Tech Talk

BROOKINGS

The Brookings glossary of AI and emerging technologies

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Editor's Note:

Many people fear artificial intelligence, but don't understand what it is or how it is being used. In our Brookings Institution Press book, Turning Point: Policymaking in the Era of Artificial Intelligence, we discuss AI applications in healthcare, education, transportation, e-commerce, and defense, and present a policy and governance blueprint for responsible and trustworthy AI. Below is a glossary of key terms drawn from that book, which we present as a living document that will be updated as the AI conversation unfolds.

Algorithms:

According to author Pedro Domingos, algorithms are "a sequence of instructions telling a computer what to do."[1] These software-based coding rules started with simple and routine tasks, but now have advanced into more complex formulations, such as providing driving instructions for autonomous vehicles, identifying possible malignancies in X-rays and CT scans, and assigning students to public schools. Algorithms are widely used in finance, retail, communications, national defense, and many other areas.

Artificial Intelligence (AI):

Indian engineers Shukla Shubhendu and Jaiswal Vijay define AI as "machines that respond to stimulation consistent with traditional responses from humans, given the human capacity for contemplation, judgment, and intention."[2] This definition emphasizes several qualities that separate AI from mechanical devices or traditional computer software, specifically intentionality, intelligence, and adaptability. AI-based computer systems can learn from data, text, or images and make intentional and intelligent decisions based on that analysis.

Augmented Reality (AR):

Augmented reality puts people in realistic situations that are augmented by computer-generated video, audio, or sensory information. This kind of system allows people to interact with actual and artificial features, be monitored for their reactions, or be trained on the best ways to deal with various stimuli.

Big Data:

Extremely large data sets that are statistically analyzed to gain detailed insights. The data can involve billions of records and require substantial computer-processing power. Data sets are sometimes linked together to see how patterns in one domain affect other areas. Data can be structured into fixed fields or unstructured as free-flowing information. The analysis of big data sets can reveal patterns, trends, or underlying relationships that were not previously apparent to researchers.

Chatbots:

Automated tools for answering human questions. Chatbots are being used in retail, finance, government agencies, nonprofits, and other organizations to respond to frequently asked questions or routine inquiries.

Cloud Computing:

Data storage and processing used to take place on personal computers or local servers controlled by individual users. In recent years, however, storage and processing have migrated to digital servers hosted at data centers operated by internet platforms, and people can store information and process data without being in close proximity to the data center. Cloud computing offers convenience, reliability, and the ability to scale applications quickly.

Computer Vision (CV):

Computers that develop knowledge based on digital pictures or videos.[3] For example, cameras in automated retail outlets that are connected to CV systems can observe what products shoppers picked up, identify the specific items and their prices, and charge consumers' credit card or mobile payment system without involving a cash register or sales clerk. CV also is being deployed to analyze satellite images, human faces, and video imagery.

Connected Vehicles:

Cars, trucks, and buses that communicate directly with one another and with highway infrastructure. This capacity speeds navigation, raises human safety, and takes advantage of the experiences of other vehicles on the road to improve the driving experience.

Data Analytics:

The analysis of data to gather substantive insights. Researchers use statistical techniques to find trends or patterns in the data, which give them a better understanding of a range of different topics. Data analytic approaches are used in many businesses and organizations to track day-to-day activities and improve operational efficiency.

Data Mining:

Techniques that analyze large amounts of information to gain insights, spot trends, or uncover substantive patterns. These approaches are used to help businesses and organizations improve their processes or identify associations that shed light on relevant questions.

Deepfakes:

Digital images and audio that are artificially altered or manipulated by AI and/or deep learning to make someone do or say something he or she did not actually do or say. Pictures or videos can be edited to put someone in a compromising position or to have

someone make a controversial statement, even though the person did not actually do or say what is shown. Increasingly, it is becoming difficult to distinguish artificially manufactured material from actual videos and images.

