copyright becomes the property of the author once the creation meets the demands of the law. However, if a work is made for hire, the employer or the one who commissioned the work would be considered the author, even if an employee or subcontractor actually created the work. The employer could be a firm, an organization, or an individual.
> . . .
> This doctrine is an important and major exception to the general rule that copyright protection properly rests with the one or the many who actually created the work. The Copyright Act named the employer and main contractor as the authors of the work even though they have not actually created the work.

Yanisky-Ravid, *supra* note 100, at 708–11.

187. Guadamuz, *supra* note 51.

188. Garcia v. Google, Inc., 786 F.3d 733, 743 (9th Cir. 2015) ("Untangling the complex, difficult-to-access, and often phantom chain of title to tens, hundreds, or even thousands of standalone copyrights is a task that could tie the distribution chain in knots.").

189. The liability of a human for the act of a robot has been described in the following way:

progress with artistic progress.[190] The corporation maintains the copyright for 95 years from publication or 120 years from creation, whichever expires first.[191] WFH thus decouples the need to find a nominal human author in the value chain without vesting rights in an algorithm.[192]

If the company developing the AI merely provides a malleable tool for downstream firms to train, the resulting works would belong to the firm as a WFH in the same way that a child filling in a paint-by-number owns the copyright to his or her creation. Just as the designer of the paint-by-number owns the copyright to the template, the company that developed the AI would retain ownership of the algorithm. What happens if an individual, rather than a firm, trains the AI? The result would be the same. At the fringes, businesses can use contracts. These license agreements would clearly define who owns rights in AI-generated works and in improvements generated by the AI's machine learning.[193] Licensors can also include confidentiality and data security restrictions to buttress their rights.

> A human may be held liable for the actions of a robot that he owns—such as autonomous cars— "as their actions can be traced back to 'programmer commands.'" . . . Where the person controlling the robot can reasonably expect the robot to create a certain product or to malfunction in a certain way, then all actions in that range revert back to the person through said agency construct. If, however, the robot's actions are outside that range of expectation, just as one cannot predict the random music that is created by wind chimes, then the "software agency" theory cannot apply. . . . I agree with the view that is expressed by Grimmelmann, regarding the possibility of assigning liability to cases involving robotic readership.

Khoury, *supra* note 160, at 649–50.

190. Yanisky-Ravid, *supra* note 102 at 712 ("It makes sense to incentivize people or firms as well as other entities to use creative AI systems to create works of authorship because doing so will most efficiently promote the proliferation of the devices and the works they produce.").

191. Hristov, *supra* note 169, at 450 ("Unlike human authors who have a limited lifespan, AI programs could perpetually exist. This challenges the predetermined term of copyright protection given to authors (life of author plus 70 years in the U.S.)").

192. This proposition is supporting by the following:

> [S]econd, it avoids the problem of vesting legal rights in a machine, which we all know is impracticable. . . . I'll close by saying that because U.S. copyright law is grounded in the protection of economic rather than moral rights, it's not inconsistent with first principles to recognize authorship in non-natural persons.) (the problem is to distinguish computer users who are genuine authors from users who merely push a button. But this is not a problem unique to computers . . . . The user who pushes a button on a music box to start it playing is not an author; the user who pushes a button on a camera to take a photograph is. Trying to allocate copyrights between computer programmer and computer user is the same kind of task as trying to allocate them between thing-maker and thing-user.

Bridy, *supra* note 104, at 400–01.

193. Emily Rich, *AI: Who Owns the Output?*, FRESHFIELDS DIGITAL (Aug. 24, 2018), http://digital.freshfields.com/post/102f11c/ai-who-owns-the-output [http://perma.cc/H8K8-C3RG].

Other common law countries appear to share this pragmatic approach.[194] In contrast, civil law countries in the Western Hemisphere are hindered by a copyright transfixed on the moral rights-basis of the human author.[195] As a result, these jurisdictions "require an inseparable nexus between human creativity and the resulting work."[196] The pragmatic nature of U.S. copyright policy has given it a competitive advantage providing a haven for global AI investments. It would be prudent to capitalize on it.

Of course, ownership issues will arise for which WFH will not be the right answer. In the case of GAN, for instance, Robbie Barrat, a 17-year-old, created the software code and uploaded it to GitHub, a code-sharing platform for others to download and use.[197] Many did, including the creators of the Belamy portrait. In this case, the author and owner of the work will be the same as a work created on Word or PowerPoint—the one who created it, not Microsoft or Barrat. In these instances, the machine merely provides the means of expressing the author's expressive vision, but it has not displaced the author.[198] Licensed users who create the document and slides, or who select the data and train the AI, own the fruits of their effort apart from the ones who provided the platform to execute their work.[199]

The foregoing discussion addresses authorship and ownership issues arising out of AI-generated works. Other important issues copyright law must resolve include how copyright law should treat training data and

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194. *See, e.g.,* New Zealand copyright law expressly defines and protects computer-generated works and vests ownership of copyright in the "person by whom the arrangements necessary for the creation of the work are undertaken." Other common law countries—for example, the United Kingdom, Hong Kong, and India—take the same approach.

195. Bridy, *supra* note 104, at 401 ("Maybe not surprisingly, civil law countries with a strong moral rights orientation in their copyright systems—for example, France, Germany, Greece, Switzerland, and Hungary - reject the notion of non-human authorship completely.").

196. This relationship between the WFH doctrine and civil law system has been described in the following way:

> Civil law systems in the droit d'auteur tradition, with a strong moral rights orientation (like French and German law), require an inseparable nexus between human creativity and the resulting work. . . . The 'work- made-for-hire' doctrine . . . [is] in stark contrast to any system based on a droit moral understanding. Without a radical policy shift such ideas are not reconcilable with the majority of European national systems.

Schönberger, *supra* note 57.

197. Flynn, *supra* note 10.

198. *See, e.g.*, Burrow-Giles Lithographic Co. v. Sarony, 111 U.S. 53, 60 (1884).

199. Levendowski, *supra* note 84, at 592 ("[T]raining data must be well-selected by humans—training data infused with implicit bias can result in skewed datasets that fuel both false positives and false negatives.").

what the relevance of AI may be in copyright enforcement. These issues are dealt with next.

B. AI as Readers

The 15,000 portraits used to create GAN's portrait at Christie's is something collectors might pay a king's ransom to assemble. For GAN, however, the portraits are just sets of data, much like scans of brain tumors or emails that machines read without regard to aesthetic, cultural, or historical value of the actual content. Similarly, deep-learning AI such as Flow Machine, IBM Watson Beat, Google Magenta, and Spotify's Creator Technology Research Lab feature software that is fed source material from contemporary hits to classics, which they analyze to find patterns in chords, tempo, and length, learning from these inputs to write their own melodies.[200]

Most machine learning requires input datasets, which typically requires making digital copies of the data.[201] Existing works are fed into the system to train it. Once trained, the algorithm can create a work that is influenced by the input works. One commentator noted that "[i]n the near future, a machine learning library may become a standard part of all operating systems, just like [transmission control protocols/Internet protocols] and database technologies have in the past."[202] A future where neural networks allow AI to operate without hard-coding to sort through data may be on the horizon.

Whether permission is needed to train the AI access data is an important issue, because using it is presumptively copyright infringement unless excused by fair use. In a milieu where the training set consists of a

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200. Dani Deahl, *How AI-Generated Music Is Changing The Way Hits Are Made*, VERGE (Aug. 31, 2018), https://www.theverge.com/2018/8/31/17777008/artificial-intelligence-taryn-southern-amper-music [http://perma.cc/NBU7-S6J2].

201. *See, e.g.*, Scott Draves, *Evolution and Collective Intelligence of the Electric Sheep, in* THE ART OF ARTIFICIAL EVOLUTION: A HANDBOOK ON EVOLUTIONARY ART AND MUSIC 63 (2007) (describing an AI that "reproduces" images given higher scores by humans); Samuel Himel & Robert Seamans, *Artificial Intelligence, Incentives to Innovate, and Competition Policy*, COMPETITION POL'Y INT'L (Dec. 19, 2017), https://www.competitionpolicyinternational.com/wp-content/uploads/2017/12/CPI-Himel-Seamans.pdf [http://perma.cc/R9FY-ERZE] ("Large datasets are a critical input for firms that want to create or use AI systems. Even the best AI algorithms are useless without an underlying large-scale dataset, because large datasets are needed for the initial training and fine-tuning of these algorithms."); Sobel, *supra* note 84, at 61 ("Some input datasets are assembled by digitizing physical media. Others are made by copying and processing born-digital data like ebooks and news photographs.").

202. Michael Borella, *The Subject Matter Eligibility of Machine Learning: An Early Take*, PATENT DOCS (Sep. 23, 2018), http://www.patentdocs.org/2018/09/the-subject-matter-eligibility-of-machine-learning-an-early-take.html [http://perma.cc/9JPG-TKSR].

myriad of works, the same sort of hold-ups that have been seen in the smartphone industry with patents might happen here too.[203] How copyright law treats the use of these datasets will determine whether AI-generated works can reliably develop without a constant threat of litigation.[204] If the threat precipitates into copyright liability, it could debilitate even the mightiest company.[205] A registered work entitles its owner to statutory damages from $750 to $150,000 per copy per work, which when multiplied by the thousands of works that typically make up a training dataset could result in devastating costs.[206]

As a matter of policy, copyright protection exists "to expand public knowledge and understanding . . . by giving potential creators exclusive control over copying of their works, thus giving them a financial incentive to create informative, intellectually enriching works for public consumption."[207] Thus, "while authors are undoubtedly important intended beneficiaries of copyright, the ultimate, primary intended beneficiary is the public, whose access to knowledge copyright seeks to

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203. Elise De Geyter, *Inside Views: The Dilemma of Fair Use and Expressive Machine Learning: An Interview with Ben Sobel*, INTELLECTUAL PROPERTY WATCH (Aug. 23, 2017), http://www.ip-watch.org/2017/08/23/dilemma-fair-use-expressive-machine-learning-interview-ben-sobel/ [http://perma.cc/663K-MZ6E].

204. The threat of copyright litigation based on data sets has been described in the following way:

> If those input data contain copyrighted materials that the engineers are not authorized to copy, then reproducing them is a prima facie infringement of § 106(1) of the Copyright Act. If the data are modified in preprocessing, this may give rise to an additional claim under § 106(2) for creating derivative works. In addition to copyright interests in the individual works within a dataset, there may be a copyright interest in the dataset as a whole.

Sobel, *supra* note 84, at 61

205. The consequences of copyright litigation over datasets has been described in the following way:

> This outcome would be devastating because the remedies that copyright law offers are mismatched with the harms an author would suffer from inclusion in input data. . . . Because machine learning datasets can contain hundreds of thousands or millions of works, an award of statutory damages could cripple even a powerful company.

