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White Paper

Artificial Intelligence Collides with Patent Law

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Contents

Introduction

Artificial intelligence (AI) is one of the most important technologies of this era.[1] Once considered a remote possibility reserved for science fiction, AI has advanced enough to approach a technological tipping point of generating groundbreaking effects on humanity and is "likely to leave no stratum of society untouched".[2] Progress in AI has shown tremendous potential for benefitting mankind by improving efficiency and savings in production, commerce, "transport, medical care, rescue, education and farming",[3] as well as for significantly cultivating "the ability and level of social governance".[4] But AI's technological advances are also expected to disrupt numerous legal frameworks, including various aspects of US patent law.[5]

Once praised by Abraham Lincoln (US President,1861-1865) as one of the three great advances in world history,[6] US patent law has achieved its main objective[7] to enhance social welfare by encouraging innovation and the dissemination of useful technical information,[8] as well as by incentivizing investment in new technologies that promote economic growth and advance social goals.[9] Underpinning this are its five main standards that govern patentability (subject-matter eligibility, utility, novelty, nonobviousness and enablement).[10] Although US patent law has proven resilient to technological and social change,[11] the anticipated disruptions from AI will challenge some of these core legal standards that serve as safeguards of patent law, and will be far more pervasive and significant than those of previous technological changes.[12] Insufficient preparation for the upcoming collisions with AI could thus result in an outdated patent system that no longer fulfils its main objectives, with harmful social, economic and ethical implications;[13] for example, an ineffective patent system will invariably result in certain negative effects on technology, which can create unintended challenges to solving important social issues, such as inequality.[14]

While the European Parliament and the Chinese State Council have issued a resolution and reports, respectively, that discuss the interplay between AI and their intellectual property systems,[15,16] no such document has been issued by the United States.[17] Moreover, the risks borne by AI require further timely dialogue on critical implicated patent law issues among patent law's relevant actors (e.g. legislators, judges, academics, practitioners) and stakeholders (e.g. scientists, entrepreneurs, investors, technologists), as well as with non-patent professionals from diverse backgrounds that are familiar with innovation and ethics (e.g. from management, finance, economics, non-profit organizations, non-patent legal fields).[18] This will help US patent law to adapt to AI in socially inclusive and ethically responsible ways. To promote meaningful dialogue, this White Paper provides an overview of AI's recent technological advances, particularly on its ability to "invent", and explores four main patent law issues that will be impacted by AI: (1) the patent subject-matter eligibility of AI technologies; (2) the patentability and inventorship of AI-generated inventions; (3) liability for patent infringement by AI; and (4) AI's role in the definition of "a person of ordinary skill in the art" in the nonobviousness standard.

Recent developments in artificial intelligence (AI)

Sometime early in this century the intelligence of machines will exceed that of humans. Within a quarter of a century, machines will exhibit the full range of human intellect, emotions and skills, ranging from musical and other creative aptitudes to physical movement. They will claim to have feelings and, unlike today's virtual personalities, will be very convincing when they tell us so. – Ray Kurzweil (2008)[19]

A. Overview of technological advances

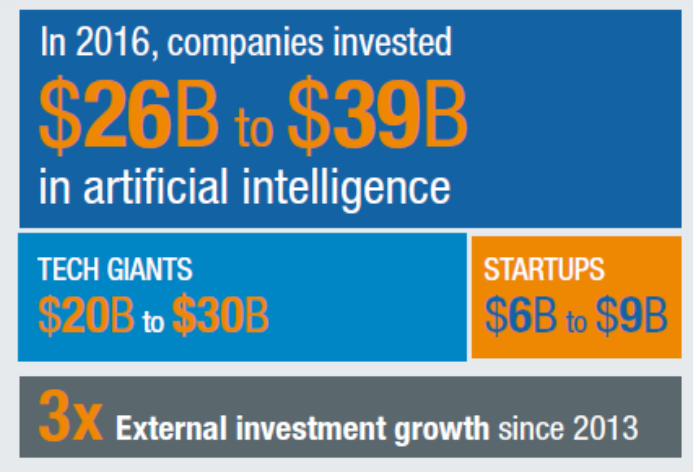
English mathematician Alan Turing introduced AI as a concept in a 1950 paper, and American computer scientist John McCarthy coined the term "artificial intelligence" during the Dartmouth Conference in 1956.[20] No single definition of AI is accepted by all practitioners. Some define it broadly as a computerized system exhibiting behaviour commonly thought of as requiring intelligence, whereas others define AI as a system capable of rationally solving complex problems or taking appropriate action to achieve its goals in real-world circumstances.[21] AI is often described based on its problem space, such as logical reasoning, knowledge representation, planning and navigation, natural language processing (NLP) and perception,[22] or based on its often-overlapping subfields, including machine learning (ML), deep learning, artificial neural networks, expert systems and robotics.[23] AI is also often categorized based on its intelligence level, such as artificial *general* intelligence (AGI), which is a notional form of AI that exhibits a level of intelligence comparable to that of the human mind, and narrow AI, which is the form of AI seen today that focuses on solving specific tasks.[24]

AI's technological breakthroughs dramatically accelerated in the last two decades, fuelled by advances in ML algorithms, exponential growth in the availability of data,[25] and improved and cheaper computing power.[26] The impressive technological progress of the last decade in particular has led to AI's ability to "perform activities which used to be typically and exclusively human", as well as to develop "certain autonomous and cognitive features – e.g. the ability to learn from experience and take quasi-independent decisions."[27] AI is now revolutionizing the way people live, work, learn, discover and communicate,[28] putting them on the threshold of an era where increasingly sophisticated robots, bots, androids and other manifestations of AI are poised to unleash a new industrial revolution.[29]

In 2013, ConceptNet 4, an AI language system developed by the Massachusetts Institute of Technology, surprisingly matched the verbal IQ of an average four-year-old,[30] dramatically surpassing its 2010 performance in which it was merely able to compete with the verbal IQ of a one-year-old.[31] In October 2015, Google's AlphaGo became the first computer program to beat a professional player – the reigning European champion Fan Hui, no less – in Go,[32] a game known for its extreme complexity;[33] with about 250 choices per move, it suggests a game-tree complexity of 10^{360}.[34] Just five months later, in March 2016, AlphaGo beat Sedol Lee, Go's 18-time world champion, before an audience of 60 million people worldwide, "catapulting AI into the public limelight and finally turning, for many, Science Fiction into Science."[35] And the rate of advancement is only expected to accelerate,[36] propelled by explosive research and investments in AI that will likely lead to many more such admirable feats in this lifetime.

Large technology corporations and start-ups invested a combined $26 billion to $39 billion in AI development in 2016 (Figure 1),[37] with an estimated increase of 300% in 2017.[38] Moreover, global revenue from cognitive systems and AI is expected to grow from nearly $8 billion in 2016 to more than $47 billion in 2020.[39]

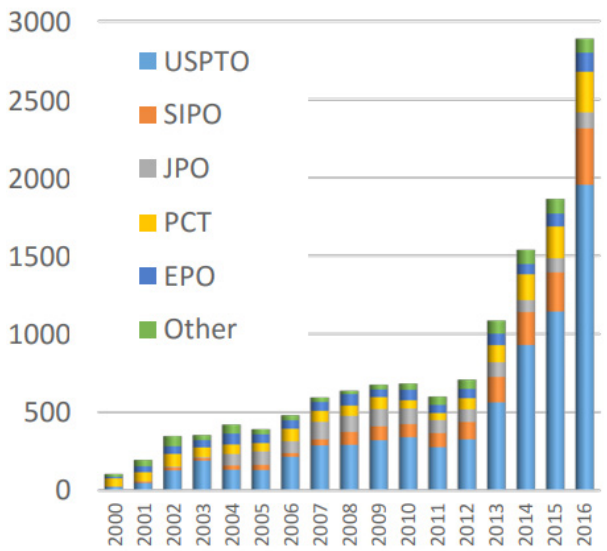
Figure 1: Global investment in artificial intelligence is growing rapidly



Source: Sachin Chitturu et al., *Artificial Intelligence and Southeast Asia's Future*, McKinsey Global Institute (2017)

AI penetration in businesses is estimated at 38%, and its adoption is predicted to grow to 62% in 2018. Similarly, AI has brought about a race for patents and intellectual property (IP) rights on AI among the world's leading technology companies,[40] with dramatic increases in the number of patent applications filed and issued on AI (hereinafter AI patents). In fact, the number of AI patents granted increased threefold, from 708 in 2012 to 2,888 in 2016 (Figure 2), and the United States alone saw an increase of 1,628 AI patents issued in the same period.[41]

Figure 2: Trend of AI patents granted by country: 2000-2016 (number of items)



Note: USPTO = United States Patent and Trademark Office; SIPO = State Intellectual Property Office of the People's Republic of China; JPO = Japan Patent Office; PCT = Patent Cooperation Treaty; EPO = European Patent Office.

Source: Hidemichi Fujii and Shunsuke Managi, "Trends and Priority Shifts in Artificial Intelligence Technology Invention: A global patent analysis", Research Institute of Economy, Trade and Industry, Discussion Paper No. 17-E-066 (2017)

B. Advances in AI's "inventiveness"

AI is no longer "just crunching numbers" but is "generating works of a sort that have historically been protected as 'creative'"[42] or as requiring human ingenuity. Recent successes have shown that AI can now independently learn how to perform complicated tasks, prove mathematical theorems and engage in artistic endeavours,[43] such as composing musicals.[44] Using techniques derived from understandings of evolution, molecular biology, neurology and human cognitive processes,[45] AI is evolving computers into "thinking machines" capable of performing creative and inventive tasks.[46]

The Creativity Machine, developed by AI pioneer Stephen Thaler in 1994, was already capable of generating new ideas through artificial neural networks, which are collections of on/off switches that automatically connect themselves to form software without human intervention.[47] In fact, the Creativity Machine can "brainstorm" new and creative ideas by combining an artificial neural network that generates output in response to self-stimulation of the network's connections with another network that perceives value in the output.[48] It is also known for having generated an invention that was ultimately issued as US Patent No. 5,852,815 on 15 May 1998,[49] which became the first-known patent to be issued to an AI-generated invention. But Thaler listed himself as the sole inventor and did not disclose the Creativity Machine's involvement to the United States Patent and Trademark Office (USPTO).[50]

Another remarkable example is the Invention Machine created by computer scientist John Koza. The Invention Machine is based on genetic programming and is modelled after the process of biological evolution.[51] It is said that the Invention Machine also created an invention that culminated in US Patent No. 6,847,851 on 25 January 2005.[52] Like the patent granted for the Creativity Machine's invention, however, only Koza and two other people were listed as inventors,[53] and the Invention Machine's involvement was not divulged to the USPTO during the patent's prosecution or application process.[54] The fact that patents have already been granted for inventions created by AI is extraordinary for technological reasons, but it also raises concerns as it touches on unexplored patent law issues relating to patentability and inventorship of AI-generated inventions.[55]

Other examples of AI's inventive ability include IBM's Watson, a computer system developed to compete with the TV game show Jeopardy![56] Watson "generates millions of ideas out of the quintillions of possibilities, and then predicts which ones are the most surprising and pleasant, applying big data in new ways."[57] The system is viewed as a fundamentally different type of AI than the Creativity Machine or the Invention Machine; it uses a more conventional architecture of logical deduction, combined with access to massive databases containing knowledge and expertise.[58] While Watson is said to be capable of generating novel, non-obvious and useful ideas,[59] it is not known whether any patent applications have been granted for its ideas. Other examples of AI inventiveness include computers programmed to independently design a new nose cone for a Japanese bullet train,[60] to design novel piston geometries for reducing fuel consumption in diesel engines, and to help develop new pharmaceutical compounds.[61]

Like AI systems that formulate inventive ideas, commercial AI technologies have recently emerged to help draft patent applications, encroaching on territory historically requiring "human ingenuity" from both inventors and patent attorneys (or patent agents). Cloem, a company based in Cannes, France, applies NLP technologies to assist patent applicants in creating variants of patent claims, coined "cloems".[62] Its computational drafting system employs various IP algorithms, NLP algorithms, semantic technologies, automated reasoning and text mining[63] to mechanically compose text for thousands of patent claims (or cloems) covering potentially novel publications.[64] In another example, AllTheClaims.com, an art project, and its sister project AllPriorArt.com (collectively "AllPriorArt") can autonomously generate patent claims and descriptions after parsing and randomly reassembling patent texts and published applications from the US patent database.[65] A more recent AI-driven service called Specifio prepares software-focused patent applications,[66] even outputting specifications and figures after receiving a set of patent claims from a user.[67] Specifio creates, analyses, extracts, synthesizes and sorts texts to generate patent applications that are each apparently around 90% complete, requiring only about an hour of an attorney's time for review.[68] Although such platforms have challenges to overcome[69] – Cloem only generates patent claims, AllPriorArt admits that "most inventions generated will be nonsensical"[70] and Specifio is mostly effective only for software-patent applications – they forecast a future where AI can accurately generate parts of or entire patent applications without input from attorneys.

