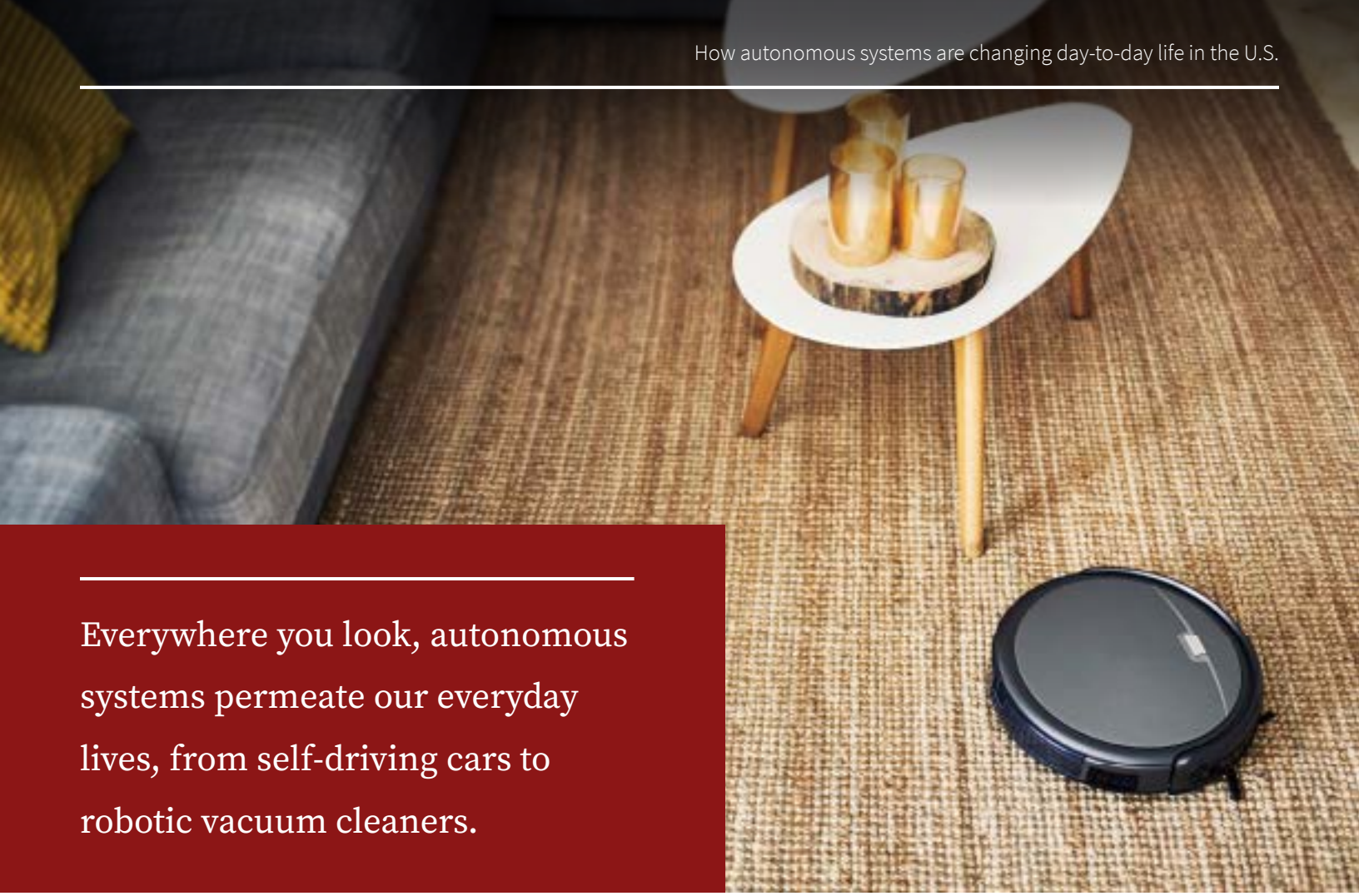
How autonomous systems are changing day-to-day life in the U.S.

