



Exponentials

These fast-evolving technologies represent unprecedented opportunities as well as existential threats. Don't get caught unaware.

Artificial intelligence 2020

The centuries-long quest to develop machines and software with human-like intelligence inches closer to reality. Scientists develop intelligent machines that can simulate reasoning, develop knowledge, and allow computers to set and achieve goals, moving closer to mimicking the human thought process. These intelligent systems improve accuracy of predictions, accelerate problem solving, and automate administrative tasks, bringing in an era of automation.

Artificial intelligence in 2020

- **Cognitive analytics**, where machines learn from experience and build associations, help develop technology systems that evolve hypothesis, draw conclusions, and codify instincts and experience.
- **Parallel information processing**, aided through chips custom-designed for artificial intelligence (AI) applications, help parallel processing of vast amounts of data.
- **Smarter gets redefined** with advances in sensor, cloud, and machine learning technology, and pushes the boundary of smarter homes, cars, infrastructure, and just about everything.

During the next decade (2014–2024), mobile robots and AI make it likely that occupations employing about half of today's US workers could be automated to some degree.

- **Deep learning** approaches allow processing of raw data, including images, speech, and natural language, thus providing deeper insights.
- **Face-reading machines** decipher microfacial expressions to build meaningful information on the emotional state of the user, improving human-computer interaction in areas of e-learning and e-therapy.
- **Intelligent automation** combines automation with artificial intelligence that allows knowledge workers, from physicians to investment analysts to plant supervisors, to process, understand, and use ballooning volumes of information.

Robotics technology 2020

2020 sees robotics gain momentum and become vital components in a number of applications. From swarms of “microbots” to self-assembling modular robots to strength-enhancing robotic exoskeletons, applications using robotics cut across industries and transform the way work is done. Robots paired with AI perform complex actions and are capable of learning from humans, driving the intelligent automation phenomenon.

Robotics technology in 2020

- **Microbots** allow emergency responders to explore environments that are too small or too dangerous for humans or larger robots; deploying them in “swarms” compensates for their relatively limited computational ability.
- **Exoskeletons** allow users to augment their physical strength, helping those with physical disabilities to walk and climb; they also find application in the military.
- **Body-machine interfaces** help amputees to feed-forward controls that detect their will to move and also receive sensorial feedback that converts digital readings to feelings.
- **Modular robots** bring forth Lego-like robotic cubes that can arrange themselves in preset patterns to accomplish specific tasks.
- **Intelligent robots** combine AI and machine learning technologies to give robots human-like expressions and reactions.
- **Robotic strength** increases as elastic nanotubes give robots muscles that are more compact and stronger than human muscles, allowing robots to outrun and outjump humans.
- **Alternately powered robots** use sources such as solar, wind, and wave energy to be powered indefinitely and to open up applications in areas that are off-grid.

- **Robotic networks** allow robots to access databases, share information, and learn from one another's experience.
- **Telepresence robots** act as your stand-in at remote locations, saving business travelers both time and money.

The robotics industry creates 3 million additional jobs between 2014 and 2020, led by consumer electronics and the electric vehicle industry.

The rehabilitation robot market grows 40-fold between 2014 and 2020, fueled by advancements in rehab/therapy robots, active prostheses, exoskeletons, and wearable robotics.

By 2020, robotics is a \$100 billion industry, equivalent in size to the worldwide medical tourism industry in 2012.

Additive manufacturing (3D printing)

Developments in “additive” manufacturing, or 3D printing, spur a second industrial revolution. Falling prices for 3D printers, coupled with growing expertise and new applications, increase the demand for and availability of this technology. Goods become significantly cheaper, high customization becomes the norm, and labor costs fall dramatically—factors that begin to reverse the trend of outsourcing to Asia. The do-it-yourself nature of 3D printing gives rise to increased intellectual property (IP) theft; by 2018, 3D printing may result in global IP losses of at least \$100 billion annually. “Bioprinting,” the use of 3D printers to produce human tissues and even organs, becomes feasible.

Additive manufacturing in 2020

- **Mass customization** and personalization of consumer goods becomes a reality, with 3D-printed toys, shoes, cosmetics, and even food products such as chocolates and meats that have “print at home” purchase options.
- **3D concrete printing** transforms architecture, with the possibility of 3D-printed concrete structure and buildings.
- **4D printing** produces responsive or “smart” objects that self-assemble or shape-shift when exposed to different stimuli.
- **3D printing minibuilders** combine robotics and additive manufacturing; the process involves fully mobile robots laying down layers of material one at a time and working together to construct objects of virtually any size. These minibuilders are under development at the Barcelona-based Institute for Advanced Architecture of Catalonia.

The 3D printing market grows at a compound annual rate of 23 percent from 2013 to 2020, reaching \$8.4 billion.

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