



DEEP DIVE: WILL WE FALL IN LOVE WITH ROBOTS? COMPANIONSHIP AND ARTIFICIAL INTELLIGENCE

In previous reports, we have examined how robots could take over jobs across industries and assist humans at home. In this report, we turn our focus to companionship between humans and robots, an issue that is emerging as scientists and companies continue to develop artificial intelligence (AI).

- 1) The household robot segment, which includes cleaning, personal assistant and companion robots, is growing rapidly. Market-measurement firm Tractica expects shipments of these robots to grow from 4.3 million in 2015 to 19.3 million by 2020.
- 2) While the household robot market, including cleaning robots, is already rather established, the market for companion robots is still in its infancy. The International Federation of Robotics (IFR) projects that, between 2015 and 2018, only 8,100 companion, assistant and humanoid robots will be sold.
- 3) Kevin Curran, a professor of computer science at Ulster University, believes that, as robots are developed to look and act more like humans, it is inevitable that people will fall in love with them.
- 4) David Levy, a British AI researcher, predicts that, by about 2050, humans could marry robots, and that the state of Massachusetts—home to one of the largest clusters of robotics companies in the world—will be the first jurisdiction to legalize marriages with robots.

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EXECUTIVE SUMMARY

“More human than human” is our motto.”

– Dr. Eldon Tyrell, *Blade Runner* (1982)

In this report, we examine how technological advancements could revolutionize relationships and love between human beings and robots.

The idea of falling in love with a robot is not currently accepted in any society in the world—most likely because robots are regarded as nonliving objects. But as AI evolves, it has the potential to surpass human intelligence, so, at some point, robots may not be perceived as objects anymore, but as equivalent to humans.

Many of the companies developing companion robots design them with humanlike functionality, such as the ability to identify their owner's feelings and to evolve their knowledge based on their owner's lifestyle and preferences. The ultimate goal is to ensure the human is happy and satisfied.

In this report, we examine how technological advancements could revolutionize relationships and love between human beings and robots. Specifically, this report looks at the following:

- **Developments in AI are progressing rapidly:** Although scientists have not yet even fully determined what human abilities are, the software for AI is expected to be mastered by around 2030.
- **Household robots are becoming more common:** Companion robots are included in the household robot category, a market that is expected to quadruple within the next four years in terms of number of units shipped worldwide.
- **Companion robots will serve humans for different purposes:** The market for companion robots is expected to grow exponentially in coming years, with robots targeted for different purposes, both platonic and nonplatonic.



Source: Shutterstock



AI IS DEVELOPING RAPIDLY

First, let us define what AI is and what scientists expect it will become in the coming years. Computer scientist John McCarthy at Stanford University defines AI as:

The science and engineering of making intelligent machines, especially intelligent computer programs. It is related to the similar task of using computers to understand human intelligence, but AI does not have to confine itself to methods that are biologically observable.

By 2029, the software for AI will have been largely mastered and the average personal computer will be equivalent to 1,000 human brains.

The development of AI is still in its early stages, partly because the cognitive sciences still have not succeeded in determining exactly what humans' abilities are, McCarthy says.

We may not yet fully understand all human abilities, but developments in AI are evolving rapidly. Ray Kurzweil, a futurist and Director of Engineering at Google, wrote in *Scientific American* that, by 2029, the software for AI will have been largely mastered and the average personal computer will be equivalent to 1,000 human brains. By 2030, Kurzweil believes, any type of experience—business, social or intimate—will be possible with anyone, real or simulated, regardless of physical proximity. The next 15 years will be pivotal in understanding how AI will change humans' everyday lives.

HOUSEHOLD ROBOTS OPEN THE PATH TO COMPANION ROBOTS

In our July 2016 report *Robots, Robotics Continue to Move from Labs to Everyday Life*, we discussed how robots are walking out of labs and into our lives. Robotic technology is increasingly being used at home for a variety of purposes, from helping with household tasks to operating as a personal assistant to solely providing companionship to the owner. According to Tractica, shipments of household robots, including personal assistant robots, will increase from 4.3 million in 2015 to 19.3 million by 2020. Tractica's figures do not, however, specify the shipments of companion robots.