Sobel, *supra* note 84, at 80.

206. 17 U.S.C. § 504(c) (2018). The remedies available for copyright infringement include the following:

> If the work in question were registered prior to the infringement, the author could claim statutory damages of at least $750 per infringed work, and up to $150,000 per work if the infringement were deemed willful. . . . Conceivably, a plaintiff could enjoin a defendant from proceeding with a machine learning operation, though it is unlikely that a court would offer such a drastic equitable remedy in a case involving input data.

Sobel, *supra* note 84, at 80.

207. Authors Guild v. Google, Inc., 804 F.3d 202, 212 (2d Cir. 2015) ("This objective is clearly reflected in the Constitution's empowerment of Congress 'To promote the Progress of Science . . . by securing for limited Times to Authors . . . the exclusive Right to their respective Writings. ' U.S. CONST., art. I, § 8, cl. 8.").

advance by providing rewards for authorship."[208] It is trite that giving authors control over all forms of exploitation of their works could limit public knowledge.[209] The fair use defense thus permits unauthorized copying to further "copyright's very purpose, '[t]o promote the Progress of Science and useful Arts.'"[210] But the defendant who asserts fair use as an affirmative defense bears the burden of proof.[211]

In determining fair use, courts have distinguished between what commentators have called *expressive* and *non-expressive* uses.[212] This distinction recognizes that copyright primarily protects authors from acts of expressive substitution through controlling the diffusion of the work to the public: it has never been about regulating access to or use of the works.[213] Non-expressive fair use recognizes that copyright protects the author's expression but not the facts about their work.

Non-expressive fair use allowed reverse engineering of game cartridges to facilitate interoperability.[214] Non-expressive fair use also allowed the production of thumbnail images to facilitate Internet searches, going a step further than source code; here, expressive elements were copied and presented to the public in miniaturized form.[215] Non-

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208. *Id*.

209. Cary v. Kearsley, 170 Eng. Rep. 679, 681 (1802) ("'[W]hile I shall think myself bound to secure every man in the enjoyment of his copy-right, one must not put manacles upon science.'").

210. Campbell v. Acuff-Rose Music, Inc., 510 U.S. 569, 575 (1994) (quoting U.S. CONST., art. I, § 8, cl. 8); 17 U.S.C. § 107 (2018) provides:

> [T]he fair use of a copyrighted work . . . for purposes such as criticism, comment, news reporting, teaching (including multiple copies for classroom use), scholarship, or research, is not an infringement of copyright. In determining whether the use made of a work in any particular case is a fair use the factors to be considered shall include—
>
> (1) the purpose and character of the use, including whether such use is of a commercial nature or is for nonprofit educational purposes;
>
> (2) the nature of the copyrighted work;
>
> (3) the amount and substantiality of the portion used in relation to the copyrighted work as a whole; and
>
> (4) the effect of the use upon the potential market for or value of the copyrighted work.

211. Am. Geophysical Union v. Texaco Inc., 60 F.3d 913, 918 (2d Cir.1994).

212. *See generally* Matthew Sag, *Copyright and Copy-Reliant Technology*, 103 NW. U. L. REV. 1607 (2009).

213. *Id.*

214. Sega Enters. Ltd. v. Accolade, Inc., 977 F.2d 1510 (9th Cir. 1992) (holding that Accolade's "intermediate copying" of Sega games was fair use, because it was necessary to gain access to the "functional requirements for Genesis compatibility"—a functional element of Sega's games ineligible for copyright protection); Sobel, *supra* note 84, at 52 ("This ruling set the precedent that the unauthorized reproduction of copyrighted works, if incidental to a non-expressive purpose, was non-infringing fair use.").

215. Kelly v. Arriba Soft Corp., 336 F.3d 811, 819, 820 (9th Cir. 2003) ("The thumbnails do not stifle artistic creativity because they are not used for illustrative or artistic purposes and therefore do not supplant the need for the originals."); Perfect 10, Inc. v. Amazon.com, Inc., 508 F.3d 1146,

expressive fair use enabled Google to scan over 20 million books to power its search engine for snippets of both copyrighted and uncopyrighted books even though that use might harm authors' "potential market."[216] More recently, a district court found probative the fact that while a photograph contained "creative elements (such as lighting and shutter speed choices)," it was "also a factual depiction of a real-world location" and the use was "purely for its factual content," to provide a depiction of the neighborhood photographed.[217] Copyright jurisprudence thus recognizes the transformative nature of these uses, distinguishing them from expressive uses which encroach upon the markets where the copyright owner is foreseeably active.

With AI, machine learning is transformative and does not harm to foreseeable markets for works used non-expressively. Datasets used to train facial recognition AI, for instance, do not depend on the artistic choices made by the photographers. Rather, they focus on "matching facts of the subject's identity with facts about their physical appearance."[218] Beyond the purposes of tagging people in Facebook posts and ensuring security, they are also used for payor authentication.[219] AI performing facial recognition requires several thousand photographs of individuals. The Labelled Faces in the Wild (LFW) database contains over 3,000 images from about 6,000 people featured in news pictures on Yahoo

1165 (9th Cir. 2007) (holding that Google Image Search repurposed images into "pointer[s] directing a user to a source of information" as part of an "electronic reference tool[,]" rather than aesthetic objects).

216. Authors Guild v. Google, Inc., 804 F.3d 202 (2d Cir. 2015) (holding that Google Books provided information "about" books, not the books' expression. Even though "snippet view" shows users the textual expression that surrounds a search term, it nevertheless furthers Google's transformative purpose by contextualizing a term's usage within a book without revealing enough expression to "threaten the author's copyright interests."). The significance of the *Authors Guild* decision has been described in the following way:

> *Authors Guild* is notable because it deploys the logic of non-expressive use to circumscribe the "potential market" for a copyrighted work—among the most important factors in fair use analysis—in a way that the image search cases do not. . . . In contrast, *Authors Guild* explicitly notes that Google Books may well harm authors' markets, but such harms "will generally occur in relation to interests that are not protected by the copyright." . . . A Google Books user interested in a single historical fact may encounter that fact in snippet view and, as a consequence, may decide not to procure an authorized copy from a bookstore or library. Google Books therefore might harm an author's market by deterring these purchasers.

Sobel, *supra* note 84, at 55

217. Brammer v. Violent Hues Prods., LLC, No. 1-17-CV-01009, 2018 WL 2921089, at *2 (E.D. Va. June 11, 2018).

218. Geyter, *supra* note 203.

219. Marr, *supra* note 84.

News.[220] The low-resolution photographs are cropped tightly around the subject's face. Most of what is expressive is removed, leaving only a physical likeness of the subject. The LFW database may not even invoke fair use if what is taken is minimal.

Even if what is taken is expressive, the granularity in those snippets and their functional use in matching rather than their aesthetic value is quintessential non-expressive use. Copyright owners' interests extend only to the protected aspect of their works. With LFW, the focus is on physical features in the photographs rather than photographers' expressive choices, and the output is matching data rather than expressive work. Since LFW cannot create copyrightable work, it cannot misappropriate work either. Considered individually, the bits of expression on which LFW is trained are of infinitesimal value in comparison to the resulting transformative use. As to potential market harm, training a facial recognition model does not engage with copyright-protected aspects of those images; thus, a market for images "qua facial recognition input data is unlikely to be a market over which copyright affords rights holders a monopoly."[221]

As datasets used to produce AI-generated work evolves from non-expressive uses such as facial recognition to clearly expressive uses in producing GAN-type paintings, fair use analysis becomes correspondingly more controversial. AI producing commercially valuable art, prose, or music trained on copyrighted works chafes uncomfortably against interests that normally attract infringement liability if done by humans. An example is Google's Smart Reply AI. Smart Reply generates three responses to emails instead of requiring users to compose responses themselves.[222] Its training data includes emails from Gmail accounts[223] as

220. Sobel, *supra* note 84, at 67 ("Because they correspond to fifteen year old news stories, it is safe to assume that most, if not all, of these images were created recently enough that they remain copyright protected.").

221. Sobel, *supra* note 84, at 76.

222. Anjuli Kannan et al., *Smart Reply: Automated Response Suggestion for Email*, *in* PROCEEDINGS OF THE 22ND ACM SIGKDD INTERNATIONAL CONFERENCE ON KNOWLEDGE DISCOVERY AND DATA MINING 955–64 (2016), http://delivery.acm.org/10.1145/2940000/2939801/p955-kannan.pdf?ip=151.181.66.30&id=2939801&acc=OA&key=4D4702B0C3E38B35%2E4D4702B0C3E38B35%2E4D4702B0C3E38B35%2E5945DC2EABF3343C&__acm__=1554570524_27cee116e76108b6ba3aa07a25fc8798 [https://perma.cc/5KMH-7NLN] (describing how Smart Reply uses machine learning to generate up to three responses to the emails which users can select instead of composing replies themselves and how the Smart Reply research team manipulated "the most frequent anonymized sentences" to train AI to express the same intention in different words, while avoiding redundant suggestions).

223. *Id.* (describing how the Smart Reply algorithm was trained on 238 million email messages).

well as novels to enable it to "generate coherent novel sentences" that make Smart Reply more conversational.[224] Both the input and the output in this example are expressive. As one commentator protested, "Google sought to make use of authors' varied and rich expression of ideas. This is the essence of copyrightable subject matter. Google's use cannot be called non-expressive; no longer is the company merely providing facts about books or furnishing a reference tool."[225]

At the same time, the use is clearly functional—to respond to and correspond with the sender of the email, rather than supplant a market for the emails or novels used as training data.[226] Smart Reply merely analyzes "the basic building blocks and patterns of human language," which are "entirely within the public domain."[227] The text does not transpose any of the expressive elements in the training data, whether those data are from its users, non-Gmail users, or the authors of novels used to train the dataset. Further, the expression in single email exchanges from the Smart Reply training dataset is of interest only to the parties. In contrast, Smart Reply could save time and effort for a myriad of Gmail users. The idea that authors of emails or novels foresee a market for their emails seems fanciful.[228]

In the context of using datasets to train AI-generated works, allowing non-expressive fair uses while prohibiting expressive fair uses sets up a

224. Samuel R. Bowman et al., *Generating Sentences from a Continuous Space*, *in* PROCEEDINGS OF THE 20TH SIGNLL CONFERENCE ON COMPUTATIONAL NATURAL LANGUAGE LEARNING 10-21 (May 12, 2016), https://www.aclweb.org/anthology/K16-1, [https://perma.cc/6MUK-KE9A]; Alex Kantrowitz, *Google Is Feeding Romance Novels To Its Artificial Intelligence Engine To Make Its Products More Conversational*, BUZZFEEDNEWS (May 5, 2016), https://www.buzzfeednews.com/article/alexkantrowitz/googles-artificial-intelligence-engine-reads-romance-novels [https://perma.cc/BX79-PCBG] (describing using the BookCorpus dataset to train AI to "generate coherent novel sentences" that could make Smart Reply more conversational); Richard Lea, *Google swallows 11,000 novels to improve AI's conversation*, GUARDIAN (Sept. 28, 2016), https://www.theguardian.com/books/2016/sep/28/google-swallows-11000-novels-to-improve-ais-conversation [https://perma.cc/LG94-ZXZA] (reporting that some of the novels were unauthorized copies of copyrighted works and that the authors were not notified, credited, or compensated for Google's use of their works).

