VOLUME 12 | ISSUE 04 | APRIL 2017

digit FastTrack

YOUR HANDY GUIDE TO EVERYDAY TECHNOLOGY

To

ROBOTICS

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- The brain
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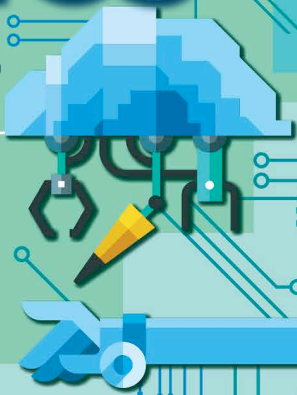

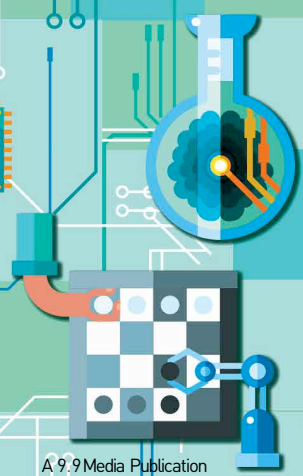

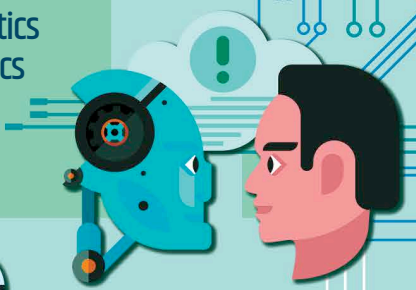

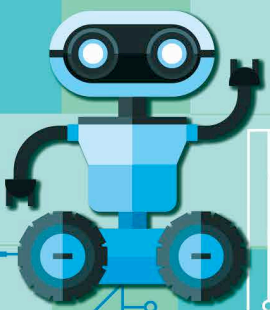

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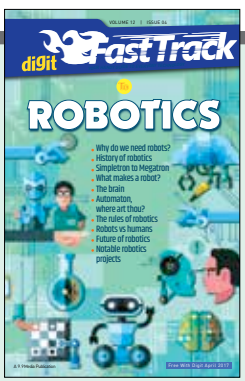


COVER DESIGN: PETERSON PJ

I am a friend

There isn't a dearth of naysayers when it comes to discussing the field of robotics. In fact, the debate about robots stealing human jobs has never been louder at any other point in history. But as every Digit reader will know, harboring a feeling of fear towards technology is only something that fools do, and any technological advancement is eventually a tool to be used as we see fit. And that is what this book aims to do - to tell you that robots are your friends if you want them to be and you should know more about them.

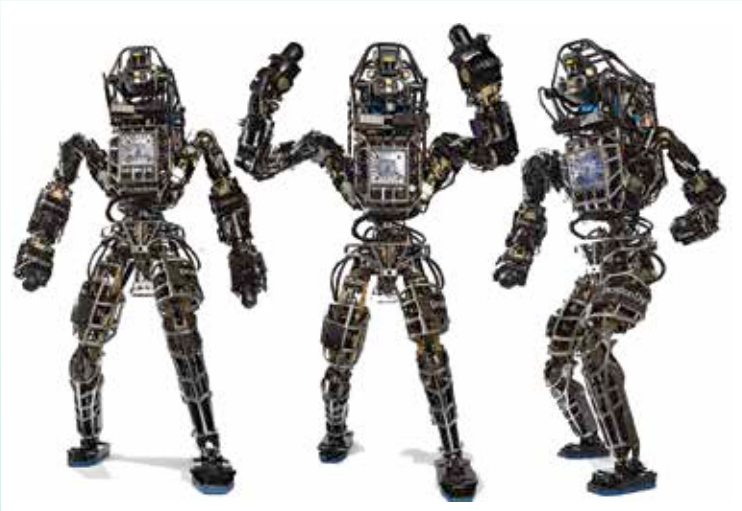
To start off, familiarising yourself with what constitutes a robot is very important. Just how smart does a smart washing machine need to be before you can call it a robot? This distinction goes a long way in taking robotics in the right direction. It is also important to know how robotics has fared over the years and why it has taken the direction it has to reach where it is now. The first few chapters in this book should take care of all of this.