Stanford | ONLINE

Table of contents



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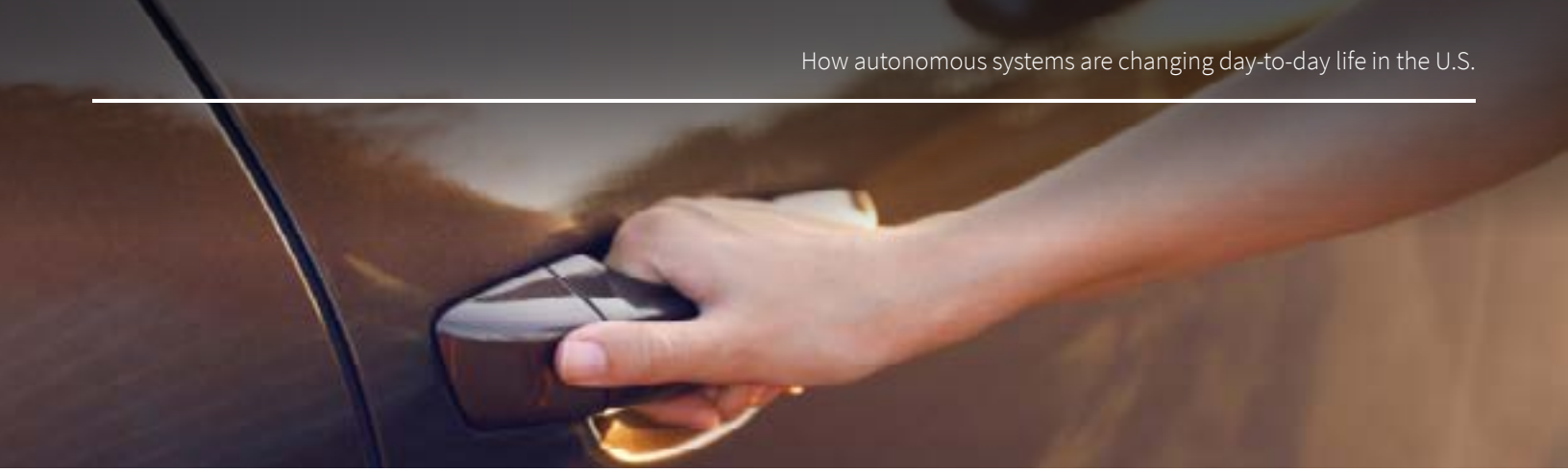
Everywhere you look, autonomous systems permeate our everyday lives, from self-driving cars to robotic vacuum cleaners. Thanks to the ongoing development of networked systems, IP-connected devices, robotics and artificial intelligence, new applications for this technology are emerging in every industry and walk of life.

As this technology evolves and matures, autonomous systems will have a profound and disruptive effect on society, changing day-to-day life in the U.S. as we know it. Never before has the field of human-computer interaction and robotics been more important. People will increasingly come to rely on autonomous systems to carry out both highly specialized and mundane tasks, and the relationship between man and machine will give rise to new questions and dilemmas. We cannot fully embrace our autonomous future without addressing the potential ethical concerns such technology presents.



According to Research & Markets, 20.8 million autonomous vehicles will be in active use on America's roads by 2030.

Taking the human element out of transportation

A decade ago, automated vehicles could be considered the stuff of science fiction and futurology. But the autonomous car market is a major economic force today, and is expected to be worth $60 billion by 2030. Several auto manufacturers, including Tesla, BMW and Mercedes, have begun to include self-driving features in their newest models, while innovators like Google continue to develop fully autonomous vehicles for the consumer market.

