

2022 EMERGING TECHNOLOGY TRENDS

MARKET AND LEGAL INSIGHTS FOR INNOVATORS



AI, MACHINE LEARNING & QUANTUM COMPUTING

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AI, MACHINE LEARNING & QUANTUM COMPUTING



Economists and commentators are split on the economic impact of AI. On the one hand, the technology could add as much as \$13 trillion to the global economy by 2030, representing a significant source of growth for gross domestic product. On the other hand, the purpose of deploying AI is typically to reduce expenses, which include the cost of labor.

SECTOR OVERVIEW

What Are AI, ML, and Quantum Computing?

Artificial intelligence (AI) is the ability of machines to mimic human intelligence to learn, reason, and perceive. AI is divided into two categories: narrow and general. Narrow AI refers to the AI systems that are developed within a narrow domain of knowledge, such as facial recognition and natural language processing. These narrow systems cannot operate or extrapolate outside the narrow domain knowledge in which they are developed.

General AI is an AI system capable of artificial human equivalent intelligence, with the ability to think, learn, plan, and act when faced with novel problems. It is not limited to a narrow domain of knowledge. Machines do not yet have an intelligence equivalent to that of humans, so general AI is currently a theoretical form of technology.

Machine learning (ML) involves the capability of machines to “learn from data rather than through explicit programming,” according to IBM. ML techniques are often used in AI systems.

Quantum computing utilizes the phenomena of quantum mechanics to process information in qubits, based on quantum properties of superposition and entanglement.

Because of these properties, quantum computers may prove far more powerful than conventional computers. They operate in multiple states all at once rather than using the binary language of zeros and ones, and this gives them the ability to solve complex problems instead of relying on binary calculations.

Associated Sectors

- Agriculture
- Financial Services
- Digital Media and Entertainment
- Cloud Technology Services
- Transportation
- Advertising
- Energy
- Telecom (including 5G Wireless)

Why Is AI Important?

Artificial intelligence imitates human capabilities effectively, efficiently, and at a low cost, thus representing a labor-saving technology. AI’s reliability could also reduce losses and errors in many settings, from industrial applications to consumer technology. For example, if self-driving cars become consistently safer than human-driven cars, the owners of those cars may pay less in auto insurance premiums.

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ENABLING SCIENCE AND TECHNOLOGY

Deep Learning

Deep learning is a subset of machine learning that uses deep neural network architectures. Neural networks are interconnected processors which work together to solve problems. They were inspired by the structure and functioning of neurons in the human brain. A neural network can be organized to have hidden layers, and as each layer of the network fires it passes a more tangible view of the data to the next layer. Deep networks may have more than 150 hidden layers to optimize and refine accuracy. Deep learning's various network architectures, such as recurrent neural networks, convolutional neural networks, and brief neural networks, have applications in speech recognition, computer vision, and bioinformatics, among many other fields. Deep learning enhances analytical and physical tasks without human intervention, thereby supporting autonomous systems.

Quantum AI

Quantum AI represents the frontier of AI development. It is based on the concept of building quantum algorithms for computational tasks in AI and ML. Although currently in its

early stages, quantum AI is expected to be the next generation of AI. In 2021, Google established its Quantum AI lab in Santa Barbara, California, where it is aiming to build a “useful, error-corrected quantum computer” within 10 years.

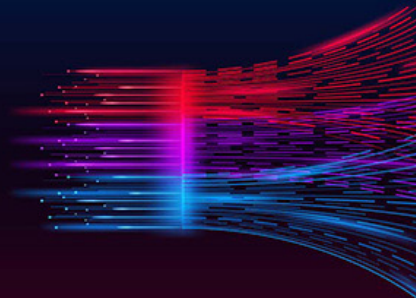
As mentioned, the ability of quantum technology to operate in superposed and entangled states is what makes it much more powerful than binary code. Applying quantum technology to AI opens the door to several applications that are beyond the capabilities of existing computers.