225. Sobel, *supra* note 84, at 69.

226. Lea, *supra* note 226 (reporting a Google spokesman defending the move since it "doesn't harm the authors and is done for a very different purpose from the authors', so it's fair use under US law," and that romance novels made good input data because they "frequently repeated the same ideas, so the model could learn many ways to say the same thing—the language, phrasing and grammar in fiction books tends [sic] to be much more varied and rich than in most nonfiction books").

227. Schönberger, supra note 59.

228. Sobel *supra* note 84, at 75 ("Even when input data comprise conventional 'works' . . . it still seems ridiculous to compare those works' value to that of a machine learning model that powers an innovative web service.").

false dichotomy about the kind of progress the law should privilege.[229] That human creativity can thrive only by fending off machine competition overlooks capabilities that allowed humans to survive and flourish throughout history. To encourage such advances, investors need clear rules incentivizing both artistic and technological progress, not a reductionist approach that stifles one to protect the other.[230]

As with WFH, civil law countries do not enjoy the flexible policy lever that fair use offers users of copyrighted works in the U.S.[231] The U.S. would be foolish not to use all that fair use has to offer to its advantage and supercharge the growth of AI-generated works. And there is another reason to do so. Bias in AI may be exacerbated by a restrictive fair use doctrine. Where training data is protected by copyright, those who use them do so secretly, preventing biases from being uncovered.[232]

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229. The impact of permissive fair use on AI has been described in the following way:

> Permissive fair use for machine learning would undeniably foster progress in the scientific field of artificial intelligence. It might also foster a certain kind of artistic progress. Unencumbered by copyright, AI could learn from all the greatest books, movies, and music. Perhaps this erudite AI would become so adept at making art as to supersede human creativity. . . . Human creators, in turn, might not derive any incentives from copyright law if robotic rivals undercut their earning potential. If robotic creators gave the public access to more, and better, works of art than any human artistic establishment could deliver—and, in so doing, marginalized the human artistic establishment—would that be the progress copyright law exists to promote?

Sobel, *supra* note 84, at 89. *See also,* Barton Beebe, *Bleistein, the Problem of Aesthetic Progress, and the Making of American Copyright Law*, 117 COLUM. L. REV. 319, 329 (2017) (distinguishing between "accumulationist" accounts of progress and a "pragmatist aesthetics" of progress, and "focuses not on the stockpiling over time of fixed, archivable works but rather on the quality of ephemeral aesthetic experience in the present. . . . [P]ragmatist aesthetics measures aesthetic progress (or regress) largely by the extent of popular, democratic participation in aesthetic practice.").

230. Reductionism has been described in the following way:

> Reductionism refers to the theory that the behaviour of a system is the sum of the behaviour of its smaller and simpler constituent parts. Reductionism is reflected in the propensity of organisations, including governments, to break down large problems into smaller problems so that aspects of national security, for example, are dealt with separately by the ministries of defence, home affairs and foreign affairs. But this approach is inadequate for dealing with complex — or wicked — problems like terrorism or climate change, which require collaboration across bureaucratic silos because the resources and expertise for dealing with them reside in more than one agency.

PETER HO, THE CHALLENGES OF GOVERNANCE IN A COMPLEX WORLD (Sandhya Venkatesh ed., 2018).

231. Schönberger, *supra* note 57 ("Unfortunately, the detour via the fair use doctrine is a luxury that European law does not offer. . . . Instead the InfoSoc Directive provides for a rigid system of exclusive rights (including a 'reproduction right') with an exhaustive list of exceptions and limitations.").

232. *See* Louise Matsakis, *Copyright Law Makes Artificial Intelligence Bias Worse*, MOTHERBOARD (Oct. 31 2017), https://motherboard.vice.com/en_us/article/59ydmx/copyright-law-artificial-intelligence-bias [http://perma.cc/3DKE-WZMP] ("If training an AI were classified as fair use in most cases, computer scientists would be free to use any work to teach their algorithms. They

The machine-centric nature of innovation and creativity warps the usual rules incentivizing the two. However, uncertainty should not unsettle us. As Charles Darwin recognized, uncertainty is a necessary pre-condition for change and adaptation.[233] If AI can learn from the greatest books, movies, and music we have to offer and create work that supersedes what has come before, how is that not both technological and aesthetic progress? Some outclassed human creators will find their livelihoods challenged if they are unwilling or unable to retrain, retool, and use AI to augment their work to remain relevant. Still, that challenge is not peculiar to creators of copyrighted work.

It is a challenge that receptionists, taxi drivers, and factory workers face in the 4IR even as they themselves have replaced the professions that went before them. Even attorneys reviewing agreements have been outclassed by LawGeex, a machine learning AI.[234] Twenty lawyers from firms such as Goldman Sachs, Cisco, Alston & Bird, and K&L Gates tasked with reviewing nondisclosure agreements for potential risks were given four hours to study the contracts. They took an average of 92 minutes and exhibited an 85% accuracy rate. The same task took LawGeex 26 seconds to complete with 94% accuracy. This is good news for lawyers who can move beyond drudge work, passing cost savings to consumers who can access cheaper legal services. The future of legal practice lies in reskilling, not in chasing after skills that technology will soon make redundant.

It is worth considering instances where fair use need not be invoked at all. First, the copy may be too ephemeral to constitute infringement. To be infringing, the alleged infringer must have fixed a copy of the copyrighted work.[235] Ephemeral copies are so fleeting that they are not considered copies at all.[236] Second, trendlines in headlines indicate that AI-generated works may soon use very small datasets. Cognitive scientists are developing algorithms to mimic more elusive aspects of the

could also disclose what they used without fear of legal repercussion."); *see also* Levendowski, *supra* note 84; *see* Daryl Lim, *Predictive Analytics: How Behavioral Economics & Artificial Intelligence can Bridge the Intellectual Property-Antitrust Divide* (forthcoming 2019) (discussing how bias affects the IP-antitrust interface).

233. Lim, *supra* note 234.

234. Cal Jeffrey, *Machine-learning algorithm beats 20 lawyers in NDA legal analysis*, TECHSPOT (Oct. 31, 2018), https://www.techspot.com/news/77189-machine-learning-algorithm-beats-20-lawyers-nda-legal.html [http://perma.cc/EMN8-H4XC].

235. *See, e.g*., Capitol Records, LLC v. ReDigi Inc., 910 F.3d 649, 657 (2d Cir. 2018).

236. *See, e.g.*, Cartoon Network LP v. CSC Holdings, Inc., 536 F.3d 121, 130 (2d Cir. 2008) (holding that movies and television programs streamed through a data buffer for 1.2 seconds did not create copies under the Copyright Act).

human mind using probabilistic techniques and a small dataset.[237] Uber's AI lab is working on AI that mimics evolution by starting with a set of random algorithms. Developers choose one that suits the task at hand and generates derivative algorithms, eventually arriving at one most appropriate for the job. This serendipitous approach to problem solving can yield results that goal-driven optimization cannot.[238] MIT researchers developed software that can recognize objects using nothing more than raw images and audio files.[239] These may render the copyright infringement issue moot at least in a small number of cases. Before concluding our discussion on the implications of AI on copyright law, it is worth briefly considering the role of AI in enforcement.

C. AI as Enforcers

AI can also detect copyright infringement, such as in photos used on websites, by looking for a certain image.[240] As the recent *Blurred Lines* lawsuit shows, infringement hinges on proving that a songwriter copied from an older work, which can be difficult to determine because humans may be subliminally influenced.[241] In that case, the majority held that musical compositions exist on a broad range of expression with a large array of elements.[242] This was severely criticized by the dissent.[243] A core point of contention was expert testimony offered by the plaintiff's music expert, who the dissent excoriated because she "cherry-picked brief

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237. Knight, *supra* note 41 (describing programs than recognize new handwritten characters and images after just seeing a few examples).

238. *A sense of curiosity is helpful for artificial intelligence*, ECONOMIST (Aug. 30, 2018), https://www.economist.com/science-and-technology/2018/08/30/a-sense-of-curiosity-is-helpful-for-artificial-intelligence [http://perma.cc/JWF6-BWJ3] ("Biological evolution was not explicitly curious about flying, and yet it still managed to come up with birds.").

239. Timothy B. Lee, *AI learns to decipher images based on spoken words—almost like a toddler*, ARS TECHNICA (Sept. 23, 2018), https://arstechnica.com/science/2018/09/ai-learns-to-decipher-images-based-on-spoken-words-almost-like-a-toddler/ [http://perma.cc/C4MN-XT5E].

240. Houstonlawy3r, *Neural Network Applications to Image Copyright Infringement*, CASHMAN IP (Dec. 6, 2017), https://www.cashmanip.com/neural-network-image-copyright/ [https://perma.cc/KW87-GNCS] ("From there images across the internet can be searched using Logistic Regression to determine which images likely infringe the copyrighted image.").

241. Williams v. Gaye, 895 F.3d 1106 (9th Cir. 2018).

242. *Id.* at 1120.

243. The dissent's criticism of the majority included:

> The majority allows the Gayes to accomplish what no one has before: copyright a musical style. "Blurred Lines" and "Got to Give It Up" are not objectively similar. They differ in melody, harmony, and rhythm. Yet by refusing to compare the two works, the majority establishes a dangerous precedent that strikes a devastating blow to future musicians and composers everywhere.

Id. at 1138 (Nugyen, J., dissenting).

snippets to opine that a 'constellation' of individually unprotectable elements in both pieces of music made them substantially similar."[244] AI trained on a dataset of "the building blocks of melody, harmony, and rhythm" would be able to digest and empower courts to make better decisions in the same way that AI has helped prognosticate disease as seen in Part II. It may also be used to parse through the *paper-trail* by which other AIs generate their works. With an AI, the scope of training datasets is finite, and copying is evidentially easier to prove through audio-finger printing and analysis.[245]

Like the creative arts, AI will continue to play an ever more prominent role in artistic and technological progress. Companies are increasingly reliant on AI to generate, simulate, and evaluate test results. They function more quickly and efficiently than their human agents while minimizing constraints put in place by human biases or time.[246] As seen in Part II.C, AI can also combine prior art across diverse fields in nonobvious and creative ways. With respect to patent practice, the use of AI in search and examination will become increasingly more important to the continued viability of the patent system.[247] These developments raise novel and important questions for patent law, policy, and practice. These issues will be considered next.