Deep Learning:

A subset of machine learning that relies on neural networks with many layers of neurons. In so doing, deep learning employs statistics to spot underlying trends or data patterns and applies that knowledge to other layers of analysis. Some have labeled this as a way to "learn by example" and a technique that "perform[s] classification tasks directly from images, text, or sound" and then applies that knowledge independently.[4] Deep learning requires extensive computing power and labeled data, and is used in medical research, automated vehicles, electronics, and manufacturing, among other areas.

Digital Sovereigns:

The speed, scope, and timing of technology innovation today is often decided not by government officials but by coders, software designers, and corporate executives. Digital sovereigns set the rules of the road and terms of service for consumers. What they decide, directly or indirectly, has far-reaching consequences for those using their software or platform. The power of business decisionmakers raises important governance questions regarding who should decide on matters affecting society as a whole and the role that policymakers, consumers, and ethicists should play in digital innovation.

Distributed Collaboration:

Connecting frontline people with others who have differing skills and getting them to work together to solve problems. Distributed collaboration differs from current governance paradigms that emphasize hierarchical, top-down decisionmaking by those who do not always have relevant knowledge about the issues being addressed. The new model takes advantage of the fact that a range of skills are needed to resolve technology issues, and those skills are located in different subject areas and organizational parts. Rather than keeping AI expertise in isolation, distributed collaboration brings together

software and product designers, engineers, ethicists, social scientists, and policymakers to draw on their respective expertise and integrate their knowledge to solve pressing problems.

Dual-Use Technologies:

Many technologies can be used in a good or ill manner. The very same facial recognition system could be used to find missing children or provide a means for mass surveillance. It is not the technology per se that raises ethical issues but how the technology is put to use. The dual-use nature of technologies makes regulation difficult because it raises the question of how to gain the benefits of technology innovation while avoiding its detrimental features.

Facial Recognition (FR):

A technology for identifying specific people based on pictures or videos. It operates by analyzing features such as the structure of the face, the distance between the eyes, and the angles between a person's eyes, nose, and mouth. It is controversial because of worries about privacy invasion, malicious applications, or abuse by government or corporate entities. In addition, there have been well-documented biases by race and gender with some facial recognition algorithms.

5G Networks:

These are fifth-generation wireless telecommunications networks that have been deployed in major cities and feature faster speeds and enhanced capabilities for transmitting data and images. As such, 5G networks enable new digital products and services, such as video streaming, autonomous vehicles, and automated factories and homes that require a fast broadband.

Hyperwar:

High-tech military situations in which robots, sensors, AI, and autonomous systems play important roles and command decisions have to unfold at speeds heretofore unseen in warfare. Because of the acceleration of the pace and scope of conflict, countries will have to conduct simultaneous operations in every warfare domain and national leaders will need to accelerate technology innovation to build a safe and stable future.[5]

Machine Learning (ML):

According to Dorian Pyle and Cristina San Jose of the *McKinsey Quarterly*, machine learning is "based on algorithms that can learn from data without relying on rules-based programming."[6] ML represents a way to classify data, pictures, text, or objects without detailed instruction and to learn in the process so that new pictures or objects can be accurately identified based on that learned information. ML furthermore can be used to estimate continuous variables (such as estimating home sales prices) or to play games. Many of its insights come by examining prior data and learning how to improve understanding.

Natural Language Processing (NLP):

The analysis of textual information to make sense of its meaning and intentions. NLP software can take a large amount of text and see how words are linked together to assess positive or negative sentiment, relationships, associations, and meaning. For example, researchers can study medical records to see which patient symptoms appear to be most related to particular illnesses.

Neural Networks:

Researchers use computer software to "perform some task by analyzing training examples" and by grouping data based on common similarities.[7] Similar to the neural nodes of a brain, neural networks learn in layers and build complex concepts out of simpler ones. They break up tasks, identify objects at a number of different levels, and apply that knowledge to other activities. These kinds of systems allow computers to learn

and adapt to changing circumstances, similar to the way a brain functions. Deep learning and many of the most prominent recent applications of machine learning operate through neural networks (e.g., driverless cars, deepfakes, and AlphaGo game playing).

