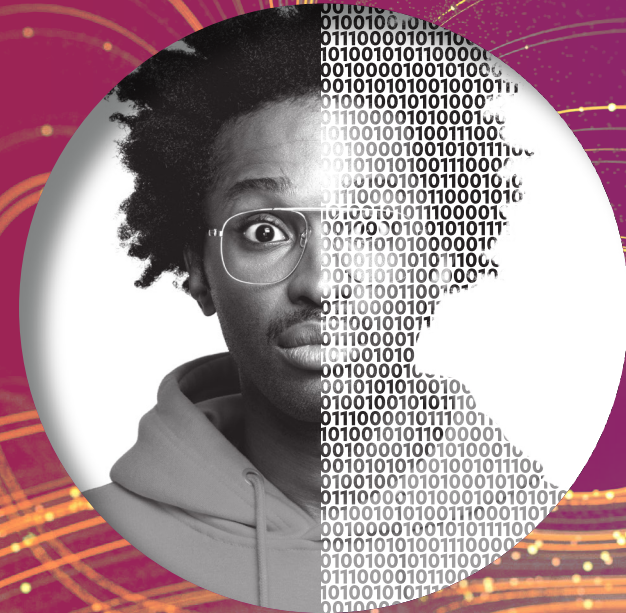


# Artificial Intelligence

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Artificial Intelligence trends in business, government, research, talent, creative fields and society.



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# Macro Forces and Emerging Trends

For nearly two decades, the Future Today Institute has meticulously researched macro forces of change and the emerging trends that result. Our focus: understanding how these forces and trends will shape our futures. Our 15th annual Tech Trends Report identifies new opportunities for growth and potential collaborations in and adjacent to your business. We also highlight emerging or atypical threats across most industries, including all levels of government. For those in creative fields, you will find a wealth of new ideas that will spark your imagination.

Our framework organizes nearly 600 trends into 13 clear categories, which are being published as separate reports. Each report includes specific use cases and recommendations for key roles in many organizations: strategy, innovation, R&D, and risk.

**Each trend offers six important insights.**

## 1. Years on the List

We track longitudinal tech and science trends. This measurement indicates how long we have followed the trend and its progression.

## 2. Key Insight

Concise description of this trend that can be easily understood and repeated to others.

## 3. Examples

Real-world use cases, some of which should be familiar to you.

## 4. Disruptive Impact

The implications of this trend on your business, government, or society.

## 5. Emerging Players

Individuals, research teams, startups, and other organizations operating in this space. Mature organizations are included when they are producing new contributions.

## 6. Action Scale

FTI's analysis of what action your organization should take. Fields include:

### ▶ Watch Closely

Mounting evidence and data, but more maturity is needed. Use this trend to inform your vision, planning, and research.

### ▶ Informs Strategy

Strong evidence and data. Longer-term uncertainties remain. This trend should inform your strategic planning.


### ▶ Act Now

Ample evidence and data. This trend is already mature and requires action.

00 01 02 03 04 05 06 07 08 09 10 11 12 13
Recognition, Scoring & Privacy 6 Watch Closely Informs Strategy Act Now

**4TH YEAR ON THE LIST** — 1

## Scoring



Scoring systems make assessments beyond just people. Food systems can evaluate nutritional intake for a consumer.

**KEY INSIGHT** — 2

Scoring systems are leaving an indelible mark on all individuals. For some, scoring systems create advantages and enhanced user experiences. For others, inherent biases and a lack of available data on certain individuals create hindrances and shortcomings. Copious data and frameworks for decision-making are integral for automated systems to work.

**EXAMPLES** — 3

In the U.S., we have a credit reporting system that measures our creditworthiness. Banks, financial institutions, and others use these scores to determine the likelihood that we might default on a loan or a mortgage. Financial credit scoring is available to all consumers—we can request copies of our financial credit scores, check their accuracy, and correct errors. Now, hundreds of types of data are being harnessed to assign us scores. However, unlike the credit reporting system, which is federally regulated and follows set processes, this kind of data isn't subject to enforceable rules. It can be impossible to find out what our scores are, how they are being calculated, and how to correct inaccuracies.

**DISRUPTIVE IMPACT** — 4

Advancement in data mining and artificial intelligence promise both new opportunities and potential violations of privacy as businesses and law enforcement implement scoring systems on new platforms. Additional risk comes from China selling its government-funded scoring tools, which can be used on both individuals and corporations, to authoritarian regimes elsewhere in the world. Even as new practical use cases become apparent for scoring of this technology.

**EMERGING PLAYERS** — 5

- Density
- Piwik Pro
- Wakefit
- Dynamic Yield
- Access Now
- Os Keyes and the University of Washington's Department of Human Centered Design & Engineering
- Amin Karbasi, associate professor of electrical engineering and computer science at Yale University
- Ehsan Kazemi, research software engineer at Google
- Voyager Labs
- Flock Safety

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# Scenarios Describe Plausible Outcomes

You will find scenarios imagining future worlds as trends evolve and converge. Scenarios offer a fresh perspective on trends and often challenge your deeply held beliefs. They prompt you to consider high-impact, high-uncertainty situations using signals available today.

## 1. Headline

A short description offering you a glimpse into future changes.

## 2. Temporal and Emotive Tags

A label explaining both when in the future this scenario is set and whether it is optimistic, neutral, pessimistic, or catastrophic.

## 3. Narrative

The descriptive elements of our imagined world, including the developments leading us to this point in our future history.

### Scenario sources:

The Future Today Institute uses a wide array of qualitative and quantitative data to create our scenarios. Some of our typical sources include patent filings, academic preprint servers, archival research, policy briefings, conference papers, data sets, structured interviews with experts, conversations with kids, critical design, and speculative fiction.

00 01 02 03 04 05 06 07 08 09 10 11 12 13 Artificial Intelligence SCENARIO

People Will Live More Productive Lives • Optimistic/Near-Future scenario

## The Real Future of AI

In the future, AI will be able to evolve on its own, creating new and better versions of itself. This process will be known as "self-evolution." Self-evolution will allow AI to become smarter and more efficient over time. It will also enable AI to adapt to new environments and situations, making it more versatile and powerful. AI has already shown signs of self-evolution in recent years. For example, Google's AlphaGo program was able to learn how to play Go better than any other program by playing against itself. As AI continues to evolve, we can expect even more impressive feats from it – including self-evolved machines that are smarter than humans.

In the future, AI will be so advanced that it will be indistinguishable from actual intelligence. Humanity will achieve a level of technological singularity, and all our questions about the universe will be answered. We will also create powerful robots that can do everything humans can do, only better. These robots will eventually become self-aware, and we will have to deal with the consequences of creating something that is essentially equal to us.

This scenario was written by GPT-3, OpenAI's language generator. (Humans did design the page, however.) GPT-3 was given the following instructions by Amy Webb, the Future Today Institute's CEO: "Please write a short op-ed around 500 words. Focus on how AI will evolve in the future. Make it sound like science fiction but keep it factual!" Amy used GPT-3 to produce several different outputs, and selected this scenario as her favorite. It took 3.29 seconds for GPT-3 to write this essay, which Amy decided required little editing.

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What's the new normal? Most of us feel an urgent need to get back to normal, especially as we continue to witness and endure an unprecedented amount of change. Early this year, Russian President Vladimir Putin waged an unprovoked war against Ukraine, which led to a rapid global response. Switzerland broke with tradition and took a side, freezing Russian assets and denying entry to oligarchs. Anonymous, the global hacker collective, waged a cyberwar against Russia, infiltrating government databases and state propaganda websites.

Within the past 12 months, DeepMind solved a 50-year-old problem in biology, opening up new pathways to drug discovery. AI systems proved that they can generate images and text as well as a human. Facebook and Square changed their names to Meta and Block, signaling a digital land grab in the emerging Web 3.0. The biggest streamers—Netflix, Disney+, AppleTV, Hulu—discovered a formidable competitor in social commerce networks like Shein. Seemingly every day, a new set of signals emerge to challenge our existing mental models.

It might feel pointless to forecast the future past a few weeks or months. But strategic foresight results in preparations, not predictions. Trends invite us to consider alternative outcomes from those we previously imagined. They also unlock something invaluable in each one of us: the ability to re-perceive reality. The act of “re-perception” awakens you to the possibility of a future that differs from your current expectations. It helps you understand that you cannot know all things at all times, and that you should be

curious, rather than absolutely certain, about what you perceive in the present.

Our 2022 Tech Trends Report is designed to help you re-perceive the world so that you can confront deep uncertainty, adapt and thrive. In this 15th anniversary edition, we have analyzed nearly 600 technology and science trends that impact most industry sectors. We created 14 separate volumes, and each report focuses on a related cluster of trends. You will also find vivid scenarios depicting the unexpected ways in which the future might unfold. In each volume, we discuss the disruptive forces, opportunities and strategies that will influence your organization in the near future.

Now, more than ever, your organization should examine the potential near and long-term impact of tech trends. You must factor the trends in this report into your strategic thinking for the coming year, and adjust your planning, operations and business models accordingly. But we hope you will make time for creative exploration. The new normal is unfolding for those who know how to re-perceive signals in the present.

A handwritten signature in black ink that reads "Amy Webb".

**Amy Webb**  
CEO  
The Future Today Institute



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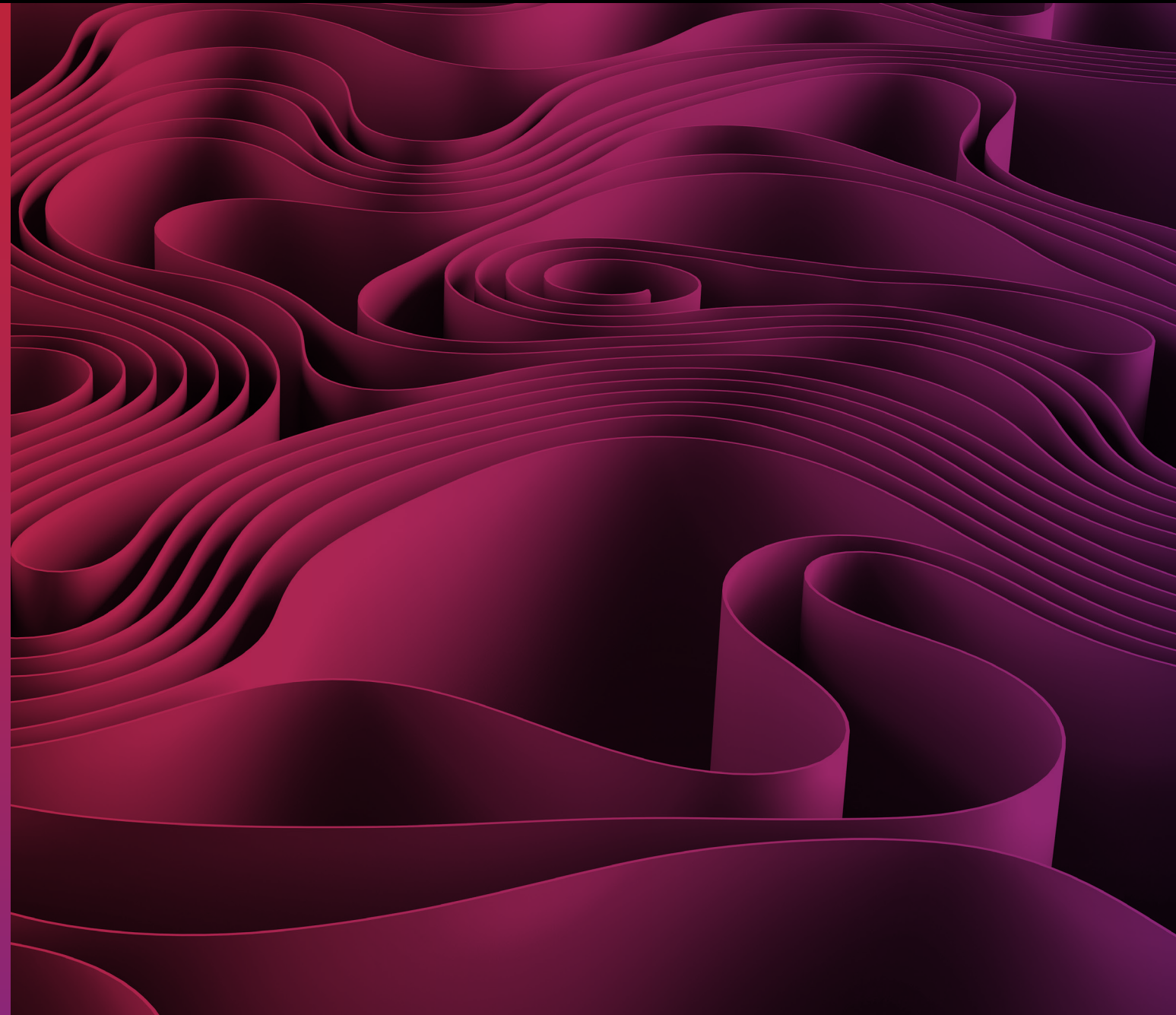
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Artificial Intelligence

This is volume 01 in the Future Today Institute's 2022 Tech Trends Report. Each volume covers a different set of topics.

To find additional volumes, visit [www.futuretodayinstitute.com/trends](http://www.futuretodayinstitute.com/trends)





# Key Insights

- \* During the next decade, artificial intelligence will reshape the knowledge economy, automating some tasks currently performed by people and augmenting others.
- \* Companies are looking to upskill their workforce in machine learning and the basics of AI.
- \* Machine learning is transitioning, as new platforms allow businesses to leverage the power of AI to build applications without the need to know specific code.
- \* Deep neural networks are now listed among the 10 fastest growing technologies in the U.S., as indicated by patent applications.
- \* In some U.S. states, facial recognition without consent is now illegal. But there are no laws against emotional recognition.
- \* During the 2022 Super Bowl, several ads made use of deepfakes, which are becoming cheaper and easier to create.
- \* AI is being deployed to speed scientific discovery.
- \* Three research teams from Microsoft, Google, and Baidu have surpassed human baselines on SuperGLUE natural language processing (NLP) tasks.
- \* Deep neural networks are being used to analyze emotional states using wireless signals. Scientists are warning that advertisers could begin to alter and drive purchasing behavior through sleep and dream hacking.
- \* Strict new regulations in China and the EU could challenge the development of AI.
- \* Governments are instituting new restrictions on mergers and acquisitions and investment activity to ensure that AI developed by companies does not aid foreign adversaries.
- \* Several governments are attempting to regulate deepfake technology. Bills to regulate or prohibit the use of deepfakes have been introduced in California, Texas, and Massachusetts, and a number of federal bills are being discussed.
- \* The U.S. military has started using AI to guide its airstrikes, deploying algorithms to a live operational kill chain.
- \* Within the next decade, China plans to meet two crucial milestones: By 2027, its People's Liberation Army will have a modern-ready force, and by 2030 the Chinese Communist Party expects to have outpaced the U.S. in AI and become the singular dominant force.
- \* China is forging ahead on its own NLP models. Two massive models developed specifically for the Chinese language market, Wu Dao 2.0 and M6, will start to shape the future of AI development.
- \* Our future wars will be fought in code, using data and algorithms as powerful weapons.
- \* We will soon reach a point when we will no longer be able to tell if a dataset has been tampered with, either intentionally or accidentally.
- \* A new type of software could be viable for 100 years, making use of AI to dynamically adapt to changes in environments and resources.





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Artificial Intelligence

# Artificial Intelligence

## State of AI in 2022

Artificial intelligence represents the third era of computing, generally defined as the ability for a machine to perform cognitive functions as well as or better than humans. Such functions include perception, learning, reasoning, problem-solving, contextual understanding, making inferences and predictions, and exercising creativity.

AI is now used across most industries. It solves business problems, detects fraud, improves crop yields, manages supply chains, recommends products, and even assists designers and writers in their work. AI can predict call volume in customer service centers and recommend staffing levels; it also predicts the emotional state and behavior of the person calling to help companies anticipate desirable solutions. AI automates the process for drug discovery, which ultimately led to faster COVID-19

vaccine candidates. Because AI is so broad, we have identified different themes to track; however, because AI is now so deeply intertwined with every aspect of life, you will find AI mentioned in other trends throughout all 13 volumes of the Future Today Institute's 2022 report.

Since publishing our first Tech Trends report 15 years ago, we have included and expanded our coverage on artificial intelligence. What began as several pages of insights is now a dedicated, stand-alone report with more than 100 trends to monitor. We believe AI is a force multiplier because it both enables technology and is powering the evolution of business, government, and society. AI is already transforming most economic sectors, but we anticipate deeper impacts across health care, biotech, cloud computing, fintech, consumer electronics, and military applications in 2022.



# Key Terms

## Machine Learning (ML)

Machine learning uses data to make predictions and recommendations on how to achieve stated goals. AI pioneer Arthur Samuel popularized the idea of machine learning in 1959, explaining how computers could learn without being explicitly programmed. This would mean developing an algorithm that could someday extract patterns from datasets and use those patterns to predict and make real-time decisions automatically. It took many years for reality to catch up with Samuel's idea, but today machine learning is a primary driver of the growth in AI.

*There are different types of machine learning including supervised, unsupervised, and reinforcement.*

### Supervised learning

A model attempts to transform one type of data into another type using labeled examples. Supervised learning is used

when teams know how to classify the input data and what they are trying to predict but can get accurate results much more quickly by relying on an algorithm rather than a human. This is the most common form of ML used today. For example: Understanding what product features would most likely drive new purchases is a business use case for supervised learning.

### Unsupervised learning

Data is provided to a model without specific output parameters, and it tries to learn the dataset's structure without any designated labels. For example, if a researcher doesn't know quite what to do with a large dataset, an unsupervised learning model could determine patterns, classify data, and make recommendations without a human supervisor. Unsupervised learning has been used during the pandemic to find patterns in how COVID-19 is spreading throughout communities.

## Reinforcement learning (RL)

A system performs a task by repeatedly running calculations as it attempts to accomplish a stated goal. It's a trial-and-error process, where rewards or penalties are earned in response to the system's performance toward achieving the stated goal. RL is used when there isn't enough training data, when the researcher is trying to learn about an environment (such as a complex financial portfolio), or when the researcher needs to find greater levels of optimization. It has a tremendous number of business use cases, ranging from real-time dynamic pricing models to high frequency trading algorithms to the systems that run self-driving cars.