In the US, approximately one in 10 households will own a consumer robot by 2020, up from one in 25 in 2015.



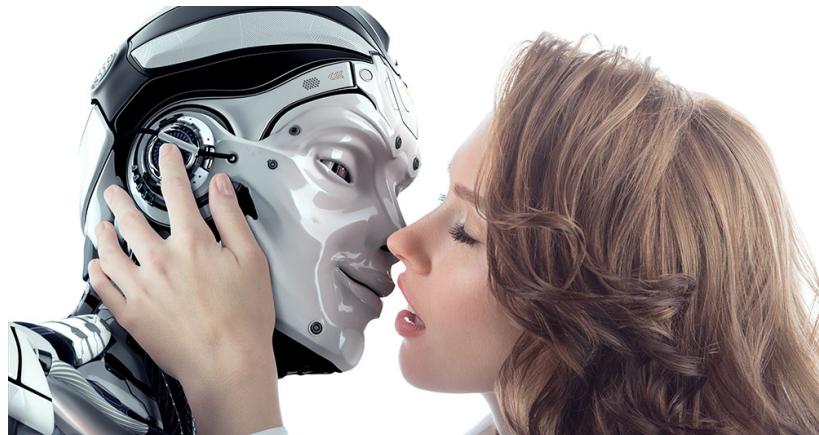
Source: Shutterstock

Market research firm Juniper Research thinks that one in 10 American households will own a consumer robot by 2020, up from one in 25 in 2015. The company highlights that, at the early stages of market development, task-oriented robots will take over household chores, such as vacuum cleaning, but that consumer expectations and demand for more complex AI robots are increasing.

In some other countries, the domestic use of robots is expected to become the norm even faster. In 2006, the South Korean Ministry of Information and Communication estimated that, by 2020, every home in South Korea will have a household robot. These could include anything from vacuum cleaners to toys—although companion robots' share of all household robots is still expected to be relatively low in 2020.

Concept of Love for Humans and Robots

What is love? Different authors and great thinkers define it differently, but most agree that love, in its different forms, is something people seek in order to feel fulfilled. Greek philosopher Plato separated love into two different forms, erotic love (*erôs*) and friendship (*philia*). He argued that the best kind of friendship is where *philia* comes into existence with *erôs*, which, in turn, nourishes *erôs*, strengthening and developing it.



Source: Shutterstock

In the future, humans will be able to customize their own robots, and people may question why a human would choose to have a relationship with another human instead of with a robot.

Shakespeare wrote in *The Merchant of Venice*, “But love is blind, and lovers cannot see the pretty follies that themselves commit,” making the point that love makes us sometimes lose control of our feelings and behavior.

Scientists have come to conclusions similar to Shakespeare's. In their paper “Reduced Cognitive Control in Passionate Lovers,” psychologists Henk van Steenbergen, Sandra J. E. Langeslag, Guido P. H. Band and Bernhard Hommel state:

Falling in love is an experience that involves very intense affective and cognitive changes, including euphoria and overwhelming joy, increased arousal and energy, emotional dependency on the partner, craving for emotional union with the beloved, and obsessional thoughts about and focused attention on the special other.

Signs of falling in love are not only psychological; they are also physical, and can include rapid heartbeat. While human-human love is the norm in society, falling in love with nonhumans is expected to become more common in the future. Kevin Curran, a professor of computer science at Ulster University, told technology magazine *The Institute* that, as robots are developed to look and act more like us, it is inevitable people will fall in love with them.

Research suggests that humans empathize with humanoid robots in ways that are similar to how they empathize with other humans.

In the future, when humans will be able to customize their own robots, Curran believes that people may question why a human would choose to have a relationship with another human instead of a robot. But no matter how much a human may love a companion robot, the feeling will ultimately be just one-sided, as a robot can never truly think. Its thinking will still come down to the algorithm's selection—and therefore, it will never truly love, Curran says.

Nor will robots experience the side effects of falling in love, such as rapid heartbeat and increased energy. Love will not make robots "go blind," either, no matter how they may have been programmed to love their owners. But these factors may not matter to people, as long as they love someone and their needs are fulfilled in emotional or physical ways, or both.