Discussions of invention-creating AI, such as the Creativity Machine and the Invention Machine, as well as of current patent-drafting technologies like Cloem, AllPriorArt and Specifio, foretell a world in which AI can autonomously complete the entire inventive and patenting process. This would start with an AI that generates inventive ideas and then prepares entire patent applications to protect those ideas, without any human input.[71] AI's entry into areas that have historically required "human ingenuity" raises many critical legal and policy questions that must be addressed: for example, should AI-generated inventions be protected, and if so, to what extent? And if

patentability of AI-output inventions becomes legally accepted, then should AI be able to receive inventorship status?[72]

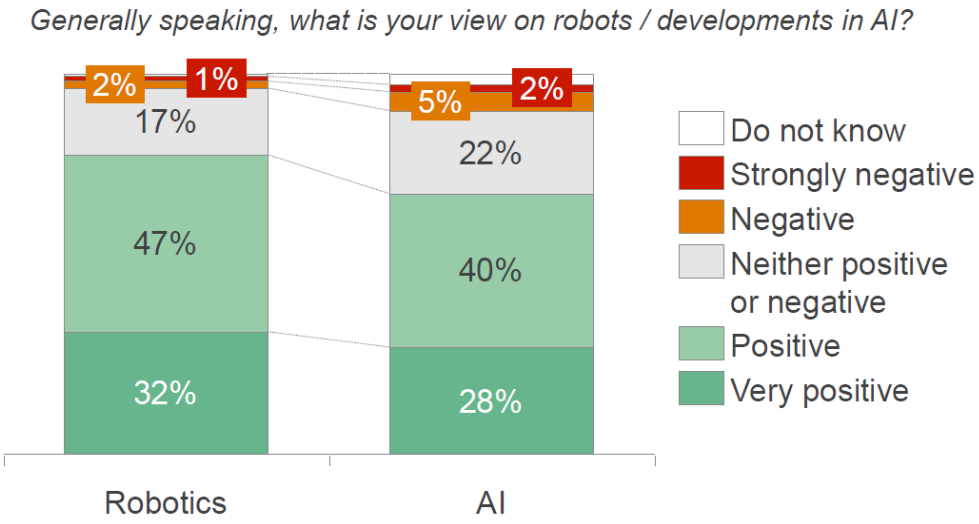
C. Increased acceptance of AI

The public's view of AI has become friendlier in recent years, which can indirectly impact legal and policy considerations.[73] Although the perception of AI has historically been more guarded in the United States than in East Asia (such as in Japan, South Korea and China),[74] AI's increased prevalence, coupled with better understanding of its potential benefits, have improved its reception in the United States; according to research jointly published by Arm and Northstar Research Partners, most of the surveyed consumers predicted a better future for society from AI, whereas only a fifth expected AI to have a negative effect.[75]

Outside the United States, notable trends and events indicate the extent of public acceptance of AI in certain societies, which may influence the US approach to AI. In Europe, for example, a recent survey conducted by the European Parliament showed that 68% expressed positive views on AI, and an even higher proportion (79%) had positive outlooks on robotics (Figure 3).[76]

In Japan, Deep Knowledge, a venture capital firm, named an AI-based robot, Vital, to its board of directors in 2014.[77] Going even further, Saudi Arabia declared Sophia, an AI-powered robot, a citizen in October 2017, making "her" the world's first AI citizen.[78] Such increased acceptance of AI as an independent "being" or "citizen" can significantly impact policy considerations[79] on patent law issues, particularly on whether AI can be treated as an "inventor" or "infringer".

Figure 3: Respondents overall have a positive attitude towards robotics and AI



Source: Tatjana Evas, European Parliamentary Research Service, "Public consultation on robotics and Artificial Intelligence: First (preliminary) results of public consultation" (13 July 2017)

Patent law issues impacted by AI

Some guidance and scholarly discussions on AI's effects on copyright law have taken place. For example, in the wake of a court decision involving a selfie-taking monkey, the United States Copyright Office updated its interpretation of "authorship" in 2016 to clarify that it would not register works produced by a *machine* or a mere mechanical process that operates randomly or automatically. It stressed that copyright law only protects "the fruits of intellectual labor" that are "founded in the creative powers of the mind".[80] However, no such guidance has been provided and much less dialogue has taken place regarding the repercussions of AI on US patent law.[81] And, in the face of AI's rapid technological changes and societal effects,[82] further discussions on AI's patent law implications are paramount to facilitate any necessary changes in the US patent system so that it can continue to achieve its main objectives[83] and help avoid negative social, economic and ethical effects.[84]

A. The patent subject-matter eligibility standard for AI

Before exploring truly "disrupted" and less explored patent topics, such as the patentability of inventions created by AI, this White Paper addresses the current, hotly debated topic of patent subject-matter eligibility for software, particularly for AI software. Although an increasing number of AI patents are being issued in the United States,[85] the present legal framework on patentable subject matter became more stringent in 2014 and poses heightened challenges for patent applicants in obtaining AI patents. Given that AI could have much greater impact on society than "non-intelligent" software, more discussions are needed on the elevated standard's impact on innovation, ethics and the economy. After all, as warned by Justice Richard Linn of the United States Court of Appeals for the Federal Circuit (hereinafter Federal Circuit), the "danger of getting the answers to these questions wrong is greatest for some of today's most important inventions", such as in computing and in AI.[86]

1. Legal framework for the patentability of "AI patents"

Title 35 of the United States Code, Section 101 (hereinafter 35 U.S.C. § 101) limits patentable subject matter to "new and useful process, machine, manufacture, or composition of matter, or any new and useful improvement thereof".[87] Patent claims that are directed to abstract ideas (e.g. a mathematical algorithm), natural phenomena or laws of nature are not eligible for patent protection;[88] the Supreme Court of the United States explained that "they are the basic tools of scientific and technological work," and that granting monopolies on those tools through patent rights might impede innovation.[89]

The Supreme Court, in *Alice Corporation Pty. Ltd. v. CLS Bank International*,[90] recently made it more challenging for applicants to obtain patents on software or "computer-implemented inventions".[91] The seminal *Alice* decision has been interpreted and applied by the Federal Circuit and various lower federal district courts to generally exclude patent claims directed to subject matter that could be performed through an "ordinary mental process", "in the human mind" or by "a human using a pen and paper",[92] with the limited exception for claims that specifically provide ways to achieve technological improvements over the tasks previously performed by people (e.g. containing an "inventive concept").[93]

This aspect of *Alice*'s legal framework creates tension with AI patents because the goal of AI is often to replicate human activity.[94] For example, in *Purepredictive, Inc. v. H20.AI, Inc.*, the United States District Court for the Northern District of California held that the asserted claims of US Patent No. 8,880,446 covering AI-driven predictive analytics[95] were "directed to a mental process and the abstract concept of using mathematical algorithms to perform predictive analytics".[96] After further finding that the patent's claims "do not make a specific improvement on an existing computer-related technology", the court invalidated the claims for being directed to patent-ineligible subject matter.[97]

Similarly, in *Blue Spike, LLC v. Google Inc.*, applying the *Alice* test, the court held that the patent claims covered a general purpose computer implementation of "an abstract idea long undertaken within the human mind" because they sought to model "the highly effective ability of humans to identify and recognize a signal" on a computer.[98] After further finding that the claims merely covered "a wide range of comparisons that humans can, and indeed, have undertaken since time immemorial" – and thus lacking any "inventive concept" – the court held that the claims were invalid.[99] This trend has made it more challenging for patent applicants to obtain AI patents during prosecution or for patent owners to defend the validity of their patents during litigation.

2. Discussion points on the present legal standard

Discussions need to address whether the present subject-matter patentability standard promotes the main objectives of US patent law. For example, whether the present standard promotes or stifles innovative technologies relating to AI is an important question.[100] Many have argued that patents provide incentives for innovation, investment and invention,[101] and that awarding patent rights to software can encourage investment in software-related research[102] and further promote innovation. This argument would apply analogously to AI, but the case for innovation may be stronger, given the greater potential of AI than general software. Others have argued that patents on software stifle innovation. Some have suggested that patents should not be awarded to any software,[103] whereas others have proposed awarding shorter patent terms to software patents.[104] And, as discussed above, the courts often hold that patent claims mimicking or replicating human activity lack any "inventive concept".[105] These differing perspectives must be sufficiently considered to determine whether AI patents in fact promote innovation, or whether those technologies are better protected through other means (e.g. laws on trade secrets or copyrights). Similar conversations are needed for the other objectives of patent law. For example, the relevant actors should assess whether the present standard promotes the disclosure and dissemination of useful information and whether it incentivizes people to create new inventions.

The discussions should also account for AI-specific factors as opposed to broader software-specific considerations when assessing whether incentivizing AI through patent rights may have different or greater economic, social and ethical impact than incentivizing general software. For example, many have expressed concern that AI could make much of human employment redundant,[106] having more profound negative economic effects than prior technological changes. Others believe that AI's overall economic impact will not be very different from those of previous technological advances.[107] But even if that were true, some still find it troublesome because they believe that recent technological changes have contributed to increasing inequality and falling labour force participation.[108] Still others advocate that AI should be further promoted to facilitate making groundbreaking discoveries, which will raise productivity growth and improve the lives of people worldwide, thereby overcoming any negative impact of AI on employment and inequality.[109] Also, if the legal standard is lowered, would companies that are leading filers of AI patents gain unfair advantages? Given that AI may be able to generate further inventive ideas on its own (which general software is unable to do), the first-mover advantage for those owners of AI patents may be much greater than that of general software patents. Some believe that this will result in those first-movers having "too much power, if we don't begin to update patent law now".[110] This may exacerbate the existing risks of AI-induced wage gaps and economic inequality.[111]

How to implement legal changes to maximize the social and ethical benefits from AI should also be explored, to the extent that any patent law adjustments are deemed necessary. Lowering the subject-matter patentability standard for AI inventions relating to areas deemed more socially beneficial, such as healthcare, the environment, criminal justice and education,[112] might be one way to help balance promoting innovation with mitigating ethical concerns. These issues must be carefully examined by the relevant actors to ensure US patent law evolves to strike an optimal balance between the various competing objectives.

B. Patentability and inventorship issues for AI-generated inventions

The patentability of inventions *created* by AI,[113] as discussed in this subsection, is a different topic from and should not be confused with patentability of inventions *directed* to AI technologies, which is discussed in the preceding subsection.[114] The questions explored here are whether AI-created ideas, which otherwise would be deemed "inventive" had they been conceived by people, should be protected by the patent law system,[115] and if so, who should be awarded inventorship for such AI-generated inventions. The urgent need to address these questions[116] is underlined by instances of patents already being issued for AI-produced inventions, such as those for ideas from the Invention Machine and the Creativity Machine.[117]

1. Legal considerations for patentability and inventorship for AI

The US patent system's foundation is principally *utilitarian* and *economic* in nature,[118] justifying patent rights based mostly on the promotion of new and improved works.[119] Thomas Jefferson (US President, 1801-1809), who served as the "first administrator of our patent system" under the Patent Act of 1790[120] and as the author of the Patent Act of 1793,[121] embraced the utilitarian view[122] and believed that an "*inventor* ought to be allowed a right to the benefit of *his* invention for some certain time,"[123] "as an encouragement to *men* to pursue ideas which may produce utility".[124] Thus, the US patent law's ultimate goals are utilitarian, and how that utility is sought involves encouraging or incentivizing *human* inventors.[125]

The US Patent Act does not require a particular threshold of human control or input in the invention process for granting patent rights, but it frames the questions of inventorship and patentability in terms of *human* creation.[126] Inventorship bestows initial ownership of patent rights, generally driven by public beliefs on the justness and importance of rewarding human effort and stimulating human creativity.[127] Under US patent law, an invention requires *conception*,[128] which is "the formation in the mind of the inventor, of a definite and permanent idea of the complete and operative invention",[129] where the "inventor" refers to an "individual".[130] The Federal Circuit has consistently explained that "[t]o perform this mental act, inventors must be natural persons and cannot be corporations or sovereigns".[131] The remainder of the Patent Act and laws are also replete with references to human actions.[132] Section 101 of the Patent Act, governing patentable subject matter, focuses on "whoever" shall invent, and Section 102 on novelty prohibits the patenting of subject matter that "a person" did not invent.[133] Further, the patent application process requires an oath or a declaration from the inventor (i.e. an individual).[134] Limiting patents to human-generated inventions would also be aligned with the United States Copyright Office's approach of not protecting works produced by machines.[135]

On the other hand, the patent law's abundant references to human creativity may simply be the by-products of the times when the Patent Act and laws were put in place.[136] Given that the idea of AI-generated inventions was only recently introduced, especially its feasibility, there likely had been no pressing need to characterize the inventive process as one performed by anything other than people. Either way, neither the US Congress nor the courts have addressed whether AI-generated inventions can be patented, and if so, who should be awarded with inventorship.[137]

2. Discussion points on patentability

The patent-eligibility issue for AI-generated inventions must be explored in the context of whether patents on AI-generated inventions would further the patent law system's main objectives. Some have argued that granting patent rights to AI-generated inventions would accelerate innovation,[138] even enabling advances that would not have been possible through human ingenuity alone.[139] Others have argued that patent rights do not promote innovation, irrespective of whether inventions are generated by people or AI.[140] Under this view, more patents, resulting from AI-generated inventions, will increase social costs and monopolies, and stifle the entry of new ventures,[141] thereby hampering innovation. China's New Generation Artificial Intelligence Development Plan includes language that calls for promoting "the innovation of AI intellectual property rights",[142] which some could interpret as encouraging recognition of IP rights for AI-generated works (although no mention is made of promoting AI as inventors).