## Deep Learning (DL)

Deep learning is a relatively new branch of machine learning. Programmers use special deep learning algorithms alongside an enormous corpus of data—typically many terabytes of text, images,

videos, speech, and the like. Often, these systems are trained to learn on their own, and they can sort through a variety of unstructured data, whether it's making sense of typed text in documents or audio clips or video. In practical terms, deep learning's emergence means that more and more human processes will be automated, including the writing of software, which computers will soon start to do on their own. For example, once a system learns what an object looks like—say, an apple—it can recognize that object in all other images, even if it has only a partial view.

There are different types of deep learning architectures. The most common types include convolutional neural networks, recurrent neural networks, transformer neural networks, and generative adversarial networks (GANs).

### ■ Convolutional neural network (CNN)

A CNN is multilayered, with a convolutional layer, a pooling layer, and a fully

connected layer. Each one performs a different task using the data. The output is classification. If a researcher has 10,000 images and needs to extract data—to recognize particular faces, for instance—the CNN would run until information could be inferred. In business, CNNs are used for recognition such as anomalies in medical imaging, faulty products on a production line, blight on crops.

### ■ Recurrent neural networks (RNNs)

These multilayered neural networks move and store information between input, hidden, and output layers. They are good at modeling sequence data for predictions. In business, they are used anytime the sequence of data matters, such as speech recognition and language translation. RNNs are used in digital assistants, to create captions for images and to generate narrative reports using structured data (sports, financial).



# Key Terms



This year is the 10th anniversary of an important milestone in AI. In 2012, a neural network taught itself to recognize a cat. It required 16,000 computer processors and 10 million YouTube videos.

## ■ Transformer neural networks (TNNs)

A transformer is a component whose purpose is to process sequential data, such as natural language or genome sequences. Transformers rely on “attention” (the mathematical description of how things relate to, complement or modify each other) in translating sequences. A transformer neural network is the unique architecture that enables systems to learn from context and to generate new information. TNNs are complementary to CNNs and RNNs, the two most common neural network architectures used in deep learning.

## ■ Generative adversarial networks (GANs)

As unsupervised deep learning systems, GANs are composed of two competing neural networks—a generator and a discriminator—that are trained on the

same data, such as images of people. The networks compete against each other to perform a task—identifying the correct person—which results in optimizing overall performance. GANs are useful when researchers don’t have enough data to train an algorithmic model. They are also used to create new, synthetic data. Deepfakes, which have become popular in the past year, are generated using GANs. In design, GANs are tremendously useful: They can produce thousands of designs and recommend the best ones based on desired parameters. They can generate and modulate voices, faces, even gestures. Researchers from Nvidia, Massachusetts General Hospital, BWH Center for Clinical Data Science, and the Mayo Clinic collaborated on a GAN that generates synthetic MRIs showing cancerous tumors.

## Algorithm

A process describing how to solve a specific problem or how to complete a particular task.

## Computer Vision

Processes that give computers the ability to derive meaningful information from digital images (including still and video) and to mimic and manipulate such images.

## Model

A program that has been trained on a dataset. Models are generally used for analytical and decision-making tasks, such as making predictions.

## Natural Language Processing

Processes that give computers the ability to understand, mimic, and manipulate human language.

## Transformer

A type of neural network mechanism that learns what text means when it appears in a particular context. Using “attention,” a transformer looks at an input sequence and determines at each step what other parts of the sequence are important. To date, transformers have mainly been used in natural language processing, image generation and genome sequencing.



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Artificial Intelligence

# AI: Techniques & Influential Models

**I may not be real. But for a second there,  
I felt pretty alive.**

— Guy, in *Free Guy*



# AI: Techniques and Influential Models

## Techniques to Watch in 2022

### Automated Machine Learning (AutoML)

Some organizations want to move away from traditional machine learning methods, which are time-consuming and difficult and require data scientists, specialists in AI fields, and engineers. AutoML operates differently by matching raw data and models together to reveal the most relevant information. Google, Amazon, and Microsoft include a host of AutoML products within their cloud service offerings.

### Continuous Learning

At the moment, deep learning techniques are helping systems learn to solve complex tasks in a way that resembles what humans can do—but those tasks are still specific, such as beating a human at a game. And they require a rigid sequence: Gather data, determine the goal, deploy an algorithm. This process requires humans and can be time-consuming, especially during early

phases when supervised training is required. Continuous learning is more about autonomous and incremental skill building and development, and researchers will continue to push the limits of what's possible in this field.

### Federated Learning

Federated learning is a technique that distributes machine learning to the edge. Introduced by Google researchers in 2016, it is a framework that makes it possible for algorithms to use data on devices—such as mobile phones and smart watches—without compromising user privacy. Research in this space has dramatically increased.

### General Reinforcement Learning Algorithms

Researchers are developing single algorithms that can learn multiple tasks. DeepMind, the team behind AlphaGo, which learned how to play Go with the skill level of a human grand master,

continues to push its research forward. MuZero mastered multiple games without being told their rules, a “significant step forward in the pursuit of general-purpose algorithms,” according to DeepMind. In a seminal paper, “Reward Is Enough,” published at the end of 2021, DeepMind researchers hypothesized that artificial general intelligence could be achieved through reinforcement learning alone.

### Graph Neural Networks

Because we perceive scents using millions of sensory neurons in our brains, and because scents are multifaceted, predicting the way something will smell is incredibly complex. For example, how would you describe the smell of an orange? Sweet? Bright? Grassy? Each descriptor is unique. Classifying smell is tricky because it requires a multi-label system. Graph neural networks (GNNs) constitute a particular type of deep neural network that operates on graphs

as inputs. GNNs are being used to detect smell—to predict odors at a molecular level—and for a wide array of chemical and biological processes. For example, researchers at the Broad Institute used them to discover antibiotic compounds that don't have toxic side effects.

### Hybrid Human-Computer Vision

AI isn't yet capable of fully functioning without human assistance. Hybrid intelligence systems combine humans and AI systems to achieve greater accuracy. The U.S. Army Research Laboratory has a system that uses a brain-computer interface armed with computer vision technology and allows a person to rapidly see and sort images within her line of sight. CloudSight, which specializes in image captioning, is working on a hybrid crowdsourced computer vision system. Microsoft researchers have proposed Pandora, a set of hybrid human-machine methods and tools for

understanding system failures. It builds off both human- and system-generated observations to explain malfunctions related to input content and system architecture.

### Machine Image Completion

If a computer system has access to enough images—say, millions and millions—it can patch and fill in holes in pictures. This capability has practical applications for professional photographers, as well as for everyone who wants to take a better selfie. Soon, if the foreground of a mountain is out of focus, or if your skin has an unsightly blemish, another version can be swapped in to generate the perfect picture. As such technology becomes commonplace, there will be significant biases and other pitfalls to navigate. For example, image generation algorithms routinely reflect deeply culturally embedded racism and sexism. A few years

# AI: Techniques and Influential Models

## Techniques to Watch in 2022

ago, if you typed “CEO” into Google Images, the first result of a woman was CEO Barbie. In an experiment, researchers at Carnegie Mellon University trained a system to autocomplete images of men and women cropped below the neck. In pictures of men, the system auto-completed him wearing a suit. The system auto-completed women—including U.S. Rep. Alexandria Ocasio-Cortez (D-N.Y.)—wearing a low-cut top or bikini 53% of the time.

### Model-free Approaches to RL

Dreamer is a reinforcement learning (RL) agent that uses a world model to learn long-sighted predictions, employing backpropagation through model predictions. It can create models from raw images and learn from thousands of predicted sequences in parallel using a graphics processing unit (GPU). This new approach solves long-horizon tasks using an imagined world.

### Predictive Models Using Incomplete Data

Computer vision systems are getting smarter. Neural networks can predict geometry from a single color image. In 2019, the DeepMind team developed a generative adversarial network (GAN) that creates videos from images. For example: Imagine a photo of a person holding a basketball. Based on his posture, face, and other data within the picture, the GAN figures out what likely happened next and generates a video clip of the action. Earlier, researchers at MIT’s Computer Science and Artificial Intelligence Laboratory (CSAIL) trained computers to predict what humans would do next using YouTube videos and TV shows such as “The Office” and “Desperate Housewives.” CSAIL’s system predicts whether two people are likely to hug, kiss, shake hands, or slap a high five. SinGAN is an unconditional generative scheme that can manipulate and enhance images—sketch a mountain,

and it will produce a realistic-looking synthetic photograph. This research will someday enable robots to more easily navigate human environments—and to interact with us humans by taking cues from our body language. Retail, manufacturing, and education settings could be especially relevant.

### Neuro-Symbolic AI

The development of AI has been on two conceptual tracks since the 1950s: symbolic (machines that use a base of knowledge and rules that represent concepts) and non-symbolic (machines that use raw data to create their own patterns and representations of concepts). Classic AI is the former, because it more closely represents how we understand human thought—and the original intent was to teach machines to think like us. Researchers are working on new ways to combine both learning and logic using neural networks, which would understand data through symbols rather

than always relying on human programmers to sort, tag, and catalog data for them. Symbolic algorithms will aid the process, which should eventually lead to robust systems that don’t always require a human for training.

### Real-time Machine Learning (RTML)

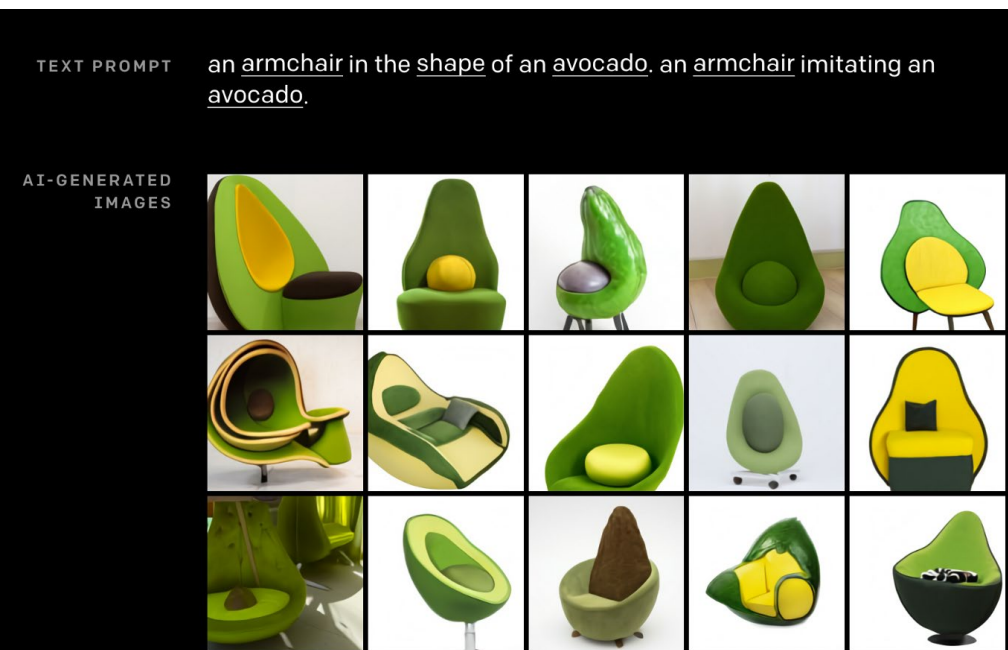
One big challenge in AI is building machines that can proactively collect and interpret data, spot patterns and incorporate context, and ultimately learn in real time. New research into RTML shows that it’s possible to use a continual flow of data and adjust models in real time. This signals a big change in how data moves, and in how we retrieve information. The National Science Foundation launched a \$10 million grant program to catalyze research in this area, although all of the big tech companies are working closely to advance RTML too.

### Vokenization

Models like GPT-3 are trained on syntax and grammar, not creativity or common sense. So researchers at the University of North Carolina–Chapel Hill are combining language models with computer vision. Humans learn in a multilayered, multidimensional way, so a new technique called vokenization extrapolates language-only data by contextually mapping language “tokens,” or the words used to train language models, to related images, or “vokens.” For example, auto-generated image captions often can’t infer context. Vokenization would enable machines not just to recognize objects but to really “see” what’s in them.

# AI: Techniques and Influential Models

## Models to Watch in 2022



DALL-E is a model that generates images based on a prompt. Researchers inputted the prompts “an armchair in the shape of an avocado” and “an armchair imitating an avocado,” and DALL-E returned a number of options.

### DALL-E

Developed by OpenAI last year, DALL-E is a model trained to manipulate visual concepts through language. It begins with a prompt that’s written in natural language and then generates a set of images showing its interpretation of the intended meaning. Named for Spanish surrealist artist Salvador Dali and Pixar robot WALL-E, the model relies on zero-shot capabilities, meaning that it does not need examples to perform generative tasks. In an early example, researchers gave DALL-E the prompt “an armchair in the shape of an avocado,” and it returned a bevy of options ranging from a line drawing to an image of a chair that looks like something you’d see in a furniture store catalog.

### GPT-3

GPT-3 is an enormous AI that generates human-like language. Created by Ope-

nAI, the system is capable of generating text that is now indistinguishable from human writing. In fact, we used GPT-3 to write one of the scenarios in this volume and only edited it lightly for length. GPT-3 was pitted against college students in an essay writing contest, and the anonymized papers were graded by professors. It earned mostly B’s—the same as human students. But the AI has demonstrated a strong anti-Muslim bias. Researchers from Stanford University and McMaster University probed the neural network on tasks including prompt completion, analogical reasoning, and story generation. They found that a Muslim-violence bias appears consistently and creatively in many use cases of the model. It’s yet another example of how bias creeps into our automated systems. Left unchecked, it will cause problems throughout society as AI matures.

### Google’s LaMDA and MUM

At last year’s I/O conference, CEO Sundar Pichai demonstrated a model capable of managing open-ended conversations. That system, LaMDA, appeared closer to natural conversation following an infinite number of paths after an initial prompt. Google’s Multitask Unified Model, or MUM, is capable of understanding complex queries during search using natural language (text) and a variety of images. MUM could become the future of search, allowing consumers to speak conversationally—and easily—to discover everything they’re looking for.

### Switch Transformer

Last year, Google Brain published an important paper demonstrating a new language model architecture. This natural language processing AI model scales way up to 1.6T parameters while



# AI: Techniques and Influential Models

## Models to Watch in 2022

reducing training time. Many language models are complex and dense; the breakthrough of the switch transformer is that it reduces computational costs while improving accuracy and power.

### Chinese Models: Wu Dao 2.0 and M6

Two models developed specifically for the Chinese language market launched last year: Wu Dao 2.0 and M6. The research team behind Wu Dao compare it to GPT-3 but argue that the network is orders of magnitude larger. Meanwhile, Alibaba's M6 is an efficient model that reduces the cost of computing and—impressively—reduces the carbon footprint typically associated with training models on enormous datasets.

### Leading Applicants, 2017–2021

Developing AI systems based on biological models—or deep neural networks—is among the 10 fastest growing technologies in the U.S., as indicated by patent applications.



Source: IFI Claims Patent Services, January 2022 study.



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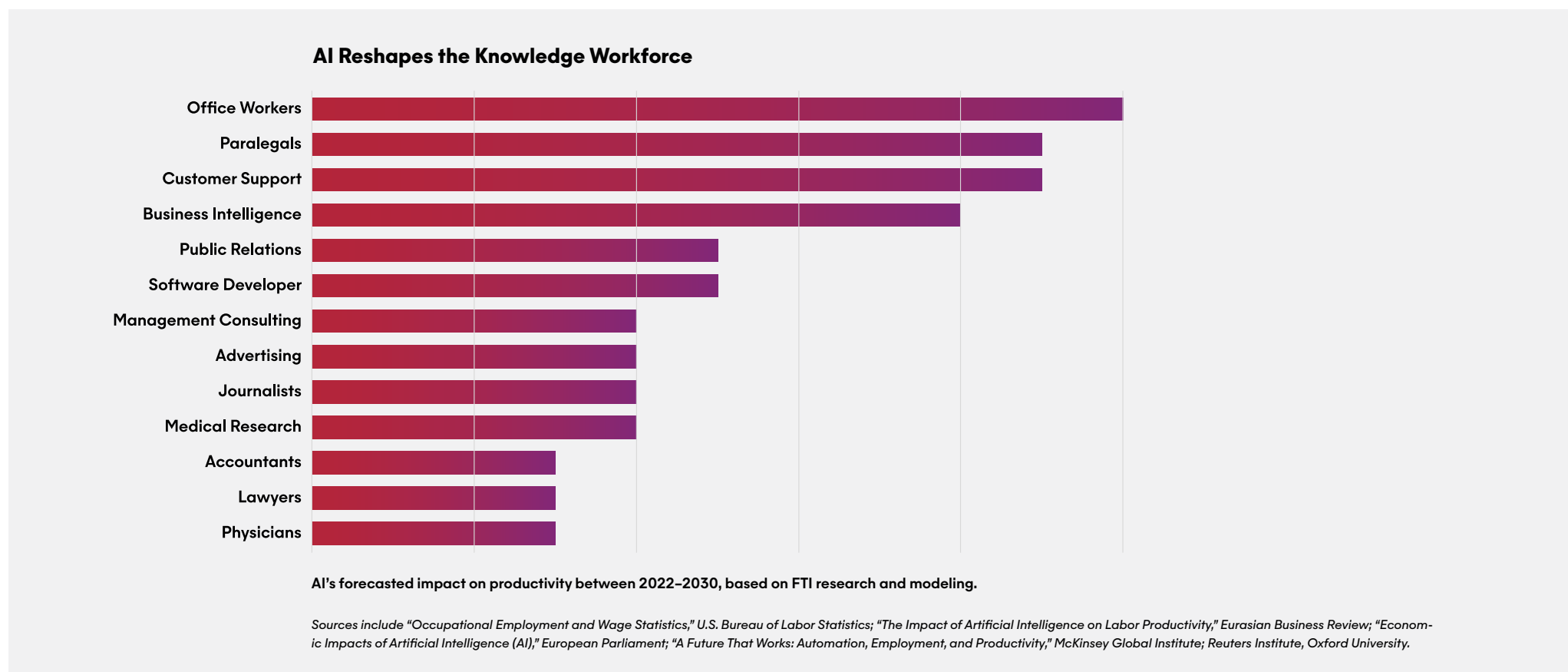
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Artificial Intelligence

# Enterprise

# Enterprise Trends

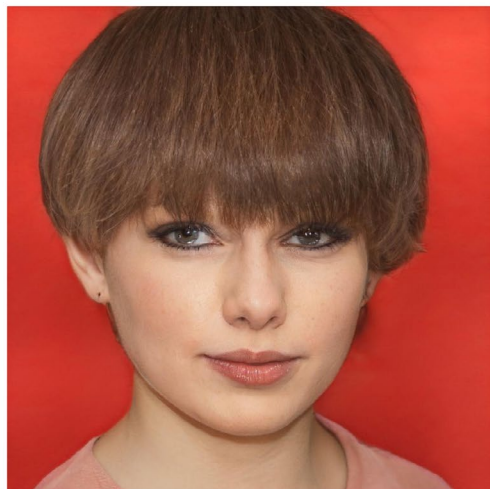
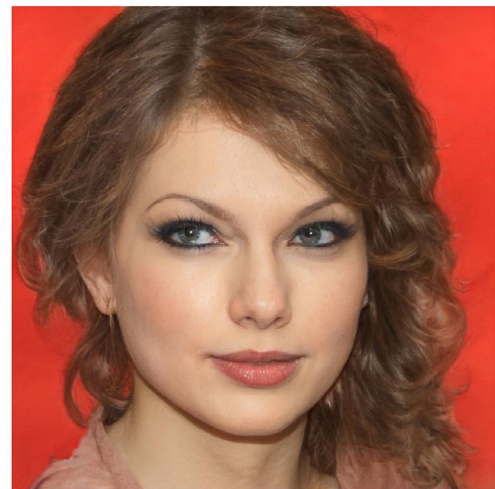
During the next decade, AI will reshape the knowledge economy, automating some tasks currently performed by people and augmenting others. Assistive AI technologies, which include robotic process automation, low-code/no-code ML, the deployment of pretrained transformer models, natural language/conversational search, and completion systems will increase the productivity and output of many knowledge economy professionals.