Automated vehicles have gone well beyond a proof of concept and are beginning to see use in different U.S. markets. Although rollout has been somewhat slow and measured as companies refine their automated systems and give the public time to warm up to this technology, highways of the future will be filled with self-driving cars. According to Research & Markets, 20.8 million autonomous vehicles will be in active use on America's roads by 2030.

Self-driving vehicles promise to make transportation safer by removing human error from the equation. AI-enabled cars could make split-second decisions and respond more quickly to dangerous road conditions. Proponents also believe that autonomous vehicles will ease congestion in the nation's most traffic-plagued cities. Self-driving cars would be able to communicate with each other to efficiently move through intersections and navigate commuter bottlenecks.

What are the ethical implications of autonomous vehicles?

Self-driving cars are at an interesting point in their evolution where they must coexist with human drivers on the road and respond to their actions. Stanford University Assistant Professor Dorsa Sadigh has done a great deal of research on the development of autonomous vehicles and how they recognize and respond to variances in human behavior. A driver could be aggressive, defensive, attentive or distracted, and self-driving vehicles need to be able to understand those differences so they can accurately predict what will happen on the road from moment to moment.

Robotic systems generally learn from human behavior by passively observing people's actions, but could more actively gather the information by probing people to elicit a response. Professor Sadigh developed an algorithm that would empower autonomous vehicles to actively "nudge" drivers—by tapping their brakes or drifting into another lane, for instance, to gather information about how drivers respond in different conditions.

There are clear ethical concerns with autonomous vehicles testing human responses by generating their own driving conditions. Drivers would essentially be participating in data collection—in this case related to their behavior—without giving their consent. It's also conceivable that autonomous cars would be able to label specific drivers as inattentive or aggressive and share that information with other vehicles so they could respond accordingly if they encounter those same drivers on the road. That information could also be sent to law enforcement agencies or insurance companies to flag potentially dangerous drivers. The potential for autonomous vehicles to monitor driver behavior is an ethical dilemma that the industry is working to address.

Advancements in AI will enable machines to recognize and respond to the nuances of human communication, including body language, facial expressions and other non-verbal cues.

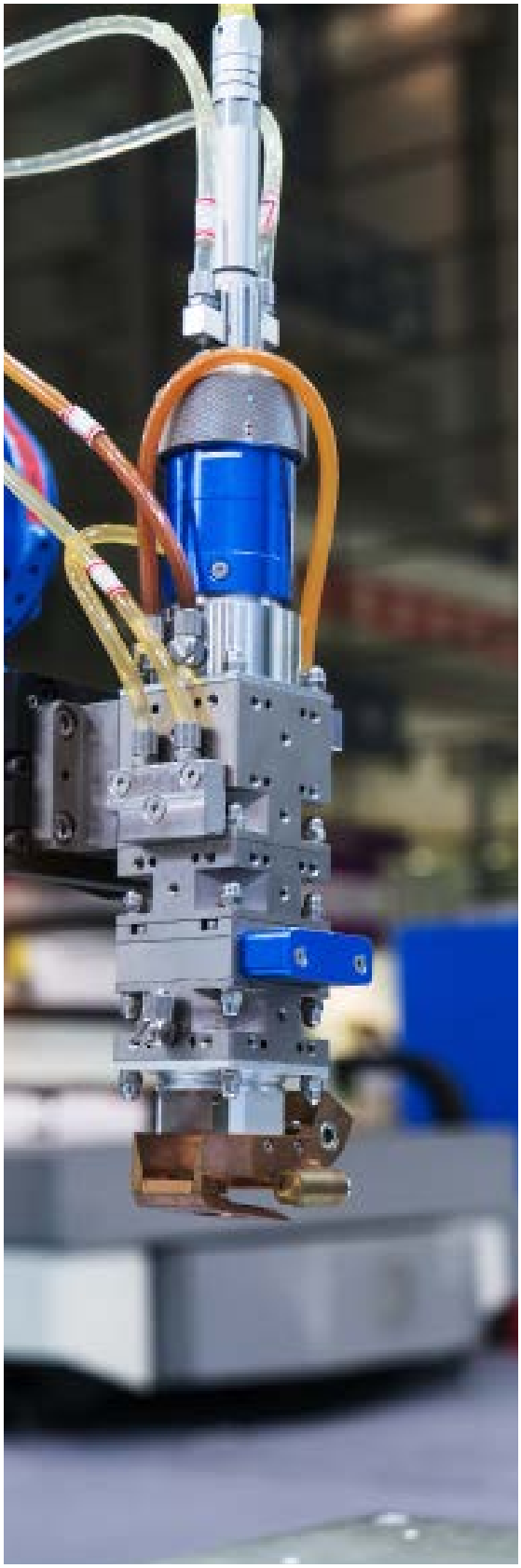
Automated machines become part of the workforce