Some point out that, even if patents on AI-generated inventions ultimately promote innovation, those patents may "negatively impact future human innovation as supplanting human invention

with autonomous algorithms could result in the atrophy of human intelligence".[143] The concern is that reduced inventive talent could lead to the elimination of high-quality research and development (R&D) jobs[144] or entire R&D-intensive industries.[145] Others even argue that the notion of awarding patent protection on AI-generated inventions should be abolished altogether. In their view, alternative tools, such as first-mover advantage and social recognition of AIs, as well as alternative technologies that prevent infringement of patent rights, can better lead to innovations and public disclosure of inventions.[146] These competing views must be carefully considered to determine the overall net impact on innovation from granting patent rights to AI-generated inventions. Each of the patent law system's other main objectives requires attention, such as assessing whether patents on AI-generated inventions would promote the dissemination of information[147] or incentivize the right "beings" to create inventions[148] that will help the system remain effective.[149]

Further, the discussions must identify possible "middle grounds" to help balance the competing objectives and factors. For example, one could consider raising the patentability standard (e.g. on nonobviousness)[150] for inventions created solely by AI, which would level the playing field to some extent between human inventors and AI. In this way, a middle ground may be provided between promoting innovation and continuing to incentivize people to invent. A similar balance may be achieved by granting different patent periods based on the level of human involvement in the inventive process.[151] In these scenarios, discussions must also address mechanisms to ensure that patent applicants are not being untruthful about AI's involvement in the inventive process to circumvent the law.[152]

Balancing the patent law's objectives to promote social, economic and ethical responsibility is another area for discussion.[153] One possibility for promoting innovation in an ethically sound way could be to raise the utility requirement for AI inventions under 35 U.S.C. § 101, which requires that the invention be *useful* to be patentable. Although the bar for utility is set relatively low today,[154] the doctrine of *moral* utility was often invoked in the late 19th century to deny patents on gambling devices.[155] Analogously, there may be grounds for raising the bar for utility just for AI-generated inventions, so that only the truly "useful" inventions by AI would be eligible for patent rights. Another possibility is to protect only certain types of AI-generated inventions deemed as having greater social benefits, such as those relating to healthcare, the environment, criminal justice and education.[156] Or perhaps the obviousness standard could be raised for just the AI-generated inventions not directed to one of those with "greater social benefits".

The possible solutions cannot lose sight of the human responsibility for AI,[157] because completely undirected, unsupervised innovations by AIs without human oversight can have negative, unintended consequences.[158] Discussions must sufficiently address how such human responsibility can be provided[159] and seek ways to promote transparency and accountability in AI.

3. Discussion points on inventorship

If inventions generated entirely by AI become eligible for patent rights,[160] the next question to address is who should be listed as the inventor. As discussed in Section III.B.1, the current law requires *conception* or "the formation in the mind of the inventor, of a definite and permanent idea of the complete and operative invention"[161] for there to be an invention. Thus, if all the conception takes place in the "mind" of an AI, then there would be no person to list as the inventor under the present law.[162] This presents two main options: (1) list AI as the inventor; or (2) list no inventors on the face of the patent.

Some argue that if AI's work "is indeed inventive, then both treating computational inventions as patentable and recognizing [AI] as an inventor would be consistent with the constitutional rationale for patent protection".[163] But to do so would require the recognition of AI as a *legal entity* or a *legal person*,[164] which is not available under current US law. Nevertheless, the general definition of a "legal person," which is "a subject of legal rights and obligations",[165] is likely broad enough to encompass AI as long as AI's role as an inventor is subject to legal rights and obligations.[166] Legal personhood and inventorship status are thus theoretically possible for AI if the legislature is willing to grant them. But it is important to assess whether granting inventorship would provide any benefits for the patent system. For example, except for AGI or superintelligent AI that has true *consciousness* (which does not exist today), AI "would not be motivated by the prospect of a patent"[167] and can continue to generate inventive ideas without any incentivizing through inventorship (like the Invention Machine and Creativity Machine).[168] Would there be any meaningful benefits in recognizing AI as inventors beyond those provided by allowing AI-created inventions to be patentable?

This leads to the second option of not listing any inventor. Although an inventor must be listed under the current law, the patent system can be adapted to award patents to AI's inventions without listing one.[169] In this scenario, however, sufficient incentives must be provided to the people involved in creating and maintaining the AI that generates inventive ideas, so that they will be motivated to continue developing such inventive AI. Given that the AI's owner will likely be listed as the resulting patent's assignee, the current patent system probably addresses the owner's interests adequately without additional recognition as an "inventor". But the interests of AI's developers (e.g. individual engineers), who are not given any credit on the face of the patent, may not be addressed sufficiently. If this inadequacy grows and obstructs innovation, a new category may need to be created for developers so that their contributions are acknowledged on the face of the patent.

Whether the decision ultimately comes down to listing AI as the inventor or not listing any inventor, the discussions must sufficiently consider the decision's likely effects on innovation and its economic and ethical repercussions.

C. Liability issues for patent infringement by AI

Another important patent law issue that will likely be disrupted by AI relates to liability in cases where AI is the violator of patent rights, given that most AIs now have the technological capacity to infringe patent claims.[170] Similar to the above discussion on AI as the inventor, the liability issue raises the question of who should be held responsible for actions taken by AI – the end user, the developer or AI itself[171] – as well as the related question of how to assess liability.

1. Legal framework for patent infringement liability

Patent rights include the right of inventors to *exclude* others from practising (i.e. infringing) the patented inventions in exchange for their respective discoveries.[172] In US patent law, infringement of a patent claim occurs when "*whoever* without authority makes, uses, offers to sell, or sells any patented invention, within the United States or imports into the United States any patented invention during the term of the patent therefor".[173] Ascertaining infringement requires a two-step analysis to: (1) determine the meaning of each term in a patent claim; and (2) show that the accused device meets each claim term (i.e. claim limitation), either literally or under the doctrine of equivalents.[174] US patent law also acknowledges "induced infringement", as when "*whoever* actively induces infringement of a patent shall be liable as an infringer",[175] which has been interpreted to mean that the alleged inducer must have knowingly aided another's direct infringement of a patent.[176] Once patent infringement is found, the infringer would have to pay damages to the patent owner in an amount adequate to compensate for the infringement (usually in the form of lost profits or reasonable royalties), and in certain cases would be enjoined or prohibited from performing the infringing activity.[177]

US laws, however, do not currently acknowledge a finding of patent infringement that is independent of human involvement,[178] and do not address how liability or damages should be handled for patent infringement by AI.[179] Helpful guidance and discussion points can be found in the *European Parliament resolution of 16 February 2017 with recommendations to the Commission on Civil Law Rules on Robotics* (hereinafter European Parliament Resolution), which explains that, today, AI cannot be held liable per se for acts or omissions that cause damage to third parties (e.g. patent infringement). Instead, AI's act would have to be traced back to a *human* agent, such as its manufacturer, operator, owner or user, if that agent could have *foreseen* and could have *avoided* AI's harmful behaviour (e.g. its infringing act).[180] But the rapid progress in AI's autonomous and cognitive features makes "the legal responsibility arising through a robot's harmful action" a crucial issue,[181] and questions "whether the ordinary rules on liability are sufficient or whether it calls for new principles and rules to provide clarity on the legal liability", especially "where the cause cannot be traced back to a specific human actor".[182]

2. Discussion points on patent infringement liability

The view that patent infringement by humans or AI should be deterred is likely not controversial. Moreover, failing to hold "someone" liable for patent infringement by AI will likely encourage using AI for infringement.[183] But more discussions on *how* to handle patent infringements by AI are required, such as on *who* should be held liable[184] and on how liability should be assessed. The answers must promote the patent law system's main objectives, as well as maximize the social, economic and ethical benefits.

The European Parliament Resolution "at least at the present stage" advocates holding a person responsible rather than an AI.[185] As to which human actor to hold liable, one possibility would be the AI's end users; as noted in the Resolution, the "rules governing liability for harmful actions – where the user of a product is liable for a behaviour that leads to harm" could apply to damages caused by AI.[186] This can create uncertainty among software users, however, and may lead to their disuse of otherwise helpful AI.[187] It would also be unfair in many instances, given that end users often cannot foresee the patent infringement, especially if they are individuals and not sophisticated corporations. Patent owners sue the companies that develop and/or sell the products much more frequently than the end users of those products, and even in those cases where the end users are sued and held liable, they are often indemnified by the products' manufacturers.[188]

This leads to the other option of holding the developer or manufacturer of AI accountable. Holding a product's manufacturer liable for patent infringement is common practice in patent litigation.[189] This may be suitable in the AI context as well because the developers ultimately create the AI (that infringes the patent), are usually in a relatively better position to foresee the infringement than the end users, and have likely derived economic value from the AI (e.g. selling AI to the end users).[190] The manufacturer may also be held liable in the context of product liability, "where the producer of a product is liable for a malfunction",[191] as provided in the resolution. In this case, AI's infringing act would have to be analogized to the product "malfunction".

Even so, with truly autonomous AI, can a human agent really anticipate against or properly oversee the AI to avoid infringement? Would holding people liable for unforeseeable acts deter AI's development and use because of people's fears of being held liable for unexpected patent infringement, and therefore hinder innovation? Thus, for truly autonomous AI, the traditional rules may "not suffice to give rise to legal liability for damage caused by a robot, since they would not make it possible to identify the party responsible for providing compensation and to require that party to make good the damage it has caused".[192]

So, how should liability for patent infringement by truly autonomous AI be handled? One possibility, as suggested in the European Parliament Resolution, "could be an obligatory insurance scheme, as is already the case, for instance, with cars", although the insurance system for AI would have to account for all potential responsibilities in the chain (instead of just people's actions, as in car insurance systems). The resolution also raises the possibility of supplementing such an obligatory insurance system with a *fund* to ensure that reparation can be made for damages where no insurance coverage exists.[193]

Another option would be to hold the AI itself liable,[194] which would require recognizing AI as a *legal person* (or legal entity).[195] As explored in Section III.B.3, the definition of a legal person is likely broad enough to include AI. In addition, there may be greater incentives in granting legal personality to AI in the context of determining liability than in the context of awarding inventorship.[196] The European Parliament Resolution recognizes this possible need for AI personhood in considering liability for damages caused by AI: "creating a specific legal status for robots in the long run, so that at least the most sophisticated autonomous robots could be established as having the status of electronic persons responsible for making good any damage they may cause, and possibly applying electronic personality to cases where robots make autonomous decisions or otherwise interact with third parties independently."[197]

Once the entity responsible for patent infringement caused by AI is determined, careful deliberation is needed on how liability should be assessed. The European Parliament Resolution asserts that, regardless of the legal solution selected for addressing liability, the future legislative instrument should

in no way restrict the type or extent of damages that may be recovered or limit the forms of compensation that may be offered to the aggrieved party, on the sole basis that the damage was caused by a *non-human* agent.[198] If a human agent is to be held responsible, the resolution advises that "their liability should be *proportional* to the actual level of instructions given to the [AI] and of its degree of autonomy, so that the greater a[n AI's] learning capability or autonomy, and the longer a[n AI's] training, the greater the responsibility of its trainer should be".[199] The Resolution also mentions potentially applying *strict liability* or the *risk management approach*, subject to an in-depth evaluation, although some argue that strict liability against the human developer would be misguided.[200] And if AI itself were to be held liable after being given special legal status, the liability of AI may be treated analogously to how the liability of corporations is assessed for patent infringement.[201]

Some are even entirely against the current liability system; they argue that a contractual solution is required instead because it provides parties with a predictable solution to liability.[202] Under this view, parties using an AI should employ contractual terms (e.g. indemnification clauses) to best avoid liability for direct infringement by AI.[203] These options and considerations must be assessed by weighing their social, economic and ethical implications, while striving to ensure efficient, transparent and consistent implementation of legal certainty for citizens, consumers and businesses alike.[204]

D. Nonobviousness standard for AI

The nonobviousness standard is designed to maintain a "penumbra" around the stock of known devices and techniques to ensure that patent rights are not granted to trivial or obvious extensions of what is already known.[205] The nonobviousness requirement has been described as "the ultimate condition of patentability"[206] and "the most important of the basic patent requirements".[207] Among the patentability requirements, the nonobviousness standard is the primary hurdle for most patent applications.[208] The doctrine has faced many complexities and hurdles[209] because of difficulties in determining what constitutes "obvious" and who the hypothetical *person of ordinary skill in the art* (POSITA) should be.[210] In addition, what will be considered non-obvious, and thus patentable, must reflect the changing inventive practices.[211] But setting the benchmarks for nonobviousness and "ordinary skill in the art" for AI adds another layer of indeterminacy, especially for superintelligent AI (or AGI) that is capable of "recursive self-improvement".[212] What is *obvious* in the era of AI?