People Could Empathize with Robots the Way They Do with Humans



Source: Shutterstock

Research conducted by Toyohashi University of Technology in Japan found that humans can empathize with robots the same way they do with other humans. The neurophysiological research examined humans' ability to empathize with robots in perceived pain, such as we experience when we cut a finger with a knife.

Similar findings were discovered by researchers at the University of Duisburg-Essen in Germany. Participants were shown videos of a small robot being treated in an affectionate or violent way while their

psychological response was measured. Participants reported negative feelings when they were shown a video of the robot being abused, compared with the robot being treated affectionately.

These results suggest that we empathize with humanoid robots in ways that are similar to how we empathize with other humans. Although these findings do not interpret exactly what emotions human beings have when interacting with robots, or if the level of affectionate feelings for robots could be equal to the feelings they have for other humans, they do imply that it is possible for humans to experience deeper feelings than just sympathy for robots.

Companion Robots for Different Purposes

In our June 2016 report *Technology for Mobility-Constrained Seniors*, we showed how the first mass-produced AI social robots, such as Jibo, are serving older people by performing everyday household tasks, and how they also act as companions to seniors. This kind of “artificial companionship” is more likely to remain the norm among seniors, with robots being caretakers and keeping their owners company; seniors are unlikely to fall in love with such companion robots. However, advances in AI make it increasingly likely that robots will be developed to serve people across ages, including as life partners.

Although the first mass-produced AI robots have been targeted to seniors, advances in AI make it increasingly likely that robots will be developed to serve people across age different age groups.



Source: Jibo

“Technosexuals” are defined as those who are attracted to gadgets and robots, especially humanlike robots. According to *The Atlantic* magazine, a subculture of this group includes those who are attracted to robots that do not necessarily have a humanoid appearance. These attractions to robots can be both platonic and nonplatonic.

In 2007, British AI researcher David Levy predicted that love with robots will be as normal as love with other humans in future decades. Levy reiterated this in an interview with science-news website *Live Science*, where he predicted that, by around 2050, humans will be able to marry robots. Levy predicted that the state of Massachusetts will be the first jurisdiction to legalize marriages with robots, as the state, and the Boston area in particular, is home to one of the largest clusters of robotics companies in



the world, partly as a consequence of the many world-renowned research universities located in the area.

The legalization of same-sex marriage in the US in June 2015 has reignited debates among some futurists over whether robots could, at some future point, have the same rights as humans to get married. Currently, the four principles of and traditions for a marriage in the US, according to the US Supreme Court, are:

- **Individual autonomy:** the right to personal choice regarding marriage.
- **Right to intimate association:** supporting a two-person union unlike any other.
- **Safeguarding children and families:** protecting the rights of childrearing, procreation and education.
- **Marriage is a keystone of American social order:** states have contributed to the fundamental character of marriage by placing it at the center of many facets of the legal and social order.

Currently, humans cannot legally marry robots, as robots are not considered "persons."

Do robots meet these marriage criteria? Currently, robots are programmed to obey humans or the algorithms that humans have created, so they are not identified as "persons." They cannot decide whether or not they want to get married to a human being, so the first principle noted above does not apply to robots. However, they could provide companionship to lonely people, so they could support a two-sided union. Robots cannot produce children, but, as we discuss later, some existing robots already educate and safeguard their owners, which include children. None of the aspects of marriage being "a keystone of American social order"—which might include taxation, inheritance and property rights, hospital access, and health insurance—are particularly relevant to robots currently, although they may become so in the future.