Automation is nothing new in the workplace. Automated machines are already widely used in manufacturing, for instance, where they offer better consistency and productivity than human operators. Further improvements with autonomous systems and technology will allow these machines to tackle more delicate, complex and nuanced work that requires a great deal of dexterity.

Deloitte explained that as autonomous robots evolve, incorporating more sophisticated sensors and AI algorithms, they will become faster and more efficient, as well as being able to make more intelligent decisions without any human input. The net result will be lower labor costs, improved accuracy and increased productivity. Automated machines could also be used to tackle dangerous or high-risk work, such as handling corrosive chemicals, helping to make work environments much safer. From a financial perspective, fewer worksite injuries would reduce insurance and workers' compensation costs.

Advancements in AI will enable machines to recognize and respond to the nuances of human communication, including body language, facial expressions and other non-verbal cues. Deloitte researchers envision a future workforce where humans and machines work side by side, interacting with each other.

What are the ethical implications of a human-robot workforce?

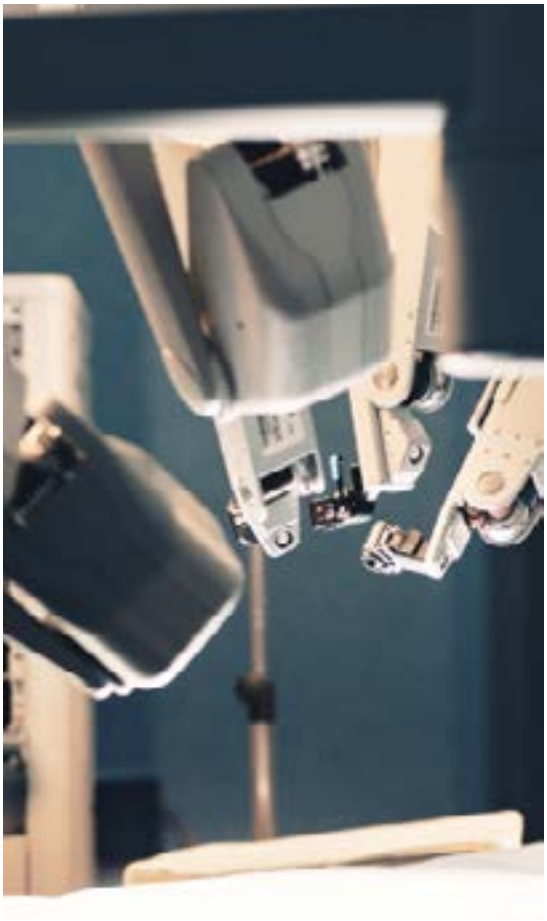


With human and robot workers operating so closely to each other, inevitably they will affect one another—potentially in ways that aren't immediately apparent. As discussed, AI-driven robotic systems learn from people through observation. How can we be sure that robotic workers pick up on the right practices and characteristics without also replicating malicious or harmful behavior?