Cognitive Computing

Cognitive computing is a combination of computer science and cognitive science designed to simulate the human thought process. It overlaps with AI and involves many of the same underlying technologies. For example, to solve complex problems cognitive applications may use data mining, visual recognition, and natural language processing.

Early adopters are deploying the technology for customer acquisition, customer engagement, and customer service, among other uses.

TO MITIGATE HARMFUL BIAS, THE NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST) PROPOSED AN APPROACH THAT MANAGES BIAS THROUGH THREE STAGES (PRE-DESIGN, DESIGN AND DEVELOPMENT, AND DEPLOYMENT) MODELED ON THE AI DEVELOPMENT LIFE CYCLE.



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SECTOR AND INDUSTRY SIGNALS

NASA ‘Tipping Point’ Program to Use AI-Driven Analytics

Among other objectives, NASA’s “[Tipping Point](#)” program aims to develop robots that can navigate the moon’s surface without human intervention. [Bosch](#) will support the program through “AloT”—a combination of AI and Internet of Things (IoT) that refers to intelligent processing capabilities. Bosch’s focus is on connecting devices to acquire data, process it, and use it through AI, with the ultimate goal of creating a robot that can safely and reliably navigate on the moon.

Apple Acquires AI Startups to Improve Speech, Image Recognition

In May 2020, Apple took a step toward advancing its speech recognition software through the [purchase](#) of ML startup Inductiv. A few months earlier, Apple also [acquired](#) Xnor.ai to use its image recognition technology for security applications. Other notable AI and data company acquisitions by Apple in recent years include Tuplejump, Laserlike, Turi, and Perception.

Growth Prospects of Industrial AI Strengthen

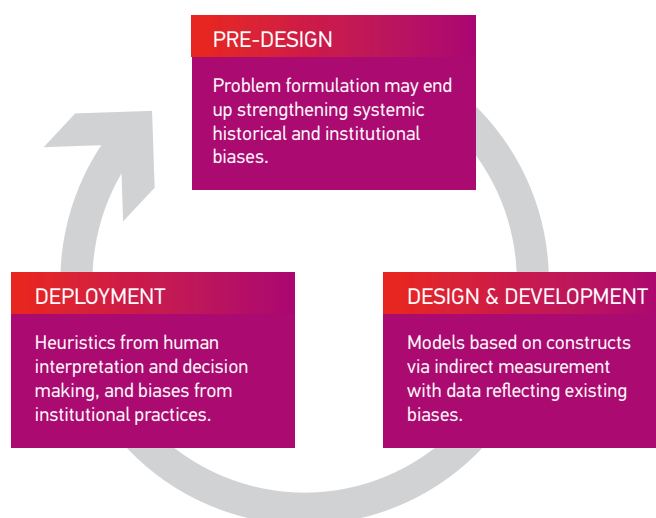
Industrial AI helps [automate](#) industrial processes with new technologies for purposes that include supply chain optimization, crop maximization, and predictive analysis. PitchBook expected that in 2021, companies would spend around \$9.9 billion on industrial AI, and that the market for industrial AI will increase at a 24.1% compound annual growth rate to reach \$18.9 billion in 2024. A few [recent innovations](#) in the industrial AI sector include McFly’s intelligent agricultural monitoring drone and GAGO’s large-scale application of AI technology in crop production.

NIST Proposes New Methods to Identify and Manage Harmful AI Biases

In June 2021, the National Institute of Standards and Technology (NIST) issued a [proposal](#) to advance methods for understanding and reducing harmful forms of AI bias. Citing the International Organization for Standardization, NIST notes the definition of bias in statistical terms is “the degree to which a reference value deviates from the truth” and cautions that not

all forms of bias are negative. Bias can either contribute to, or mitigate, harmful or discriminatory outcomes.