1. Legal framework for nonobviousness

According to 35 U.S.C. § 103, for an invention to be patentable, the differences between its subject matter and the prior art (e.g. disclosures or events that existed before the invention) must be such that the subject matter as a whole would not have been *obvious* before the effective filing date of the claimed invention to a POSITA to which the claimed invention pertains.[213] Obviousness is thus viewed from the perspective of a POSITA, and not from that of the inventor.[214] While some uncertainty surrounds the precise definition of a POSITA, judicial guidance exists: a POSITA has been described as "a person of ordinary creativity, not an automaton"; as a "hypothetical person … who is presumed to have known the relevant art at the time of the invention"; and as "one who thinks along the line of conventional wisdom in the art and is not one who undertakes to innovate".[215]

2. Discussion points on how to define a "person of ordinary skill in the art"

As AI becomes ubiquitous, or at least more prevalent in various industries, discussion is required on whether the present definition of a POSITA is adequate – requiring a *person* and not an automaton – or whether it should be adjusted so that it can also mean a person equipped with AI if the use of AI is common practice in that technology space. Revising the definition to encompass a person's use of AI would substantially raise the bar for nonobviousness. Setting the standard too high could prevent deserving inventions from being patented and could thus hamper innovation.[216] On the other hand, a hurdle that is set too low can result in a flood of junk patents and in more patent cases being filed (especially by "patent trolls") against true innovators, which can impede businesses and economic growth.[217]Some proponents for changing the POSITA definition (so that it refers to a person using AI, or even just the AI itself)[218] argue that, as "inventive" machines continue to improve and increasingly raise the bar of patentability,[219] only the most innovative technologies will become patented. But this can also result in less patents being granted on human-generated inventions, which can pose several risks as discussed in Section III.B. Moreover, if AI becomes truly superintelligent, then AI as a POSITA could also mean that all innovative activities will eventually be deemed obvious (in the "eyes" of the superintelligent AI).[220] Some even argue that traditional patent law is irrelevant, and that other, non-patent incentives should be used to provide the gatekeeping function of nonobviousness.[221] Further discussions on these issues should identify the benefits and risks of changing the POSITA definition to allow AI participation with these differing views in mind.

E. Additional implications

This subsection explores other patent law issues that may be implicated by AI and that should be further reviewed by the relevant actors. One example is the question on how to treat patent applications prepared entirely by AI.[222] If more advanced versions of Cloem, AllPriorArt or Specifio reach a technological point of being able to both generate inventive ideas and prepare entire patent applications for those ideas without human input, should such practice be regulated? Although patent laws focus less on who *prepared* the patent applications[223] than on who came up with the *inventive* ideas, the discussions must explore whether having no rules that govern this issue can have negative real-life effects on the patent system. For example, if such AI-powered computers or tools begin to file an overbearing number of patent applications, this may cripple the examination process at the USPTO, which currently is unlikely to have the necessary resources to process the flood of applications.[224] However, this problem may be counterbalanced by raising the application fee and other administrative fees associated with filing patent applications, so that only the higher-quality patent applications get filed.

Another related issue is whether AI-generated content should qualify as prior art.[225] If so, that may intensify the burden on the USPTO's ability to vet the relevant prior art, which may decrease its chances of effectively identifying the best prior art. Similarly, if AI-generated content qualifies as prior art, the present requirement for patent applicants to disclose to the USPTO "all information known to that individual to be material to patentability"[226] may also become more difficult to satisfy, meriting consideration of imposing certain regulations on treating AI-generated content as prior art. But, disallowing prior

art that was created by AI, just because of practical challenges, may run afoul of the policy considerations that underlie the legal standards on prior art. The practical considerations must thus be balanced with the intentions behind requiring the USPTO to identify the best prior art and/or behind requiring patent applicants to disclose all material prior art that is known to them.

Lastly, the USPTO may have to start adopting AI to assist its patent examiners in analysing the increased number of patent applications.[227] This will likely help the examiners review the patent applications in view of the increased number of prior art[228] that would also need to be searched for and analysed. But if AI becomes advanced enough to serve not merely as a tool but as a patent examiner, an interesting situation may arise in which *inventors/patent attorneys* and *patent examiners* are both AIs. The ultimate decision of patentability could then come down to which AI is smarter and/or which AI people ultimately agree with. What effects would such situations have on innovation and human ingenuity?

Conclusion

The patent law's "governance" and treatment of AI can have deep impacts on innovation, the economy and society. Given how quickly AI is advancing, it is paramount that the relevant stakeholders – patent and non-patent professionals alike – proactively engage in further research and discussions with one another to find ways for the patent system to promote innovation while minimizing any negative social and ethical implications.[229] The preceding sections of this White Paper explored four main patent law issues affected by AI that merit further discussions.

First, the present standard on patent-eligible subject matter needs to be carefully evaluated to determine whether it has any material negative impact on AI or AI-driven technologies. If so, the relevant actors must search for possible adjustments to the standard that can better achieve the patent law's main objectives, such as promoting innovation, disseminating useful information and incentivizing investment in helpful technologies. The anticipated benefits from the contemplated changes must then be weighed against the negative social and ethical implications that may arise from those changes. The relevant actors should also consider other available mechanisms for promoting and protecting AI innovation (e.g. laws on trade secrets or copyrights) to help assess whether any of the identified shortfalls in the patent law's subject-matter eligibility standard can be rectified through other means.

Second, the question of whether inventions that are created entirely by AI should be protected with patents needs to be answered. To help arrive at an effective solution, the relevant actors must diligently analyse the potential positive and negative effects – from technological, socio-economic and ethical viewpoints – from patenting AI-generated inventions, and then assess these effects in view of one another. Possible middle grounds between the competing interests must be identified to help the patent system achieve its main objectives in a well-balanced manner. If the relevant actors ultimately decide to allow AI-created inventions to be patentable, then they must also decide whether inventorship should be awarded to AIs that generated those inventive ideas.

Third, the present liability laws do not account for situations where patent infringement is committed independently by an AI. The relevant actors need to explore "who" should be held liable in those situations and how remuneration should be assessed. The different existing liability frameworks must be analysed to identify their relative strengths, and new approaches should be researched to see if they can function more effectively than the existing liability systems.

Fourth, further discussions are necessary on whether changes need to be made to the present definition of a "person of ordinary skill in the art" (POSITA), which is a hypothetical person through which obviousness of an invention is evaluated. As the use of AI becomes more prevalent, the actual people "of ordinary skill" that work in various industries will increasingly rely on AI. Thus, a categorical exclusion of AI's involvement from the definition of a POSITA can risk having a nonobviousness standard that fails to accurately reflect the real-world level of obviousness. But on the flip side, as AI becomes "smarter", incorporating the use of AI into the definition of a POSITA would likely result in more inventions being deemed obvious and, ultimately, in a smaller number of patents being granted. In this scenario, if AI reaches superintelligence one day, would that not mean that everything will be considered obvious? These questions must be studied to help arrive at a nonobviousness standard that is accurate.

Approaches to the issues discussed in this White Paper must be comprehensive and multifaceted, so an optimal balance can be struck between the various competing factors. This will help the US patent law to continue adding the "fuel of interest to the fire of genius", as described by Abraham Lincoln,[230] in ways that are socially inclusive and ethically responsible.

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Endnotes

[1] See Lauren Goode, "Google CEO Sundar Pichai compares impact of AI to electricity and fire", The Verge (19 January 2018), https://www.theverge.com/2018/1/19/16911354/google-ceo-sundar-pichai-ai-artificial-intelligence-fire-electricity-jobs-cancer ("Google CEO Sundar Pichai, speaking at a taped television event hosted by MSNBC and The Verge's sister site Recode, said artificial intelligence is one of the most profound things that humanity is working on right now and compared it to basic utilities in terms of its importance."); Sam Shead, "Microsoft exec: 'AI is the most important technology that anybody on the planet is working on today", Business Insider (5 August 2016), http://www.businessinsider.de/microsoft-exec-ai-is-the-most-important-technology-that-anybody-on-the-planet-is-working-on-today-2016-5?r=UK&IR=T ("Dave Coplin, chief envisioning officer at Microsoft UK, told an audience of business leaders at an AI conference that AI is 'the most important technology that anybody on the planet is working on today.'").

[2] Civil Law Rules on Robotics - European Parliament resolution of 16 February 2017 with recommendations to the Commission on Civil Law Rules on Robotics (2015/2103(INL)), Eur. Parl. Doc. P8 TA 0051, at ¶B (2017) (hereinafter European Parliament Resolution); see [Notice of the State Council Issuing the New Generation of Artificial Intelligence Development Plan], (promulgated by State Council, 8 July 2017), at 1 (China), translated at The Foundation for Law & International Affairs, https://flia.org/notice-state-council-issuing-new-generation-artificial-intelligence-development-plan (hereinafter China AI Plan) ("artificial intelligence will profoundly change human social life and the world").

[3] European Parliament Resolution, *supra* note 2, at ¶E.

[4] China AI Plan, *supra* note 2, at 2.

[5] See Ben Hattenbach and Joshua Glucoft, "Patents in an Era of Infinite Monkeys and Artificial Intelligence", Stan. Tech. L. Rev. 19(2), 32 (2015) ("The coming wave of computer-generated material is on a collision course with our patent laws."); see also Liza Vertinsky and Todd M. Rice, "Thinking About Thinking Machines: Implications of Machine Inventors for Patent Law", B.U. J. Sci. & Tech. L. 8(2), 574, 576-77 (2002) (discussing the growing use of computers to augment human capabilities and replace human operators, as well as its effects on the invention process that cannot easily be accommodated within the current patent system).

[6] Abraham Lincoln, "Second Lecture on Discoveries and Inventions" at the Phi Alpha Society of Illinois College at Jacksonville (11 February 1859), https://www.thenewatlantis.com/publications/second-lecture-on-discoveries-and-inventions.

[7] See National Research Council, *A Patent System for the 21st Century* (Stephen A. Merrill et al. eds, 2004) ("High levels of innovation in the United States would seem to be evidence that the intellectual property system is working well."). But see "Time to fix patents", The Economist (8 August 2015), https://www.economist.com/news/leaders/21660522-ideas-fuel-economy-todays-patent-systems-are-rotten-way-rewarding-them-time-fix?fsrc=scn/tw/te/pe/st/timetofixpatents (stating that there are problems with the patent system and emphasizing the need for a clearer and simplistic approach).

[8] See US Const., art. I, cl. 8 ("[T]o Promote the Progress of Science and useful Arts."); Graham v. John Deere Co., 383 U.S. 1, 6 (1966) ("Innovation, advancement, and things which add to the sum of useful knowledge are inherent requisites in a patent system which by constitutional command must 'promote the Progress of . . . useful Arts.'"); accord. Committee on the Judiciary of the United States Senate, Report of the President's Commission on the Patent System 2 (1966); Erica Fraser, "Computers as Inventors – Legal and Policy Implications of Artificial Intelligence on Patent Law", SCRIPTed 13(3), 305 (2016); Colin R. Davies, "An evolutionary step in intellectual property rights – Artificial Intelligence and intellectual property", Computer L. & Security Report 27(6) (2011).

[9] See National Research Council, *supra* note 7, at 39 ("Ultimately, the test of a patent system is whether it enhances social welfare, not only by encouraging invention and the dissemination of useful technical information but also by providing incentives for investment in the commercialization of new technologies that promote economic growth, create jobs, promote health, and advance other social goals."); see also Mazer v. Stein, 347 U.S. 201, 219 (1954).

[10] Cf. Graham v. John Deere, *supra* note 8, 383 U.S. at 3-4 (discussing novelty, utility and nonobviousness as part of the patentability standard under the Constitution); see also 35 U.S.C. §§ 101 (utility), 102 (novelty), 103 (nonobviousness), and 112 (enablement).

[11] See Vertinsky and Rice, *supra* note 5, at 582 (explaining that "the conceptual underpinnings of the US patent system have proven to be remarkably robust to technological and social change"); National Research Council, *supra* note 9, at 42 ("[T]he patent system has proven highly adaptable to changes in technology.").

[12] See Vertinsky and Rice, *supra* note 5, at 605 ("Thinking machine technologies pose challenges to the invention process that are likely to be more pervasive and significant than previous technological changes because this new technology operates directly to transform the invention process.").