Moving on, we look at what really constitutes a robot - its mind and its matter. Have you ever wondered where all those fancy prototypes, that keep popping up on your social feeds, are now and why don't you see a pet robot dog in every household right now? We did a little research, and what we found out constitutes the next portion of this book.

Eventually, the big question arises - how will humans fare against robots? And if the situation ever arises where humans HAVE to fare against robots, what rules will they fight by? Understanding the direction robots are taking in our labs is crucial to determining that the future being foretold by the naysayers doesn't become a reality. Of late, that seems to happen quite a lot *cough*POTUS*cough*.

The best way to understand the reality that we live in, with respect to robotics, is to look at some of the most interesting robotics projects being undertaken around the world. We are not just talking about niche R&D being done in secret labs, but also college kids building amazing things and open sourcing them.

And remember, robots can be anything that you choose them to be - good, bad, or even a vacuum cleaner.

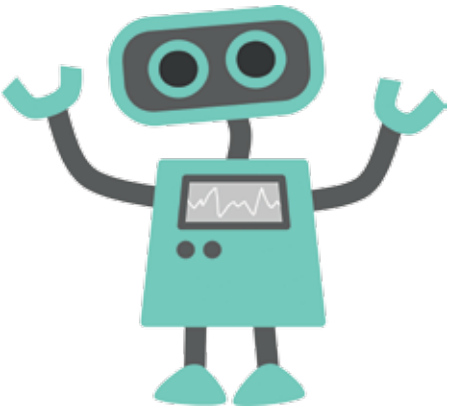


WHY DO WE NEED ROBOTS?

When did man decide that he needed a smart and mechanical man-friday?

It is the year 2039. You wake up at 5.30, all fresh and not at all sleepy, all thanks to your Smart Bed which logs data about your sleep cycles and habits and creates the perfect environment for you to sleep. You jump into the bathing station; you are scrubbed and showered. You remember seeing the advertisement of the latest version of the bathing station which even dresses you up. You make a mental note to check it out later. You head to the kitchen and sit down on the dining table where your Home Assistance Butler V2.5 serves you a wholesome meal. It's not only delicious but also has all the right nutritional values. You leave for your office in your self-driving car and reach on time. Traffic isn't a problem anymore

in a world where all cars communicate with each other. They calculate the optimum route and speed to reach their destinations. Your workstation boots up as soon as you enter and you sit down to work on your current project – a robot that helps you make more robots. Seems like a stretch?



Robots have infiltirated every aspect of our lives and we are surrounded by them without even realizing this.

Back to 2017, we are slowly but steadily moving towards a completely automated future. Take a look around you, technology giants are working hard to make self-driving cars a reality, and they are really, really close. New innovations and breakthrough technologies are coming out almost everyday. If you had told someone 30 years ago that they could see and talk to anyone across the globe in realtime, they probably wouldn't have believed you, in fact maybe even calling you just another nutjob. Nonetheless, the future is here now and the magical thing that is changing our lives currently are 'robots'.

What is a machine and what is a robot? Is my toaster a robot too?