To mitigate harmful bias, NIST proposed an approach that manages bias through three stages (pre-design, design and development, and deployment) modeled on the AI development life cycle. NIST cautions that bias can occur in each of these stages, as shown by the following chart.



In March 2021, five U.S. financial regulators [issued](#) a request for information on how banks use AI. In addition, the U.S. Federal Trade Commission (FTC) released [guidelines](#) on truth, fairness, and equity in AI. In May, Sen. Edward Markey and Rep. Doris Matsui [introduced](#) the Algorithmic Justice and Online Platform Transparency Act of 2021. Meanwhile, Sen. Ron Wyden planned to [reintroduce](#) the Algorithmic Accountability Act in 2021. Internationally, the European Commission [proposed](#) new rules on AI in April.

All current and proposed AI laws have [three elements in common](#): (1) an obligation to conduct risk assessments and to document how risks are mitigated or resolved; (2) accountability and independence, meaning the personnel who test and validate the AI should be different from those who originally developed it, and the testers should have different

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SECTOR AND INDUSTRY SIGNALS (CONT'D)

incentives than the developers; and (3) a duty to continuously review AI systems.

There are industry-led solutions to combating AI bias as well. One of these is the use of synthetic data, which replicates real-world statistical components without variables that could produce harmful outcomes. This form of desirable (nonharmful) data generation bias is created by adding either synthetic or redundant data samples to a data set.

Retail Industry Among Top Supporters of AI

In 2020, International Data Corporation (IDC) identified retail and banking as the two industries that spend the most on AI solutions globally. At the time, IDC said retailers focused their investments on improving the customer experience via chatbots and recommendation engines, while banks prioritized fraud analysis and investigation as well as program advisors and recommendation systems.

More recently, IDC updated its findings to note that retailers will overtake banks as the top spenders on AI. This is because retailers are deploying AI in a wider range of applications, including inventory management. Two early adopters are Home Depot and Wayfair. Home Depot is in the early stages of using ML to spot products that need to be restocked on store shelves. Wayfair relies heavily on computer vision to match shoppers' searches with the items they're looking to buy. Other notable developments include Walmart's partnership with Adobe to offer AI-powered substitutions, pickup, and delivery. Target invested in AI to improve recommendations and offer a virtual product-trying application. Costco and other grocers

have leveraged ML to keep track of fresh food inventory and reduce waste.

Government Acquisitions of AI Technologies

The U.S. Department of Defense (DOD) intends to speed up its AI acquisition through a rapid procurement process. The project, called Tradewind, is intended to help the Joint Artificial Intelligence Center (JAIC) find use cases for AI throughout the military and acquire the right algorithms. As we have discussed elsewhere, the DOD policy seeks to promote "Responsible AI" in defense procurements, which reaffirms the department's ethical principles. Reportedly, at least nine projects worth approximately \$74 million are in the program's pipeline.

Efforts are underway to deploy AI elsewhere in the federal government as well. The leaders of the U.S. Senate Homeland Security and Government Affairs Committee proposed the Artificial Intelligence Training for the Acquisition Workforce Act, which, if adopted, would set up a training program for federal workers to learn more about AI technology.

Healthcare-AI Subsector Sees Growing Number of Applications

One of the main applications of AI in the healthcare industry is drug and compound development, because it considerably reduces the time and money needed to market new drugs and represents a significant competitive advantage. Other applications include clinical decision support, genetic analytics, healthcare administration, and personal health.



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IMPACT

Economic

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Social

Microsoft-funded research suggests that on a global level, low- and middle-income countries will be more exposed to the negative impacts of AI, such as automation. This could increase social inequalities and political instability in those countries.

Another issue is the perpetuation of social inequities through algorithmic discrimination. As discussed above, AIs can

produce both harmful and beneficial forms of bias. Knowing how to identify and mitigate harmful bias, and how to use synthetic data, will produce fairer results.