Source: Shutterstock

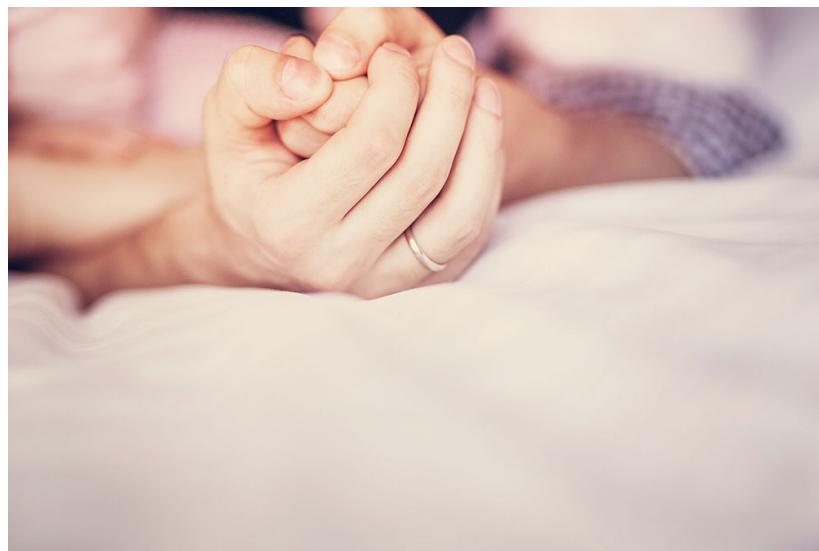
Some other countries have legislation similar to the US marriage legislation noted. Currently, human-robot marriage would not accord with the set legislations, and so, such marriages could not happen unless robots' rights were to be changed.

Intimacy with Nonhumans Becoming More Common

Whether people will be allowed to marry robots or not, relationships between them will inevitably occur. In a 2015 report, futurologist Dr. Ian Pearson argued that human-robot sex will overtake human-human sex by 2050. He says that many people currently have reservations about sex with robots, but as the AI and robots' mechanical behavior improves, and as people start to build strong emotional bonds with robots, prejudices will gradually evaporate.

Not everyone is happy with robots being used as companions or for intimacy purposes. The Campaign Against Sex Robots was launched in 2015 by Kathleen Richardson, Senior Research Fellow in Ethics of Robotics at De Montfort University in Leicester, to raise awareness about sex robots and their potential impact on society. She highlights her concerns that robots used for intimacy purposes will further sexually objectify women and children, and that they "will further reduce human empathy that can only be developed by an experience of mutual relationship."

In sum, Pearson predicts that prejudices toward robots could gradually evaporate, and study results from the Toyohashi University of Technology indicate that humans' empathy for robots could grow over time, but Richardson argues that the growing empathy for robots could have detrimental effects on humans.



Source: Shutterstock

EXTENSIVE SALES OF COMPANION ROBOTS TO START AFTER 2020

Companion robots are not likely to be mass produced until after 2020, when manufacturing and product design costs are expected to be lower.

The IFR has projected that demand for and sales of domestic-use robot companions, assistants and humanoids—robots that are designed to imitate human mobility, dexterity, and sensory and cognitive skills—will increase. However, in its *World Robotics 2015* yearbook, the IFR estimated that, in 2014, only 482 such robots were sold worldwide. This is significantly lower than the IFR's estimated total number of units of domestic-use robots sold worldwide in 2014, 4.7 million.

The IFR estimates that approximately 8,100 companion robots will be sold worldwide between 2015 and 2018. In its *Robot Revolution—Global Robot & AI Primer* report, Bank of America Merrill Lynch noted that the IFR's projections may be conservative, as more than 4,000 of SoftBank's Pepper human companion robots were sold in 2015 alone. In Japan, some 3,000 households are already equipped with a Pepper, according to website Robotics News.

The IFR further estimates that 35.1 million domestic-use robots will be sold worldwide between 2015 and 2018, so the 8,100 companion robots that the organization thinks will be sold during that period comprise only a small part of the total projected unit sales of robots.

The IFR also says that, despite the significant number of potential customers, only a few companies have developed companion robots for personal and domestic use. High manufacturing costs and high product design costs are two key factors behind the somewhat sluggish market growth in recent years. The IFR expects that manufacturers will not be able to mass produce companion robots until after 2020.



Source: Science Daily

The market for companion robots is still in infancy, and it is difficult to define which categories different types of companion robots belong to. For example, the IFR has not broken out the robot companions, assistants and humanoids category into further subcategories, but it does categorize True Companion—a company that designs robots for intimacy purposes—as a manufacturer of “other professional service robots, not specified.” This category sold just 114 units in 2014, according to the IFR, and it projects that 2,000 units will be sold between 2015 and 2018. As more companies

enter the market for domestic-use robots, and the segment matures, category definitions are likely to be clarified.