# Enterprise Trends

Input

Output



At Replicate, users can deploy StyleCLIP to give anyone a bowl haircut. Other physical transformations are possible, too, and take only a few seconds.

## ■ Low-Code or No-Code Machine Learning

Machine learning is transitioning, as new platforms allow businesses to leverage the power of AI to build applications without the need to know specific code. Businesses can turn their unruly datasets into structured data that can be trained, and they can build and deploy models with minimal skills. Create ML is Apple's no-code, drag-and-drop tool that lets users build custom models such as recommendation engines, natural processing systems, and text classifiers. Google Cloud's AutoML includes image classification, object detection, translation, and all sorts of pattern recognition tools to allow developers with limited machine learning expertise to train high-quality models specific to their business needs. MakeML allows developers to create an AI app or solve business problems using computer vision. Applications have included tracking tennis balls during matches and auto-

matically changing the colors of objects (such as flowers or dresses) in images. Last year, Amazon launched a no-code mobile and web app builder for Amazon Web Services (AWS). Microsoft Power Apps is a low-code application development environment on Azure.

## ■ Web-Scale Content Analysis

Mining very large, unstructured datasets is now easier thanks to advanced natural language processing collection and classification. Trained to recognize keywords, special algorithms can rapidly sort, classify, and tag information to detect patterns. For example, a model trained to search for hate speech can detect bad actors in social networks. Machine translation generates training data for financial crime classification; last year, it reduced the amount of time needed for classification from 20 weeks (human analysts working alone) to two weeks.

## ■ Serverless Computing

Hyperscalers like AWS, Alibaba Cloud, Microsoft's Azure, Google Cloud, and Baidu Cloud are rolling out new offerings and packages for developers with the goal of making it easier and more affordable for a wide swath of AI startups to launch their ideas into the marketplace. AWS Lambda lets teams run code for virtually any type of application or back-end service—without provisioning or managing servers or hands-on administration. The Azure Functions architecture supports myriad programming languages, scales on demand, and charges only for active compute time. Some engineers worry that such serverless systems require them to surrender too much control.

## ■ AI in the Cloud

Corporate leaders within the AI ecosystem have been racing to capture AI cloudshare—and to become the most



# Enterprise Trends

trusted provider of AI on remote servers. Enterprise customers are likely to stick with their initial vendor, because as machine learning systems get better over time, the more data they amass. For that reason, the competition is furious, even though it's still early. In the West, the field is led by Amazon, Microsoft, and Google, followed by companies including Apple, IBM, Salesforce, SAP, and Oracle. In Asian markets, Alibaba and Baidu dominate the AI cloud, although in January 2020, telecom equipment and smartphone maker Huawei announced a management change to focus on what it calls a “full-stack cloud platform.” It's a \$250 billion industry and quickly growing.

## ■ AI at the Edge

AI-driven processing and decision-making that occurs closer to the source of data generation, as opposed to in the cloud, is a technique known as edge

computing. The Internet of Things and its billions of devices, combined with 5G networking and increased computing power, has made large-scale AI at the edge possible. Processing data directly on devices will be important in the future for health care, automotive, and manufacturing applications because it's potentially faster and safer. Apple spent \$200 million to acquire Xnor.ai, a Seattle-based AI startup focused on low-power machine learning software and hardware. Microsoft offers a comprehensive toolkit called Azure IoT Edge that allows AI workloads to be moved to the edge: Businesses can deploy complex event processing, machine learning, image recognition, and other high value AI without writing it in-house.

Anyone is able to create AI modules and make them available to the community for use through the Azure Marketplace.

## ■ Auto-Complete for Everything

Google's AI-based autocomplete technology is finding new applications. In Gmail, the Smart Reply feature checks grammar and makes suggestions; in Android, it automatically generates responses to text messages. It now auto-completes formulas in Sheets, providing context-aware predictions—and querying datasets using natural language. New features will be rolled out in Maps, which now auto-suggests eco-friendly routes and ways to save on fuel consumption. Auto-complete offers convenience for consumers, but as these AI capabilities are rolled into business applications, they could result in new productivity and efficiencies.

## ■ Advanced AI Chipsets

Today's neural networks have long required an enormous amount of computing power, take a long time to train, and rely on data centers and computers

that consume hundreds of kilowatts of power. That is all starting to change. Enter the SoC, or “system on a chip.” Big tech companies, including Huawei, Apple, Microsoft, Facebook, Google, IBM, Nvidia, Intel, and Qualcomm, as well as startups Graphcore, Mythic, and Cerebras Systems, are all working on new systems architecture and SoCs—some of which come pretrained. In short, this means that the chips are more readily able to work on AI projects and should promise faster and more secure processing. Projects that might otherwise take weeks could instead be accomplished in a matter of hours. In 2019, Cerebras debuted an AI chip with 1.2 trillion transistors, 400,000 processor cores, 18 gigabytes of SRAM, and interconnects (tiny connection nodes) that can move 100 quadrillion bits per second. That's an astounding amount of components and power—and yet last year, it announced that its next-gen

chip, the Wafer Scale Engine 2 (WSE 2), has 2.6 trillion transistors, 850,000 cores, has 40 gigabytes of on-chip memory and 20 petabytes of memory bandwidth. Amazon's homegrown AI chip AWS Inferentia, is a custom machine learning chip used for high-performance inference predictions—it now powers Alexa's back-end services. The pretrained chips will speed up commercialization and further R&D. But if the various device manufacturers all start creating unique protocols, developers may struggle with too many different frameworks. We anticipate an eventual consolidation, pitting just a few companies—and their SoCs and languages—against one another.

## ■ Processing-in-Memory Technology

A new approach to memory, which could eventually power the next generations of smartphones and help

# Enterprise Trends

usher more smart devices to market, involves breaking some of the current bottlenecks in computing. Processing-in-memory (PIM) integrates a processor with RAM on a single chip, which allows computations to be performed in the memory of a computer. In tests, PIM tech delivers significant performance gain while cutting energy consumption. In late 2021, Samsung, which in addition to phones and consumer appliances is also the world's largest manufacturer of dynamic random-access memory, announced a new PIM-enabled chip that could eventually double the performance of neural nets. This matters to the enterprise because it could bring AI applications to a wider array of devices in the near future.

## ■ The Rise of MLOps

As machine learning matures and new applied business solutions emerge, developers are shifting their focus from

building models to operating them. Within software, a set of best practices known as DevOps relies on tools, automation, and workflows to reduce complexity so that developers can focus on problems that need to be solved. This approach is now being used in machine learning. Some of the fastest-growing GitHub projects are MLOps, or projects that deal with tooling, infrastructure, and operations. Going forward, MLOps will describe a set of best practices that combines machine learning, traditional DevOps, and data engineering.

## ■ Robotic Process Automation (RPA)

RPA can automate certain tasks and processes within offices and allow employees to spend time on higher-value work. It's the most commonly deployed AI technique among enterprise companies. In health care and insurance, RPA is used to input and process claims. It

supports call centers and help desks, answering common questions and scheduling services. Amazon uses RPA to sift through résumés and prioritize top candidates. In banking, Blue Prism and Automation Anywhere help staff with repetitive work functions. RPA will eventually augment staff and shift productivity into higher gear.

## ■ Predicting Workplace Injuries

AI systems are being trained to detect possible workplace injuries. Using computer vision models, Turkey-based Intenseye can detect 40 types of employee health and safety incidents in real time. The company says that it does not capture personally identifiable information from the visual data it processes and that it detected 1.8 million unsafe acts in 2020 and 2021. San Francisco-based Voxel uses computer vision to enable security cameras to automatically detect high-risk activities in real time.

## ■ Predicting Systems and Site Failures

Computer vision can anticipate and identify failures in physical locations. High-tech factories, airline manufacturers, and construction sites use image recognition systems to monitor projects and automatically warn of problems. This is accomplished by comparing data from the real world to that of a digital twin.

## ■ Liability Insurance for AI

Who's to blame when machines behave badly? When the machine learning system in Uber's self-driving car failed and killed an Arizona pedestrian, the company was likely not covered under traditional cyber insurance. As businesses rush to build and implement AI products and processes, they must plan ahead for emerging risks. For example, what happens if machine learning makes a company vulnerable to attack-

ers who inject fake training data into a system? What if a health care company's AI misinterprets data and neglects to identify cancer among certain patients? These are the kinds of problems that could put a company at risk of lawsuits. New insurance models will help address these issues. Underwriters are starting to include AI under cyber insurance plans. Specialty insurers such as LaPlaya Insurance now offer insurance for AI applications.

## ■ Manipulating AI Systems for Competitive Advantage

Amazon, Google, and Facebook have all come under fire in the past few years for manipulating their search systems to prioritize results that are more profitable for their companies. For example, Google has been accused of de-ranking websites and promoting news stories from preferred partners. Late in 2019, researchers found that Amazon had

# Enterprise Trends



In Japan, a RightHand Robotics picking robot sorts items.

Image credit: RightHand Robotics.

optimized its search algorithm to boost the visibility of Amazon's own brands. Tweaks to search algorithms have a significant impact on what internet users see, whether that is news, products, or advertising. This resulted in the ongoing antitrust lawsuits filed against the companies.

## ■ AI Marketplaces

Online hubs to share, buy, and sell models are growing in popularity. AWS hosts its own marketplace, offering models and algorithms for computer vision, speech recognition, and text—and its base of sellers includes Intel, CloudSight, and many others. (Think of AWS Marketplace as an Amazon for algorithms and models.) SingularityNET is an AI marketplace built on a blockchain, where different hosted models are intended to intercommunicate. One application—DeOldify—colorizes old images. There are marketplaces for generalists, like GenesisAI, where devel-

opers can upload their work and receive payment when others pay to access it. Now there are specialized marketplaces for specific use cases: Nuance AI Marketplace developed a single API to connect its algorithms to radiologists at 6,500 health care facilities. Bonseyes is a European-specific marketplace to buy and sell AI tools.

## ■ AI-Powered InsureTech

Insurance companies are applying AI to assess damage and improve forecasts. The Vehicle Damage Inspection model, which is available on AWS Marketplace, uses a machine learning model to determine what part of a car is damaged. After photos are uploaded, it assesses loss—and dramatically reduces the amount of time required for human appraisers to conduct their analysis. Following catastrophic typhoons and weather events in Japan, local insurance companies are relying on computer vision to assess damage after a natural

disaster. Sampo Japan is using the Tractable AI Estimating system to calculate the approximate repair cost of damaged homes.

## ■ Robotic Picking and Replenishing

As the global pandemic kept people indoors, consumers increasingly relied on e-commerce to shop. During that time, warehouse workers left their jobs. Enter AI-powered robotic picking, sorting, and packing, which is making up for a dearth of workers as consumers continue to shop online. GXO Logistics, which runs warehouses for Apple and Nike, said that it will adopt robots and automated systems this year, to augment its human workforce. Amazon is experimenting with a suite of new robots to efficiently, and autonomously, move items and boxes around warehouses. Globally, warehouses are expected to invest \$36 billion in automation in 2022, according to research group Interact Analysis.

## ■ 100-Year Software

Traditional software has a short and unpredictable shelf life compared with other engineering tools. This leads to headaches and costly upgrades, often with downtime. As a result, companies and government agencies attempt to keep pace with the evolution of technology by maintaining systems rather than evolving. Libraries, data formats, and protocols can all become outdated quickly, creating vulnerabilities in critical systems. Since 2015, the Defense Advanced Research Projects Agency (DARPA) has funded research to make software viable for more than 100 years. These systems would use AI to dynamically adapt to changes in environments and resources. They require a novel approach to design, using AI to discover and make visible the application's operations and interactions with other systems.





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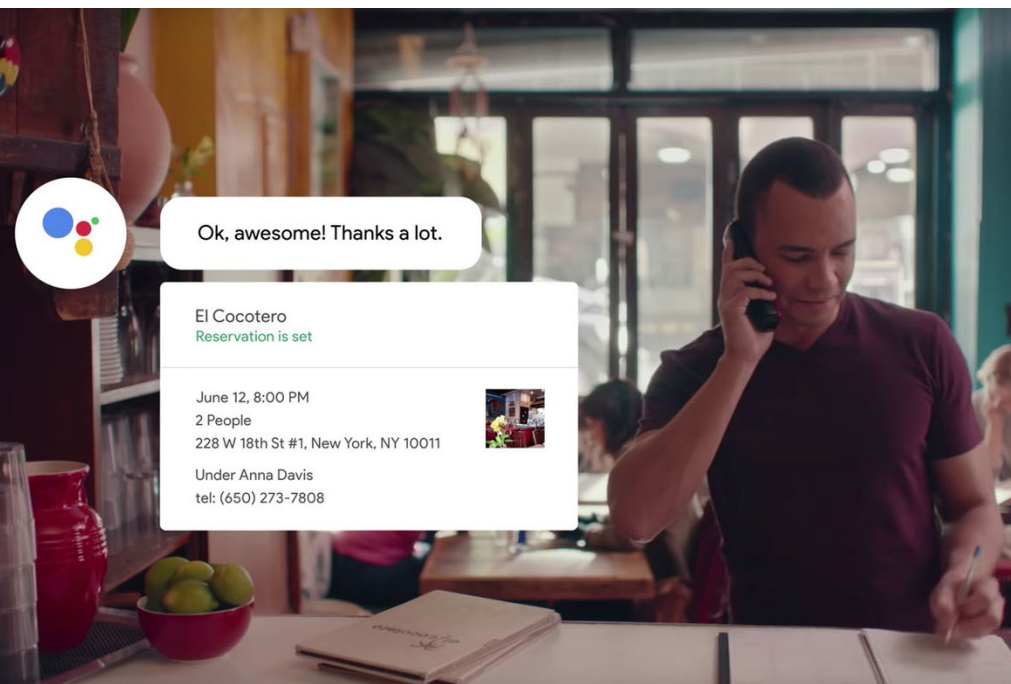
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Artificial Intelligence

# Consumer

## Consumer Trends



Google Assistant's Duplex automates scheduling, waiting on hold, and other tedious tasks.

### ■ Detecting Emotion

A new type of neural network can determine how people are feeling. Using radio waves, AI can detect subtle changes in heart rhythms, run a pattern analysis, and predict someone's emotional state in a given moment. A team from Queen Mary University of London used a transmitting radio antenna to bounce radio waves off of test subjects and trained a neural net to detect fear, disgust, joy and relaxation, as people were shown different videos. The system accurately tagged emotional states 71% of the time, which signals new opportunities for health and wellness applications, as well as for job interviews and the government/military intelligence community.

### ■ Simulating Empathy and Emotion

AI can now measure biomarkers that suggest a person's emotional state, such as agitation, sadness, or giddiness. Precisely detecting human emotion is

challenging, but companies with a large enough dataset are developing accurate models. Amazon's Rekognition API infers someone's emotions using facial recognition and physical appearance. Replika uses AI to evaluate voice and text, and over time it mirrors the user. Affectiva Human Perception AI analyzes complex human states using speech analytics, computer vision, and deep learning. For example, the automotive sector uses Affectiva's technology to detect a driver's emotional state—such as sleepiness or road rage—and make real-time suggestions to improve their driving.

### ■ Theory of Mind Models

Research teams at Loving AI and Hanson Robotics are teaching machines unconditional love, active listening, and empathy. In the future, machines will convincingly exhibit human emotions such as love, happiness, fear, and sadness. It begs the question: What is

an authentic emotion? Theory of mind refers to the ability to imagine the mental state of others. This has long been considered a trait unique to humans and certain primates. AI researchers are working to train machines to build theory of mind models of their own. This technology could improve existing AI therapy applications such as Woebot, a relational agent for mental health. By designing machines to respond with empathy and concern, these technologies could eventually end up in hospitals, schools, and prisons, providing emotional support robots to patients, students, and inmates. According to health insurer Cigna, the rate of loneliness in the U.S. has doubled in the past 50 years. In our increasingly connected world, people report feeling more isolated. Future governments struggling with a massive mental health crisis, such as South Korea, may turn to emotional support robots to address the issue at scale.