IV. AI & PATENTS

In 2018, *Nature* published an article about how AI is changing discovery of novel drug compounds and structures of a variety of diseases.[248] AI has also been used in diagnosing diseases, customizing treatment, mapping genes in different cell categories, and creating virtual animal and human models for drug tests.[249] The intersection of AI and

244. *Id.*

245. Dredge, *supra* note 99.

246. Fraser, *supra* note 44 (noting that AI has assisted in creating patentable inventions for several decades, recent improvements to AI and exponential growth in computing power will likely further enable computers to produce useful inventions and become major drivers of innovation in fields like electronics, robotics, health and pharmaceuticals, materials, and nanotechnology).

247. Joff Wild, *Artificial intelligence and the future of the patent system,* IAM (July 11, 2018), https://www.iam-media.com/law-policy/artificial-intelligence-and-future-patent-system [http://perma.cc/QZ56-PVMS] ("These issues . . . challenge the utility of the patent system. If not addressed, they could potentially devalue it and lead to decline in its use. There is simply way too much data for a human to read, analy[z]e and understand. It is clear we need help. Step up artificial intelligence (AI).").

248. Nic Fleming, *How Artificial Intelligence Is Changing Drug Discovery*, 557 NATURE S55 (May 2018), https://www.nature.com/articles/d41586-018-05267-x1 [http://perma.cc/FP29-VVZU].

249. Grantland Drutchas, *Artificial IP: Can Drugs Discovered Using AI Be Patented?*, CHI. LAW. 76 (Oct. 2018).

patent law raises important issues: What happens when the AI takes the inventive step in producing the technological breakthrough?[250] Can a novel drug identified by AI be "invented"? How should these breakthroughs affect the regard for the notional person—the PHOSITA—by which much of patent doctrine is measured? How does AI change the equation when it comes to infringement? How can AI help save the patent system from obsolescence? We consider these questions here.

A. AI & Inventorship

The literature on AI and IP cites the "Creativity Machine" and the "Invention Machine" as examples of AI creating patentable inventions.[251] It is striking that neither of the applicants identified the computers as the inventors. Who owns a patent turns on who, as an initial matter, invented the patent. Inventorship looks at who invented the subject matter of the patent and refers to the individual who invented or discovered the subject matter of the invention.[252] An *inventor* must conceive the invention[253] but need not reduce it to practice.[254] Conception is the "formation in the mind of the inventor, of a definite and permanent idea of the complete and operative invention, as it is hereafter to be applied in practice."[255]

The issue of ownership, or who owns legal title to the subject matter claimed in the patent, is starker in patent law than in copyright.[256] Because patent law has no equivalent of WFH, individual inventors need to expressly assign their inventions to their employers for corporate ownership of inventions. It follows that with regard to patent law, unlike copyright law, the absence of a human inventor to bridge the chain of

250. Toby Bond, *How Artificial Intelligence is set to disrupt our legal framework for Intellectual Property rights*, IPWATCHDOG (June 18, 2017), http://www.ipwatchdog.com/2017/06/18/artificial-intelligence-disrupt-legal-framework-intellectual-property-rights/id=84319/ [http://perma.cc/T248-69DY] (noting that AI will be the entity taking the inventive step, drawing new conclusions between the observed and the unknown).

251. U.S. Patent No. 5,852,815 (filed May 15, 1998); U.S. Patent No. 6,857,851 (filed Jan. 16, 2003).

252. Mark D. Penner and Mark Vanderveke, *Could the Creations of Artificial Intelligence be Entitled to Intellectual Property Protection*?, FASKEN (June 27, 2018), https://www.fasken.com/en/knowledgehub/2018/06/could-the-creations-of-artificial-intelligence-be-entitled-to-intellectual-property-protection [http://perma.cc/3D97-X5L8] (an "inventor" is defined as the individual who invented or discovered the subject matter of the invention).

253. MPEP § 2137.01 (9th ed. Rev. 8, Jan. 2018) ("Unless a person contributes to the conception of the invention, he is not an inventor.").

254. *Id.* (reduction to practice may be satisfied either when the invention is actually carried out and is found to work for its intended purpose, or when a patent application having a sufficient disclosure is filed); *see also* Cooper v. Goldfarb, 154 F.3d 1321, 1327 (Fed. Cir. 1998).

255. *See* Mergenthaler v. Scudder, 11 App. D.C. 264, 276 (D.C. Cir. 1897).

256. Vapor Point LLC v. Moorhead, 832 F.3d 832 (2016).

inventorship and ownership between machine and corporation becomes critical.

In the absence of an assignment, the original applicant is presumed to be the owner.[257] A human or corporate assignee of the invention could be recognized as the applicant and own the resulting patent, but this presupposes that a computer has the legal capacity to assign property, which it does not. This may create an impetus to introduce WFH to patent law similar to what currently exists under copyright law. That should not be radical. Their headwaters are the same—the IP Clause of the Constitution confers limited exclusive rights to promote artistic and technological progress. It is trite that while the streams of copyright and patent law mostly run parallel, they sometimes intermingle, and ideas cross-pollinate across their banks.[258]

It is unlikely, though, that an AI can qualify as an inventor under current law. Conception can be performed only by natural persons because AI has no *mind* to speak of. This conclusion is buttressed by the Supreme Court's interpretation of patent-eligible subject matter as "anything under the sun that is made by man."[259] The Dictionary Act provides that "[i]n determining the meaning of any Act of Congress . . . the [word] . . . 'individual,' shall include every infant member of the species homo sapiens."[260] It is true that on its face, *person* and *whoever* may not be limited to humans or *individuals* since these terms could include corporations, companies, associations, firms, partnerships, societies, and joint stock companies. Further, no true infant is capable of inventing anything potentially patentable. One conclusion may be that *person* or *individual* would, in and of themselves, preclude AI from being recognized as an inventor. At the same time, patent law expressly vests ownership rights initially in human inventors, not companies.[261] The anchoring of inventorship to the human inventor stems from a desire to

257. 37 C.F.R. § 1.42 (2018) (referring to the "applicant" as the inventor).

258. Impression Prod., Inc. v. Lexmark Int'l, Inc., 137 S. Ct. 1523, 1527 (2017) ("The two share a 'strong similarity and identity of purpose,' and many everyday products . . . are subject to both patent and copyright protections.").

259. Diamond v. Chakrabarty, 447 U.S. 303, 309 (1980).

260. 1 U.S.C. § 8(a) (2018).

261. *See* 35 U.S.C. § 100(f) (2018) (stating that the U.S. patent system only recognizes individuals as inventors); *see* New Idea Farm Equip. Corp. v. Sperry Corp., 916 F.2d 1561, 1566 (Fed. Cir. 1990) (stating that inventors cannot be companies); Ben Hattenback & Joshua Glucoft, *Patents in an Era of Infinite Monkeys and Artificial Intelligence*, 19 STAN. TECH. L. REV. 32, 46 (2015) (stating that inventors cannot be machines); *see also*, C. Soans, *Some Absurd Presumptions in Patent Cases*, 10 PAT. TRADEMARK & COPYRIGHT J. RES. & EDUC. 433, 438 (1966) (noting that the prevalent view is that a new patentable concept is a "mental creation by a human being").

recognize and reward human ingenuity apart from economic benefit derived from the disclosure of the patented invention.[262]

The Patent Act states that "[p]atentability shall not be negated by the manner in which the invention was made."[263] However, that section deals specifically with the nonobviousness enquiry and, in particular, suggests that hindsight should not be used in determining whether the invention was obvious.[264] It would be a stretch to negate case law and statutory law indicating the need for a human agent in the inventive process, including both conceiving of the invention and reducing it to practice. Thus, unlike copyright law where WFH specially recognizes corporations as the author-owner, a human must in the first instance be named as an inventor with regard to patentability—at least for now.[265]

Beyond the question of vesting rights in the AI itself, inventorship issues may still arise. The list of possible human inventors includes the hardware and software developers, data trainers, and anyone who recognized the significance of AI-generated results.[266] For instance, if A develops an AI and assigns it to B, who operates the AI on a cloud server provided by C, using training data provided by D, and the AI produces an invention—who is the inventor? Joint inventorship springs from a significant contribution to the conception of the invention such that a person of ordinary skill in the art could construct the invention without unduly extensive research or experimentation.[267] A collaborator who contributes to the conception of just a single claim may be a joint

262. Liza Vertinsky & Todd M. Rice, *Thinking About Thinking Machines: Implications of Machine Inventors for Patent Law*, 8 B.U. J. SCI. & TECH. L. 574, 585 (2002) (arguing that human creativity should be encouraged and recognized as underpins popular and political support for the patent system); *see also* Graham Dutfield, *Collective Invention and Patent Law Individualism: Origins and Functions of the Inventor's Right of Attribution*, 5 WIPO J. 25, 25–26 (2013), https://www.wipo.int/edocs/pubdocs/en/intproperty/wipo_journal/wipo_journal_5_1.pdf, [https://perma.cc/8ESE-DCFQ] (noting that human inventorship recognizes the value placed on the products of human minds and the individuals who produce them).

263. 35 U.S.C. § 103 (2018).

264. See Ashley Allman Bolt, *Combating Hindsight Reconstruction in Patent Prosecution*, 64 EMORY L.J. 1137 (2015).

265. Beech Aircraft Corp. v. EDO Corp., 990 F.2d 1237, 1248 (Fed. Cir. 1993) (holding that "only natural persons may be 'inventors'").

266. Tull, *supra* note 76, at 42 ("The list of possible human inventors includes the AI software and hardware developers, the medical professionals or experts who provided the data set with known values or otherwise provided input into the development of the AI, and/or those who reviewed the AI results and recognized that an invention had been made.").

267. In re Verhoef, 888 F.3d 1362, 1366 (Fed. Cir. 2018) (A joint inventor may "contribute . . . to the conception or reduction to practice of the invention."); Ethicon, Inc. v. U.S. Surgical Corp., 135 F.3d 1456, 1460 (Fed. Cir. 1998); *see also* Kimberly-Clark Corp. v. Procter & Gamble Distrib. Co., 973 F.2d 911, 917 (Fed. Cir. 1992) (holding that each joint inventor must generally contribute to the conception of the invention); Sewall v. Walters, 21 F.3d 411, 415 (Fed. Cir. 1994).

inventor,[268] and each joint inventor need not equally contribute.[269] At the same time, a collaborator must "make a contribution to the claimed invention that is not insignificant in quality, when . . . measured against the dimension of the full invention," and "do more than merely explain to the real inventors well-known concepts and/or the current state of the art."[270] In the previous example, B and D arguably satisfy the requirement of joint inventorship if D's employees selected the data and B fed the data in to discover the invention.[271] So may A and C, though the assignment and hosting make their claims to the invention more tenuous.