Overview of Companion Robots

Robot developer Kaname Hayashi believes that achieving “subconscious communication,” such as wanting to touch a robot or needing to be heard, is often more important for humans than verbal interaction is.

As we noted earlier, the market for companion, assistant and humanoid robots is still in its infancy. Some companion robots for domestic use are already on the market, and many are under development. Below, we list some companion robots that are currently in development.

Kaname Hayashi, the “father” of Pepper, one of the most famous AI robots in the world, is developing a companion robot called **Groove X**. One of the key functions of the robot is to improve the owner’s mood, performance and self-esteem by helping him or her achieve self-realization. Hayashi has said he does not want to call the robot a “cure to loneliness,” but that he believes sometimes people want to be isolated from other humans for whatever reason, and that, on such occasions, people may wish to be accompanied by a robot.

According to news agency EFE, Hayashi is developing Groove X to be able to communicate with people on the subconscious level. He discovered that achieving “subconscious communication,” such as wanting to touch the robot or needing to be heard, is often more important for humans than verbal interaction is. The Groove X robot, which will be smaller in size than the Pepper robot, is expected to hit the market in 2019.

Some companion robots, such as **Buddy** from Blue Frog Robotics, are designed for use by the whole family. Buddy, which at the time of writing was available for preorder from €646 (US\$731), can socially interact with people and teach children through play. The robot also comes with home security functions; for example, it can send the owner alerts regarding unusual situations, such as fires and floods.

The Buddy Companion Robot



Source: Blue Frog Robotics

Hanson Robotics' **Sophia** robot is designed to look like a combination of Hollywood star Audrey Hepburn and the wife of the company's founder, David Hanson. This AI robot made its first public appearance at the SXSW 2016 festival in Austin, Texas. Sophia is designed to show facial expressions, and interact verbally and nonverbally with people. According to Hanson Robotics, Sophia's intelligence grows, and the robot can connect with people regardless of age, gender and culture. Similar to Groove X, Sophia is likely to serve the purpose of socializing and keeping its owner company. The company's long-term mission is to dramatically improve everyday lives with highly intelligent robots that can provide comforting companionship.

The Sophia Robot



Source: SophiaBot

While the robots mentioned above are designed to serve their owners by providing companionship and entertainment, some companies, including Abyss Creations and True Companion, are developing robots for intimacy purposes. Customers can design many of the features of the humanlike and human-size robots made by these companies.

At the same time, some of the companies that make companion robots are strictly emphasizing that customers who purchase robots must not engage in sexual acts with them. According to *The Japan Times*, SoftBank, the company behind Pepper, states in its user agreement that "the policy owner must not perform any sexual act or other indecent behavior" with the product. As researchers and companies continue to develop AI and companion robots, we will almost certainly see a vast range of products to serve different purposes in the decades ahead.

KEY TAKEAWAYS: COMPANION ROBOTS WILL INEVITABLY BECOME MORE POPULAR

The starting point for companion robot sales is very low, with only a few thousand having been sold so far worldwide. But in the coming years, millions of households are expected to buy robots, including those designed to provide companionship.

Developments in AI will have a significant impact on people in the coming decades, but for the time being, it is difficult to discern just how extensive that impact will be. Some experts in AI and robotics believe that human-

Human-robot partnerships, platonic and nonplatonic, could one day be as normal as human-human relationships.



robot partnerships will one day be as normal as human-human relationships are today. The types of human-robot relationships will likely be varied, and could include platonic and nonplatonic, and emotional and nonemotional relationships. The question of giving robots the same rights as humans has not been an issue so far, and it may not become one even in the coming decades—but it is possible that legislation could be changed as intimate bonds between humans and robots become part of everyday life.

The fundamental issue with people falling in love with robots is to what extent society will accept robots being treated as humans. Regardless of the question of whether or not it is ethical to fall in love with a nonhuman, AI-equipped robots are likely to change the way some people's emotional and physical needs are fulfilled.



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