[13] Cf. China AI Plan, *supra* note 2, at 2 ("Artificial intelligence is a disruptive technology that can affect government management, economic security and social stability, and even global governance, which may lead to problems of changes in employment structure, impact law and social ethics, violat[i]ng personal privance and challenge international relations."); National Research Council, *supra* note 7, at 81 ("In addition to qualified intellectual property professionals, appointments to the Federal Circuit should include people familiar with innovation from a variety of perspectives—management, finance, and economics, as well as nonpatent areas of law affecting innovation.").

[14] See David Rotman, "Technology and Inequality", MIT Tech. Review (21 October 2014), https://www.technologyreview.com/s/531726/technology-and-inequality (discussing technology's impact on inequality).

[15] See European Parliament Resolution, *supra* note 2, at ¶18 ("although some aspects appear to call for specific consideration; calls on the Commission to support a horizontal and technologically neutral approach to intellectual property applicable to the various sectors in which robotics could be employed"); see also Report with recommendations to the Commission on Civil Law Rules on Robotics (2015/2103(INL)), Eur. Parl. Doc. A8-0005/2017, at 28 (2017) ("The resolution calls on the Commission to come forward with a balanced approach to intellectual property rights when applied to hardware and software standards and codes that protect innovation and at the same time foster innovation." (Explanatory Statement section)).

[16] See China AI Plan, *supra* note 2, at 25, art. V(A) ("Strengthen the research on legal, ethical and social issues related to AI, and establish laws, regulations and ethical frameworks to ensure the healthy development of AI. Carry out research on legal issues such as civil and criminal responsibility confirmation, privacy and property protection, information security utilization related to the application."); id. at 26, art. V(C) ("Strengthen the protection of intellectual property in the field of AI. Improve technological innovation in the field of AI, patent protection and standardization of interactive support mechanism to promote the innovation of AI intellectual property rights. Establish AI public patent pools. Promote the use of AI and the spread of new technologies.").

[17] The Obama Administration issued three reports on AI, but none discusses the US's IP or patent systems. See generally, Networking and Info. Tech. Research and Dev. Subcomm., Exec. Office of the President Nat'l Sci. and Tech. Council, The National Artificial Intelligence Research and Development Strategic Plan (2016) (hereinafter 1st Obama Report); Exec. Office of the President Nat'l Sci. and Tech. Council Comm. on Tech., Preparing for the Future of Artificial Intelligence (2016) (hereinafter 2nd Obama Report); Exec. Office of the President, Artificial Intelligence, Automation, and the Economy 8 (2016) (hereinafter 3rd Obama Report). The Trump Administration issued a short report titled "Science & Technology Highlights in the First Year of the Trump Administration", which has a short section on AI, but is likewise silent on IP or patents. See Exec. Office of the President, Office of Sci. and Tech. Policy, Science & Technology Highlights in the First Year of the Trump Administration (2018). Also, a bill has been introduced and is pending in Congress on AI, but it also does not discuss the intellectual property system. See FUTURE of Artificial Intelligence Act of 2017, H.R. 4625, 115th Cong. (2017) (bill introduced in the House of Representatives); S. 2217, 115th Cong. (2017) (corresponding bill introduced in the Senate) (collectively, "FUTURE of AI Act").

[18] See Liza Vertinsky, "An Organizational Approach to the Design of Patent Law", Minn. J.L. Sci. & Tech. 13(1), 211 (2012) ("Any possibilities for patent law change must be examined in light of the characteristics, entrenched interests and past practices of those making and implementing patent laws. Thus, for example, the competing and complementary interests of the United States Patent and Trademark Office (USPTO), Congress and the courts become important factors in policy design."); see also National Research Council, *supra* note 7, at 81 ("The office should seek advice from a wide variety of sources and maintain a public record of the submissions in developing such guidelines, and the results should be given appropriate deference by the courts. The Court of Appeals for the Federal Circuit ('Federal Circuit') also should ensure its exposure to a variety of expert opinions by encouraging submission of amicus briefs and by exchange with other courts. In addition to qualified intellectual property professionals, appointments to the Federal Circuit should include people familiar with innovation from a variety of perspectives—management, finance, and economics, as well as nonpatent areas of law affecting innovation.").

[19] Ray Kurzweil, "The Coming Merging of Mind and Machine", Scientific American (23 March 2009), https://www.scientificamerican.com/article/merging-of-mind-and-machine; see also Alan Turing, "Computing Machinery and Intelligence", Mind 59(236), at 433-60 (1950) (discussing Alan Turing's famous question of whether machines can think).

[20] 2nd Obama Report, *supra* note 17, at 5.

[21] 2nd Obama Report, *supra* note 17, at 6; accord. Sachin Chitturu et al., *Artificial Intelligence and Southeast Asia's Future*, McKinsey Global Inst. 4 (2017); Benjamin Alarie, Anthony Niblett and Albert H. Yoon, "How Artificial Intelligence Will Affect the Practice of Law", Univ. of Toronto Fac. of L. 8 (2017), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3066816. For differing taxonomies of AI, see FUTURE of AI Act, *supra* note 17, at 3-5 (defining AI as including five categories). For a discussion on difficulties associated with defining AI, see Gary Lea, "Why we need a legal definition of artificial intelligence", World Economic Forum (7 September 2015), https://www.weforum.org/agenda/2015/09/why-we-need-a-legal-definition-of-artificial-intelligence.

[22] 2nd Obama Report, *supra* note 17, at 7 (citing Frank Chen, "AI, Deep Learning, and Machine Learning: A Primer", Andreesen Horowitz (10 June 2016), https://a16z.com/2016/06/10/ai-deep-learning-machines).

[23] Michael Mills, Thomson Reuters, "Artificial Intelligence in Law: The State of Play" (2016), https://www.neotalogic.com/wp-content/uploads/2016/04/Artificial-Intelligence-in-Law-The-State-of-Play-2016.pdf; accord. Ben Allgrove and Yoon Chae, "Considerations For Attorneys Using Artificial Intelligence", Law360 (14 February 2018), https://www.law360.com/articles/1009857/considerations-for-attorneys-using-artificial-intelligence. Machine learning (ML) is often seen as one of the most important technical approaches to AI and refers to a statistical process that tries to derive a rule or procedure from a body of data in a way that explains the data or can predict future data. 2nd Obama Report, *supra* note 17, at 8.

[24] See FUTURE of AI Act, *supra* note 17, at § 3(a)(2) (2017) ("The term 'artificial general intelligence' means a notional future artificial intelligence system that exhibits apparently intelligent behavior at least as advanced as a person across the range of cognitive, emotional, and social behaviors."); id. at § 3(a)(3) ("The term 'narrow artificial intelligence' means an artificial intelligence system that addresses specific application areas such as playing strategic games, language translation, self-driving vehicles, and image recognition."); see also 2nd Obama Report, *supra* note 17, at 7 ("A broad chasm seems to separate today's Narrow AI from the much more difficult challenge of General AI.").

[25] Data is expected to grow to 163 zettabytes (i.e. 163 trillion gigabytes) by 2025, which is 10 times the 16.1 ZB of data generated in 2016. See David Reinsel et al., Int'l Data Corp., "Data Age 2025: The Evolution of Data to Life-Critical" (April 2017), https://www.seagate.com/files/www-content/our-story/trends/files/Seagate-WP-DataAge2025-March-2017.pdf.

[26] See 2nd Obama Report, *supra* note 17, at 6 ("The current wave of progress and enthusiasm for AI began around 2010, driven by three factors that built upon each other: the availability of *big data* from sources including e-commerce, businesses, social media, science, and government; which provided raw material for dramatically *improved machine learning approaches and algorithms*; which in turn relied on the capabilities of *more powerful computers*."); accord. Microsoft, *The Future Computed* (2018); Alec Ross, *The Industries of the Future* (2016).

[27] European Parliament Resolution, *supra* note 2, at ¶Z; see also James Boyle, "Endowed by Their Creator?: The Future of Constitutional Personhood", Governance Studies at Brookings (9 March 2011), at 5 (quoting Rodney Brooks, founder of MIT's Humanoid Robotics group, which, although written as a sceptic, states "Eventually, we will create truly artificial intelligence, with cognition and consciousness recognizably similar to our own.").

[28] 1st Obama Report, *supra* note 1, at 3.

[29] European Parliament Resolution, *supra* note 2, at ¶B.

[30] Anthony Cuthbertson, "Artificial intelligence program ConceptNet matches 4-year-old child in IQ test", Int'l Business Times (7 October 2015), http://www.ibtimes.co.uk/artificial-intelligence-program-conceptnet-matches-4-year-old-child-iq-test-1522836.

[31] Klaus Schwab, World Economic Forum, *The Fourth Industrial Revolution* (2016). An improved ConceptNet 5 has also been released since. See Robert Speer and Catherine Havasi, MIT Media Lab, "Representing General Relational Knowledge in ConceptNet 5" (2012), http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.383.5758&rep=rep1&type=pdf.

[32] Burkhard Schafer, "Editorial: The Future of IP Law in an Age of Artificial Intelligence", SCRIPTed 13(3), 283 (December 2016), https://script-ed.org/wp-content/uploads/2016/12/13-3-schafer.pdf.

[33] Go was described as the "most complex professional game man has ever devised" by Demis Hassabis, the head of Google's Deepmind. See Hope Reese, "The 6 Most Exciting AI Advances of 2016", TechRepublic (14 December 2016), https://www.techrepublic.com/article/the-6-most-exciting-ai-advances-of-2016.

[34] Louis V. Allis, *Searching for Solutions in Games and Artificial Intelligence,* 8th ed. (1994).

[35] Schafer, *supra* note 32, at 284.

[36] See Tom Simonite, "Do We Need a Speedometer for Artificial Intelligence?", Wired (30 August 2017), https://www.wired.com/story/do-we-need-a-speedometer-for-artificial-intelligence ("The result is the latest in a string of recent findings that some view as proof that advances in artificial intelligence are accelerating."); Microsoft, *supra* note 26, at 16 ("Looking ahead to 2038, we can begin to anticipate the rapid changes that lie ahead."); see also Eran Kahana, Abstract for Conference, "Intellectual Property Infringement by Artificial Intelligence Applications", Stanford Univ. L. School (2012), https://web.stanford.edu/dept/law/ipsc/PDF/Kahana,%20Eran%20-%20Abstract.pdf ("According to futurist Ray Kurzweil, in just eight years from now, AI will demonstrate intelligence levels that are indistinguishable from that of humans.").

[37] See Chitturu, *supra* note 21, at 3 (showing that companies invested $26 billion to $39 billion in AI, of which $20 billion to $30 billion came from tech companies); accord. Jacques Bughin et al., *Artificial Intelligence: The Next Digital Frontier?*, McKinsey Global Inst. (June 2017).

[38] Gil Press, "Top 10 Hot Artificial Intelligence (AI) Technologies", Forbes (23 January 2017), https://www.forbes.com/sites/gilpress/2017/01/23/top-10-hot-artificial-intelligence-ai-technologies/#142db5611928.

[39] See Bloomberg Law, "2017 Outlook IP, Privacy, Tech and Telecom", Daily Report for Executives, at S-6 (2016).

[40] Louis Columbus, "McKinsey's State of Machine Learning and AI, 2017", Forbes (9 July 2017), https://www.forbes.com/sites/louiscolumbus/2017/07/09/mckinseys-state-of-machine-learning-and-ai-2017/#49a8427a75b6.

[41] See Hidemichi Fujii and Shunsuke Managi, "Trends and Priority Shifts in Artificial Intelligence Technology Invention: A global patent analysis", Research Inst. of Econ., Trade and Indus., Discussion Paper No. 17-E-066, (2017); see also Charlotte Beale, "Fourth Industrial Revolution technology patents are flourishing", World Economic Forum (11 December 2017), https://www.weforum.org/agenda/2017/12/fourth-industrial-revolution-technology-patents-internet-things-smart-object (discussing a rapid rise in the number of patent applications filed in Europe for smart object technologies such as AI); European Parliament Resolution, *supra* note 2, at ¶D ("whereas annual patent filings for robotics technology have tripled over the last decade.").

[42] Hattenbach, *supra* note 5, at 32.

[43] Fraser, *supra* note 8, at 306.

[44] *Beyond the Fence*, the first musical composed by AI, was described as "surprisingly humane and earthy" although "at its core, it's classic, even clichéd, stuff." Schafer, *supra* note 32, at 284; see also Stewart Pringle, "Beyond The Fence: how computers spawned a musical", New Scientist (3 March 2016), https://www.newscientist.com/article/2079483-beyond-the-fence-how-computers-spawned-a-musical.

[45] Vertinsky and Rice, *supra* note 5, at 576.

[46] Vertinsky and Rice, *supra* note 5, at 576; see also Hattenbach, *supra* note 5, at 35 ("Indeed, computers are already independently designing genuinely useful inventions in a number of fields.").