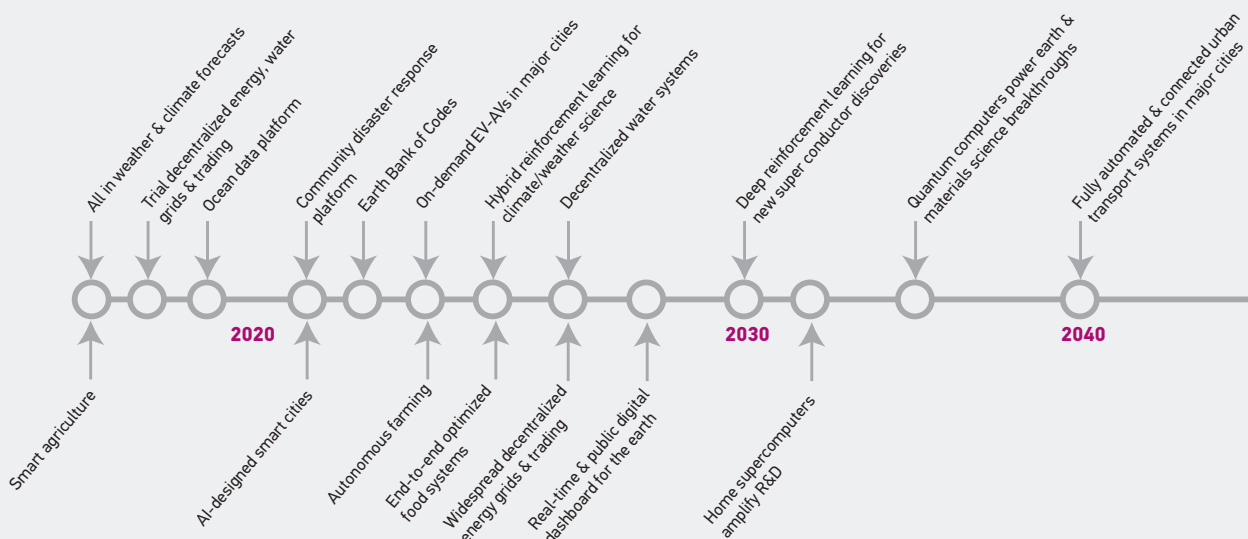
Environmental

AI is helping countries meet their sustainable development goals (SDGs). For example, climate modeling that incorporates AI is supporting climate action, which is SDG 13. NASA, IBM, and Microsoft continue to use AI and ML to improve the efficiency of climate models. PwC proposed a timeline outlining the different ways in which AI could support the environment.

Policy

The U.S. government adopted a new defense bill (the National Defense Authorization Act for Fiscal Year 2021) and earmarked \$6.4 billion of government funding to AI initiatives. The legislation provides for the creation of a National Artificial Intelligence Initiative Office, which will be led by the White House. The office's mission is to serve as a point of contact for federal departments and agencies that use AI.