The law assumes that the named inventors "are the true and only inventors."[272] Inventorship on issued patents is presumed to be correct, and a challenger must prove its case by "clear and convincing evidence" and provide corroborating evidence.[273] When an inventor is not named on an issued patent or a person is named in error, the U.S. Patent and Trademark Office (PTO) may correct inventorship.[274] If inventorship can be corrected, then the error will not render the patent invalid.[275] A court may also order correction of inventorship, but an omitted inventor who moves for correction must meet a "heavy burden."[276]

There are perils to not naming the correct inventors. First, the PTO may reject claims where an application does not correctly name all inventors.[277] Second, patent applicants who intentionally falsify inventorship to the PTO risk invalidation of any issued patent based on inequitable conduct.[278] Third, patentees seeking to enforce their rights

268. *Ethicon, Inc.*, 135 F.3d at 1460.

269. *In re Verhoef*, 888 F.3d at 1366.

270. *Id.*

271. Jason Lohr, *Artificial intelligence drives new thinking on patent rights*, HOGAN LOVELLS: LIMEGREEN IP NEWS (July 15, 2016), https://www.limegreenipnews.com/2016/07/artificial-intelligence-drives-new-thinking-on-patent-rights/ [http://perma.cc/42R7-ZH3Q].

272. Drone Techs. v. Parrot S.A., 838 F.3d 1283, 1292 (Fed. Cir. 2016).

273. Vapor Point LLC v. Moorhead, 832 F.3d 1343, 1349 (Fed. Cir. 2016), *cert. denied sub nom*, Nanovapor Fuels Grp., Inc. v. Vapor Point, LLC, 137 S. Ct. 1121 (2017) (leaving in place an order by the lower court to correct inventorship based on clear and convincing evidence that two joint inventors were omitted).

274. 35 U.S.C. § 256(a) (2018).

275. 35 U.S.C. § 256(b) (2018).

276. Eli Lilly & Co. v. Aradigm Corp., 376 F.3d 1352, 1358 (Fed. Cir. 2004).

277. In re Verhoef, 888 F.3d 1362, 1367–68 (Fed. Cir. 2018) (affirming the PTO's rejection of claims under pre-AIA § 102(f) because the applicant did not name his co-inventor on the application, reasoning that the applicant did not conceive of every claim); MPEP § 2157 (9th ed. Rev. 8, Jan. 2018) (Although the AIA version of § 102 does not include a subsection (f) or contain the same language as pre-AIA § 102(f), the PTO has indicated it will continue to reject errors of inventorship under 35 U.S.C. §§ 101, 115 (2018)).

278. Therasense, Inc. v. Becton, Dickinson & Co., 649 F.3d 1276, 1290 (Fed. Cir. 2011) (en banc) ("To prevail on a claim of inequitable conduct, the accused infringer must prove that the

might have their suits dismissed for nonjoinder if a court determines that the patent does not name all joint inventors.[279] Moreover, as with WFH, licenses, joint development agreements, and assignments need to reflect clearly the parties' intention in invention ownership, as do indemnification agreements on liability.

Are patent applicants then trapped in a catch-22? AI cannot be named as an inventor even though the human role may be minimal or nonexistent. Yet listing a human inventor who made no actual conceptual contribution could be misleading or even fraudulent. One option is to eliminate the statutory requirement to identify an inventor altogether. The underlying question then becomes who should own the invention. Furthermore, it allows inventorship issues arising from a sliver of facts to trump the benefit that naming inventors within an established and time-honored system brings.[280]

It may be better for AI to be identified in a patent application as long as AI is used. Patent applications do not currently require applicants to disclose the use of AI in the inventive process, much less that the AI invented the invention.[281] This becomes particularly important when identifying the PHOSITA in the AI-era, where the "person of ordinary skill in the art" may no longer be a person at all. Identification of the PHOSITA is centrally relevant to issues of patentability and patent scope. For example, claim construction, novelty, and obviousness are all determined from the PHOSITA's point of view. The relevant standard

patentee acted with the specific intent to deceive the PTO."); *see also id.* at 1292 ("[I]nequitable conduct renders an entire patent (or even a patent family) unenforceable."); PerSeptive Biosys., Inc. v. Pharmacia Biotech, Inc., 225 F.3d 1315, 1322–23 (Fed. Cir. 2000) (holding asserted patents unenforceable for inequitable conduct based on incorrect inventorship based on "at least five specific instances of intentional falsehoods, misrepresentations, and omissions" directed to the material issue of inventorship).

279. Ethicon, Inc. v. U.S. Surgical Corp., 135 F.3d 1456, 1468 (Fed. Cir. 1998) (holding that "one co-owner has the right to impede the other co-owner's ability to sue infringers by refusing to voluntarily join in such a suit.").

280. Fraser, *supra* note 44 ("[E]liminating this requirement would obviate certain justifications for the patent system, such as the fair reward and moral benefit of recognition. This could have tangible impacts on scientists and engineers who gain professional credibility and even monetary benefits based on their status as a named inventor on patents.").

281. Ana Ramalho, *Patentability of AI-Generated Inventions: is a Reform of the Patent System Needed?*, https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3168703, [https://perma.cc/W3HL-MS6M] ("[N] either laws nor Examination Guidelines seem to mandate that the applicant indicate the means through which she created the invention."); *id.* (describing how the prosecution history of the invention "Apparatus for Improved General-Purpose PID and non-PID Controllers" makes no mention of the AI used to develop the invention, nor the use of the AI in developing his idea. The inventor admitted that "the whole invention was created by a computer").

will vary widely depending on whether the inventor is the AI, the augmented human user, or the AI developers.

B. AI as the PHOSITA

An inventor cannot receive a patent for an invention that is only a trivial or *obvious* modification of the prior art.[282] The obviousness inquiry requires "a comparison between what is claimed to have been invented in the patent and what was already known to a person of ordinary skill in the field of art pertaining to the invention."[283] Courts and the PTO apply a three-step procedure:[284] (1) they determine the scope and content of the prior art; (2) they compare the differences between the prior art and the claims at issue; and (3) they assess the level of ordinary skill in the pertinent art.[285]

In step one, the PHOSITA is presumed to have knowledge of all the analogous prior art in addition to the ordinary skill of one who practices in that area of technology.[286] Analogous art includes only those prior art references that either arise in the same field of endeavor or deal with the same problem the inventor has attempted to solve.[287] A reference may be considered reasonably pertinent if:

> it is one which, because of the matter with which it deals, logically would have commended itself to an inventor's attention in considering his problem. If a reference disclosure has the same purpose as the claimed invention, the reference relates to the same problem, and that fact supports use of that reference in an obviousness rejection.[288]

Prior art that teaches away from the combination by suggesting its undesirability or yielding unexpected results indicates the nonobviousness of the invention.[289] In step two, because inventions consist of new combinations of pre-existing elements, the sum of analogous prior art must contain each element of the claimed invention as well as provide a "motivation to combine" the references by the PHOSITA.[290] Prejudice

282. 35 U.S.C. § 103 (2018).
283. Securitypoint Holdings, Inc. v. United States, 129 Fed. Cl. 25, 35 (2016).
284. *See* KSR Int'l Co. v. Teleflex Inc., 550 U.S. 398 (2007).
285. Graham v. John Deere Co., 383 U.S. 1, 17 (1966) (The court may also assess secondary considerations.).
286. *See, e.g.*, *In re* Winslow, 365 F.2d 1017, 1020 (C.C.P.A. 1966).
287. *In re* Clay, 966 F.2d 656, 659 (Fed. Cir. 1992).
288. Sci. Plastic Prods., Inc. v. Biotage AB, 766 F.3d 1355, 1359 (Fed. Cir. 2014), *cert. denied*, 135 S.Ct. 2380 (2015).
289. *In re* Gurley, 27 F.3d 551, 553 (Fed. Cir. 1994).
290. *In re* Rouffet, 149 F.3d 1350, 1357 (Fed. Cir. 1998).

from prior failures in the relevant art is an important factor in nonobviousness analysis.

A PHOSITA that is either AI-augmented or an AI *inventor* can thread non-analogous art and is unfettered by biases due to prior failures is clearly superior to a PHOSITA fettered by the limitations of human cognition.[291] An inventive step obvious to an AI capable of testing millions of prototypes in a fraction of the time that a skilled artisan needs may be staggeringly nonobvious to a skilled person, or moderately obvious to that same person with access to a similar AI system. How should patent law respond?

One option is to raise the bar for patentability by modifying the criteria explicitly to require consideration of AI.[292] Professor Ryan Abbott has argued that the PHOSITA should include an express consideration of "technologies used by active workers."[293] In particular,

> [t]his change will more explicitly take into account the fact that machines are already augmenting the capabilities of workers, in essence making more obvious and expanding the scope of prior art. Once inventive machines become the standard means of research in a field, the test would also encompass the routine use of inventive machines by skilled persons. . . .To obtain the necessary information to implement this test, the Patent Office should establish a new requirement for applicants to disclose when a machine contributes to the conception of an invention, which is the standard for qualifying as an inventor.[294]

Another option is to exclude inventions that might have been created even without the patent system.[295] To do so would create a subcategory of patent rules for AI-inventions that risks arbitrariness and may be difficult to cabin. Yet, what is the alternative?

After all, applicants need not declare to the PTO whether an AI was involved in the inventive step. They can use the benchmark of a human

291. Ramalho, *supra* note 281 ("The use of AI in the inventing process can cause the field of analogous arts to be broadened in practice, given the unbiased nature of AI (and therefore the real possibility that AIs will look for solutions to problems in non-analogous fields)."); *see also* Ryan Abbott, *Everything Is Obvious*, 66 UCLA L. REV. 2, 37 (2019) ("[A] machine is capable of accessing a virtually unlimited amount of prior art. Advances in medicine, physics, or even culinary science may be relevant to solving a problem in electrical engineering. Machine augmentation suggests that the analogous arts test should be modified or abolished once inventive machines are common, and that there should be no difference in prior art for purposes of novelty and obviousness.").

292. Ramalho, *supra* note 283, at 26 ("It would therefore be advisable to consider adding a 'made by AI' factor as an indication of obviousness.").

293. Abbott, *supra* note 293, at 6.

294. Abbott, *supra* note 293, at 6.

295. Abbott, *supra* note 293, at 45 ("inventions which would not be disclosed or devised but for the inducement of a patent.").