According to Wikipedia, a machine is any mechanical device that "changes the direction or magnitude of a force". Machines can be divided into six simple categories:

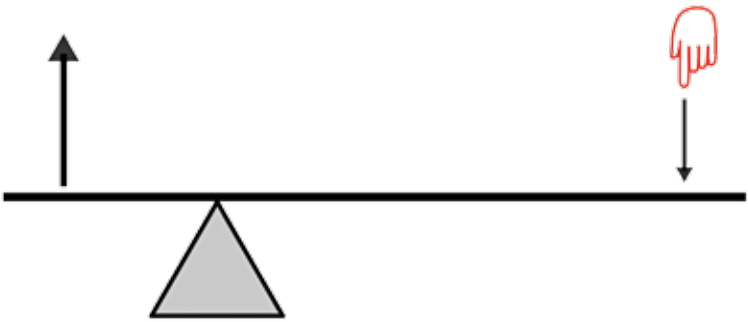
1. Lever
2. Wheel and axle
3. Pulley
4. Inclined plane
5. Wedge
6. Screw

A machine can be any of these six or a combination of two or more that performs a certain task.

A robot is, well, much more complicated. It can be a combination of machines such that:

- It can be programmed
- Interacts with the environment and takes in 'perceptions'

- Processes data and works autonomously to some extent
- Capable of making changes to its physical environment



A lever is one of the simplest machines. These six simple machines form the basis for all mechanical tools, complex machines and robots.

The main difference between a machine and a robot is that robots are 'smarter' in the sense that a machine is capable of only performing a set of specific tasks or motions while a robot takes input from its surrounding, processes the data, and then interacts with the environment. A robot can be programmed to perform a variety of tasks and is capable of taking decisions about its actions based on a number of factors.

It might seem surprising to some, but there is still debate about the exact definition of what a robot is and there's a lot of ambiguity surrounding the word. A toaster is a simple machine because it is capable of performing only a certain task and does not take decisions of its own, while a 3D printer can be called a robot, as it takes input about the design and then processes it to determine how exactly to print the model.

Not every machine can be called a robot while every robot will have some or the other element of these simple machines.

Characteristics of a robot

A machine needs to have some defining characteristics before being counted as a robot. Following are the basic defining characteristics of a robot that a machine must have to be called a robot:

- **Sense** – The machine should be capable of interacting with its environment and sense its surrounding. This can be done using any number of sensors such as light sensors, chemical sensors, pressure and touch

sensors etc. The machine needs to know about its surrounding in order to perform an action.

- **Movement** – Either the machine should be capable of movement in its surrounding environment or it should have moving parts that somehow interact with the environment. This part of the robot is called 'actuators'.
- **Energy** – The machine should have a power source that provides it energy. It can be anything from solar power to rechargeable-batteries.
- **Intelligence** – The most defining characteristic of a robot, intelligence is what primarily sets apart a robot from a machine. It should possess some sort of intelligence such that it processes and takes decisions about its action based on the data it collects from its sensors.

Unlike popular misconception, a robot doesn't have to necessarily look like us humans. Infact, most of today's robots don't. An android robot that looks like us and is capable of mimicking our actions and features is still some time away.

History and origin of the word 'robot'

The word 'robot' is old and didn't always mean what it does in this age. Robot meant 'forced labor' and was used to refer to the system of slavery spread across central Europe, until it was abolished in the year 1848.

The word again popped up in the year 1920, when Karel Capek, a Czech writer, wrote a play titled *Rossum's Universal Robots*. In the play, workers were mass produced from synthetic organic material and were called robots. Strangely, the play was not only the first instance of robots but also the first popular media to showcase a robot uprising and a dystopian futuristic world. Karel Capek didn't know that his play was going to give birth to a whole new sub-genre of sci-fi where robots take over the world and turn against humanity. I guess we have someone to thank for the Terminator franchise.

Not every robot looks like a humanoid and has arms and legs. The Roomba vacuum cleaner is a robot that cleans your house's floors on its own.

Greek mythology features a number of characters that possess many of the traits of a robot. *Hephaestus*, the Greek God of craftsmen, made a three-legged table capable of moving around on its own, and a man made out of bronze called Talos. Back home, there are legends of King Ajatashatru of Magadha dynasty gathering Buddha's relics and hiding them somewhere underground protected by robots or *'bhuta vahana yantra'*.