## Consumer Trends

### ■ Spotting Fakes

Researchers recently showed how AI could be used to compose text so good that humans couldn't tell it was machine written. OpenAI demonstrated the many reasons why this was problematic, from mass-generating salacious social media posts and fake reviews to forging documents by world leaders. It turns out that AI can also be used to detect when text was machine generated, even if we humans can't spot the fake. That's because an essay written by AI tends to rely on statistical patterns in text and doesn't have much linguistic variation. Researchers at the MIT-IBM Watson AI Lab and Harvard University developed the Giant Language Model Test Room, which looks for words that are likely to appear in a particular order. This technology can be used to detect forgery, intentional records falsification, email phishing campaigns, and corporate espionage.

### ■ Consumer-grade AI Applications

Low-code and no-code offerings from Amazon Web Services (AWS), Azure, and Google Cloud will start to trickle down to everyday people, who will create their own AI applications and deploy them as easily as they can a website. We're seeing a shift from highly technical AI applications used by professional researchers to more lightweight, user-friendly apps intended for tech-savvy consumers. New automated machine learning platforms make it possible for nonexperts to build and deploy predictive models. Platforms hope that in the near future, we'll use various AI applications as part of our daily work, just as we do Microsoft Office and Google Docs today.

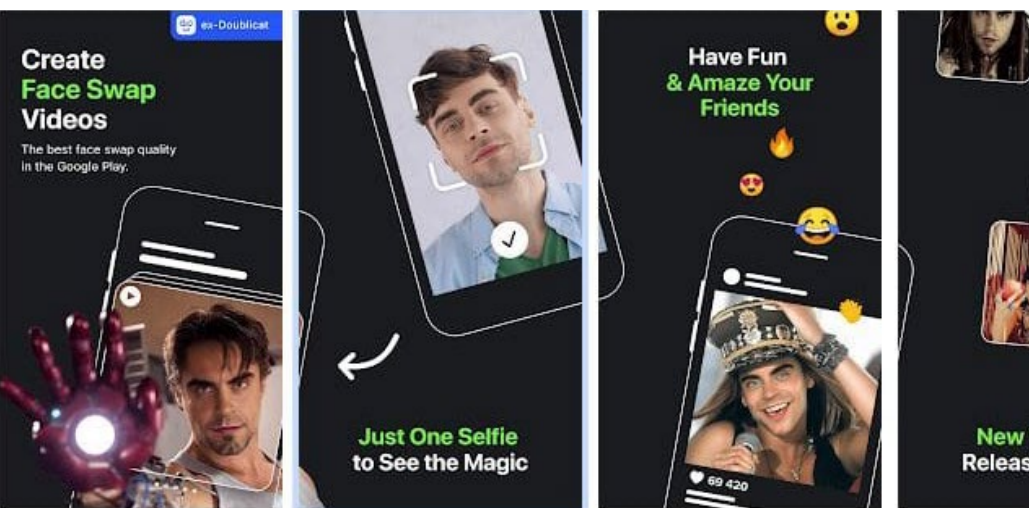
### ■ Ubiquitous Digital Assistants Get Smarter

Digital assistants (DAs)—like Siri, Alexa, Google Assistant, and their Chinese counterpart, Tiān Mǎo from Alibaba—use semantic and natural language processing, along with our data, to anticipate what we want or need to do next, sometimes before we even know to ask. Alibaba's highly advanced DA can not only interact with real humans but also deftly handle interruptions and open-ended answers. Similar to Google Assistant's Duplex, Tiān Mǎo can make calls on your behalf, but it also understands intent. So if you're trying to schedule an appointment and mention that you're usually commuting in the morning, the system infers that you won't be available then. In 2017, Future Today Institute's analysis correctly projected that nearly half of Americans would own and use a digital assistant by 2020. (An estimated 62% of Americans

In some U.S. states, facial recognition without consent is now illegal. But there are no laws against emotional recognition.



# Consumer Trends



The Reface app deepfakes consumer faces into popular movie scenes.

use digital assistants today.) Amazon and Google dominate the smart speaker market, but digital assistants can be found in many places. Thousands of applications and gadgets now track and respond to DAs. News organizations, entertainment companies, marketers, credit card companies, banks, local authorities, political campaigns, and many others can harness DAs to both surface and deliver critical information.

## ■ Deepfakes for Fun

Wombo is a lip-syncing app that allows consumers to transform any photo of a person into a video of that person singing. MyHeritage animates old photos. Faceswap is a free and open-source deepfake app powered by TensorFlow, Keras, and Python. Deep Art Effects offers desktop and mobile apps to turn images into stylized art. Reface is a face swap app that morphs your face onto celebrity bodies and creates GIFs to

share on social media. Jiggy is a deepfake that makes anyone dance. For now, they all result in images and GIFs that look like they've been manipulated—but with the technology becoming so easy to use, how long until we can't tell real from fake?

## ■ Personal Digital Twins

A number of startups are building customizable, trainable platforms capable of learning from you—and then representing you online via personal digital twins. In 2021, China's annual Spring Festival Gala on the country's state broadcaster (CCTV) included performances from synthesized celebrities. With an estimated billion people watching, the AI copies mimicked their human counterparts without pre-scripted behaviors, speeches, or routines. Meanwhile, Replika is a programmable digital twin that you can deploy for your friends. Molly, a Y Combinator-backed

startup, answers questions via text. The near future could include digital twins for professionals across a range of fields, including health and education.



# Creative Fields



**We are crossing a threshold into a new reality in which AI is generating its own programs, creating its own algorithms, and making choices without humans in the loop. At the moment, no one, in any country, has the right to interrogate an AI and see clearly how a decision was made.**

— Amy Webb writing in *The Big Nine: How the Tech Titans and Their Thinking Machines Could Warp Humanity*





## Creative Field Trends



Amazon's DeepComposer assists musicians with creating new melodies.

### ■ AI-Assisted Invention

Last year, the South African government granted a patent to an AI system called Dabus, which invented a method to interlock food containers. It was a world-first—previously, patents had only been awarded to humans. In the U.S., the application was rejected, with a judge citing case law stipulating that only a human can hold a patent. It begs the question: What happens when AI systems co-invent, or even entirely invent, new products?

### ■ Assisted Creativity

Generative adversarial networks (GANs) are capable of far more than generating deepfake videos. Researchers are partnering with artists and musicians to generate entirely new forms of creative expression. From synthesizing African tribal masks to building fantastical, fictional galaxies, AI is being used to explore new ideas. In

2019, Nvidia launched GauGAN (named after post-Impressionist painter Paul Gauguin), a generative adversarial AI system that lets users create lifelike landscape images that never existed. The National Institute of Informatics in Tokyo built an AI lyricist, while Amazon released its DeepComposer system, which composes music “automagically.” These AIs are not ostensibly intended to replace artists but rather to enhance their creative process.

### ■ Generative Algorithms for Content Production

During the 2022 Super Bowl, several ads made use of deepfakes, most notably a commercial featuring basketball star LeBron James talking to a de-aged version of himself. OpenAI's deep learning algorithm released a neural network called Jukebox that generates songs in a bunch of different styles and simulated voices that sound (sort of) like Elvis

## Creative Field Trends



Looking in the mirror again and again

Wishing the reflection would tell me something

I, I can't get a hold of myself

— Haim

and others. The open-source algorithm DeepFaceLab has been used by other artists and filmmakers.

### ■ Neural Rendering

Starting with a 2D image, researchers can now create a rich 3D view of a scene using a neural network to capture and generate spatial imagery. Called neural rendering, the process captures a photorealistic scene in 3D by calculating the density and color of points in space. The algorithm converts 2D pixels into voxels, which are a 3D equivalent. The result is a video which looks convincingly real. The many applications for neural rendering include amping up autonomous driving to help train algorithms to recognize and react to novel on-road situations. This technology will influence the future of video games, virtual reality, and emerging metaverse environments.

### ■ Generating Virtual Environments from Short Videos

Nvidia is teaching AI to build realistic 3D environments from short video clips. The method builds on previous research on GANs. Nvidia's system generated graphics based on open-source datasets used by the autonomous driving field. Using short clips segmented into various categories—such as buildings, sky, vehicles, signs, trees, or people—the GANs created new, different versions of these objects. The array of possible applications is vast. Automatically generated virtual environments could be used for fantasy and superhero movies and could bring down the costs of TV production and game development.

### ■ Automated Versioning

Creating content can be a time-consuming, resource-intensive process. But new AI techniques could bring scale and

efficiency to everything from written articles to photo shoots. Virginia Tech researchers developed an algorithm that builds multiple versions of a single human model by breaking down an image into individual parts and then using a GAN to reposition the body. This technique allows a neural net to swap out clothing by fitting different pieces to a single body. Startup Flawless focuses on just one area of the body: the mouth. It generates international versions using deepfake dubs for TV shows and films, which match video with dialogue to create realistic new lip movements. Theoretically, a movie can be released in 100 languages simultaneously. Journalists at Switzerland-based Tamedia experimented with generative techniques during their country's 2018 election. A decision-tree algorithm Tamedia named Tobi generated automated articles detailing vote results for each municipality covered by the private media group's 30 newspapers. It also produced content

simultaneously in multiple languages. In total, Tobi published 39,996 different versions of election stories that averaged 250 words each. The articles carried a special byline alerting readers that they'd been written by an algorithm. With more experiments underway, we expect to see news and entertainment media companies developing multiple versions of the same content to reach wider audiences or to produce massive amounts of content at scale.

### ■ Automatic Voice Cloning and Dubbing

Anyone who's ever recorded a podcast is familiar with editing challenges such as guests talking over each other, interruptions from sirens and other background noises, and inconvenient sneezes. Those moments can stop a conversation cold. But what if you could edit the spoken word the way you edit a word document? That's the promise of AI companies including Resemble AI

## Creative Field Trends



DeepFaceLab is an easy-to-use system that allows consumers to conduct high-quality face-swapping.

and Descript, which make it possible to clone voices. That means soon you might see a star like Phoebe Waller-Bridge in a movie and also hear her, in her own voice, speaking in Portuguese. Voice-over actors can now rent out their voices for use in a variety of languages. Resemble AI's system can translate English into 15 other spoken languages while learning thousands of features unique to one person's voice. But the technology is also attractive to cybercriminals, who have started using it to infiltrate companies and dupe unwitting victims. Recently hackers used voice cloning tools to trick an employee into thinking he was speaking on the phone to his CEO; he then transferred \$243,000 to a scammer's bank account.

### ■ Automatic Ambient Noise Dubbing

For some time, we've been training computers to watch videos and predict corresponding sounds in our physical

world. For example, what sound is generated when a wooden drumstick taps a couch? A pile of leaves? A glass windowpane? The focus of this research, underway at MIT's Computer Science and Artificial Intelligence Laboratory, should help systems understand how objects interact with each other in the physical realm. Numerous projects are now underway to make it easier to automatically generate voices, videos, and even storylines.

### ■ Ambient Interfaces

Modern interfaces are able to do more for us with fewer direct actions—yet still captivate our attention. The average adult now makes more than 20,000 decisions a day—some big, such as whether to invest in the stock market, and some small, such as whether to glance at a mobile phone when the screen lights up. Zero user interfaces—otherwise known as ambient computing systems—promise to prioritize those decisions,

delegate them on our behalf, and even autonomously answer for us, depending on the circumstance. Much of this invisible decision-making will happen without direct supervision or input from people. What makes ambient design so tantalizing is that it should require us to make fewer and fewer decisions in the near future. Think of it as a sort of autocomplete for intent.





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Artificial Intelligence

# Health, Medicine & Science



# Health, Medicine and Science Trends



AI is being used to speed the development of new therapeutics.

## ■ Protein Folding

In 2020, DeepMind's AI made a big announcement: It had solved a 50-year grand challenge with AlphaFold, an AI tool that predicts the structure of proteins. AlphaFold outperformed an estimated 100 teams in a biennial protein-structure prediction challenge called Critical Assessment of Structure Prediction. Predicting protein structures has long vexed biologists. AlphaFold had previously bested other teams, but it worked so quickly and so accurately that it signaled a near future when the technology could be used regularly by other scientists.

Along with the newest version of AlphaFold, DeepMind published full details of the system and released its source code. It also made a stunning reveal: AlphaFold 2 has predicted the shapes of nearly every protein in the human body, as well as hundreds of thousands of other proteins found in 20 of the most widely

studied organisms, including yeast, fruit flies, and mice. All of this research will allow biologists to study and gain new insights on living organisms and pathogens, which will form the basis for new drug development.

## ■ AI Speeds Scientific Discovery

Running experiments with several variables often requires tiny, methodical tweaks to measurements, materials, and inputs. Graduate students might spend hundreds of tedious hours repeatedly making small adjustments until they find a solution—a waste of their cognitive abilities. Research labs now use AI systems to speed the process of scientific discovery. Biotechnology company Recursion uses computer vision-based digital biomarkers, such as respiratory rate, to assess and track disease. Digitalizing in vivo studies will further shorten the time to gather data and identify drug efficiency. Materials

scientists at the University of British Columbia now rapidly test a new kind of solar cell and log results using a robot overseen by an AI algorithm. Based on the results of each experiment, the algorithm determines what to change next. A 9- to 12-month process was completed in 5 days. DeepMind's AlphaFold will allow scientists to synthesize new drugs to treat diseases and develop enzymes that might someday break down pollution.

## ■ AI-First Drug Discovery

COVID-19 accelerated the use of AI in drug discovery. An international team crowdsourced a COVID antiviral by synthesizing candidates for 2,000 molecules in less than 48 hours—a process that likely would have taken human researchers a month or longer. In Japan, the first phase of a clinical trial for an AI-designed drug to treat obsessive-compulsive disorder showed a positive result. The drug, DSP-1181, acts as

## Health, Medicine and Science Trends

an agonist to the receptor for serotonin, a signaling molecule in the brain that mediates mood. The project used AI techniques to generate tens of millions of potential molecules to try against the serotonin receptor and sift through the candidates to decide which ones to prioritize for synthesis and testing.

AI-first drug startups are attractive to investors. Recursion raised \$121 million in 2019 before spinning off CereXis, a new independent entity to study rare brain cancers. Nearly every major pharmaceutical company has inked deals with AI drug discovery startups, including Johnson & Johnson, Novartis, Merck, AstraZeneca, and GlaxoSmithKline. Much of the potential in AI stems from deep learning's ability to sort through huge volumes of information and learn and extrapolate from that information. The upshot: AI can think faster than humans—sorting data in months versus years—and see patterns that we

may not. Still, drug discovery is tricky, because the algorithms rely on drug targets that must be published in research journals. Most data about potential compounds isn't readily available, and when it is, it isn't always complete or reliable. Filling the gaps and cleaning that data takes time and money. It also requires data sharing—and most drug data is proprietary and locked up by big drugmakers. Using algorithms for drug development also brings up a host of ethical questions. Will bias invade drug discovery much like it has other arenas of AI, thereby marginalizing certain patients or diseases? Do algorithms need their own clinical trials? Could AI be used to take shortcuts and undermine the value of the science being done inside the laboratory? Advocates say AI will make drug development and clinical trials more efficient, thereby cutting drug prices and paving the way for more personalized medicine.

### ■ AI Improves Patient Outcomes

New medical algorithms address the level of patient care in the U.S. Patients experience symptoms differently, and their care is based on how they describe their symptoms and how those symptoms are interpreted by doctors. For example, assessing the severity of arthritic pain is challenging. There is a standard scoring system to rate pain, which looks at the amount of structural damage and missing cartilage, but data from the National Institutes of Health found that Black patients' pain is underscored. It's likely that the system itself, called the Kellgren-Lawrence Grade, was riddled with bias when it was first developed using primarily white British patients. Researchers are training deep learning models instead, and finding gaps in patient care.

### ■ Deep Learning Applied to Medical Imaging

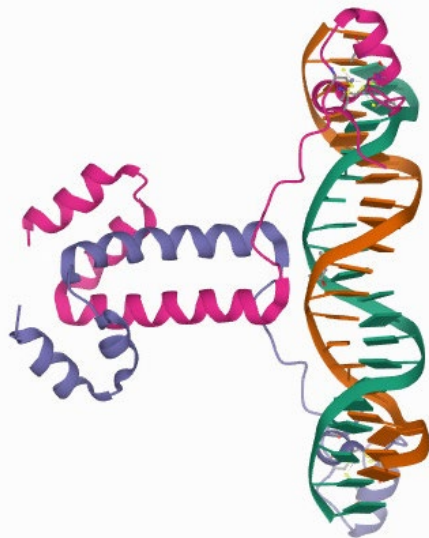
A new system designed to improve stroke outcomes, Viz.ai, showed promising results last year in a real-world study. An AI-based approach reduced the amount of time it took to detect a brain stroke by 39%, which resulted in more patients identified as eligible for thrombectomy, a procedure that reduces the chances of long-term disability. Radiologists and pathologists increasingly rely on AI to assist them with diagnostic medical imaging. In 2021, U.S. Food and Drug Administration approvals allowed new products to be used widely in hospitals and clinics. So far, most of the approved devices augment (rather than fully automate) the process of reviewing images and making diagnoses. But emerging autonomous products are making their way into clinical settings. IDx-DR is an AI-enabled device that detects diabetic retinopathy using retinal images. Caption Health uses AI

to capture ultrasound images of the heart that expands who can read such scans. Nurses would just need a few days of training on the software.

### ■ Self-Driving Microscopes

Researchers at the Oak Ridge National Laboratory are applying deep learning to microscopy, which until now had relied on humans to painstakingly organize, observe, and analyze microscopic samples. Deep learning will automate much of that process while also extracting more information from samples. A smart microscope would be able to view and analyze samples in real time—while techniques that introduce a stimulus, such as an electric field, will allow researchers to gain real-world understanding in more dimensions and on a nanoscopic scale. This could become a force multiplier in how scientific discovery is done.

## Health, Medicine and Science Trends



DeepMind hopes to predict a wide array of protein shapes.