Even mirroring human movement can be problematic since robots rely on demonstrations, and not all of the information provided by such presentations are useful. Professor Sadigh noted that having people explicitly state their preferences for robotic behavior, meanwhile, could be overly time-intensive. In addition, if the person listing preferences isn't entirely clear on the goal of those queries, they may give faulty instructions.

Conversely, robots' actions and behavior can impact human workers just as easily. Highly efficient, emotionless robots could cultivate an environment that pushes employees to work faster while also avoiding making any mistakes. That could lead to more workplace stress and injuries, and cause human employees to burn out quickly.

One Yale study found that by programming robots to occasionally make mistakes and confess to those errors, employees felt less stress and experienced a greater sense of camaraderie with their autonomous coworkers. The relationship between human and robotic workers needs to be navigated carefully to account for these kinds of concerns.



Autonomous systems improve healthcare outcomes

AI is already a familiar face in the healthcare industry: scheduling chatbots, sensor-equipped medical devices and patient-diagnosing algorithms are all currently in use or being piloted in different markets. Advancements in robotics and autonomous systems will further drive innovation in healthcare, improving the quality of care and providing specialized treatments.

Remote surgery is one of the most compelling applications for sophisticated robotics, allowing doctors to perform complex procedures without being physically present. This technology could enable specialists to perform life-saving surgeries on patients across the country or even planet, without ever coming into contact with them. In China, for instance, a neurosurgeon successfully performed brain surgery on a patient with Parkinson's Disease who was located more than 1,800 miles away.

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Stanford University Professor Allison Okamura has worked to address one of the biggest hurdles to remote surgery: recreating the tactile sensation of physically touching and holding medical instruments without being in the same room as the patient. This is extremely important for performing procedures where the slightest error could have fatal results. Using haptic technology, Professor Okamura has developed remote surgery tools that provide sensory feedback.

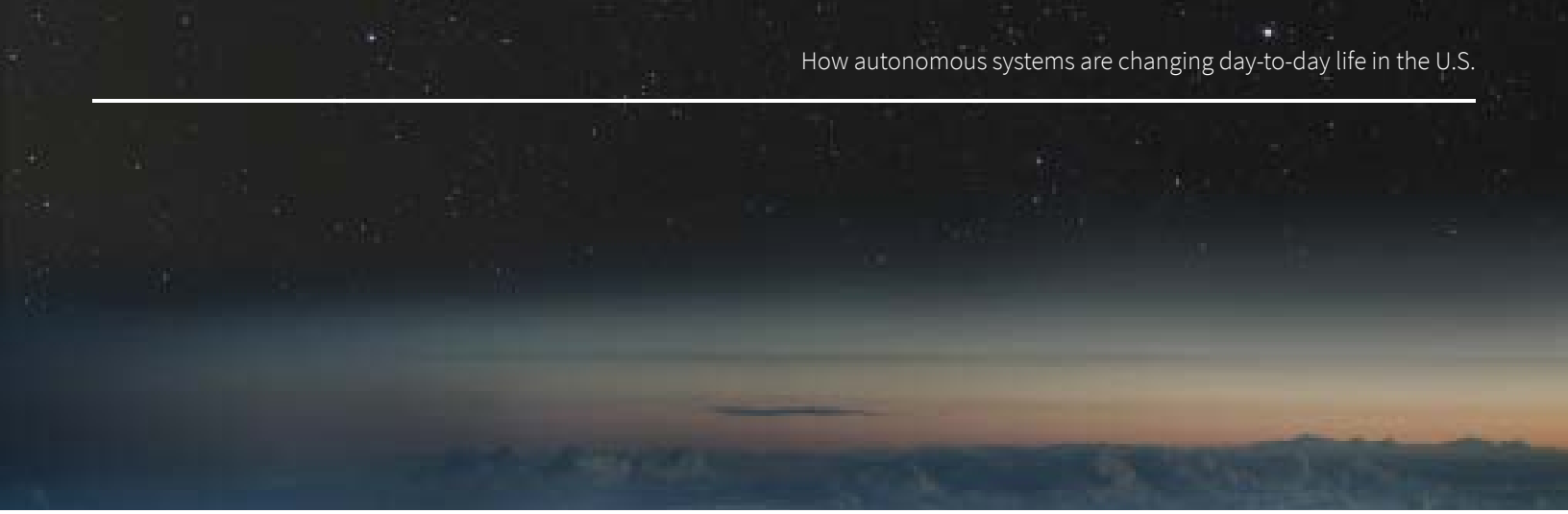
Elsewhere, researchers like Stanford's Krishna Shenoy are experimenting with implantable brain sensors that analyze and record the neuron activity that controls motor skills and body movement. Taken a step further, this information could be used to create robotic limbs for amputees and patients suffering from paralysis. Patients could control those prosthetics with the same seamless motor skills as if they were communicating with their own limbs.