Quantum Computing:

Quantum computers have tremendous capacity for storing and processing information because their storage processes are not in the form of a zero or one, as is the case with traditional computers. Rather, they take advantage of superposition—the fact that electrons can be in two places at once—to create "quantum bits" that store multiple values in each point.[8] That capability dramatically increases storage capacity and decreases processing times, thereby improving the scope of data, textual, or image analysis.

Singularity:

Futurist Ray Kurzweil describes a singularity as a "machine-based superintelligence [that is] greater than human intelligence."[9] It combines advanced computing power with artificial intelligence, machine learning, and data analytics to create super-powered entities. There are extensive (and unresolved) debates regarding whether humanity will face a computing singularity in the next 50, 100, or 250 years.

Social Credit Systems:

The ubiquity of people's online activities enables technology that tracks behavior and rates people based on their online actions. As an illustration, some organizations have piloted systems that compile data on social media activities, personal infractions, and behaviors such as paying taxes on time. They use that data to rate people for creditworthiness, travel, school enrollment, and government positions.[10] These systems are problematic from an ethical standpoint because they lack transparency and can be used to penalize political opponents.

Supervised Learning:

According to *Science* magazine, supervised learning is "a type of machine learning in which the algorithm compares its outputs with the correct outputs during training. In unsupervised learning, the algorithm merely looks for patterns in a set of data."[11] Supervised learning allows ML and AI to improve information processing and become more accurate.

Techlash:

The backlash against emerging technologies that has developed among many individuals. People worry about a host of problems related to technology innovation, such as privacy invasions, mass surveillance, widening income inequality, and possible job losses. Figuring out how to assuage understandable human fears is a major societal challenge going forward.

Virtual Reality (VR):

Virtual reality uses headsets equipped with projection visors to put people in realistic-seeming situations that are completely generated by computers. People can see, hear, and experience many types of environments and interact with them. By simulating actual settings, VR can train people how to deal with various situations, vary the features that are observed, and monitor how people respond to differing stimuli.

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[1] Pedro Domingos, *The Master Algorithm: How the Quest for the Ultimate Learning Machine Will Remake Our World* (New York: Basic Books, 2018).

[2] Shukla Shubhendu and Jaiswal Vijay, "Applicability of Artificial Intelligence in Different Fields of Life," *International Journal of Scientific Engineering and Research*, vol. 1, no. 1 (September 2013), pp. 28–35.

[3] Jason Brownlee, "A Gentle Introduction to Computer Vision," *Machine Learning Mastery*, July 5, 2019.

[4] Math Works, "What Is Deep Learning?" undated.

[5] John R. Allen and Amir Husain, "Hyperwar and Shifts in Global Power in the AI Century," in Amir Husain and others, *Hyperwar: Conflict and Competition in the AI Century* (Austin, TX: SparkCognition Press, 2018), p. 15.

[6] Dorian Pyle and Cristina San Jose, "An Executive's Guide to Machine Learning," *McKinsey Quarterly*, June, 2015.

[7] Larry Hardesty, "Explained: Neural Networks," *MIT News*, April 14, 2017.

[8] Cade Metz, "In Quantum Computing Race, Yale Professors Battle Tech Giants," *New York Times*, November 14, 2017, p. B3.

[9] Quoted in Tom Wheeler, *From Gutenberg to Google: The History of Our Future* (Brookings, 2019), p. 226. Also see Ray Kurzweil, *The Singularity Is Near: Where Humans Transcend Biology* (London: Penguin Books, 2006).

[10] Jack Karsten and Darrell M. West, "China's Social Credit System Spreads to More Daily Transactions," *TechTank* (blog), Brookings, June 18, 2018.

[11] Matthew Hutson, "AI Glossary: Artificial Intelligence, in So Many Words," *Science*, July 7, 2017.