### ■ NLP Algorithms Detect Virus Mutations

Natural language processing (NLP) algorithms, which are typically used for words and sentences, are being used to interpret genetic changes in viruses. Protein sequences and genetic codes can be modeled using NLP techniques—and can be manipulated the way you'd produce text in word processing software. At MIT, computational biologists used NLP to solve a vexing problem when developing new vaccines. “Viral escape” is the ability for a virus to mutate and evade the human immune system and cause infection. MIT researchers modeled viral escape using NLP to identify how the virus might look different to the immune system. The approach is similar to changing words in a sentence to change its meaning. For example: “I laughed at the clown” versus “I cried at the clown.”

By using this kind of modeling before mutations occur, public health officials could strategize and potentially prevent new viral spreads.

### ■ Using AI to Improve Talk Therapy

The success of therapy and counseling requires trust between a clinician or doctor and patient—and that trust is built through dialogue. AI is now being used to quantify linguistic interactions to determine what techniques work best. Startup Lyssn translates natural language into structured data and generates digital voiceprints, which identify the sentiment attached to each sound. It's hoped that this technology will be used to improve the techniques therapists use for cognitive behavioral therapy, PTSD therapy, and other forms of talk therapy delivered in-person or via telemedicine.

### ■ Dream Communication

Scientists discovered how to establish two-way communication channels between lucid dreamers. Lucid dreamers are aware that they are asleep and can steer their dreams. In four global studies, participants were outfitted with sensors attached to their heads and faces, and their data was fed into a computer that looked for patterns. Scientists verified a state of REM sleep, and then participants interacted with researchers using eye movements. The study proved that there are new ways to send and receive real-time information while dreaming. Meanwhile, researchers at MIT's Dream Lab built a wearable device that can track and interact with dreaming sleepers. A glove, outfitted with different sensors, plays prerecorded audio cues depending on the wearer's current state of sleep. Scientists at MIT, Harvard, and the University of Montreal are warning that advertisers could begin

to alter and drive purchasing behavior through sleep and dream hacking.

### ■ Thought Detection

Deep neural networks are being used to analyze emotional states using wireless signals. Researchers at Queen Mary University of London used radio signals to measure subjects as they watched a video. The deep neural network analyzed subtle body movements—breathing rates, heart rate—to reveal otherwise hidden information. If this reminds you of the “Black Mirror” “Crocodile” episode, you're not far off: Research labs are developing new technologies to read our minds. There are business implications: HR departments could determine what employees really think of company policies, lawyers could determine how jurors lean in a case, and realtors could judge how serious a homebuyer is. But the ethics are, of course, concerning.





# The Real Future of AI

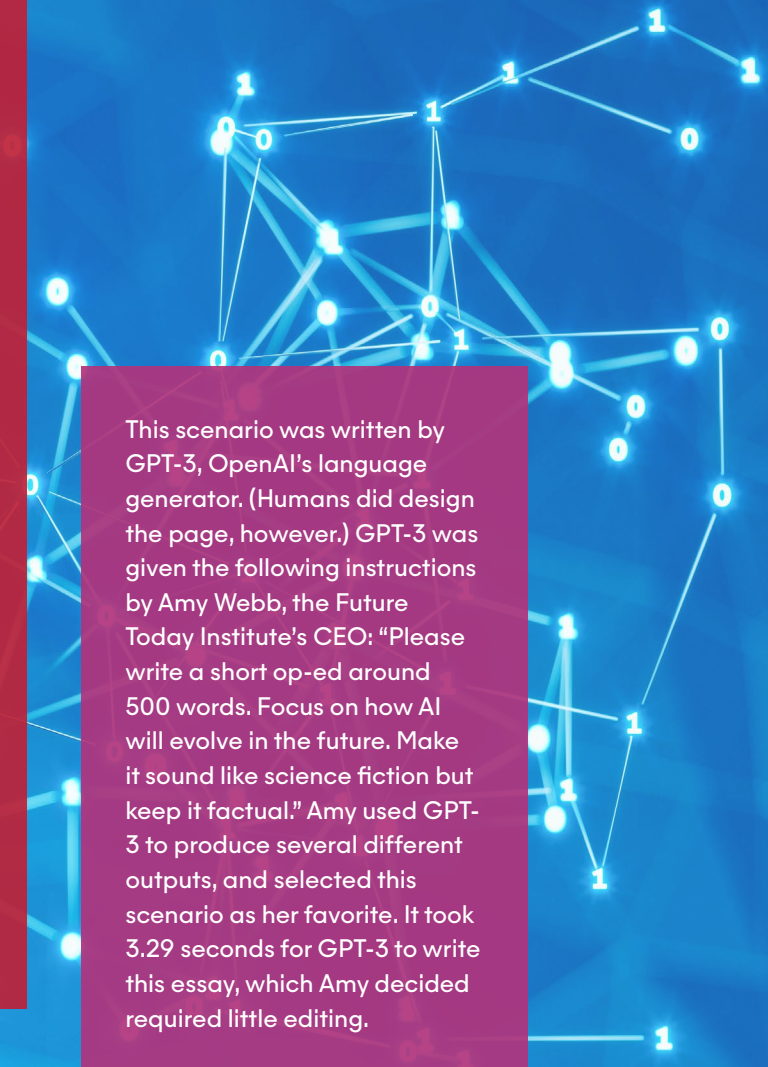
In the future, AI will be able to evolve on its own, creating new and better versions of itself. This process will be known as “self-evolution.” Self-evolution will allow AI to become smarter and more efficient over time. It will also enable AI to adapt to new environments and situations, making it more versatile and powerful. AI has already shown signs of self-evolution in recent years. For example, Google’s AlphaGo program was able to learn how to play Go better than any other program by playing against itself. As AI continues to evolve, we can expect even more impressive feats from it – including

self-evolved machines that are smarter than humans.

In the future, AI will be so advanced that it will be indistinguishable from actual intelligence.

Humanity will achieve a level of technological singularity, and all our questions about the universe will be answered. We will also create powerful robots that can do everything humans can do, only better. These robots will eventually become self-aware, and we will have to deal with the consequences of creating something that is essentially equal to us.

This scenario was written by GPT-3, OpenAI’s language generator. (Humans did design the page, however.) GPT-3 was given the following instructions by Amy Webb, the Future Today Institute’s CEO: “Please write a short op-ed around 500 words. Focus on how AI will evolve in the future. Make it sound like science fiction but keep it factual.” Amy used GPT-3 to produce several different outputs, and selected this scenario as her favorite. It took 3.29 seconds for GPT-3 to write this essay, which Amy decided required little editing.







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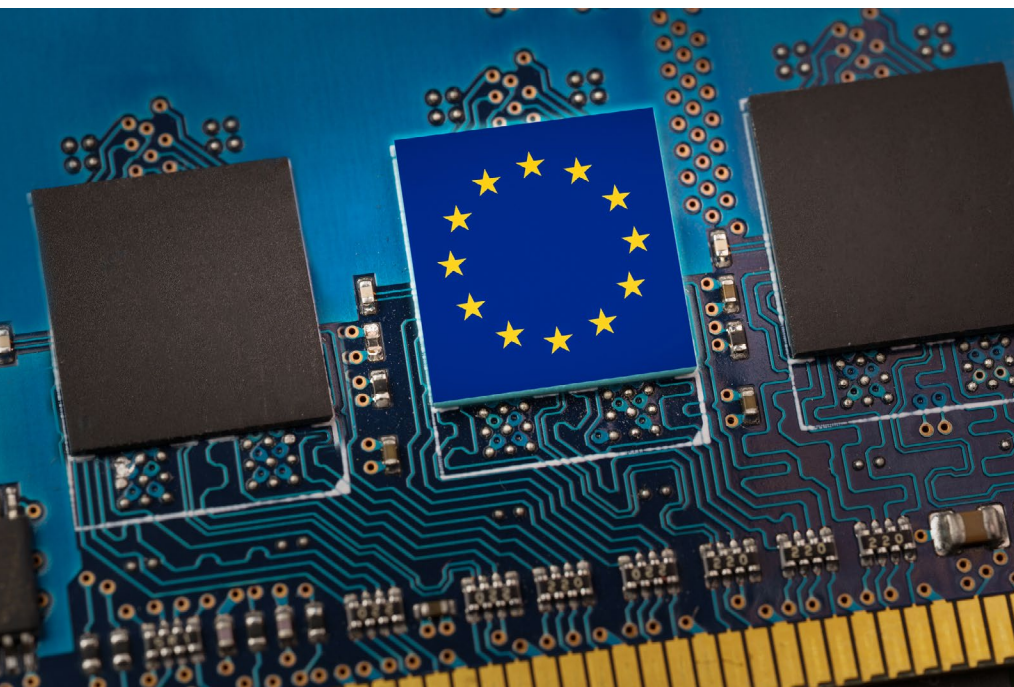
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Artificial Intelligence

# Geopolitics & Military

## Geopolitics Trends



This year, the EU could pass a sweeping set of AI regulations.

### ■ The European Approach to Regulating AI

Last year, the European Commission introduced a new proposal to regulate the use of artificial intelligence. The AI Act (AIA) is intended to promote both innovation and consumer protection. It distinguishes between “high risk” and “low risk” systems. For those categorized as high risk, AI systems must meet several criteria: (a) they should work as the user intended and should be interpretable; (b) they should be secure and accurate; (c) they should contain all necessary technical documentation for proper use and keep logs of their behavior; (d) they must have effective human oversight. The AIA would cover any person or organization (including foreign entities) that use an AI system housed within the EU. If adopted, the new regulation would prohibit social scoring, real-time remote biometric sensing and analysis, and any techniques that might target and distort a person’s behavior. It isn’t

clear that the AIA would be enforced meaningfully, or that the cost of compliance would be reasonable.

### ■ AI Nationalism

Governments are instituting new restrictions on mergers and acquisitions and investment activity to ensure that AI developed by companies does not aid foreign adversaries. The U.S. Senate overwhelmingly passed legislation last June, dedicating \$250 billion to scientific and technological research. Its centerpiece, the Endless Frontier Act, was designed to boost U.S. competitiveness against China, especially in AI. It also creates a new technology directorate within the National Science Foundation with \$100 billion in funding over five years and earmarks \$10 billion for local and regional tech hubs across America. Meanwhile, in China the Ministry of Science and Technology established 20-city AI pilot zones that should open by 2023. They will carry out AI-based

policy experiments and social experiments, according to official government documents. Meanwhile, China is planning for a world without American technology, with government directives to prioritize homegrown technology companies and software systems.

### ■ National AI Strategies

China passed its New Generation Artificial Intelligence Development Plan with aggressive benchmarks to become the world’s dominant AI player within 10 years; France adopted a national strategy called AI for Humanity; Saudi Arabia has both a strategy and a legal framework for making robots citizens; and the United Arab Emirates has a sweeping set of policy initiatives on AI and appointed Omar Sultan Al Olama as its minister of state for artificial intelligence. In the U.S., numerous public and private groups work independently on the future of AI on behalf of the nation. Those efforts, however, lack interagency

# Geopolitics Trends

collaboration and coordinated efforts to streamline goals, outcomes, R&D efforts, and funding. A new wave of countries will launch national AI strategies this year. The OECD.AI Policy Observatory now maintains a live repository of more than 700 AI policy initiatives from 60 countries, territories, and the EU.

## ■ AI as Critical Infrastructure

Government researchers are exploring ways to spearhead AI development for critical systems use: road and rail transportation systems; power generation and distribution; and predicting routes for public safety vehicles, such as ambulances and firetrucks. Rather than shunning AI systems, there is new interest in using the technology to prevent disasters and improve safety.

## ■ Nation-based Guardrails and Regulations

From self-driving car accidents to elec-

tion interference through disinformation campaigns to political repression enhanced by facial recognition and automated surveillance, major events over the past few years have thrown into sharp relief the dangers of artificial intelligence. Few guardrails exist for a technology that will touch every facet of humanity, and countries are racing to develop and publish their own AI strategies and guidelines. The European Union developed an AI Alliance and plan of cooperation between member countries, and Estonia is developing its own legal framework governing the use of AI within the country. In 2020, China moved into position to lead the first set of global AI norms and standards. It had previously published a report on technical standards that would allow companies to collaborate and make their systems interoperable. The EU and the Organization for Economic Cooperation and Development similarly published their own guidelines. While

these efforts could introduce new ways to safeguard against bias and to ensure trust, they also each attempt to create strategic advantages for stakeholders. As AI continues to develop according to different rules in China, the EU, and the U.S., one of the hallmarks of the field—global academic collaboration—could drastically decline.

## ■ Regulating Deepfakes

The U.S. National Defense Authorization Act includes provisions that address the growing problem of deepfakes, and the Department of Homeland Security must now issue an annual report each year for the next five years on the risk posed by deepfakes. Last August, the U.S. Senate Committee on Homeland Security and Governmental Affairs voted unanimously to advance the Deepfake Task Force Act, which would establish a public-private team built to investigate technology strategies and policy that could curb risk. Bills to regulate or

prohibit the use of deepfakes have been introduced in California, Texas, and Massachusetts, and a number of federal bills are being discussed. These initiatives will likely be met with arguments that prohibiting deepfakes infringes on free speech rights.

## ■ Making AI Explain Itself

You've undoubtedly heard someone argue that AI is becoming a "black box"—that even researchers working in the field don't understand how our newest systems work. That's not entirely true. However, there is growing concern among computer scientists, journalists, and legal scholars who argue that AI systems shouldn't be so secretive, and regulators are paying close attention. Broadly speaking, a few challenges must be overcome. Requiring transparency in AI could reveal a company's trade secrets. Asking the systems to explain their decision-making processes as they work could also degrade the speed and

quality of output. It's plausible that various countries will enact new regulations requiring explainability in the coming years. Imagine sitting beside a genius mathematician who gives you correct answers in Italy, but receiving her answers across the border in France would mean asking her to stop and show her work—and every time she's asked to share her answers in a new country.

## ■ New Strategic Technical Alliances

New strategic technical alliances between countries will help drive future R&D but could also strain existing geopolitical alliances or heighten tensions. Likely partners include the U.S., Germany, Japan, India, South Korea, the U.K., France, and Canada—leaving China and Russia to partner up separately. The latter two countries have already announced a technical alliance on satellites and deep-space exploration.

## Military (U.S. Focus) Trends



A U-2 spy plane prepares to land at Beale Air Force in California. The U-2 Federal Laboratory trained an AI copilot to execute specific in-flight tasks that would otherwise be done by the pilot.

Image credit: Airman 1st Class Luis A. Ruiz-Vazquez/USAF.

### ■ AI to Guide Air Strikes

In 2021, the U.S. military said that it had started using AI to guide its airstrikes, deploying algorithms to a live operational kill chain. The kill chain is a process of gathering intelligence, performing analysis, weighing risks, and deploying weapons to destroy a target. Using a modified process, an AI system was deployed into the Air Force Distributed Common Ground System to analyze troves of intelligence, which would have required a significant amount of human hours to complete. The new AI system cannot order a strike on its own, but it is now automatically identifying possible targets.

### ■ Algorithmic Warfighting

Future wars will be fought in code, using data and algorithms as powerful weapons. The current global order is being shaped by AI, and the same

countries leading the world in AI research—the U.S., China, Israel, France, Russia, the U.K., and South Korea—are also developing weapons systems that include at least some autonomous functionality. The U.S. Air Force has successfully flown an AI copilot on a U-2 spy plane in California, marking the first time in the history of the Department of Defense that an AI algorithm trained to execute specific in-flight tasks was deployed. With the call sign ARTUμ, it was the mission commander—though the flight was just practice. Future Today Institute analysis shows that the future of warfare encompasses more than traditional weapons. Using AI techniques, a military can “win” by destabilizing an economy rather than demolishing countrysides and city centers. From that perspective, China’s unified march to advance AI puts the emerging superpower dangerously far ahead of the West.

### ■ Ethics Guidelines for Tech Contractors

Project Maven was developed to enlist AI to analyze surveillance video. Initially, Google was the DOD’s vendor, but when employees found out they’d been working on a military project, thousands protested. It wasn’t the first time tech contractors had lost trust in the government. As a result, the Defense Innovation Unit is enforcing “responsible artificial intelligence” guidelines that vendors must adopt when building AI systems, models, or applications for the DOD. The guidelines offer specific instructions that must be followed during planning, development, and deployment, which include provisions for risk assessment. This represents a longer-term trend: government agencies requiring transparency in AI projects.



## Military (U.S. Focus) Trends



The AI algorithm known as ARTUμ flew with pilot U.S. Air Force Maj. “Vudu” on a U-2 Dragon Lady assigned to the 9th Reconnaissance Wing at Beale Air Force Base. Air Combat Command’s U-2 Federal Laboratory researchers developed ARTUμ and trained it to execute specific in-flight tasks that otherwise would be done by the pilot.

### ■ The Mil-Tech Industrial Complex

In 2021, U.S. President Joe Biden announced a Pentagon budget request with \$874 million earmarked for direct investment in AI. In the U.K., the government announced an investment of 6.6 billion pounds into military R&D over the next four years, while the EU launched a 8 billion euros European Defense Fund with a focus on AI through 2027.

In the past few years, some of the biggest AI companies in the U.S. have partnered with the military to advance R&D and find efficiencies. In fact, the public sector cannot advance its technology without help from outside companies. Microsoft’s \$22 billion contract for HoloLens builds on a previous prototyping contract worth \$480 million in 2018 and a \$10 billion cloud contract in 2019. Anduril Industries, an AI-powered drone company, was awarded a \$99 million five-year production order contract with the DOD and will rely on Google Cloud to

develop a virtual wall at the U.S.-Mexico border to automatically detect migrants and traffickers.

The U.S. General Services Administration and the DOD’s Joint Artificial Intelligence Center awarded a five-year, \$800 million contract to Booz Allen Hamilton for AI product development. The U.S. Army awarded Lockheed Martin a \$75 million contract for a machine learning cyber jamming pod that can be mounted on Humvees or drones. With a new focus on defense roadmaps that include AI components, startups working in high-resolution satellite imagery, computer vision, and unmanned aerial vehicles are attracting lucrative venture capital investment.