What are the ethical concerns with autonomous systems in healthcare?

There are a number of ethical dilemmas to consider with healthcare robots, depending on how they are implemented. The biggest concern, however, revolves around trust. Proponents of self-driving vehicles have had to grapple with this issue as well. Handing over processes and tasks that have life-or-death implications to automated systems requires confidence that those technologies will always act in people's best interests.

If a robotic caregiver gathers medical data from a patient, how can that individual be confident their personal information won't be disseminated to other people or entities. Could that information be shared with one's insurance company without their consent?

Realizing the full potential of robotics and autonomous systems in healthcare may involve giving robots permission to be caregivers over the human body. Is that a decision people are comfortable making?



Advanced algorithms enable robots to reach out and grab objects with incredible precision and speed when in the gravity-free void of space.

Autonomous systems venture where humans can't

Space exploration presents a number of challenges, not least of which is the inhospitable environment that must be traversed to support further research. Robotics and autonomous systems are an ideal solution to that problem, and satellites, probes and other devices have provided the human race with invaluable information about neighboring planets, celestial bodies and the greater universe.

Even with remotely controlled robotics, there are problems that need to be addressed. Communication delays between probes and human operators located light-years apart would prevent either from making split-second decisions. Consider that NASA employees experienced up to 20-minute delays when sending instructions to the Mars rover. In terms of space exploration, Mars is right next door.

Autonomous systems will address this issue by giving probes and other exploration robots the authority to direct their own actions. Stanford University Assistant Professor Marco Pavone has developed a number of technologies to help robots operate in space and other harsh environments. For instance, advanced algorithms enable robots to reach out and grab objects with incredible precision and speed when in the gravity-free void of space. Pavone and his team have also developed robots specifically designed to function in low-gravity environments like an asteroid.

What are the ethical concerns with autonomous space exploration?

Similar to transportation and healthcare applications, the major ethical concern with using autonomous systems for space exploration comes down to a matter of trust. There is an additional complication to consider when it comes to this particular field, however. The inherent communication delays make it all but impossible for human operators to maintain consistent oversight with autonomous probes. How can people verify that these autonomous systems will make decisions that make sense from a human perspective when they are on their own on the frontiers of space?

Pavone argues that these concerns must be addressed at the design and testing stages. Given the extreme variables and unknown conditions that a robotic probe will encounter during space travel, however, it is extremely difficult to plan for every contingency and predict how autonomous systems will respond.

Autonomous systems shape our future

Autonomous systems are driving innovation in many industries, helping to address some of the most pressing issues facing humankind. The technology is already part of our everyday life in some capacity, but more applications, along with more ethical implications, will emerge as it continues to mature, evolve and grow more sophisticated.

Eventually, autonomous systems will come to touch every aspect of life, creating more demand for knowledgeable and skilled specialists to manage and maintain those solutions and answer ethical concerns. To learn more about this technology and begin your own career in this exciting field, consider enrolling in the Robotics & Autonomous Systems graduate certificate program from Stanford Center for Professional Development.