PHOSITA to show that their invention was nonobvious, but they cannot have it both ways. Applicants can choose to (1) declare the AI's involvement and be judged by a higher AI-PHOSITA standard that would render more things obvious or (2) not use AI and be bound by a lower human-PHOSITA standard. Therein lies both the solution and the seeds of the greedy applicant's own destruction. If the patent specification fails to enable the human PHOSITA to make and use the claimed invention without undue experimentation, the claim will be invalid for lack of enablement.[296] Similarly, if the human PHOSITA cannot discern that the inventor possessed the invention on the claim's effective filing date, that claim is invalid for failure to meet the written description requirement.[297]

Finally, if the human PHOSITA reading the claims in light of the specification and prosecution history cannot discern their objective boundaries, the claims fail for lack of definiteness.[298] This is because AI systems often operate in a black box.[299] In this regard, using AI techniques to explain AI functionality or locating an inventive concept outside the AI interacting with other elements may ameliorate this obstacle.[300]

C. *AI as Infringers*

IBM's Watson AI is used in Aerialtronic drones, Under Armour's fitness apps, and Weather Underground's weather prediction app.[301] Machine learning enables Watson to write new algorithms, and in that process, infringe on patents that might not have been anticipated when the

296. 35 U.S.C. §112 (2018).

297. As to written description, "[t]he standard for satisfying the written description requirement is whether the disclosure 'allow[s] one skilled in the art to visualize or recognize the identity of the subject matter purportedly described.'" Alcon Research Ltd. v. Barr Labs. Ltd., 745 F.3d 1180, 1190(Fed. Cir. 2014) (quoting Enzo Biochem, Inc. v. Gen-Probe Inc., 323 F.3d 956, 968 (Fed. Cir. 2002)). The written description requirement demands that the specification fully support or describe the invention claimed. 35 U.S.C. § 112(a) (2018) ("The specification shall contain a written description of the invention.").

298. Nautilus, Inc. v. Biosig Instruments, Inc., 572 U.S. 898, 911–12 (2014); *see* 35 U.S.C. § 112(b) (2018) (requiring that a claim must be sufficiently definite to inform the public of the bounds of the protected invention, i.e., what subject matter is covered by the exclusive rights of the patent).

299. *See* Kaavo Inc. v. Amazon.com Inc., 323 F. Supp. 3d 630, 642 (D. Del. 2018) (rejecting AI claims that gave "no details on how the forecasting is done, and no algorithm [wa]s provided").

300. Danny Tobey, *Alice in Wonderland: Navigating the Strange World of Patenting AI*, AIPLA NEWSSTAND (Dec. 21, 2018), https://www.lexology.com/library/detail.aspx?g=26fa0357-e1dd-410b-aadf-c8903ede9807 [http://perma.cc/9PFP-QUBW].

301. Marc Ferranti, *IBM's Watson IoT Hits the Skies with Aerialtronics drone deal*, ComputerWorld, (Sept. 16, 2016), http://www.computerworld.com/article/3121224/internet-of-things/ibms-watson-iot-hits-the-skies-with-aerialtronics-dronedeal.html [http://perma.cc/N7KW-LGAP].

initial iteration was developed.[302] Multiple actors may be involved in its development and operation. This makes it difficult to determine which party is liable should direct infringement occur.

AI-generated works might infringe preexisting rights of others in several ways. First, the AI could perform steps recited in the claims of a patented invention. A lens designed by AI could infringe patents on optical lens and electrical circuit technology.[303] Similarly, AI-enabled systems that map the fastest route between two points could ensnare both the AI developer and the agent who implements the system under a direct infringement theory where they cumulatively perform all the patented steps.[304]

302. Bridget Watson, *A Mind of Its Own-Direct Infringement by Users of Artificial Intelligence Systems*, 58 IDEA: J. FRANKLIN PIERCE FOR INTELL. PROP. 65, 80 (2017) ("Through machine learning, Watson can alter its own programming."); *see also id.* at 81 ("The following fictitious example demonstrates how infringement of a patent-protected method occurs. Weather Underground uses Watson to make weather predictions. After multiple months of data evaluation, Watson develops a new method of weather prediction and uses the new method in its subsequent predictions.").

303. *Id.* at 76.

304. 35 U.S.C. § 271(a) (2018) (Direct infringement occurs when a party "makes, uses, sells, offers to sell, or sells any patented invention . . . during the term of the patent."). Here is one infringement hypothetical:

> For example, consider a patented method for determining the fastest route to a destination, which considers traffic patterns, satellite data, and road conditions. Company A, the controlling company, creates and sells an artificial intelligence system to Company B, the agent. Company B directs the system to better determine the fastest route to a destination by inputting information from traffic patterns, satellite data, and road conditions. Using the inputted information, the system identifies an approach for determining the fastest route between two definitions, which happens to be the same method claimed in the patent. By performing each step in the method for determining the fastest route between two destinations, the system, under B's current control, infringed on the patent. Using the definition of direct infringement, this would constitute infringement of the patent.

Watson, *supra* note 304, at 78–79 (2017). A and B may also infringe where A contracts with B to perform one or more steps in the claims, while A performed the rest of the steps:

> For example, the system sold by Company A and bought by Company B is directed to develop an algorithm for determining the fastest route to a destination. Company B directs the system to perform steps one and two, which are identical to steps one and two from the patent. The system then develops the remaining steps, identical to those of the patent. Thus, Company B directing the system to develop the remaining steps would also constitute infringement under the definition of direct infringement.

Watson, *supra* note 304, at 79. The current interpretation of direct infringement has been described in the following way:

> Under the rule provided by the Federal Circuit in *Akamai*, direct infringement of a patent-protected method occurs when all of the steps are "performed or attributed to a single entity. . . . Therefore, when an artificial intelligence system creates a method and implements that method to produce a result, infringement occurs if that method is patent-protected such that the system performs each and every step of the method claim."

Watson, *supra* note 304, at 81.

The 4IR also introduced an amplified likelihood of infringement unknown in the biochemical industry until now.[305] Every step in the value chain from invention to manufacturing, diagnosis, prescription, delivery, and treatment could involve software.[306] In chemical industries involving few technology layers, the invention is usually clearly identified by settled terminology, and a thorough patent search can support a tolerably reliable freedom to operate report.[307]

In contrast, software exists in the messy realm of complex cumulative technologies with overlapping rights over abstract technologies described by non-standardized terminology.[308] The relationship among rights owners is one of interlocking interdependence,

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305. The increased likelihood of infringement has been described in the following way:

> The digital transformation changes processes in companies, as well as their product and service offerings across all industries. This creates a new IP management situation for many companies, especially in traditional, risk-averse industries (e.g. chemicals and pharmaceuticals). . . . For companies doing business in traditional industry sectors with little or no focus on information technology (IT) and computer technology, using new technologies imposed by the digital transformation leads to situations where the old paradigms of exclusivity or freedom to operate no longer apply. Rather, IP risk management approaches seem to be more appropriate.

Peter Bittner, *Intellectual Property Management Challenges Arising from Pervasive Digitalisation: The Effect of the Digital Transformation on Daily Life*, *in* 5 INTELLECTUAL PROPERTY AND DIGITAL TRADE IN THE AGE OF ARTIFICIAL INTELLIGENCE AND BIG DATA 67, 71-72 (2018), http://www.i3pm.org/files/misc/CEIPI-ICTSD_Issue_5.pdf [https://perma.cc/W5FG-QJZ7].

306. *Id.* at 71 ("Production and logistics processes undergo disruptive digital redesigns enabled by Internet of Things technologies and robotics. Even the innovation processes in companies change dramatically by relying more and more on computer-aided innovation, with artificial intelligence applications developing rapidly.").

307. Alissa Zeller, *Influences of Digital Transformation on Freedom-to-Operate Processes in the Chemical Industry*, *in* 5 INTELLECTUAL PROPERTY AND DIGITAL TRADE IN THE AGE OF ARTIFICIAL INTELLIGENCE AND BIG DATA 75, 78 (2018), http://www.i3pm.org/files/misc/CEIPI-ICTSD_Issue_5.pdf [https://perma.cc/W5FG-QJZ7] ("For chemical products, a meaningful in-depth FTO analysis can be done because of the clearly defined product (chemical formula) and the limited number of patents per product. Both restrict the patent search and its analysis to a reasonable scope.").

308. An example of this problem was described in the following way:

> For example, when an innovation is made in the application layer (which is frequently the case in the smart product context), a patent search may reveal other IP rights targeting innovations in this layer. However, it is practically impossible to gain insights regarding the IP situation in the lower levels of the technology stack. Further, even within the same layer there are typically many claims floating around which pursue similar goals. It is to be expected that many patents exist that show overlaps in the scope of protection.

Bittner, *supra* note 305. Zeller described this problem in the following way:

> For IT inventions, the key challenge in addition to the large number of patents for both a comprehensive search and its analysis is the lack of a standardised technical terminology. One and the same innovation can be defined in different terms. Thus, even if a potentially relevant patent can be identified, its scope of protection may be difficult to assess.

Zeller, *supra* note 309.

typically resolved via cross-licensing patent portfolios.[309] Even good-faith product clearance searches cannot deliver a clean and reliable report.[310] It is likely that any AI system will infringe dozens or even hundreds of patents in various technology layers. In the AI-enabled world, all industries, regardless of where they might have started, must embrace a risk management strategy calibrated according to discernable patent portfolios and players.[311] Market players should own aspects of AI solutions that are attractive to others to improve their negotiating power when the time comes to gain access to others' patent portfolios.

Besides liability for patent infringement, AI can also pose a challenge to patent validity. One key ground is that AI patents-in-suit fail to recite patent-eligible claims. The Supreme Court noted forty years ago that "[i]n choosing such expansive terms as 'manufacture' and 'composition of matter,' modified by the comprehensive 'any'; Congress plainly contemplated that the patent laws would be given wide scope."[312] It explained that "Congress took this permissive approach to patent eligibility to ensure that 'ingenuity should receive a liberal encouragement.'"[313] But the Supreme Court's decision in *Alice Corp. Pty. Ltd. v. CLS Bank Intern*. sounded the death knell for many software patents, including those covering AI inventions.[314] As the Honorable Richard Linn of the Court of Appeals for the Federal Circuit observed:

309. Bittner, *supra* note 305 ("In other words, you may have a patent on a particular invention where somebody else has a patent on an invention that will necessarily be used for the implementation of your own invention, thus providing a bar to commercial use of your own invention.").

310. Bittner, *supra* note 305 ("[E]ven if a company acts in good faith and has made a product clearance search before going to market with a new product, in the digital world there is always a high risk that other IP rights (at other layers and even at the same layer) are infringed."); *see also* Zeller, *supra* note 309 ("The market players will prefer to respect third-party patents through a risk-based FTO analysis followed by cross-licensing of patent portfolios, including mutual balance payments.").