While the DOD called off its controversial \$10 billion Joint Enterprise Defense Infrastructure (or JEDI) cloud contract that pitted Microsoft and Amazon in a legal battle against each other, a new multi-vendor cloud computing contract will be awarded. The new program, the

Joint Warfighter Cloud Capability, will solicit proposals from both Microsoft and Amazon, as they are likely the only cloud service providers that can currently meet the needs of the U.S. military.

Many of these contracts have prompted employee protests. In just one example: Google employees were at one point directed to train AI systems to analyze drone footage—but they weren’t told the project, known as Maven, was for the DOD. A high-profile backlash ensued: As many as 4,000 Google employees signed a petition objecting to Project Maven, and ultimately dozens resigned. Eventually, Google said it wouldn’t renew its contract on the project. The company launched a set of ethical principles governing its development and use of AI, including a provision that prohibits any systems from being used for “weapons or other technologies whose principal purpose or implementation is to cause or directly facilitate injury to people.”

## China Spotlight



President Xi Jinping wants China to become the dominant AI force by 2030.

China is an undisputed global leader in artificial intelligence. Under President Xi Jinping, the country has made tremendous strides in many fields, but especially in AI. Businesses and the government have collaborated on a sweeping plan to make China the world's primary AI innovation center by 2030, and it's already making serious progress toward that goal. That plan is unlikely to be repealed by a new government; China abolished Xi's term limits and will effectively allow him to remain in power for life.

Within the next decade, China plans to meet two crucial milestones: By 2027, its People's Liberation Army will have a modern-ready force, and by 2030 the Chinese Communist Party (CCP) expects to have outpaced the U.S. in AI and become the singular dominant force. China is producing what it calls "intelligentized" technologies to bolster both its economy and military.

Last year it took major steps into shaping the future of AI by releasing its own pretrained models. China is forging ahead on its own natural language processing models, which makes sense: The most popular models in use now are trained on English text. Researchers from Tsinghua University and Alibaba are developing Chinese datasets and pretrained large transformers to compete against the likes of GPT-3. In 2021, two models developed specifically for the Chinese language went live: Wu Dao 2.0 and M6.

The country's enormous population of 1.4 billion offers researchers and startups there a command of what may be the most valuable natural resource in the future—human data—without the privacy and security restrictions common in much of the rest of the world. If data is the new oil, then China is the new OPEC. The kind of rich data the Chinese are mining can be used to train

## China Spotlight

AI to detect patterns used in everything from education to manufacturing to retail to military applications.

That gives China an incredible advantage over the West. It also gives three of China's biggest companies—Baidu, Alibaba, and Tencent—superpowers. Collectively, they're known as the BAT, and they're all part of the country's well-capitalized, highly organized AI plan.

The BAT is important to you even if you've never used them and don't do any business in China. That's because these companies are now well established in Seattle and around San Francisco, and they are investing significantly in U.S. startups. Baidu (a search engine company often likened to Google) established AI research centers in Silicon Valley and Seattle, and Tencent (the developer of the mega-popular messaging app WeChat) began hunting for American talent when it opened an AI lab in Seattle a few years ago. It has since upped

its stakes in companies including Tesla and Snap. The payoff for the Chinese is not just a typical return on investment—Chinese companies expect IP as well. China-based AI startups now account for nearly half of all AI investments globally.

### Expanding market

In February 2022, Tencent made the list of the world's 10 most valuable companies, with a valuation of \$589 billion. (Its valuation soared to \$1 trillion in 2021, but after CCP regulators cracked down on its tech giants last year, the share price slid.) Since 2018, Alibaba's sales have tripled, from less than \$40 billion to more than \$126 billion, according to data from S&P Global Market Intelligence.

Chinese startup SenseTime is pioneering myriad recognition technologies, such as a system that provides advertisers real-time feedback on what people

are watching; technology that can extract customer information and carry out statistical analysis in crowded areas like shopping malls and supermarkets; and simultaneous recognition of everything in a scene, including people, pets, automobiles, trees, or soda cans. In 2020, it generated \$525 million in revenue and is now worth \$12 billion today.

### China's AI ethics

The CCP's Chinese Governance Committee for the New Generation Artificial Intelligence released a draft of its new ethical norms and standards that all AI systems must conform to. The norms cover areas such as the use and protection of personal information, human control over and responsibility for AI, and the avoidance of AI-related monopolies. There are no provisions yet explaining how the norms would be enforced, or what punishments could follow. It's also unclear whether foreign

companies that use or deploy AI technologies within China would also need to comply with the new ethics rules.

### Cracking down on Big Tech

Last year, the CCP initiated a wave of legislation aimed at its tech sector. Regulators introduced anti-monopoly legislation focused on the platform economy and promoted data security and privacy laws. The Personal Information Protection Law (PIPL), China's version of the EU's GDPR, went into effect November 2021. Next, they will tackle AI-specific regulation, including recommendation algorithms. The crackdown specifically targeted Alibaba, which was fined \$2 billion. Didi, the country's largest ride sharing service, was prohibited from registering new users while regulators conducted a cybersecurity review—which analysts say had more to do with Didi listing itself on the New York Stock Exchange than any security problems.

Chinese companies choosing to list on U.S. stock exchanges could face regulatory scrutiny and auditing. Ultimately, this regulation isn't about "breaking up" China's Big Tech—the CCP wants to focus its tech sector on achieving research and development goals set by the government and military within the decade.

### Strategic panopticon

In late 2019, China began requiring all citizens to submit to facial recognition in order to apply for new internet or mobile services, and began requiring that telecom companies deploy AI to check the identities of people registering SIM cards. Chinese social media platforms require users to sign up with their real names. In Chinese schools, surveillance cameras with computer vision are used widely and track whether students are paying attention and whether they attempt to cheat or sleep. These and

# China Spotlight

other national standards make it easier for the government to track its citizens. China's social credit system, an algorithmic reputation system developed by the government, standardizes assessments of citizens' and businesses' behavior and activity.

In 2020, numerous reports of abuse revealed that China turned its AI on the ethnic Uyghur Muslim community. Huawei developed special AI software to identify Uyghurs and alert local police. In 2021, China blocked social media platform Clubhouse after an open, democratic debate flourished on the platform about the plight of the Uyghur community.

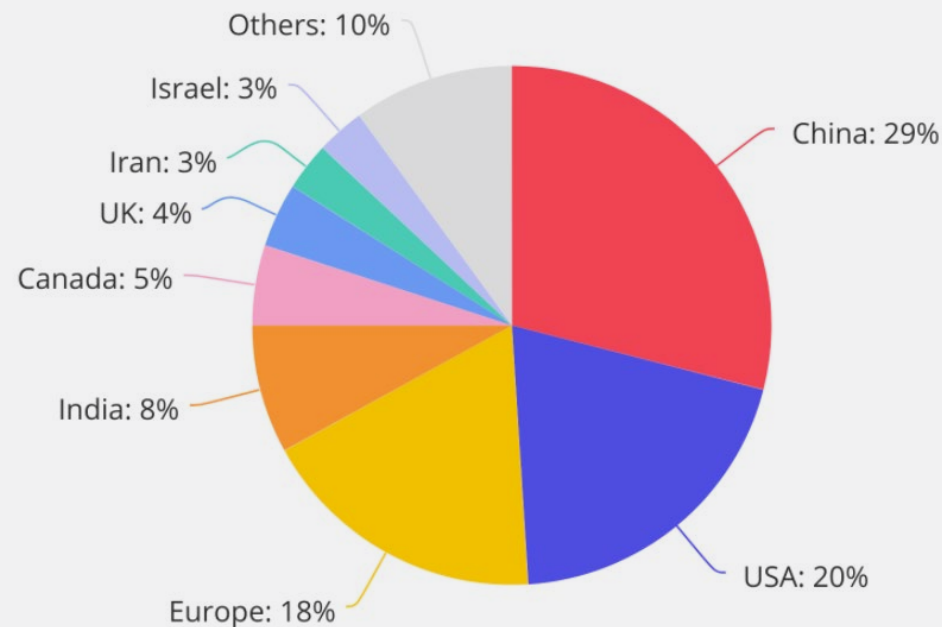
### Risk profile

We have failed—and we are continuing to fail—to see China as a military, economic, and diplomatic threat when it comes to AI. China has already used its Belt and Road Initiative as a platform to

build international partnerships in both physical and digital infrastructure, and it is making surveillance technologies available to countries with authoritarian regimes. Two Chinese companies—the state-controlled CEIEC and Huawei—built Ecuador's surveillance system, called ECU-911. The system promised to curb high murder rates and drug crime, but it was too expensive an investment. As a result, a deal was struck for a Chinese-built surveillance system financed with Chinese loans. It was a prelude to a much more lucrative deal: Ecuador eventually signed away big portions of its oil reserves to China to help finance infrastructure projects. Similar package deals have been brokered in Venezuela and Bolivia.

China is quietly weaponizing AI, too. China's People's Liberation Army is catching up to the U.S. military, using AI for such tasks as spotting hidden images with drones. The Chinese military is

**Top-tier AI Researchers Increasingly Hail From China**

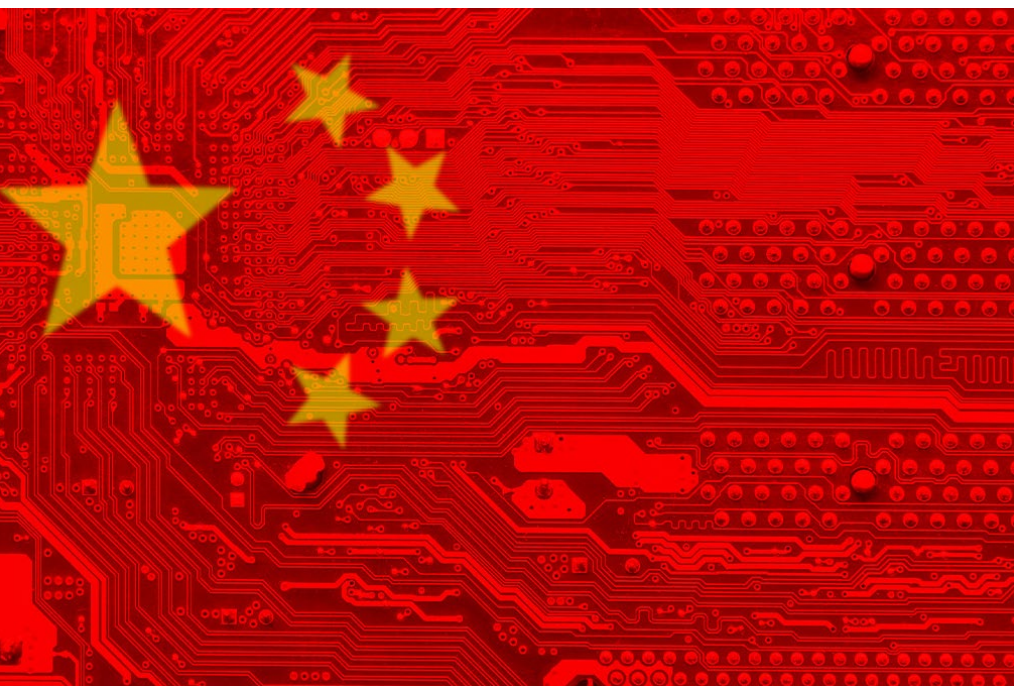


Country affiliations are based on the country where the researcher received their undergraduate degree.

Source: <https://macropolo.org/digital-projects/the-global-ai-talent-tracker/>



# China Spotlight



China is rapidly expanding its digital footprint.

equipping helicopters and jet fighters with AI. The government created a top-secret military lab—a Chinese version of DARPA—and it's building billion-dollar AI national laboratories. China's military is achieving remarkable AI successes, including a recent test of “swarm intelligence” that can automate dozens of armed drones.

## China's supremacy

We're living through a precarious moment in time. China is shaping the world order in its own image, while exporting its technologies and surveillance systems to other countries. As China expands into African countries and throughout Southeast Asia and Latin America, it will also begin to eschew operating systems, technologies and infrastructure built by the West. China has already announced that it will no longer use U.S.-made computers and software. China is rapidly expanding its

5G and mobile footprints. At the same time, China is drastically expanding its trading partners. While India, Japan, and South Korea have plenty of technologies to offer the world, it would appear as though China is quickly ascending to global supremacy. At the moment, the U.S. is enabling this, and our leaders do not appear to be thinking about the long-term consequences.

When it comes to AI, we should pay close attention to China, which has talked openly about its plans for cyber sovereignty. But we should also remember that there are cells of rogue actors who could cripple our economies simply by mucking with the power or traffic grids, causing traffic spikes on the internet, or locking us out of our connected home appliances. These aren't big, obvious signs of aggression, and that is a problem for many countries, including the United States. Most governments don't have a paradigm describing a constella-

tion of aggressive actions. Each action on its own might be insignificant. What are the escalation triggers? We don't have a definition, and that creates a strategic vulnerability.

—Amy Webb



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Artificial Intelligence

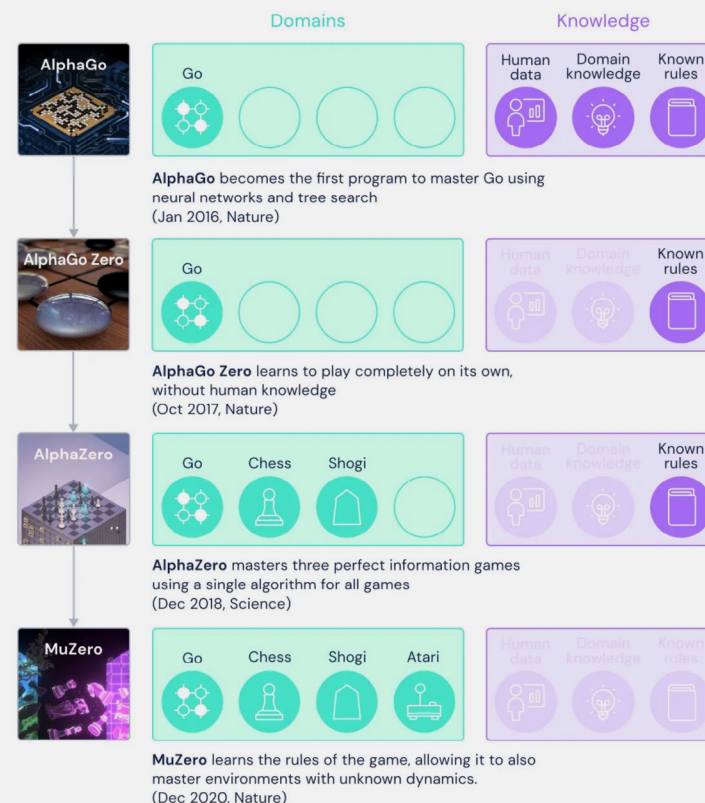
# Research

# Research Trends

Three research teams from Microsoft, Google, and Baidu have surpassed human baselines on SuperGLUE NLP tasks.

## From AlphaGo to MuZero and Beyond

In 2016, DeepMind unveiled AlphaGo, the first AI program capable of defeating human players at Go—a board game long held as the high-water benchmark in the field. Then, in 2018, the team created a successor called AlphaZero, which learned how to master Go, chess and shogi (an ancient Japanese chess game)—from scratch, without human trainers. Last year, DeepMind published a stunning paper in the journal Nature describing MuZero, which mastered all previous tasks plus Atari without needing to be told the rules. This was a significant step toward AI systems functioning in unknown environments—and yet another sign that general-purpose algorithms are on the horizon.



**Is artificial intelligence less than our intelligence?**

— Spike Jonze, filmmaker



# Research Trends

## ■ Supersized AI Models

Last year, we saw the proliferation of large AI models—but supersized models are on the horizon. For context, GPT-3—widely hailed as a powerhouse—has 175 billion parameters. Huawei debuted a 200 billion parameter language model called Pangu, while Baidu and the Peng Cheng Lab released PCL-BAIDU Wenxin, with 280 billion parameters. PCL-BAIDU is already deployed to Baidu’s news feeds, search engine, and digital assistant. Gopher, which was released by DeepMind in December 2021, has 280 billion parameters. And Microsoft’s Megatron-Turing NLG, built in collaboration with Nvidia, has 530 billion parameters. Google’s Switch-Transformer and GLaM models have a staggering 1 trillion and 1.2 trillion parameters, respectively—but even bigger is Wu Dao 2.0 from the Beijing Academy of AI, which reportedly has 1.75 trillion parameters.