[47] Ryan Abbott, "I Think, Therefore I Invent: Creative Computers and the Future of Patent Law", B.C.L. Rev. 57(4), 1079 (28 September 2016), http://lawdigitalcommons.bc.edu/bclr/vol57/iss4/2 (citations omitted).

[48] Abbott, *supra* note 47, at 1084 (the Creativity Machine is thus able to generate new patterns of information and adapt to new scenarios without additional human input). It is also said that the Creativity Machine produced "not one but about 2,000 potentially superior toothbrush designs", which were submitted to Gillette. See Robert Plotkin, *The Genie in the Machine: How Computer-Automated Inventing Is Revolutionizing Law and Business*, (2009).

[49] See Abbott, *supra* note 47, at 1085.

[50] Abbott, *supra* note 47, at 1085-86.

[51] Abbott, *supra* note 47, at 1086-87.

[52] Abbott, *supra* note 47, at 1087 (citing Jonathon Keats, "John Koza Has Built an Invention Machine", Popular Sci. (19 April 2006)).

[53] See US Patent No. 6,847,851.

[54] See Abbott, *supra* note 47, at 1087 ("Once again, the Patent Office seems to have had no idea of the AI's role in the Invention Machine's Patent.").

[55] See *infra* Section III.B.

[56] Abbott, *supra* note 47, at 1089 (citing Jo Best, "IBM Watson: The inside story of how the Jeopardy-winning supercomputer was born, and what it wants to do next", TechRepublic (2013), https://www.techrepublic.com/article/ibm-watson-the-inside-story-of-how-the-jeopardy-winning-supercomputer-was-born-and-what-it-wants-to-do-next).

[57] IBM, "Computational Creativity", http://www.research.ibm.com/cognitive-computing/computational-creativity.shtml#fbid=jalKDwvY3c3 (accessed 2 January 2018).

[58] Abbott, *supra* note 47, at 1089 (citing David Ferrucci et al., "Building Watson: An Overview of the DeepQA Project", AI Mag. 31(3) (Fall 2010), at 59, 68-69).

[59] Abbott, *supra* note 47, at 1089-90.

[60] Hattenbach, *supra* note 5, at 35 (improving the train's aerodynamic performance and reducing the noise level for passengers (citing Plotkin, *supra* note 48, at 61)).

[61] Hattenbach, *supra* note 5, at 35 (citations omitted).

[62] Victoria Slind-For, "Cloem, PepsiCo, Coca-Cola, InDyne: Intellectual Property", Bloomberg Tech. (3 October 2014), https://www.bloomberg.com/news/articles/2014-10-03/cloem-pepsico-coca-cola-indyne-intellectual-property.

[63] Cloem, "Technology", https://www.cloem.com/flat/technology (accessed 29 December 2017).

[64] See Fraser, *supra* note 8, at 307.

[65] Fraser, *supra* note 8, at 308 (citing Nora Young, "Fighting patent trolls with stuff and nonsense", CBC Radio (17 April 2016), http://www.cbc.ca/radio/spark/317-inspiration-overload-chatbot-mania-and-more-1.3534300/fighting-patent-trolls-with-stuff-and-nonsense-1.3534351); see also All Prior Art, http://allpriorart.com (accessed 1 January 2018); All The Claims, http://alltheclaims.com (accessed 1 January 2018).

[66] See Artificial Lawyer, "Meet Specifio the AI Start-Up Automating Patent Drafting" (28 July 2017), https://www.artificiallawyer.com/2017/07/28/meet-specifio-the-ai-start-up-automating-patent-drafting ("At present the focus is only on software-related patent applications.").

[67] See Specifio, https://specif.io ("Simply email claims to Specifio's automated system and in only a few minutes get back a complete patent application—with figures!") (accessed 31 January 2018); see also David Hricik, "Machine Aided Patent Drafting: A Second Look", PatentlyO (25 August 2017), https://patentlyo.com/hricik/2017/08/machine-patent-drafting.html.

[68] Artificial Lawyer, *supra* note 66.

[69] Fraser, *supra* note 8, at 308.

[70] All Prior Art, About, http://allpriorart.com/about (accessed 5 February 2018).

[71] See Abbott, *supra* note 47, at 1080 ("Soon computers will be routinely inventing, and it may only be a matter of time until computers are responsible for most innovation.").

[72] These are further discussed in Section III.B *infra*.

[73] See generally Paul Burstein, "The Impact of Public Opinion on Public Policy: A Review and an Agenda", Pol. Res. Q. 56(1), 29 (2003).

[74] Ross, *supra* note 26, at 21-22.

[75] ARM and Northstar, "AI Today, AI Tomorrow" §5 (2017), http://pages.arm.com/rs/312-SAX-488/images/arm-ai-survey-report.pdf.

[76] Tatjana Evas, European Parliamentary Research Service, "Public consultation on robotics and Artificial Intelligence: First (preliminary) results of public consultation" (13 July 2017).

[77] Ellie Zolfagharifard, "Would you take orders from a ROBOT? An artificial intelligence becomes the world's first company director", Daily Mail (19 May 2014), http://www.dailymail.co.uk/sciencetech/article-2632920/Would-orders-ROBOT-Artificial-intelligence-world-s-company-director-Japan.html.

[78] Zara Stone, "Everything You Need to Know About Sophia, The World's First Robot Citizen", Forbes (7 November 2017), https://www.forbes.com/sites/zarastone/2017/11/07/everything-you-need-to-know-about-sophia-the-worlds-first-robot-citizen/#1a37aec846fa.

[79] See generally Burstein, *supra* note 73. For further discussion on the regulatory and policy approaches towards AI in different unions and countries, such as the European Union, the United Kingdom, the United States, China, Singapore, Australia and the UAE, see FTI Consulting, "Artificial Intelligence: The Race is On – The Global Policy Response to AI" (5 February 2018).

[80] Julia Dickenson, Alex Morgan and Birgit Clark, "Creative machines: ownership of copyright in content created by artificial intelligence applications", European Intellect. Prop. R. 39(8), 457 (2017).

[81] Fraser, *supra* note 8, at 307 ("In response to computer-generated works of art, a discussion of the implications of these works on copyright law is emerging; however, there is comparatively little examination of the repercussions of computer-generated invention on patent law."); accord. Schafer, *supra* note 32, at 287.

[82] See *supra* Section II.

[83] Otherwise, the US patent system may get impacted in ways that it is currently not sufficiently equipped to accommodate. See Fraser, *supra* note 8, at 307.

[84] For discussion on how to generally (not necessarily in a patent context) promote safe, ethical and socially beneficial AI, see Microsoft, *supra* note 26, at 50-84 (chapters discussing the principles, policies and laws for the responsible use of AI); IEEE, "Ethically Aligned Design: A Vision for Prioritizing Human Well-Being with Autonomous and Intelligent Systems – Version 2" (2017) (providing societal and policy guidelines in order for AI to remain human-centric and serve humanity's values and ethical principles); and Seth D. Baum, "On the Promotion of Safe and Socially Beneficial Artificial Intelligence" (Global Catastrophic Risk Inst., Working Paper 16-1, 29 July 2016), http://gcrinstitute.org/papers/16-1.pdf (discussing means for promoting AI that is designed to be safe and beneficial for society).

[85] See *supra* Section II.A.

[86] Smart Sys. Innovations, LLC v. Chicago Transit Auth., 873 F.3d 1364, 1378 (Fed. Cir. 2017) (Linn, J., dissenting and concurring in part).

[87] 35 U.S.C. § 101.

[88] Diamond v. Diehr, 450 U.S. 175 (1981).

[89] Robert P. Merges, Peter S. Menell and Mark A. Lemley, *Intellectual Property in the New Technological Age* (Vicki Been et al. eds, 6th ed., 2012) (citing Mayo Collaborative Servs. v. Prometheus Lab., Inc., 566 U.S. 66 (2012)).

[90] Alice Corp. v. CLS Bank Int'l, 134 S. Ct. 2347, 2355 (2014) (setting forth a two-prong test for determining patent-eligibility, in which the first step is determining whether the claims are directed to a patent-ineligible concept, such as an abstract idea and, if so, the second step is considering "the elements of each claim both individually and 'as an ordered combination' to determine whether the additional elements 'transform the nature of the claim' into a patent-eligible application", in search for an "inventive concept.").

[91] See e.g. Matthew Bultman, "3 Years After Alice, Patent Applicants Facing Better Odds", Law360 (23 October 2017), https://www.law360.com/articles/976914/3-years-after-alice-patent-applicants-facing-better-odds; John Conley, "Are Software Patents Dead?—Alice's Implications for Life Sciences", Genomics Law Report (21 July 2015), https://www.genomicslawreport.com/index.php/2015/07/21/are-software-patents-dead-implications-for-life-sciences; Morningside IP, "The Alice Decision and Its Fallout in the U.S." (11 May 2017), http://www.morningsideip.com/the-alice-decision-and-its-fallout-in-the-u-s/.

[92] See e.g. Intellectual Ventures I LLC v. Erie Indem. Co., No. 2017-1147, 2017 U.S. App. LEXIS 22060, at *6-14 (Fed. Cir. 3 November 2017) (holding that claims "that could be 'performed in the human mind or by a human using a pen and paper' are directed to patent-ineligible mental processes"); CyberSource Corp. v. Retail Decisions, Inc., 654 F.3d 1366, 1372 (Fed. Cir. 2011) (same); Fair Warning IP, LLC v. Iatric Sys., Inc., 839 F.3d 1089, 1097 (Fed. Cir. 2016) ("analysing information by steps people go through in their minds, or by mathematical algorithms, without more, as essentially mental processes within the abstract-idea category."); Synopsys, Inc. v. Mentor Graphics Corp., 78 F. Supp. 3d 958, 963 (N.D. Cal.. 20 January 2015) (holding that a mental process is "a subcategory of unpatentable abstract ideas").

[93] See e.g. McRO, Inc. v. Bandai Namco Games Am. Inc., 837 F.3d 1299, 1314-15 (Fed. Cir. 2016); see also Blue Spike, LLC v. Google Inc., No. 14-CV01650-YGR, 2015 U.S. Dist. LEXIS 119382, at *13-16 (N.D. Cal. 8 September 2015) ("To the extent artificial intelligence inventions—or the present 'invention'—involve an inventive concept, they could be patentable even if they have, at their core, an abstract concept."), aff'd in Spike v. Google Inc., No. 2016-1054, 2016 U.S. App. LEXIS 20371 (Fed. Cir. 2016).

[94] Artificial general intelligence (AGI) is one that surpasses human intelligence, and narrow AI is one that replicates narrow human activities or tasks. *See* FUTURE of AI Act, *supra* note 17, at § 3(a)(2).

[95] See US Patent No. 8,880,446 at Abstract and 6:57-59.

[96] Purepredictive, Inc. v. H20.AI, Inc., No. 17-cv-03049-WHO, 2017 U.S. Dist. LEXIS 139056, at *13 (N.D. Cal. 29 August 2017).

[97] See Purepredictive, Inc., *supra* note 96, at *17.

[98] Blue Spike, LLC v. Google Inc., No. 14-CV01650-YGR, 2015 U.S. Dist. LEXIS 119382, at *13-16 (N.D. Cal. 8 September 2015), aff'd in Spike v. Google Inc., No. 2016-1054, 2016 U.S. App. LEXIS 20371 (Fed. Cir. 2016).

[99] Blue Spike, LLC, *supra* note 98, at *17-18; see also *supra* note 92.

[100] The Chinese State Council calls for strengthening the protection of intellectual property in the field of AI, as well as improving "patent protection and standardization of interactive support mechanism to promote the innovation of AI intellectual property rights". China AI Plan, *supra* note 2, at 26, art. V(C); see also National Research Council, *supra* note 7, at 39 ("Ultimately, the test of a patent system is whether it enhances social welfare, not only by encouraging invention and the dissemination of useful technical information but also by providing incentives for investment in the commercialization of new technologies that promote economic growth, create jobs, promote health, and advance other social goals.").

[101] Daniel F. Spulber, "How Patents Provide the Foundation of the Market for Inventions", Northwestern Law & Econ. Research Paper No. 14-14 (26 June 2014), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2487564.

[102] The Wall Street Journal, "The Experts: Does the Patent System Encourage Innovation?" (16 May 2013), https://www.wsj.com/articles/SB10001424127887323582904578487200821421958.

[103] Some assert that software patents should not be patentable and that *Alice* is "an important and meaningful step in the right direction". See e.g. Free Software Foundation, "US Supreme Court makes the right decision to nix Alice Corp. patent, but more work needed to end software patents for good" (19 June 2014), https://www.fsf.org/news/fsf-statement-on-alice-corp-v-cls-bank.

[104] Electronic Frontier Foundation, "Defend Innovation", https://web.archive.org/web/20151222074452/https://defendinnovation.org/proposals (accessed 7 January 2018).

[105] See *supra* Section III.A.1.