311. Bittner, *supra* note 305 ("Dependent on the associated risk, the range of actions may include anything from 'ignore the IP right' to 'take your product off the market.'").

312. Diamond v. Chakrabarty, 447 U.S. 303, 308–09 (1980).

313. *Id*. at 308.

314. Alice Corp. Pty. Ltd. v. CLS Bank Int'l, 573 U.S. 208, 217–18 (2014) (*Alice* articulated a two-part test for whether claims are directed to patent-eligible subject matter under 35 U.S.C. § 101(2018): whether they are directed to a judicially-excluded law of nature, a natural phenomenon, or an abstract idea, and if so, whether any element or combination of elements in the claim is sufficient to ensure that the claim amounts to significantly more than the judicial exclusion. The end goal was to "distinguish patents that claim laws of nature, natural phenomena, and abstract ideas from patents that claim patent-eligible applications of those concepts."); *id.* at 217 (*Alice* stated that there is "considerable overlap between step one and step two, and in some situations this analysis could be accomplished without going beyond step one." Rather than focusing on a generally-accepted and understood definition of, or test for, what an "abstract idea" encompasses, courts instead "examine earlier cases in which a similar or parallel descriptive nature can be seen—what prior cases were about, and which way they were decided.").

"Despite the number of cases that have faced these questions. . .great uncertainty yet remains. And the danger of getting the answers to these questions wrong is greatest for some of today's most important inventions in computing," including "artificial intelligence."[315]

Computer-implemented inventions have been patentable since the 1990s.[316] However, widespread use of AI in patents and related innovation may be limited by the patentability of those inventions, making return on investment uncertain.[317] Many AI patents recite generic computer implementation of abstract processes, or contain elements that are well-understood, routine, and conventional such as taking input data, running the data through an algorithm, and obtaining output data.[318] While machine learning strives to train a computer to do something humans cannot practically do, that result is insufficient to avoid invalidity. Claims "reciting specific types of data associations, detailing the training phase

315. Tobey, *supra* note 300.

316. Bittner, *supra* note 305 ("For decades, patent protection for so-called computer-implemented inventions has been available and most of the major patent offices grant such claims on software-related inventions when the software is used to solve a technical problem in a non-obvious manner."); *see* Mizuki Hashiguchi, *The Global Artificial Intelligence Revolution Challenges Patent Eligibility Laws*, 13 J. BUS. & TECH. L. 1, 15 (2017) ("[C]ases illustrate the importance of specificity and technical contribution in establishing patent eligibility of artificial intelligence under United States law.").

317. Hashiguchi, *supra* note 33, at 29 ("The implicit, de facto requirements for patent eligibility may be at odds with the nature presently manifested by artificial intelligence technology.").

318. *See, e.g.*, PurePredictive, Inc. v. H2O.AI, Inc., No. 17-cv-03049-WHO, 2017 WL 3721480 (N.D. Cal. 2017). The invention was a way of generating a "predictive ensemble in an automated manner . . . regardless of the particular field or application, with little or no input from a user or expert" via machine learning. *Id.* at *1. The district court found that the claims amounted collecting and analyzing information and did not improve a technological process. Particularly, "[t]he first step, generating learned functions or regressions from data—the basic mathematical process of, for example, regression modeling, or running data through an algorithm—is not a patentable concept." *Id.* at *5. Further, the next two steps were mathematical processes that not only could be performed by humans but also go to the general abstract concept of predictive analytics rather than any specific application. The court found that "just because a computer can make calculations more quickly than a human does not render a method patent eligible," even if it would be physically impossible for a human to do so. *Id.* Moving on to part two of *Alice*, the claimed ensemble technique addressed a broad scope of problems rather than being focused on solving a specific technical problem. Furthermore, the claims did not describe a specific physical architecture and instead was focused on software modules. As a consequence, the claims failed both parts of the Alice test, were ruled ineligible under § 101, and therefore held invalid. *See* Michael Borella, *The Subject Matter Eligibility of Machine Learning: An Early Take*, PATENT DOCS (Sept. 23, 2018) http://www.patentdocs.org/2018/09/the-subject-matter-eligibility-of-machine-learning-an-early-take.html [http://perma.cc/FL7A-RZRE] ("machine learning claims can potentially be even more vulnerable to § 101 challenges when the claims recite only data manipulation and do not provide a well-defined technological need or advantage.").

and/or the structure of the model, and placing the model within the context of a larger system" would more likely survive invalidity challenges.[319]

Jurisprudence on patent-eligible subject matter imposes a strict but unclear set of rules on computer-implemented technology.[320] The policy's impetus to require specificity and description of technical improvement aims to prevent preemption.[321] Yet, "if the patent eligibility jurisprudence imposes requirements that cannot realistically be met by AI inventions due to the technology's inherent nature, these inventions will inevitably be foreclosed from patent protection."[322] Further, with the 4IR blurring the boundaries among industries, biomedical AI inventions related to methods and apparatuses that perform AI-enabled analyses face similarly high hurdles as software.[323] After *Alice*, courts are more likely to uphold AI patents aimed at improving software itself rather than the world around it.[324]

The European Patent Office (EPO) recently issued guidelines on the patentability of AI and machine learning technologies.[325] AI technologies are treated as "mathematical methods" and thus patent ineligible unless

319. Borella, *supra* note 320.

320. Hashiguchi, *supra* note 33, at 10 ("[B]y comparing the claim with those that were found to be directed to abstract ideas in previous cases. Hence, examining court decisions on patent eligibility is vital to understanding the range of artificial intelligence inventions that are likely to be regarded as patent-eligible.").

321. Mayo Collaborative Serv. v. Prometheus Labs., Inc., 566 U.S. 66, 70 (2012) ("Laws of nature, natural phenomena, and abstract ideas" are "the basic tools of scientific and technological work," adding that the "monopolization of those tools through the grant of a patent might tend to impede innovation more than it would tend to promote it."); *see also* Alice Corp. Pty. Ltd. v. CLS Bank Int'l, 573 U.S. 208, 216 (2014) ("The concern underlying the exceptions to [35 U.S.C.] § 101 is not tangibility, but preemption.").

322. Hashiguchi, *supra* note 33, at 28 ("Patent eligibility laws, in their current form, would not be able to confer their benefits to protect artificial intelligence technology.").

323. Ariosa Diagnostics, Inc. v. Sequenom, Inc., 788 F.3d 1371 (Fed. Cir. 2015) (finding a novel method of prenatal diagnosis of fetal DNA was patent-ineligible because the presence of cell-free fetal DNA was a natural phenomenon method steps "were well-understood, conventional, and routine," despite acknowledging it was a "breakthrough"); *see* Susan Y. Tull & Paula E. Miller, *Patenting Artificial Intelligence: Issues of Obviousness, Inventorship, and Patent Eligibility*, 1 J. ROBOTICS, ARTIFICIAL INTELLIGENCE & L. 313, 317 (2018), https://www.finnegan.com/images/content/1/9/v2/197825/PUBLISHED-The-Journal-of-Robotics-Artificial-Intelligence-L.pdf [https://perma.cc/GP3Z-QX7A] (warning that the current law "could well curtail the patent protections afforded medical AI absent a change in Supreme Court precedent or statute").

324. *See Alice Corp. Pty. Ltd.*, 573 U.S. at 222–25 (The Supreme Court has suggested that claims "purport[ing] to improve the functioning of the computer itself," or "improv[ing] an existing technological process" might not succumb to the abstract idea exception).

325. European Patent Office, *Guidelines for Examination* § 3.3.1, (2018), https://www.epo.org/law-practice/legal-texts/html/guidelines2018/e/g_ii_3_3_1.htm [http://perma.cc/M4PB-5295] (dealing with "artificial intelligence and machine learning").

"directed either to a method involving the use of technical means (e.g. a computer) or to a device," which gives the subject matter a "technical character."[326] The guidelines give two examples of such a technical application: first, a neural network in a heart-monitoring apparatus to identify irregular heartbeats; second, AI classifying digital content based on attributes such as pixels.[327] The EPO's guidelines are the first official patent examination guidance specifically to address the eligibility of AI-generated inventions.[328]

If a similar position is taken in the U.S., AI related to controlling or manipulating tangible or intangible objects would face minimal scrutiny[329]—so would claims directed to specific data structures, rules, combinations, or steps that result in improvements in computer functions.[330] In contrast, high-level user implementations using a general-purpose computer would not.[331] Patent applicants would do well to detail "the computing or mathematical techniques applied by the system or describing how the computer interacts with other components to drive the AI processing."[332]

Another difficulty for AI inventions is describing how the AI produces the result. Even AI developers cannot explain "why and how their computer programs made an artificial intelligence system behave in a certain way."[333] One way around that issue is to make explicit what is implicit. A company called Cortica connected a live, cortical segment of a rat's brain to a microelectrode array. This enabled Cortica to study how

326. *Id*.

327. *Id*.

328. Aaron Gin, *EPO Releases Patentability Guidance for AI-based Applications*, PATENT DOCS (Oct. 21, 2018), https://www.patentdocs.org/2018/10/epo-releases-patentability-guidance-for-ai-based-applications.html [http://perma.cc/Y4PW-PPWG].

329. Jonathan Bockman et al., *Patenting Artificial Intelligence in the U.S.–Considerations for AI Companies*, AIPLA NEWSSTAND (Nov. 8 2018), https://www.jdsupra.com/legalnews/patenting-artificial-intelligence-in-60718/ [http://perma.cc/RX6J-ZJWB].

330. *Id*.

331. *Id*.

332. Tull, *supra* note 325.

333. Hashiguchi, *supra* note 33, at 29. The article further states:

> The mechanism of artificial intelligence is often inexplicable. Even computer scientists who write computer programs for artificial intelligence systems sometimes have difficulty explaining why and how their computer programs made an artificial intelligence system behave in a certain way. This reality conflicts with the de facto specificity requirement. . . . Under the present patent eligibility jurisprudence, an invention is more likely to be deemed ineligible for patent protection if the configuration of the invention is not described with specificity. However, the configuration of some artificial intelligence cannot be understood, let alone described with specificity. Such artificial intelligence inventions are likely to be foreclosed from patent protection.

Hashiguchi, *supra* note 33, at 29–30.

electrical signals interact with the cortex, to identify neurons responsible for processing specific stimuli, and from there, to build models to simulate the brain's processes.[334] This breakthrough allows patents more accurately to describe the processes involved in implanting AI algorithms. It also allows developers to pinpoint where the AI made an erroneous analysis and to retrain its deep-learning neural networks.