AI FOR THE EARTH GAME CHANGERS: INDICATIVE TIMELINE



Source: PwC Research

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LEGAL IMPLICATIONS

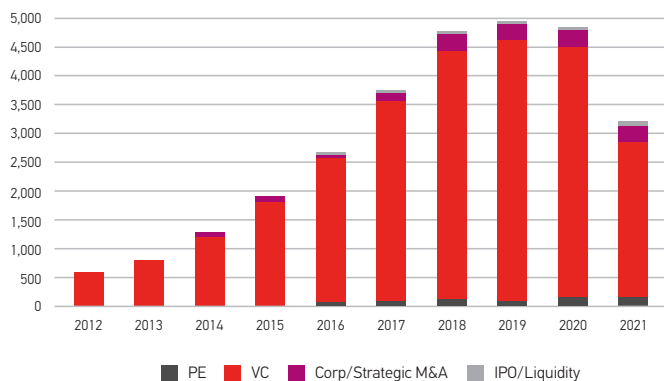
OUTLOOK

Transactions | AI and ML Investment Values Increasing

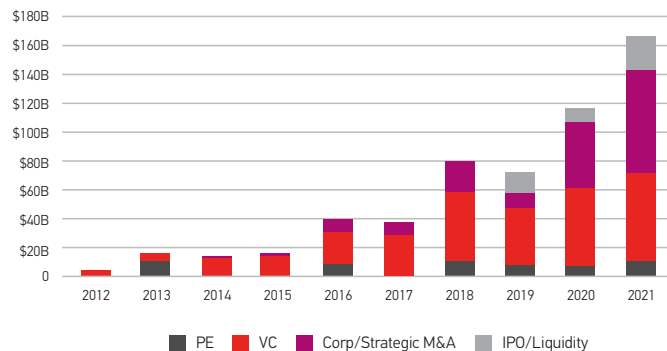
Venture capital and private equity investment in artificial intelligence and machine learning technology companies continues to rise in value, even as deal volumes have remained relatively flat over the past three years. As the space becomes more mature, the levels of strategic M&A and public listings have risen.

The pace of consolidation moderated in 2020, following five years of growing M&A deal volume, although the numbers through the end of July 2021 suggest that the pace may be picking up again. The largest tech companies have been active in acquiring AI and ML companies, particularly those that focus on AI core software, natural language processing, and consumer AI.

INVESTMENTS OVER TIME
Deal Count



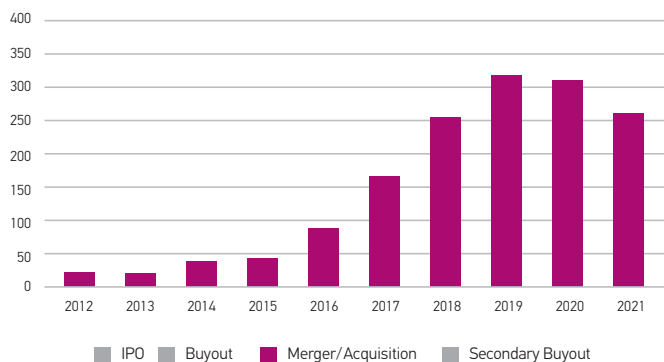
INVESTMENTS OVER TIME
Capital Raised



Data retrieved 29 July 2021

Source: PitchBook Data

AI MERGERS & ACQUISITION TRENDS
Deal Count



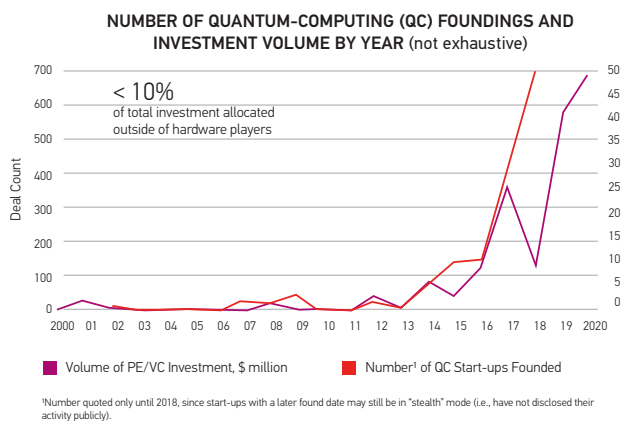
Source: PitchBook Data

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LEGAL IMPLICATIONS (CONT'D)

Transactions | Interest in Quantum Computing Rising Sharply

The ranks of new quantum technology–focused companies began to rise steadily in 2014. Since then, investment and M&A activity in the quantum computing space have been accelerating, particularly over the last two years. Deal volumes and values are smaller than those for AI and ML, reflecting that it is a nascent subsector.



Source: Crunchbase, PitchBook, McKinsey analysis

Litigation | Alleged Biases in Decision Support and Collection of Confidential Information Subjects of Recent AI Litigation

As AI technology becomes more deeply embedded in a wide variety of tools to support decision-making, reports have emerged alleging that the algorithms, data, and models used in these systems may demonstrate biases. There has been an increase in lawsuits against companies and organizations that use “black box” AI tools to provide guidance for decisions related to areas such as employment, consumer credit, or criminal justice.