[106] Jason Furman, "Is This Time Different? The Opportunities and Challenges of Artificial Intelligence", Remarks at *AI Now: The Social and Economic Implications of Artificial Intelligence Technologies in the Near Term* 1 (7 July 2016), https://obamawhitehouse.archives.gov/sites/default/files/page/files/20160707_cea_ai_furman.pdf.

[107] Furman, *supra* note 106, at 1.

[108] See Furman, *supra* note 106, at 4-8; Rotman, *supra* note 14 (discussing technology's impact on inequality).

[109] See Furman, *supra* note 106, at 14.

[110] Plotkin, *supra* note 48, at 7 ("Tomorrow, patents on artificial invention technology will determine *who owns the right to invent*. Patent law will therefore confer awesome power on those who take advantage of it—too much power, if we don't begin to update patent law now.").

[111] See 2nd Obama Report, *supra* note 17, at 2 ("Analysis by the White House Council of Economic Advisors (CEA) suggests that the negative effect of automation will be greatest on lower-wage jobs, and that there is a risk that AI-driven automation will increase the wage gap between less-educated and more-educated workers, potentially increasing the economic inequality."); European Parliament Resolution, *supra* note 2, at ¶K ("whereas in the face of increasing divisions in society, with a shrinking middle class, it is important to bear in mind that developing robotics may lead to a high concentration of wealth and influence in the hands of a minority").

[112] See China AI Plan, *supra* note 2, at 19 (calling for the acceleration of "the application of innovative AI for the public" around "education, health care, pension and other urgent needs in society"); 2nd Obama Report, *supra* note 17, at 1 and 13 (listing fields of "health care, transportation, the environment, criminal justice, and economic inclusion" under "Applications of AI for Public Good").

[113] There have also been interesting discussions on whether AI should be patentable if it reaches a truly human-like consciousness. See e.g. Boyle, *supra* note 27, at 2 (discussing that the USPTO does not allow patent applications over human beings).

[114] See *supra* Section III.A.

[115] This White Paper focuses less on situations in which AI is used merely as a tool to help people in the inventive process, a much less controversial issue, as that is already common practice and is being addressed by the current legal framework. In such scenarios, the "conception" is still being performed by the human inventors, whereas AI is only helping that idea be reduced to practice.

[116] For discussion of some of the other patent law/patentability issues impacted by AI, see Fraser, *supra* note 8, at 319-322, and Vertinsky and Rice, *supra* note 5, at 588-596.

[117] See *supra* Section II.B.

[118] Merges, *supra* note 89, at 2 and 11.

[119] For more details, see Merges, *supra* note 89, at 11-17.

[120] Graham v. John Deere, *supra* note 8, 383 U.S. at 7 ("Thomas Jefferson, who as Secretary of State was a member of the group, was its moving spirit and might well be called the 'first administrator of our patent system.'").

[121] Graham v. John Deere Co., *supra* note 8, 383 U.S. at 7 ("He was not only an administrator of the patent system under the 1790 Act, but was also the author of the 1793 Patent Act.").

[122] Golan v. Holder, 565 U.S. 302, 348-349 (2012) ("This utilitarian view of copyrights and patents, embraced by Jefferson and Madison").

[123] Merges, *supra* note 89, at 259-260 (citing Letter to Oliver Evans (May 1807), V Writings of Thomas Jefferson 75-76 (Washington ed.)) (emphasis added).

[124] Golan v. Holder, *supra* note 122, 565 U.S. at 348 (emphasis added).

[125] The other two theories often posited for property rights – the natural rights perspective and the personhood justification – also involve human nature. For example, the natural rights perspective, set forth by John Locke, asserts that people are entitled to rights in a property based on the labour they put into obtaining that property. See Carol M. Rose, "Possession as the Origin of Property", U. Chi. L. Rev. 52(1) (1985). And the personhood theory, as advanced by Georg Wilhelm Friedrich Hegel, states that a person can become a real self only by engaging in a property relationship with something external, and thus property is "the first embodiment of freedom and so is in itself a substantive end". See Margaret Jane Radin, "Property and Personhood", Stan. L. Rev. 34(5), 957, 970 (1982).

[126] Vertinsky and Rice, *supra* note 5, at 585 (citing Diamond v. Chakrabarty, 447 U.S. 303, 309 (1980) (reaffirming that the Patent Act covers "anything under the sun made by man.")).

[127] Vertinsky and Rice, *supra* note 5, at 585; see also Fraser, *supra* note 8, at 328 ("Secondly, identifying the inventor has been suggested as a form of quid pro quo for employer ownership of patents rights.").

[128] To be awarded with inventorship, the inventor must *conceive* the inventive idea, and not merely contribute to reducing the inventive idea to practice after conception – for example, a person that merely follows another person's instructions (e.g. conducting experiments) cannot be a co-inventor. See Sewall v. Walters, 21 F.3d 411 (Fed. Cir. 1994).

[129] Burroughs Wellcome Co. v. Barr Labs., Inc., 40 F.3d 1223, 1227-28 (Fed. Cir. 1994).

[130] 35 U.S.C. § 100(f).

[131] University of Utah v. Max-Planck-Gesellschaft Zur Forderung Der Wissenschaften EV, 734 F.3d 1315, 1323 (Fed. Cir. 2013); see also Beech Aircraft Corp. V. Edo Crop., 990 F.2d 1237, 1248 (Fed. Cir. 1993) ("[O]nly natural persons can be 'inventors.'" (citing 35 U.S.C. §§ 115-118)); New Idea Farm. Equip. Corp. v. Sperry Corp., 916 F.2d 1561, 1566 n.4 (Fed. Cir. 1990) (barring legal entities from obtaining inventorship status because "*people* conceive, not companies").

[132] Vertinsky and Rice, *supra* note 5, at 585.

[133] Vertinsky and Rice, *supra* note 5, at 585 (citing 35 U.S.C. §§ 101 and 102).

[134] Vertinsky and Rice, *supra* note 5, at 585 (citing 35 U.S.C. §§ 115 and 118).

[135] See *supra* Section III.

[136] See Abbott, *supra* note 47, at 1097 ("Legislators were not thinking about computational inventions in 1952") (citing Karl F. Milde, Jr., "Can a Computer Be an 'Author' or an 'Inventor'?", J. Pat. Off. Soc'y 51, 378, 379 (1969)); Davies, *supra* note 8, at 606 ("[T]he writer would submit that this [any person] was simply a term of convenience by the drafters who had not considered the possibility of any conflicting claims"); see also Mark Lyon et al., "When AI Creates IP: Inventorship Issues to Consider", Law360 (10 August 2017) (pointing out that the bar against "corporations or sovereigns" was "premised on the fact that a corporation cannot contribute to the conception of an invention", and may thus be inapplicable to AI).

[137] See Lyon, *supra* note 136.

[138] See Fraser, *supra* note 8, at 326 ("On its face, widening patentability to include inventions generated autonomously by computers would provide an incentive that would accelerate innovation and generate exponentially more inventions quicker, while requiring less skill and fewer resources than would otherwise be possible."); see also Abbott, *supra* note 47, at 1104 ("[T]reating computational inventions as patentable and recognizing creative computers as inventors would be consistent with the Constitutional rationale for patent protection.").

[139] Fraser, *supra* note 8, at 306 (citations omitted); see also Ava Chisling, "Enter the Dawn of AI+IP", Medium (12 April 2017), https://medium.com/@avajoy/enter-the-dawn-of-ai-ip-bf5adc1bbc8c ("Because intellectual property legislation is meant to incentivize innovation by rewarding creators and protecting their investments, there may not be sufficient motivation for IP creation without IP protection. . . Promote the use of AI and the spread of new technologies.").

[140] Abbott, *supra* note 47, at 1105 (citations omitted).

[141] See also Abbott, *supra* note 47, at 1105.

[142] See China AI Plan, *supra* note 2, at 26, art. V(C) ("Strengthen the protection of intellectual property in the field of AI. Improve technological innovation in the field of AI, patent protection and standardization of interactive support mechanism to promote the innovation of AI intellectual property rights.").

[143] Fraser, *supra* note 8, at 327 (citations omitted); see also Abbott, *supra* note 47, at 1106-07.

[144] This should also take into consideration the public's heightened fear of jobs being replaced by AI. See e.g. Charlotte Edmon, "This is when a robot is going to take your job, according to Oxford University", World Economic Forum (26 July 2017), https://www.weforum.org/agenda/2017/07/how-long-before-a-robot-takes-your-job-here-s-when-ai-experts-think-it-will-happen; Matt McFarland, "Robots: Is your job at risk?", CNN Tech (15 September 2017), http://money.cnn.com/2017/09/15/technology/jobs-robots/index.html; Kevin Drum, "The AI Revolution is Coming—And It Will Take Your Job Sooner Than You Think", Mother Jones (26 October 2017), http://www.motherjones.com/kevin-drum/2017/10/you-will-lose-your-job-to-a-robot-and-sooner-than-you-think-2/.

[145] Fraser, *supra* note 8, at 327 (citing Vertinsky and Rice, *supra* note 5, at 586, and Robert Plotkin, AutomatingInnovation.com, About, http://www.automatinginvention.com/about.html (accessed 2 January 2018)).

[146] Shlomit Yanisky-Ravid and Xiaoqiong Liu, "When Artificial Intelligence Systems Produce Inventions: The 3A Era and an Alternative Model for Patent Law" (1 March 2017), Cardozo L. Rev., forthcoming.

[147] Some suggest that AI inventorship leads to greater disclosure and commercialization. See Abbott, *supra* note 47, at 1104 (citing The Economist, "Innovation's golden goose" (12 December 2002), http://www.economist.com/node/1476653); see also Fraser, *supra* note 8, at 325.

[148] *See* Fraser, *supra* note 8, at 307 ("[T]he advent of computer-generated invention will raise important questions regarding the legal implications of protecting the results of such systems, specifically, whether the right activity is being rewarded to the right person, to the right extent, and on the right conditions.").

[149] Some believe that "[w]hile there are potential scientific and economic risks, they are manageable through means other than patent exclusion". Fraser, *supra* note 8, at 328.

[150] Cf. Yanisky-Ravid, *supra* note 146, at 3 (discussing the "non-obviousness standard used by other scholars to afford patent protection to inventions by AI systems").

[151] See Fraser, *supra* note 8, at 332 ("If this were the result of patenting computer-generated inventions, the patent system's 20-year monopoly may prove too great a reward for an activity that has become too easy to justify it.").

[152] For example, there have already been instances of AI-generated inventions that received patent rights, without the involvement of AI being disclosed to the USPTO. *See supra* Section II.B (discussing the Creativity Machine and the Invention Machine).

[153] For discussion on how to generally (not necessarily in a patent context) promote safe and socially beneficial AI, see Microsoft, *supra* note 26, at 50-84 (chapters discussing the principles, policies and laws for the responsible use of AI); IEEE, *supra* note 84 (providing societal and policy guidelines in order for AI to remain human-centric and serve humanity's values and ethical principles); and Baum, *supra* note 84 (discussing means for promoting AI that is designed to be safe and beneficial for society).

[154] See Merges, *supra* note 89, at 29.

[155] See Merges, *supra* note 89, at 187.

[156] See China AI Plan, *supra* note 2, at 19 (calling for the acceleration of "the application of innovative AI for the public" around "education, health care, pension and other urgent needs in society"); 2nd Obama Report, *supra* note 17, at 1 and 13 (listing fields of "health care, transportation, the environment, criminal justice, and economic inclusion" under "Applications of AI for Public Good").

[157] Lyon, *supra* note 136.

[158] Lyon, *supra* note 136.

[159] See Lyon, *supra* note 136 (discussing the benefits of limiting inventorship to ideas involving some level of human activity).

[160] See *supra* Section III.B.2.

[161] Burroughs Wellcome Co. v. Barr Labs., Inc., 40 F.3d 1223, 1227-28 (Fed. Cir. 1994).

[162] See also Ryan Abbott, "Hal the Inventor: Big Data and Its Use by Artificial Intelligence", in *Big Data Is Not a Monolith*, MIT Press (Cassidy R. Sugimoto et al., eds, 2016) 13-14, https://ssrn.com/abstract=2565950 (hereinafter Abbott Two) (discussing problems that would arise from awarding inventorship to the first person(s) to see the AI's inventive results).

[163] Abbott Two, *supra* note 162, at 14.

[164] Nicolas Petit, "Law and Regulation of Artificial Intelligence and Robots: Conceptual Framework and Normative Implications", at 19 (9 March 2017), http://ssrn.com/abstract=2931339. There are engaging discussions on AI's "personhood". See e.g. Boyle, *supra* note 27, at 6 ("In the coming century, it is overwhelmingly likely that constitutional law will have to classify artificially created entities that have some but not all of the attributes we associate with human beings."); Samir Chopra and Laurence White, "Artificial Agents – Personhood in Law and Philosophy", Brooklyn College (22 August 2004), http://www.sci.brooklyn.cuny.edu/~schopra/agentlawsub.pdf; Davies, *supra* note 8, at 617 (section on "Personality of machine").