The first documented account of a robot can be traced back to 4th Century BC Greece, where a mathematician called Archytas of Tarentum designed a mechanical bird called 'Pigeon', propelled by steam. Throughout history, there have been many similar designs and mentions of devices that look and work like a robot.

Industrial robots led to robots becoming more mainstream. Robots could not only increase the efficiency and accuracy, but also reduce the number of workers required. The first robot to be used on a production line was the Unimate Robot. It was first installed in the General Motors, Ternstedt plant in USA. The robot had a 4,000 pound heavy arm that was programmed to stack hot pieces of metals.

Within the next two decades, robots had started to gain a foothold in industry and there were more than 3,000 industrial robots in operation around the globe. Currently, there are more than 1.3 million robots being used in various industries and the number is going to keep on rising.

Hephaestus was the Greek God of craftsmanship credited with making the first robots.

Types of robots and their uses

According to the International Federation of Robotics, robots today can be categorised into two categories – service robots and industrial robots. Industrial robots have revolutionised the production world, increasing the efficiency and reducing manual labour significantly. This $9.5 billion dollar industry is only going to grow.

Service robots, a relatively new field, has also seen major advancement in the past few decades, slowly integrating into our daily lives. The adoption has been so seamless that we don't even realise we are surrounded by robots everywhere. There are robots that help researchers explore the seabed, robots like the Mars Rover that not only traverses an unknown terrain on an alien planet but collects data samples from its surrounding and processes it as well.

The robots can be broadly categorised into the following segments:

- **Factory robots** – A breed of industrial robots that help design, manufacture and package things. Almost the entire manufacturing industry is automated right now and everything from cars to airplanes to safety pins, are manufactured using robots.
- **Healthcare robots** – An upcoming breed of robots that help in the healthcare industry. They include everything from intelligent prosthetics, to electronic wheelchairs (like the one Stephen Hawking has), and robots capable of filling prescriptions in pharmacies.
- **Research robots** – This category of robots, consists of new machines being developed to solve a variety of real world problems that the current generation of robots are not capable of solving. New technologies and designs are being used to produce this category of robots which include nanobots (nano scale robots), swarm robots (inspired by the colonies of insects, these robots work together to complete a particular task) and much more.
- **Life saving robots** – These robots feature all the machines that directly or indirectly reduce the risk factor of human life. There are military robots capable of defusing bombs while humans can stay away at a safe distance. Mining robots have reduced the risk on human life drastically, doing all the risky drilling and mining work. Work is being done on developing robots that can extract humans from distressed zones at times of earthquakes and wars.

Robots and their effect on our society.

Japan has more than 40% of all the robots in the world, making it the country with the highest number of robots, and potentially, the first one to go down, in case of a robot uprising.

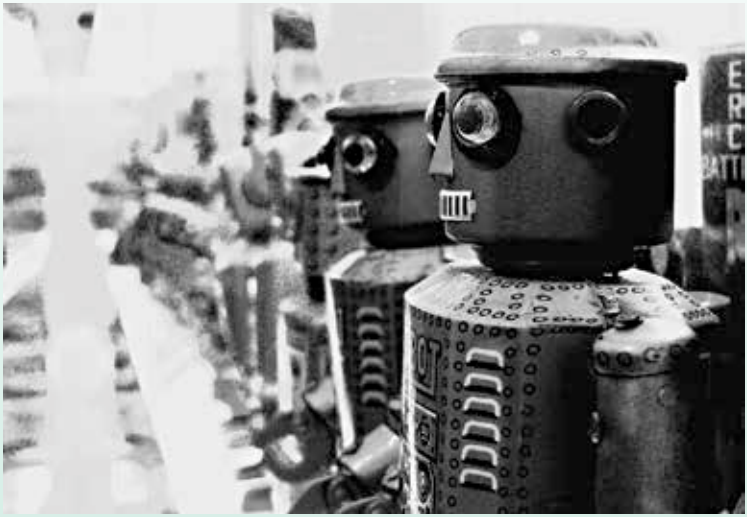
Robots have come to become deeply ingrained into our lives in the 21st century society to such an extent that sometimes all we look at are their pros. We are blinded to their cons (also vulnerable to a robot uprising capable

of eliminating the human race). Since the advent of the industrial age, robots were touted to replace physical labour and make human workforce obsolete. No doubt, this has also led to new jobs for people who can design, develop and operate these robots. But over the past couple of decades, robots have taken more jobs than they have created, leading many technologists including Bill Gates, to argue that we need to slow down the automation of our lives through robots so that we can figure out ways to create more jobs.