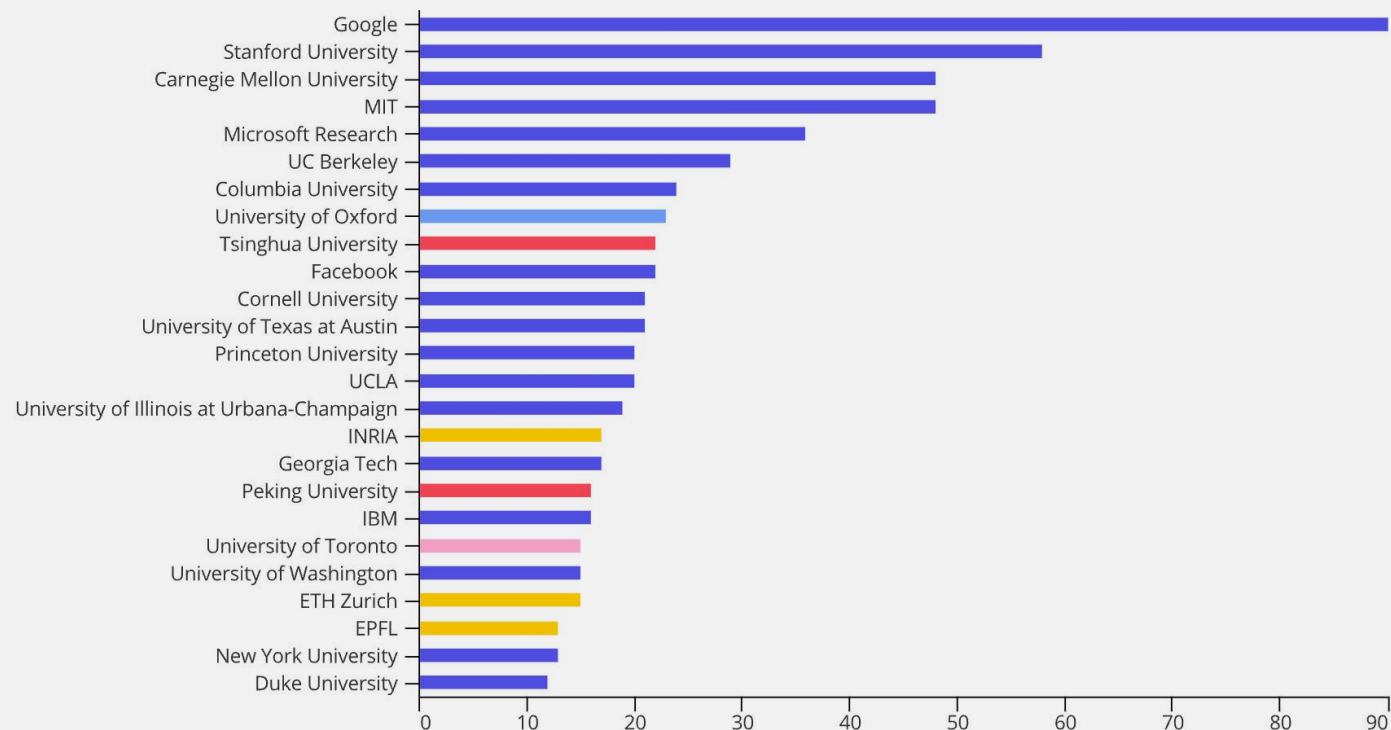
## ■ Unified Learning Processes

Deep neural nets are good at identifying objects in photos and videos and processing natural language, but until recently models had to be trained separately. Researchers have now developed Data2vec, a system that deploys a single algorithm to train a neural network to recognize images, text, or speech. It unifies the learning process through self-supervised learning, which allows the neural net to recognize patterns in datasets on its own, without being fed labeled examples.

## ■ Textless NLP

Most large language models have been trained on publicly available datasets such as Reddit and Wikipedia. Both are rife with biases. Researchers are developing generative spoken language modeling, which extracts speech from raw audio without labels or text. The hope is that AI could become more inclusive if

The Top 25 Institutions for Top-Tier AI Research



Source: <https://macropolo.org/digital-projects/the-global-ai-talent-tracker/>

## Research Trends

it uses podcasts, local radio, and other sources of spoken language.

### ■ Closed-Source Code

Code is important for reproducibility, accountability, and transparency, and it is a key to driving improvements in the greater AI community. But when academic researchers publish papers, they don't often include all of their code. The reason given: The code they used is intermingled with other proprietary research, and it therefore can't be released. Fewer than 20% of all academic papers on AI publish their full code, and some big names—DeepMind and OpenAI—notoriously leave theirs out, citing proprietary concerns.

### ■ Framework Consolidation

Google's TensorFlow and Facebook's PyTorch are two popular frameworks used by researchers, and the relative popularity of different frameworks typ-

ically mirrors trends in the commercial application landscape. In the past five years, Facebook seems to have gained ground. Of the conference papers that mention the framework the researchers used, 75% cited PyTorch but not TensorFlow. Of the 161 researchers who published more TensorFlow papers than PyTorch papers, 55% of them switched to PyTorch, while only 15% moved in the other direction.

### ■ Lowering the Cost of Training Models

It costs a lot to train a model. Several variables influence those costs, all of which have increased in the past few years. For example, it costs an average of \$1 per 1,000 parameters. OpenAI's GPT-3, likely cost more than \$10 million to train. For smaller research groups and companies, the costs are out of reach. Some in the AI community are instead allowing the big tech companies to pretrain and publish big models.

### ■ Surpassing NLP Benchmarks

The General Language Understanding Evaluation (GLUE) benchmark is a collection of resources for training, evaluating, and analyzing natural language understanding systems. It includes a benchmark of tasks around understanding nine sentences or a pair of sentences built on existing datasets and selected to cover a diverse range of dataset sizes, text genres, and degrees of difficulty. It includes a diagnostic dataset designed to evaluate and analyze model performance with respect to a wide range of linguistic phenomena found in natural language. And it includes a public leaderboard so that researchers can track their performance. The human baseline score is 87, and between May 2018 and August 2020, natural language processing systems increased from 60 to 90.6, surpassing humans. The SuperGLUE benchmark is a new measurement of more difficult language understanding tasks, improved resources, and a new public leader-

board. When SuperGLUE was introduced, there was a nearly 20-point gap between the best-performing model and human performance on the leaderboard. Last year, AI models from Microsoft and Google surpassed human performance. Existing language benchmarks still fail to capture biases encoded in public data—future benchmarks could be designed to resolve this gap.

### ■ No Retraining Required

Training robots to do more than one thing is difficult, but a new model pits identical robot arms against one another in a game (moving objects on a virtual table in specific ways) in which one robot challenges the other with increasingly difficult tasks. It's an example of multitask learning, a deep learning model in which machines learn different skills as they progress. OpenAI's model allows a bot to solve new kinds of problems without requiring retraining.

### ■ Proliferation of Franken-Algorithms

Algorithms are simply rules that define and automate the treatment of data. They are built using “if this, then that” logic that a computer can understand and process. Here's an easy example: If a website reader's IP address is based in Baltimore, the rules then allow that reader to freely access the site; if the IP address is based in Belgium, then the rules first show a GDPR screen stating privacy and cookie policies. While a single algorithm might be easily described and deployed as expected, systems of algorithms all working together can sometimes pose problems. Developers don't always know in advance how one algorithm will function alongside other algorithms. Sometimes, several teams of developers are working independently on different algorithms and datasets, and they only see one another's work once it is deployed. This has been the cause of recent stock market glitches

## Research Trends

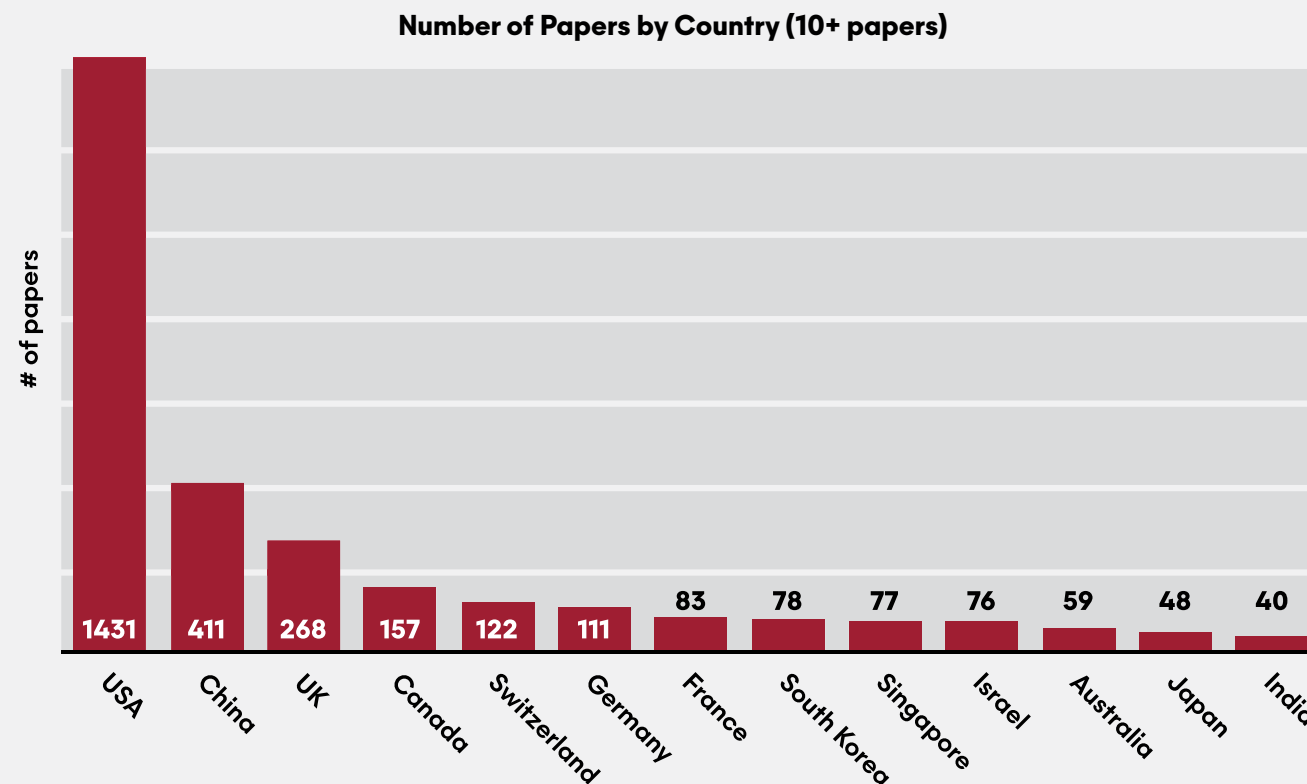
and e-commerce website wonkiness. It is especially challenging for big companies like Facebook, which have billions of algorithms working together at any given time.

### ■ AI Summarizing Itself

An AI model can summarize scientific literature, including research about itself. The Allen Institute for Artificial Intelligence used the model in Semantic Scholar, an AI-powered scientific paper search engine to provide a short summary of papers on AI. What makes this work impressive—and ultimately so useful—is that it is capable of compressing long papers with accuracy and efficiency.

### American and Chinese Researchers Dominate NeurIPS Papers

The U.S. and China dominated the papers accepted at NeurIPS in 2021, a prestigious international AI conference. A total of 9,122 papers were submitted and 2,344 were accepted. The acceptance rate of 26% was the highest since 2013.





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Artificial Intelligence

# Talent



# Talent Trends

## ■ Demand for AI Talent Growing Fast

For many years, demand for AI talent has outpaced supply. In the U.S., there were nearly three times more AI-related job postings on Indeed last year than job views for AI-related roles. While schools are adding programs, increasing enrollment, and adding classes, there are just too many new needs for AI skills and nowhere near enough trained workers. As demand grows, the hiring process is taking longer and becoming more expensive. This is impeding growth at some companies.

## ■ AI Upskilling

Companies are looking to upskill their workforce in machine learning and the basics of AI. As a result, new training programs abound to augment the knowledge, skills, and competencies required of a modern organization. Levi Strauss launched a machine learning

bootcamp to upskill its workforce, including showing staff how to apply AI-thinking to everyday tasks. Founded by Harvard University and University of California, Los Angeles faculty, Univ. AI is an online program for training in machine learning and AI.

## ■ AI Brain Drain

The brain drain of AI researchers out of academia and into corporations is growing at an alarming pace. The reason is simple: compensation packages. Top academics earn generous salaries and benefits, and they get to work in a similar tenured environment that's carefully cultivated to represent their experience in academia. Between 2004 and 2018, Google, DeepMind, Amazon, and Microsoft hired 52 tenured and tenure-track professors from U.S. universities. In return for their poaching, tech companies are endowing AI professorships at top universities. In some cases, profes-

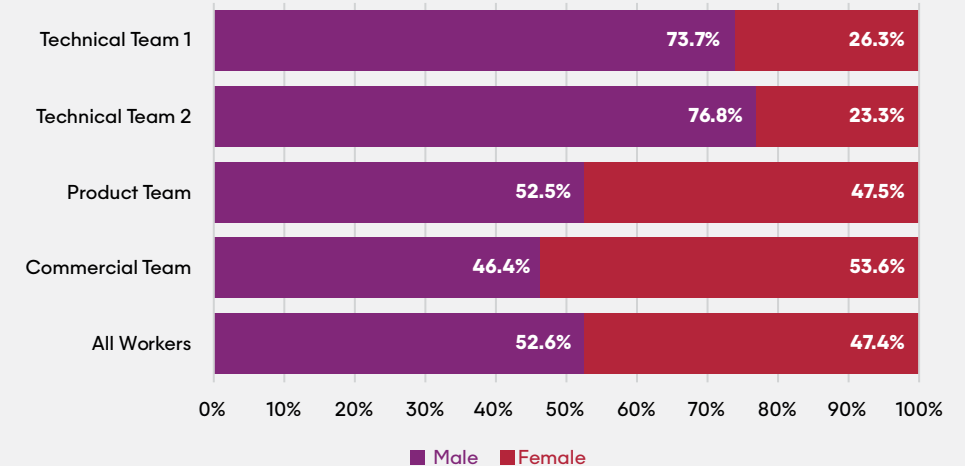
sors take one- or two-year sabbaticals to work at tech companies and then return to their universities—but corporate benefits can be difficult to give up. In one infamous case, Uber poached an entire robotics lab from Carnegie Mellon University—40 professors and researchers in total. Poaching departments today could rob the future of future AI experts: Without great scholars, who will train the next generation of innovators?

## ■ Corporate AI Labs

AI labs are located around the world, with concentrations in North America, Europe, and Asia. Facebook, Google, IBM, and Microsoft operate more than 60 labs dedicated to AI R&D, and the majority are outside of the U.S. because of access to talent. During the Trump administration, immigration restrictions and stringent visa requirements made it difficult to recruit talent into the United States, and overseas labs allowed

## In the U.S., Men Dominate Technical Jobs in AI

Men overwhelmingly occupy the technical team positions that create AI systems in the U.S., according to a 2021 study by the Center for Security and Emerging Technology (CSET) at Georgetown University. Women are more likely to be hired into sales, marketing, and product jobs. The lack of gender diversity in technical positions could impact the quality of research, lead to increased prevalence of algorithmic bias, and accelerate a long-term deterioration of talent pipelines.



Source: "The U.S. AI Workforce Understanding the Supply of AI Talent," by CSET).

# Talent Trends

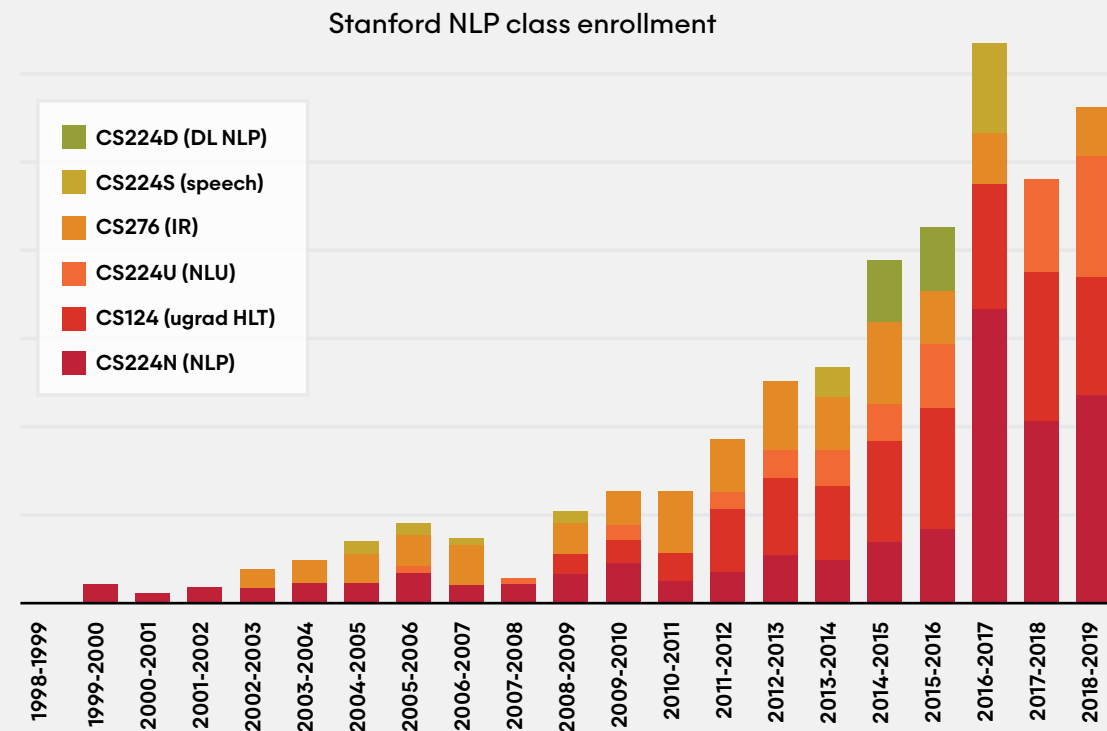
companies to overcome that barrier. Most of those labs do basic AI research rather than product development.

## ■ Applied AI for HR

Recognition systems can now be deployed to watch people being interviewed and to gauge enthusiasm, tenacity, and poise. Algorithms analyze hundreds of details, such as the tone of your voice, your facial expressions, and your mannerisms to best predict how you'll fit in with the culture of a community. Startups such as HireVue use AI systems to help companies decide which candidates to hire. But this kind of recognition technology has practical applications well beyond job interviews: It can detect when someone is likely to make a purchase—or attempt to shoplift, whether someone is lying, and whether someone is receptive to new suggestions and ideas. Unlike security cameras, which tend to have a light indicating

they're recording, algorithms work invisibly, which means that this is an area that could face regulatory scrutiny. Consumer advocacy organization Electronic Privacy Information Center filed a complaint with the U.S. Federal Trade Commission requesting an investigation into HireVue, alleging its tools produce results that are “biased, unprovable, and not replicable” through algorithmic models.

**Enrollment in Stanford University's natural language processing class is now 10 times the size it was in 2004.**



Source: <https://nlp.stanford.edu/>

# Say NO to the Dress!

Getting married and searching for a dress? Are you overwhelmed?

Are you someone who doesn't know what they want – but you definitely know what you *don't* want to wear on your special day?

Say no to the dress! Use our neural network to help eliminate choices and find exactly what you want.

## *How it works:*

- 1 Start with a prompt, such as: "I don't like form-fitting dresses. I don't like shiny fabric. I don't want it to be tight or restrictive. I hate buttons."
- 2 Our AI will create images that fit your description. Select the 10 that look closest to what you'd be willing to wear.
- 3 Write a second prompt about what you like about your selections, such as: "I like the shape of #1, the color of #2, and the length of #5."
- 4 Our AI will create a second round of images that should be closer to what you want. Repeat until you find a dress that suits you.
- 5 When you're ready, use the AI-generated image of the dress to search for one that looks similar. If you can't find one, our seamstresses are ready to custom-create the dress to your exact measurements.