Social media and other digital media platforms have relied heavily on AI technology to help moderate user-generated content. Conflicts regarding social media companies’ actions in deleting posts and suspending or banning users are on the rise generally, and the use of AI to enforce these policies is

also coming under fire. Critics suggest that AI is being used to suppress legitimate speech, and also to suppress speech from specific racial, ethnic, gender, or political sources.

Automated voice assistants incorporate AI in their systems, including extensive use of recorded data to further train the AIs. However, the collection and use of that data—as well as the conditions and extent of what is actually collected—have prompted lawsuits. Further, when the information collected includes data that is confidential or otherwise protected by law, such as conversations between patients and medical professionals, the risk of litigation increases.

Privacy | Datasets Needed for AI, ML Raise Privacy Implications

Advanced machine learning is only possible with significant amounts of data—often user data that includes personally identifiable information. Both the collection and the use of this data raise compliance and ethical risks that companies may need to address.

One of the main risks is the use of data for purposes that were not anticipated at the time the data was collected. This may occur when companies purchase or leverage third-party datasets to train their algorithms. From a commercial perspective, the key is to provide appropriate notice, and secure appropriate consent, when collecting the personal information—or ensure that a supplier has done the same, even though the AI supply chain is increasingly complex.

Regulatory | US Financial Services Regulators Looking Closely at AI and ML, While FTC Issues New AI Guidelines

A recent notice in the Federal Register suggests that regulators are seeking to update rules concerning the use of AI and ML in financial services. In March 2021, a collection of U.S. federal bank and financial services regulators, including the U.S. Department of the Treasury (DOT), the Board of Governors of the Federal Reserve, the Federal Deposit Insurance Corporation (FDIC), the FTC’s Bureau of Consumer Protection,

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LEGAL IMPLICATIONS (CONT'D)

and the National Credit Union Administration (NCUA) issued a joint [request for information](#) on how banks use AI and ML. The regulators note that they are seeking to determine whether any clarifications in their rules would be helpful to ensure AI is used in a “safe and sound manner.”

Meanwhile, the FTC released [new guidelines](#) on “truth, fairness, and equity” in AI in April 2021. These guidelines define unfairness as any act that “causes more harm than good,” suggesting the agency will take a more active approach to addressing instances in which AI systems could potentially introduce racial or other illegal biases into consumer and employment decisions.

LITIGATION DEVELOPMENTS

US Immigration and Customs Enforcement (ICE) Faces Class Action Over Use of Automated Risk Assessment Tool

The New York Civil Liberties Union filed a [class action](#) against ICE over the government agency’s use of the Risk Classification Assessment Tool, an automated system that makes recommendations regarding whether people awaiting an immigration hearing should be held or released. The plaintiffs in the suit, filed in the U.S. District Court for the Southern District of New York, charge that the system has been manipulated to recommend detention in nearly every case, improperly denying due process. *Jose L. Velesaca v. Chad Wolf et al.*, case number 1:20-cv-0180, in the U.S. District Court for the Southern District of New York.

PATENT TRENDS AND OUTLOOK

International Developments Push the Debate Over Whether an AI Can Be an Inventor

A July 2021 [patent](#) granted in South Africa is the first in the world to recognize an AI system, known as DABUS in this case, as the inventor—while granting patent ownership to DABUS’ owner, Stephen Thaler. The same patent is the subject of legal proceedings in the [United States](#), the U.K., and elsewhere in

Europe, where patent authorities had previously [refused](#) to grant patents if an AI was listed as the inventor.