The characterization of patents as a "public franchise" rather than a property right has also made their value less certain.[335] Trade secrets are sometimes a viable alternative if reverse engineering is difficult, as this avoids the uncertainty of compliance with the vague standard, as well as lengthy and costly validity and infringement determinations.[336] However, if the subject matter has become public, both patent protection and trade secret protection will be unavailable.[337] Yet despite the uncertainty of software-related patents, AI patent filings (which are based on software code) have grown dramatically across the major jurisdictions.[338] And this is cause for cheer.

Investment in AI patents represent faith in a cornerstone technology that could accelerate innovation, requiring less human skill and fewer resources over time. In particular, AI provides a means to achieve inventions that human cognitive limitations cannot achieve. Disclosure through published patents would nourish and spur scientific endeavor. Following the wake of mobile phones, television, and radio, affordable AI-generated technology could help democratize the benefits of those endeavors. Then again, this assumes that the patent prosecution system

334. Quain, *supra* note 35 ("The result, according to Cortica, is an approach to AI that allows for advanced learning while remaining transparent.").

335. Oil States Energy Servs., LLC v. Greene's Energy Grp., LLC, 138 S. Ct. 1365, 1373 (2018) ("This Court has recognized, and the parties do not dispute, that the decision to grant a patent is a matter involving public rights—specifically, the grant of a public franchise."); Gene Quinn, *The Supreme Court is wrong, a patent is not a franchise* (May 1, 2018), https://www.ipwatchdog.com/2018/05/01/supreme-court-patent-franchise/id=96644/ [http://perma.cc/2SJR-YLJP].

336. Robert Stoll, *Alternative Routes to Protection of Innovation*, IPWATCHDOG (June 13, 2018), https://www.ipwatchdog.com/2018/06/13/alternative-routes-to-protection-of-innovation/id=98373/ [http://perma.cc/AC8F-L2TP] ("Innovative algorithms . . . may be easier and more effectively protected by trade secret.").

337. Andrea W. Jeffries et al., *Protecting Artificial Intelligence IP: Patents, Trade Secrets, or Copyrights?*, JONES DAY (Jan. 9, 2018), https://www.jonesday.com/protecting-artificial-intelligence-ip-patents-trade-secrets-or-copyrights-01-09-2018/ [https://perma.cc/47XD-96TP].

338. World IP Organization, *WIPO Technology Trends 2019 – Artificial Intelligence*, WIPO (2019), https://www.wipo.int/edocs/pubdocs/en/wipo_pub_1055.pdf [http://perma.cc/7ZRQ-TLRA] (noting the largest portfolio of AI patents is held by IBM, with 8,290. Other top AI patent-holders include Microsoft with 5,930, Toshiba with 5,223, Samsung with 5,102, and NEC with 4,406. Of the four academic institutions in the top 30, three are from China.).

remains viable, and that it will take AI to ensure that the system remains so.

D. AI & Patent Prosecution

The overwhelming volume of potential prior art makes any novelty or nonobviousness analysis uncertain.[339] The PTO issued its ten millionth patent in June 2018, which joined "over 100 million other patent documents, 70 million plus journal articles and over four billion indexed web pages in the corpus of information that potentially needs to be searched to establish novelty."[340] The pace at which the corpus of prior art grows continues to accelerate. "It took 122 years to issue the one millionth patent in 1911. It took just over three years to go from nine million to 10 million."[341] The PTO has shown an openness to AI innovation, with an 89% allowance rate for AI patents from 2011 to early 2018.[342]

Deciphering the sea of potential prior art has also become more difficult. Six in ten patent documents are now in Chinese, Japanese, or Korean, often without an English language equivalent.[343] In addition, today's innovation takes place at the intersection of different art units, and patent examination has not kept pace. AI will be crucial to help break the language barriers needed to bring all this prior art onto a single interoperable highway for search and examination. Further, rather than expecting human examiners to be proficient in a multitude of highly complex and specialist disciplines, AI can unlock insights hidden behind those barriers.

Along with the four other largest patent offices in the world—China, Korea, Japan, and the European Union—the PTO is on a drive to reduce

339. Wild, *supra* note 247 ("The patent system today is challenged as never before. The requirements of novelty and non-obviousness are becoming increasingly difficult to meet and determine with any great level of certainty."); There are myriad issues facing the global patent system which, if not addressed, could lead to a decline in its use. Put simply, there is way too much data for humans to properly digest.

340. Wild, *supra* note 247.

341. Wild, *supra* note 247.

342. Eric Sutton, *Artificial Intelligence 2.0: Artificially Intelligent Guidance For Obtaining Artificial Intelligence Patents, as presented to IPO*, PATNOTECHNIC (Mar. 7, 2018), www.patnotechnic.com/2018/04/artificial-intelligence-20-artificially.html [http://perma.cc/RE5C-5CFE].

343. *Id*. ("Secondly, for some time we have operated in a world where the majority of new inventions don't have any detail in English. Of the 5.6 million patent documents published globally in 2017, over 62% are in Chinese, Japanese or Korean, often with no English language equivalent. This too is problematic. It means that the working language of innovation is essentially robbed of the open disclosure intended when patent exclusivity is given out.").

redundancy and improve patent quality.[344] All five patent offices share the view that AI will be critical to these efforts.[345] Key applications of AI include classification, prior art searches, and machine translations. For example, AI augments prior art searches by matching ideas, not merely keywords. The searches identify the most relevant technical literature quickly, as keywords are converted into multiple concepts from a database of interrelated concepts.[346]

AI is replacing boolean and positional searching for patent-related discovery. These legacy methods use syntaxes and manual categorization to comb through large amounts of patent literature. In addition to replicating the same processes more efficiently, AI can overcome ambiguities that confound classic keyword searches by searching similar concepts in parallel.[347] This "essentially solves the problem searchers run into when they don't know what they don't know."[348] The search results deliver comprehensive and relevant useful results with less redundancy to get to the proverbial result needle in a patent-search haystack.

V. CONCLUSION

From a glimmer in the eye of a Victorian woman ahead of her time, AI has become a cornerstone of innovation that "will be the defining technology of our time."[349] In turn, AI can make a difference in accelerating disruptive innovation by bringing a data-driven approach to

344. Carl Kukkonen & Matt Johnson, *Major Patent Offices Meet to Discuss Adoption of AI Tools*, JONES DAY: PTAB LITIG. BLOG (July 3, 2018), https://www.lexology.com/library/detail.aspx?g=80f9ca5f-a2d3-47f6-a588-4156e405b85b [http://perma.cc/3MM3-FLGK] ("The goal of the IP5 is to eliminate unnecessary duplication of efforts amongst the IP5 offices as well as increasing the efficiency of patent examination efficiency and quality.").

345. *Id.* ("During the meeting, the impact of artificial intelligence (AI) on the patent system was identified as one of the main strategic priorities for the offices.").

346. Sandeep Kumar, *Patent Search: The Evolution from Manual to Artificial Intelligence*, AIPLA NEWSSTAND (Jan. 24, 2018), https://www.iam-media.com/patent-search-evolution-manual-artificial-intelligence [http://perma.cc/HJ6G-ZX44] ("The technology is evolving rapidly, with search tools entering the market which rival human cognition – such tools have the capacity and knowledge to apply logical permutations and combinations to patent data in order generate insight that would be indeterminable to a human researcher.").

347. Baxter, *supra* note 84 ("For example, our InnovationQ software is powered by [AI], which understands that two terms — like "vehicle" and "car"— can have similar meanings and single terms — like "stream" — can have multiple unrelated meanings.").

348. Baxter, *supra* note 86 (For example, if a searcher is seeking documents regarding "exchanging data using short distance radio," they may not realize they're describing Bluetooth. But AI, based on the codes applied to concepts attached to the keywords, understands the relationship and the results may include documents containing "Bluetooth" that do not contain one or more of the provided search terms.").

349. Allen, *supra* note 96.

invention and creation. In 2016, the convergence of computing power, funding, data, and open-source platforms tipped us into an AI-driven 4IR. By processing non-critical information, extending the time for meaningful thought, and identifying valuable information, AI increases the computational abilities of human brains, augmenting our creative and innovative endeavors. AI gives us the ability to extend the bounds of our rationality, and thereby the quality of the decisions we can make.

In thinking about how IP considerations apply to AI, it is helpful to remember the observation of 19th century Danish philosopher, Søren Kierkegaard, that "life can only be understood backwards; but it must be lived forwards."[350] Hindsight allows us to look back and understand the consequences of our policy choices. Just as past is not necessarily prologue, hindsight does not necessarily translate into foresight. The law must embrace change and innovation as an imperative in a journey towards an ever-shifting horizon.[351] The goal is to make better decisions today that shape the future, rather than try to regulate by predicting the future. To do this well, we need to encourage AI that both augments and disrupts how we think about creativity and innovation.

In the creative arts, AI learns what we consider to be beautiful and creates permutations both within and outside of those boundaries. At times, it may augment artistic endeavor by providing flashes of inspiration in a collaborative dance. AI evolved from augmentation, to co-creation, to becoming the artist. In many instances, WFH provides a pragmatic legal vehicle for interests to vest and negotiated by the commercial interests best placed to encourage investment in both the technology and its downstream uses. Like human-generated work, AI-generated work is an amalgam of mimicry mined from our own learning and experience. The training data it draws upon, both for expressive and non-expressive uses, are merely grist for AI's mill.[352] Consequently, fair use must be liberally applied to prevent holdup by copyright owners and stifling transformative uses enabled by AI. AI can also be used to decipher complex copyright infringement cases such as those involving musical compositions. In the technological arts, the controversy will revolve around who owns innovative breakthroughs primarily or totally attributable to AI. How should these breakthroughs affect regard for the

350. *See* SØREN KIERKEGAARD, JOURNALEN JJ:167 (1843), *reprinted in* SØREN KIERKEGAARD, 18 SKRIFTER 306 (1997), http://homepage.math.uiowa.edu/~jorgen/kierkegaardquotesource.html [http://perma.cc/D6FR-5JXM].

351. Ho, *supra* note 230.

352. *See* generally Matthew Sag, *Orphan Works as Grist for the Data Mill*, 27 BERKELEY TECH. L.J. 1503 (2012) (discussing on copyrighted works used non-expressively).

notion of PHOSITA? How does AI change the equation when it comes to infringement? And how can AI help save the patent system from obsolescence? In these areas, AI both enables and challenges how we reward individuals whose ingenuity, industry, and determination overcame the frailty of the human condition to offer us inventions that make our lives more efficient and pleasurable.

Ultimately, the promise and challenge that AI brings resides neither in machines nor in people individually. Instead, it emerges from their interplay. AI-generated work and inventions pass the Turing Test with flying colors. AI's real test is whether legal architecture built around the premise of human artistic and innovative endeavors may stifle its evolution. This process of creative destruction fuels each successive industrial revolution. Both copyright law and patent law need to address this reality head-on. The current system can adapt to the 4IR, but the rules must be applied wisely.