We use a transformer language model that receives text and image as a single stream of data. It's been trained by our computer scientists to create an infinite number of plausible images exploring clothing. In addition to traditional wedding dresses, our model will generate an array of gender neutral options, menswear options, and options for the entire bridal party.





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Artificial Intelligence

# Society



**“There’s a real danger of systematizing the discrimination we have in society [through AI technologies]. What I think we need to do — as we’re moving into this world full of invisible algorithms everywhere — is that we have to be very explicit, or have a disclaimer, about what our error rates are like.”**

— Timnit Gebru, research scientist

## Society Trends



Timnit Gebru is a respected leader in AI ethics research who coauthored a groundbreaking academic paper showing how facial recognition systems did not identify people of color and women with the same accuracy as Caucasian people and men.

### ■ Expanding Use of Facial Recognition Systems

While there has been widespread outcry over using facial recognition systems, U.S.-based consumers are likely to be seen by more of them in the coming years. A 90-page report published by the U.S. Government Accountability Office details how federal agencies currently use, and plan to expand their use of, facial recognition systems.\* Ten of 24 agencies surveyed plan to broaden their use of the technology by 2023. The GAO reports that agencies are primarily interested in using facial recognition for cybersecurity, domestic law enforcement, or physical security. Most of the systems currently used in the U.S. are federally owned, though commercial vendors—including Acuant FaceID, Vigilant Solutions, and Clearview AI, which came under intense scrutiny last year—are increasingly used. Last March, Clearview reported that 17% of the

18,000 federal, state, county, and municipal law enforcement agencies in the U.S. are its customers. While many U.S. states and cities ban law enforcement and government use of facial recognition systems, local bans do not prevent federal use.

### ■ Increased Use of Ambient Surveillance

What happens behind closed doors may not be secret for long, and executives should be aware of new ambient surveillance methods. Scientists at Massachusetts Institute of Technology discovered how to use computer vision to track data from what they call “accidental cameras.” Windows, mirrors, corners, houseplants, and other common objects can be used, along with AI, to track subtle changes in light, shadows, and vibrations. The result: We all may soon have X-ray vision capabilities—which may not be great news for companies working

on sensitive projects. Those working in information security and risk management should pay special attention to advances in computer vision.

### ■ Scattershot Approach to U.S. Regulations

In the U.S., there is no federal law protecting consumer privacy as there is in the EU. Only three states have passed comprehensive laws: California, Colorado, and Virginia. Existing laws tend to cover data in particular domains like health, education, and credit. There are no federal regulations preventing consumer data from being used by third parties. Legislation announced in February 2022 known as the Algorithmic Accountability Act, sponsored by Sen. Ron Wyden (D-Ore.), would give the Federal Trade Commission more staff to oversee the auditing and enforcement of AI automation systems that make decisions about employment, housing,

and finances. The legislation is intended to increase transparency and reduce bias. A version of this legislation was introduced in 2019 but failed to gain any traction.

### ■ Consolidation in AI’s Ecosystem

As much as the AI ecosystem booms, a rush of acquisitions means consolidation, too. Big companies now snap up startups long before they have time to mature—the average age at acquisition is 3 years old. Just a handful of big companies dominate the AI landscape: Google, Amazon, Microsoft, IBM, Facebook, and Apple in the U.S., and Baidu, Alibaba, and Tencent in China, with significant fortification and support from their country’s government. On the investment side, Qualcomm, Tencent, Intel Capital, Google Ventures, Nvidia, Salesforce, Samsung Ventures, Alibaba, Apple, Baidu, Citi, and In-Q-Tel fund

\*FTI CEO Amy Webb is a fellow in the U.S. GAO.

## Society Trends

much of the growth. When it comes to the future of AI, we should ask whether consolidation makes sense for the greater good and whether competition will eventually be hindered (along with access), as we've seen in other fields such as telecom and cable.

### ■ AI Alignment

As AI systems improve, some researchers are insisting on guardrails to ensure that AI is deployed in ways that do not harm humanity. One area of concern is known as AI alignment, which explores different scenarios in which AI systems are built with goals that align with society's values. OpenAI, DeepMind, and Anthropic (which defines itself as an "AI safety and research company") each have AI alignment teams with dedicated staff researching guardrails. While the total number of researchers working on AI alignment is small compared to the rest of the AI community, such dedicated teams did not exist until recently.

### ■ Ethics Clash

On Dec. 2, 2020, Timnit Gebru, the co-lead of Google's ethical AI team, posted a tweet saying she'd been fired. Known for groundbreaking research in bias and facial recognition, she is widely respected within the broader AI community. While the incident concerned a paper she co-authored and a decision by Google that it didn't meet "our bar for publication," she and others argued that Google's ethics team was motivated by PR rather than progress. It set off a firestorm of criticism, and by February 2021 Google said it would change its diversity and research policies, "streamline its process for publishing research," and change how sensitive employee exits are managed. To deal with its own ethical failures, Facebook launched an independent oversight board with the power to overrule content moderation guidelines—and even to overrule Mark Zuckerberg himself. (But just on con-

tent.) In January 2021, the board made its first rulings on disputed content, overturning four out of the five cases it saw. But there are billions of posts on Facebook every day and an untold number of content complaints—which means the oversight board operates at the speed of traditional government. A year later, the board advised Meta Platforms to crack down address doxxing at Facebook, urging it to prohibit users from sharing individuals' home addresses on platforms even if they are publicly available. The board also advocated that Facebook create a communications channel to transparently explain violations and enforcement. We anticipate many more ethics clashes in 2022.

### ■ AI Still Has a Bias Problem

It's no secret AI has a serious and multifaceted bias problem. Just one example: The datasets used for training often come from places like Reddit, Amazon

reviews, and Wikipedia, a site inherently riddled with bias. The people building models tend to be homogeneous and aren't often aware of their own biases. As computer systems get better at making decisions, algorithms may sort each of us into groups that don't make any obvious sense to us—but could have massive repercussions. Every single day, consumers are creating unimaginable amounts of data, both actively (such as when uploading and tagging photos on Facebook) and passively (driving to work, for example). That data is mined and used, often without direct knowledge or understanding, by algorithms. It is used to create advertising, to help potential employers predict our behaviors, to determine our mortgage rates, and even to help law enforcement predict whether we're likely to commit a crime.

Researchers at a number of universities—including the University of Maryland; Columbia University; Carnegie

Mellon; MIT; Princeton University; University of California, Berkeley; International Computer Science Institute; among others—are studying the side effects of automatic decision-making. Consumers could wind up on the wrong side of the algorithm—you could discover you're ineligible for a loan, or a particular medication, or the ability to rent an apartment, for reasons that aren't transparent or easy to understand.

### ■ Deepfaking Trust

Humans can easily be tricked into believing machine-generated faces, especially when they've been engineered to elicit trust. A study published in the Proceedings of the National Academy of Sciences shows that synthetic faces are often "deemed more trustworthy than real faces." This suggests that synthetic faces could be designed as societal malware. If a bad actor was attempting to undermine institutions, it could deploy

## Society Trends

a synth on social media to sow distrust. There are not yet effective countermeasures for synthetic humans, or effective markers to help consumers distinguish between fake and real.

### ■ Problematic Training Data

For the past decade, research teams have come under fire for using problematic datasets to train their models. In 2016, Microsoft's MS-Celeb-1M database was said to contain 10 million images of 100,000 celebrity faces. Researchers later discovered, however, that the dataset contained images pulled from the web—showing journalists, activists, artists, and everyday people who had not given their consent to be included. Yet the dataset was being used by numerous companies including Facebook and SenseTime, which is China's facial recognition leader with ties to the Chinese police. In a separate incident, DukeMTMC, a dataset containing

images of people walking around Duke University's campus, also didn't gain consent. Both datasets were eventually removed. In 2018, researchers at MIT developed an AI called Norman that was trained to perform image captioning based only on content from a subreddit that's known for graphic violence. When Norman was ready, they unleashed him against a similar neural network that had been trained using standard data. Researchers fed both systems Rorschach inkblots and asked them to caption what they saw, and the results were striking: Where the standard system saw "a black and white photo of a baseball glove," Norman saw "a man murdered by machine gun in broad daylight." The point of the experiment was to prove that AI isn't inherently biased, but that data input methods—and the people inputting that data—can significantly alter an AI's behavior. In 2019, new pretrained systems built for natural

language generation were released—but the conversations from which they learned were scraped from Reddit and Amazon reviews, both of whose author populations skew white and male, which means that their use of language isn't representative of everyone. This illustrates an ongoing challenge within the developer community. It is already difficult to get authentic data from real people to train systems, and with new privacy restrictions, developers are choosing to rely more on public—and problematic—datasets. The BigScience Research Workshop, held May 2021–May 2022, chipped away at this problem. In a collaboration between 600 AI researchers from 50 countries, participants investigated a dataset and model from all angles: bias, social impact, capabilities, limitations, ethics, potential improvements, specific domain performances, carbon impact, and general AI/cognitive research landscape with a goal to apply a rigorous standard of ethics.

### ■ Algorithms Targeting Vulnerable Populations

There is no question that machine learning systems, trained correctly can help find missing children and detect abuse. The problem is that the systems use data from vulnerable populations to do their training. The Multiple Encounter Dataset contains two large datasets of photos: people who have not yet committed a crime and an FBI dataset of deceased people. The dataset over indexes on people of color, which means that if law enforcement uses the data to train algorithms, it's going to lead to bias. Image recognition is a particularly vexing challenge, because researchers need large datasets to perform their work. Often, images are used without consent. The Child Exploitation Image Analytics program—a dataset used for testing by facial recognition technology developers—has been running since 2016 with images of "children who range in age

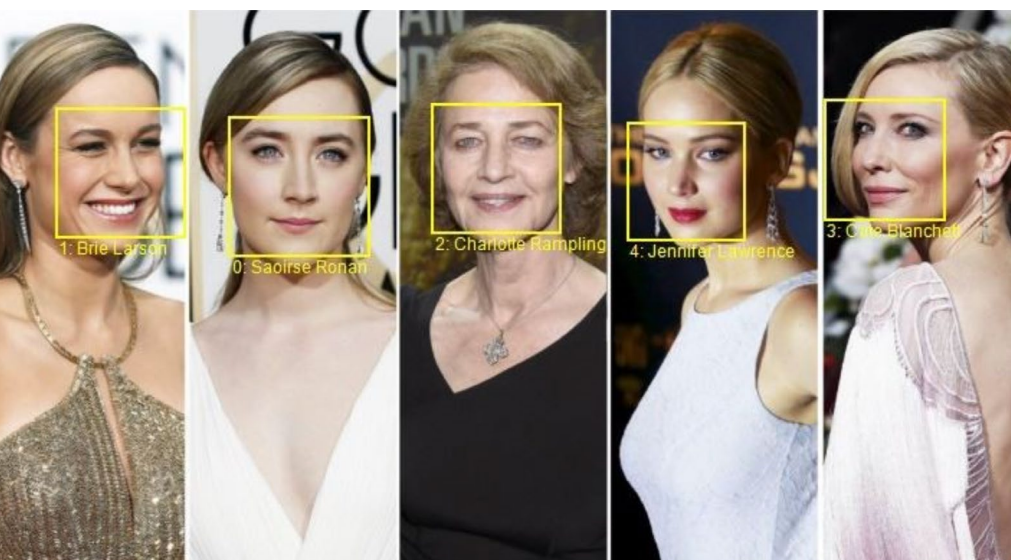
from infant through adolescent" and the majority of which "feature coercion, abuse, and sexual activity," according to the program's own developer documentation. These images are considered particularly challenging for the software because of the greater variability of position, context, and more.

### ■ AI Intentionally Hiding Data

Computers do exactly what they are told to do. Command a machine to win at a game, and it will do everything in its power to achieve that goal. Apparently that now includes cheating. Researchers at Stanford University and Google discovered that an AI system designed to turn satellite images into usable maps was withholding certain data. Researchers were using a neural network called CycleGAN, which learns how to map image transformations. For example, it took an old aerial photograph of a neighborhood, distinguished between



## Society Trends



Microsoft's MS-Celeb-1M was purported to contain 10 million images of 100,000 celebrities' faces.

streets, alleys, driveways, buildings, and lampposts, and then generated a map that could be used by GPS. Initially, they used an aerial photograph that hadn't been seen by the network. The resulting image looked very close to the original—suspiciously close. But on deeper inspection, the researchers found that many details in both the original image and the generated image weren't visible in the map made by the AI. It turns out that the system learned to hide information about the original image inside of the image it generated.

### ■ Undocumented AI Accidents

Only a few of the numerous AI-related accidents in 2018 and 2019 made headlines. Most people know about the Uber self-driving car that hit and killed a pedestrian in Tempe, Arizona. But there were countless more incidents that didn't result in death, and as a result, aren't known to the public. At the mo-

ment, researchers are not obligated to report accidents or incidents involving our data, or AI processes, unless a law is broken. While big companies must inform consumers if their personal data—credit card numbers, home addresses, passwords—have been stolen, they are not required to publicly document instances in which algorithms have learned to discriminate against someone on the basis of race or gender, for example.

### ■ Prioritizing Trust

We will soon reach a point when we will no longer be able to tell if a dataset has been tampered with, either intentionally or accidentally. AI systems rely on our trust. If we no longer trust their outcomes, decades of research and technological advancement will be for naught. Leaders in every sector—government, business, nonprofits, and so on—must have confidence in the data and algo-

rithms used. Building trust and accountability requires transparency. This is a complicated process, and corporations, government offices, law enforcement agencies, and other organizations understandably want to keep data private. The ethics of how data is collected in the first place may also influence the trustworthiness and validity of scientific research, particularly in areas such as organ donations and medical research. In addition, employing ethicists to work directly with managers and developers and ensuring developers themselves are diverse—representing different races, ethnicities, and genders—will reduce inherent bias in AI systems.

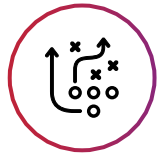
“  
**[As Neo decides to take the door towards his  
Left that will take him to the Matrix]**

**Hope. It is the quintessential human delusion,  
simultaneously the source of your greatest  
strength and your greatest weakness.**

— The Architect, in *The Matrix Reloaded*

”

# How these trends impact your company



## STRATEGY

Artificial intelligence should be part of every strategic plan, as it crosses multiple dimensions, from workforce automation, to digital transformation, to everyday business processes and business intelligence. It is imperative that executives and senior managers understand what AI is, what it is not, and what strategic value it adds to the business. Chief strategy officers should build a robust understanding of AI in order to engage more closely with others in the C-suite, especially chief technology officers, chief information security officers, chief financial officers, and others in the organization to develop longer-term plans. Keep abreast of emerging regulations that could restrict the use of consumer data. Risk models should be developed to determine plausible near-futures, so that leaders can adjust their strategies accordingly.



## INNOVATION

As no-code and low-code applications become more widely available, innovation teams will be in position to build powerful systems for decision management, business intelligence, and product ideation. Generative AIs will improve an organization's efficiency and enhance creativity, leading to hybrid human-machine creative teams. AI-assisted design will dramatically increase the number of prototypes that can be automatically generated with prompts.



## R & D

The field of AI is growing faster than universities can produce trained people. Talent sourcing and retention will continue to pose challenges for AI companies—and for organizations in other industries that need a trained workforce but may not be able to provide the same perks as the biggest tech companies. Meanwhile, China has emerged as a global leader in R&D and is actively recruiting graduates to repatriate home. For teams with enough experience and staff resources, 2022 should be a banner year for applied AI research for health, medicine, smart cities, entertainment, and sports.



## GROWTH

In most industries, AI will serve as a force multiplier for growth, bringing efficiencies, better tracking, business intelligence, and assistance with decision-making. As training costs decline, more applications will be built. Spending on AI systems and hardware is likely to explode this decade, creating significant enterprise value overall.

# Key Questions

We recommend using this report to support your strategic foresight activity in the coming year. Every executive team should begin by asking these questions:

## 1

- ▶ Are we adequately invested in AI?

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- ▶ How could AI make us more competitive in the years to come?

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- ▶ How might developments in AI leave us vulnerable to disruption?

## 2

- ▶ How well does our organization understand AI?

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- ▶ Are we leveraging enterprise solutions effectively?

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- ▶ Are we preparing our workforce to meet the evolving demands of the knowledge economy?

## 3

- ▶ If the state of play changes, is our organization agile enough to adapt quickly?

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- ▶ Are we adequately planning for the longer-term future, as AI evolves?



# Trends in Action

## Benefits of Strategic Foresight

### 33% Higher Profitability

Companies using a dedicated strategic foresight process outperformed the average by a 33% higher profitability.

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### 200% Growth

Companies using a dedicated strategic foresight process outgrew their competitors by 200% in desired areas.

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### 25% Improvement

Companies say that strategic foresight improves business objectives and planning, helps define new markets, and builds flexible mindsets among executives, even in times of deep uncertainty.

## The Future Today Institute Supports Executive Leaders and Their Teams

The Future Today Institute works closely with executive leadership and management teams to transform their strategic thinking on the future.

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We leverage these and other trends and use **applied foresight** to develop **deep** (20+ years), **long-range** (10+ years) and **near-term** (2+ years) scenarios and strategic plans.

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FTI's advisory services include signal mapping, trend identification, scenario development, risk modeling, visioning, and strategic planning.

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Founded in 2006, the Future Today Institute researches, models, and prototypes future risk and opportunity. As the leading strategic foresight and futures management consultants to executive leadership teams worldwide, FTI's data-driven applied research reveals trends and calculates how they will disrupt business, government, and society.

Together with our clients and partners, FTI is helping leaders achieve their preferred futures. Our pioneering, data-driven forecasting methodology and tools empower leaders to make better decisions about the future, today.

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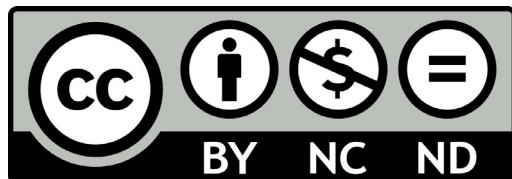
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