Other developments indicate views might be shifting in those jurisdictions, however. For example, in 2021, the U.K. Intellectual Property Office (UKIPO) released a [report](#) on consultations it had conducted regarding the impact of AI on intellectual property. Included in the report was the [suggestion](#) that UKIPO could eventually seek legislation allowing AI tools to be recognized as inventors. According to a UKIPO official, “We recognise that AI systems have an increasing impact on the innovation process. We want to ensure the intellectual property systems support and incentivise AI-generated innovation.”

COPYRIGHT ISSUES

Use of Datasets for Training ML Models Raises Copyright Issues

Machine learning requires access to large amounts of quality data to train ML models. Such training involves making a temporary copy of the training data, which raises copyright issues if the data includes copyrighted materials or datasets. Some countries have addressed this by adopting text and data mining (TDM) exceptions that allow for certain uses of copyrighted material for training machine learning models. The United States, however, has not adopted text and data mining exceptions, and companies here must rely on the fair use doctrine to determine whether such use is permissible without a license. Although there are no relevant decisions yet in AI, there are cases in other areas (such as search engines and the reverse engineering of video games) that are arguably analogous and support an argument for fair use, at least where intermediate copies are made merely for training models. However, fair use is a very fact-specific defense, which makes it hard to rely on and requires a detailed fact analysis of a particular use.

Some experts have speculated that the applicability of the fair use defense could turn on factors such as whether the model is utilizing expressive elements of the data, rather than factual ones, the nature of the output of the model, and to what

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LEGAL IMPLICATIONS (CONT'D)

extent the purpose of the model is similar to the expression contained in the training data. But there is little guidance. There is concern that the uncertainty around the legality of using copyrighted materials to train machine learning models may make it difficult for AI to thrive and may affect the quality of the models created. This uncertainty, and the fear of infringement claims, may drive companies without clear access to good data to use low-quality data, or insufficient amounts of data, to train models for AI, which may affect the quality of the models and the ability of companies to compete equally if they cannot obtain licenses. It may also exacerbate algorithmic bias due to using insufficient and outdated data.

Copyright Protection for AI-Created Works

Another interesting question at the intersection of AI and copyright is whether works created through AI are copyrightable. In the United States, copyright protection requires human authorship (which is why *Naruto the monkey* was held not to be the “author” in the famous monkey selfie case). However, the Compendium of U.S. Copyright Office Practices says that the Copyright Office “will not register

works produced by a machine or mere mechanical process that operates randomly or automatically *without any creative input or intervention from a human author.*” (emphasis added). Therefore, it may be possible to argue that a work is copyrightable if there was some human guidance in the training process (or elsewhere). Some countries, including the U.K., Ireland, Hong Kong, India, New Zealand, and South Africa, recognize statutory protection for “computer generated works,” even without human authorship contribution (with the author generally being considered the person “by whom the arrangements necessary for the creation of the work are undertaken”). Other countries are more like the United States and require human authorship.

USPTO Reports on IP and AI

In August of 2019, the U.S. Patent and Trademark Office (USPTO) issued a request for comments on questions relating to AI and patents, and in November 2019, the USPTO requested comments on certain questions regarding AI and copyright (and other forms of IP). The USPTO [published a report](#) with these comments in October 2020.

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ABOUT US

Technology Transactions & Privacy | AI, Machine Learning & Quantum Computing

Enabled by our broad experience working with many of the world's most innovative technology companies, our AI team is advising companies—from startups to *Fortune* 50 corporate giants and government agencies—as they explore the ways in which AI can help meet their organizational goals. From concept to launch, we have provided guidance to clients developing technologies related to machine perception, machine learning and reasoning, deep learning, anomaly detection, scalable data structures, clustering, image and data analytics, pattern mining, regression, classification models, natural language processing, and context awareness technologies. Our team also assists research organizations as they develop hardware architecture and deep-learning software application framework standards. Our team's multidisciplinary capabilities and experience also span the wide range of machine learning and sensing technologies, including engineering, biometrics, optics, microelectronics, systems engineering, signal processing, and neural networks.

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