[165] Ben Allgrove, "Legal Personality for Artificial Intellects: Pragmatic Solution or Science Fiction?" (June 2004) (Master of Philosophy thesis, University of Oxford), https://ssrn.com/abstract=926015. This paper provides a substantial discussion of legal personality for AI, addressing philosophical personality and legal personality, as well as the different methodologies for defining legal personality.

[166] Allgrove, *supra* note 165, at 71 ("Chapters three and four established that there is no prima facie barrier to recognising bots as legal persons. Provided that there are sufficient extra-legal considerations arguing in favour of it, the attribution of legal personality to bots is conceptually no different to its attribution to corporations, idols, ships, trade unions or, indeed, humans; it is simply a decision to identify another lexus of legal rights and obligations upon which legal logic can act.").

[167] Abbott Two, *supra* note 162, at 14.

[168] See *supra* Section II.B.

[169] See Abbott Two, *supra* note 162, at 13 ("More likely, even if Hal [the AI] is not treated as an inventor, the law will still treat Hal's [AI's] inventions as patentable.").

[170] Gabriel Hallevy, "AI v. IP: Criminal Liability for Intellectual Property IP Offenses of Artificial Intelligence AI Entities" (17 November 2015), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2691923.

[171] See Hallevy, *supra* note 170, at 1.

[172] See US Const., art. I, § 8.

[173] See 35 U.S.C. § 271(a) (emphasis added).

[174] First, the asserted patent claims must be construed as a matter of law to determine their proper scope. Markman v. Westview Instruments, Inc., 52 F.3d 967, 979 (Fed. Cir. 1995). Second, a factual determination must be made as to whether the properly construed claims read on the accused devices. Markman, 52 F.3d at 976. To prove direct infringement, "the patentee must show that the accused device meets each claim limitation, either literally, or under the doctrine of equivalents". Catalina Mktg. Int'l Inc. v. Coolsavings.com, Inc., 289 F.3d 801, 812 (Fed. Cir. 2002) (citations omitted).

[175] 35 U.S.C. § 271(b) (emphasis added).

[176] Yanisky-Ravid, *supra* note 146, at 43.

[177] See 35 U.S.C. § 284 (on damages); 7-20 Chisum on Patents § 20.04 (2017) (on injunctive relief).

[178] Bridget Watson, "A Mind of Its Own – Direct Infringement by Users of Artificial Intelligence Systems", IDEA 58(1), 65, 69 (2017); accord. Kahana, *supra* note 34, at 2; see also Yanisky-Ravid, *supra* note 146, at 43 ("As with inventorship, existing laws and precedent appear to rule out a machine or program as infringer."); Institute for Globalization and International Regulation, "Artificial intelligence (AI) and intellectual property (IP), a call for action", Maastricht Univ. Blog (11 October 2017), https://www.maastrichtuniversity.nl/blog/2017/10/artificial-intelligence-ai-and-intellectual-property-ip-call-action.

[179] Watson, *supra* note 178, at 65; see also Vishal V. Khatri et al., "Catch Me If You Can: Litigating Artificial Intelligence Patents", Jones Day (December 2017), http://www.jonesday.com/catch-me-if-you-can-litigating-artificial-intelligence-patents-12-19-2017, ("New legal theories of infringement may develop to account for these unique features of AI technology. For example, a new potential element of proving both infringement and damages may be a showing that a temporary past infringement was not a chance occurrence, but rather a necessary and unavoidable step to the current state of the AI device.").

[180] European Parliament Resolution, *supra* note 2, at ¶AD; see also Stanford Univ., *Artificial Intelligence and Life in 2030 – One Hundred Year Study on Artificial Intelligence* (2016), 46, https://ai100.stanford.edu/2016-report ("Courts might arbitrarily assign liability to a human actor even when liability is better located elsewhere for reasons of fairness or efficiency. Alternatively, courts could refuse to find liability because the defendant before the court did not, and could not, foresee the harm that the AI caused.").

[181] European Parliament Resolution, *supra* note 2, at ¶Z.

[182] European Parliament Resolution, *supra* note 2, at ¶AB.

[183] Watson, *supra* note 178, at 70.

[184] Hallevy, *supra* note 170, at 2 ("The major question is, of course, who is to be held responsible for IP offenses committed by AI entities.").

[185] European Parliament Resolution, *supra* note 2, at ¶56.

[186] European Parliament Resolution, *supra* note 2, at ¶AE.

[187] Although direct patent infringement does not require intent or knowledge, not many cases exist in which the end users with no intent or knowledge have been liable for using an infringing product; in such cases, manufacturers are generally sued for *actively inducing* the patent infringement by the end users. But see generally Gaia Bernstein, "The Rise of the End User in Patent Litigation", B.C.L. Rev. 55(5) (2014), 1443 (discussing the increasing number of instances where end users are sued directly).

[188] See Brian J. Love and James C. Yoon, "Expanding Patent Law's Customer Suit Exception", B.U. L. Rev. 93(5) (2013), 1605, 1613 ("Widespread use of indemnification agreements means that manufacturers often remain on the hook for their customers' settlements. Manufacturers also legitimately fear losing goodwill with existing customers as well as business in the future if they fail to stand up for customers accused of infringement.").

[189] Petit, *supra* note 164, at 19 ("[V]ictims can target damages claims against the *manufacturer*. In most countries, defective products laws repute manufacturers liable for damage caused by the products they bring to markets.").

[190] Cf. Petit, *supra* note 164, at 19 ("[T]he governor of an algorithmic machine could be held liable for damages. In both civil and common law, vicarious liability regimes are negligence or fault-based. They necessitate a degree of wrongdoing.").

[191] European Parliament Resolution, *supra* note 2, at ¶AE; see Stanford Univ., *supra* note 180, at 46-47 ("The role of product liability—and the responsibility that falls to companies manufacturing these products—will likely grow when human actors become less responsible for the actions of a machine.").

[192] European Parliament Resolution, *supra* note 2, at ¶AF.

[193] European Parliament Resolution, *supra* note 2, at ¶¶57-58.

[194] See Petit, *supra* note 164, at 19 ("Transposed to the subject of this paper, this means obtaining damages from the AI or robot itself.").

[195] See Petit, *supra* note 164, at 19 ("To date, however, seeking a judicial declaration of liability against an AI or a robot is a dead end. This would require the preliminary recognition of legal personhood to AIs and robots, a bold step that no legal system has yet undertaken."). For engaging discussions on AI's "personhood", see Boyle, *supra* note 27, at 6 ("In the coming century, it is overwhelmingly likely that constitutional law will have to classify artificially created entities that have some but not all of the attributes we associate with human beings."); Samir Chopra and Laurence White, *supra* note 164; Davies, *supra* note 8, at 617 (section on "Personality of machine").

[196] For a discussion on the considerations and influences on jurisprudence relating to corporate legal personality, see Allgrove, *supra* note 165, at 54-56, and Tara Helfman, "Transatlantic Influences on American Corporate Jurisprudence: Theorizing the Corporation in the United States", Ind. J. Global Leg. Stud. 23(2), 383 (2016). See also Samir Chopra and Laurence White, "Artificial Agents and the Contracting Problem: A Solution via an Agency Analysis", U. Ill. J.L. Tech. & Pol'y, 363 (13 April 2010) (discussion on legal personhood or personality for AI in a contractual context).

[197] European Parliament Resolution, *supra* note 2, at ¶59(f).

[198] European Parliament Resolution, *supra* note 2, at ¶52.

[199] European Parliament Resolution, *supra* note 2, at ¶56.

[200] European Parliament Resolution, *supra* note 2, at ¶53; see also id. at ¶54 ("Notes at the same time that strict liability requires only proof that damage has occurred and the establishment of a causal link between the harmful functioning of the robot and the damage suffered by the injured party") and ¶55 ("Notes that the risk management approach does not focus on the person 'who acted negligently' as individually liable but on the person who is able, under certain circumstances, to minimise risks and deal with negative impacts"). But see Kahana, *supra* note 36, at 2 ("A default strict liability standard against the human developer/deployer is misguided for a number of reasons. Perhaps most significantly among these is that it is probable that (e.g. in Level D app cases) that individual could not have reasonably foreseen the infringement.").

[201] See Hallevy, *supra* note 170, at 28 ("If an AI entity does have its own property or money, the imposition of a fine on it would be identical to the imposition of a fine on humans or corporations.").

[202] See Watson, *supra* note 178, at 83.

[203] See Watson, *supra* note 178, at 83-84.

[204] See European Parliament Resolution, *supra* note 2, at ¶49; see also George S. Cole, "Tort Liability for Artificial Intelligence and Expert Systems", Computer L.J. 10(2), 127 (1990).

[205] Robert P. Merges, "Uncertainty and the Standard of Patentability", Berkeley Tech. L.J. 7, 1, 14 (1992).

[206] Robert Patrick Merges and John Fitzgerald Duffy, *Patent Law and Policy: Cases and Materials*, Lexis Law Pub, 643 (3rd ed., 2002).

[207] Robert P. Merges, Peter S. Menell and Mark A. Lemley, "Intellectual Property in the New Technological Age: 2017, Volume I: Perspectives, Trade Secrets and Patents", at 161 (2017).

[208] Ryan Abbott, "Everything is Obvious", at 9 (22 October 2017), UCLA Law Review, forthcoming (hereinafter Abbott Three), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3056915.

[209] Michael Abramowicz and John F. Duffy, "The Inducement Standard of Patentability", Yale L.J. 120, 1590, 1593 (2010).

[210] See Gregory Mandel, "The Non-Obvious Problem: How the Indeterminate Nonobviousness Standard Produces Excessive Patent Grants", U.C. Davis L. Rev. 42(57), 59 (2008).

[211] Fraser, *supra* note 8, at 320.

[212] Petit, *supra* note 164, at 7; see also Abbott Three, *supra* note 208 (asserting that everything will eventually become obvious due to an increased level of a person of ordinary skill in the art involving AI).

[213] 35 U.S.C. § 103.

[214] Merges, *supra* note 205, at 14.

[215] Abbott Three, *supra* note 208, at 16.

[216] Yanisky-Ravid, *supra* note 146, at 41-42.

[217] Yanisky-Ravid, *supra* note 146, at 42.

[218] Abbott Three, *supra* note 208, at 1.

[219] Abbott Three, *supra* note 208, at 1.

[220] Abbott Three, *supra* note 208, at 1.

[221] Yanisky-Ravid, *supra* note 146, at 3.

[222] This is somewhat similar to the issue of whether AI-generated inventions should be patentable, as discussed in *supra* Section III.B.

[223] There are requirements on who can draft and file patent applications (e.g. patent lawyers and patent agents), as well as administrative rules governing their conduct.

[224] See also Fraser, *supra* note 8, at 323.

[225] For a more in-depth analysis, see Hattenbach, *supra* note 5.

[226] 37 C.F.R 1.56 (2002).

[227] Robert Ambrogi, "TurboPatent Introduces Two AI-Powered Tools for Patent Lawyers", Law Sites (28 June 2017), https://www.lawsitesblog.com/2017/06/turbopatent-introduces-two-ai-powered-tools-patent-lawyers.html ("RoboReview uses AI and predictive analytics to automatically analyze draft patent applications for novelty, patentability, antecedent basis, claim support, term consistency and more.") (Such technology can be used by both patent applicants and the USPTO); see generally John O. McGinnis and Russell G. Pearce, "The Great Disruption: How Machine Intelligence Will Transform the Role of Lawyers in the Delivery of Legal Services", Fordham L. Rev. 82(6), 3041 (2014) (discussing the various ways in which AI will assist attorneys in the future, in discovery, legal search, document generation, brief and memoranda generation, and the prediction of case outcomes).

[228] Patinformatics, LLC, "AI Patents – Applying Machine Intelligence to Patent Searching", https://patinformatics.com/ai-patents-applying-machine-intelligence-to-patent-searching (an AI tool for searching through patents) (accessed 15 January 2018).

[229] Patent law policies can derive great value from diverse viewpoints. See National Research Council, *supra* note 7, at 81 ("The office should seek advice from a wide variety of sources and maintain a public record of the submissions in developing such guidelines, and the results should be given appropriate deference by the courts. The Court of Appeals for the Federal Circuit ('Federal Circuit') also should ensure its exposure to a variety of expert opinions by encouraging submission of amicus briefs and by exchange with other courts. In addition to qualified intellectual property professionals, appointments to the Federal Circuit should include people familiar with innovation from a variety of perspectives—management, finance, and economics, as well as nonpatent areas of law affecting innovation."); cf. World Economic Forum, *Shaping the Protocols for the Technologies of the Fourth Industrial Revolution through Public-Private Cooperation* (2016) ("There is a need for a global and trusted space where the world's leading technology companies, dynamic start-ups, policy-makers, international organizations, regulators, business organizations, academia and civil society can collaborate to develop the agile policy norms and partnerships needed to stimulate the enormous potential of science and technology, deliver rapid growth and generate sustainable, positive impact for all.").

[230] Lincoln, *supra* note 6.

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