Some scientists and engineers raise the point that an utopian world is only possible if all the menial and physical tasks are being taken care of by robots. They believe that robots are the final solution to abolish all forms of slavery in the modern world.

Wheelbarrow is a remotely controlled robot capable of disarming bombs in the battlefield.

While at the same time, there are arguments about robots turning on their creators. People like Stephen Hawking and Elon Musk have warned us against a possible terminator-isque future where we might become slaves to our own creations. Robots raise a variety of ethical questions which need to be addressed soon, because looking at the pace at which the field is growing, the day when we can make a fully-functioning sentient android robot is not far away. Read on to find out where exactly the field of robotics stands right now and where it is headed.



HISTORY OF ROBOTICS

Shouldn't you know a bit more about those who might someday replace us on this planet?

To begin with, it would be better to clear out the confusion about what constitutes a robot versus a mechanical machine. While according to some definitions early computing machines as well as mechanical clocks would technically be robots, what we are looking at here are humanoid machines - machines that mimic, or excel, humans in purpose and shape.

A factory in Dongguan, China - the one belonging to Changying Precision Technology - replaced 90 per cent of its 600-strong human workforce

with robots - and soon saw a 250 per cent rise in productivity and a 20 per cent drop in defects. Last year, Foxconn replaced 60,000 of its workers in one iPhone factory with robots and announced that it aims for 30 per cent automation at its Chinese factories by 2020. While your nightmares from Westworld are going to stay that way for a good while, it is undeniable that we have arrived at an age where robots taking our jobs is no longer the stuff of conjecture. From the ancient automatons of lore to the modern day mechanoids - they've evolved faster than humans, and it would be better to know about their history before they erase ours, or NOT! (Just saying!).

The lore of the ancients

Talos represented on an ancient coin

In various cultures, some artificial creations have always been brought into their world by beings of mythical powers - clay golems, Talos from Greek mythology and more. Some of the earliest stories (since there's barely any physical evidence to credibility) and concepts date back to as far as the 4th century BC when Greek Mathematician Archytas of Tarentum proposed the design of a steam-propelled bird. Across the world, starting from Indian history to the European myths, robots have been mentioned and conceptualised throughout history - along with tales of them protecting, or attacking, mankind. But one of the first documented designs of a humanoid robot came much later in Da Vinci's notebooks from the year 1495. The designs, most likely based on his anatomical research for the Vitruvian man, were intricate and detailed a mechanical knight that could sit up, wave its arms and move its head and jaw.

The 18th century saw a lot of activity in the field of robotics. Automatons in this century - mostly as toys or means of entertainment for the rich - were actually capable of acting, drawing, flying and even playing music. Jacques de Vaucanson, who designed and constructed multiple iconic automatons of

Da Vinci's design was way ahead of its time

that era, was a robotics pioneer of this time. In 1737, Vaucanson built the Flute player, The Tambourine Player and his most famous work, the Digesting Duck. This bird automaton had 400 moving parts in each wing (an astonishing number for that time) and it could actually flap its wings, consume water and grains and then defecate. This was achieved through a hidden compartment of fake 'digested food'. Such frauds were commonplace around the time as the onlookers mainly viewed automatons as means to entertain.

The humanoids arrive

The 19th century saw multiple areas of progress that made advanced robotics (compared to the impractical automatons of the 18th century) a greater possibility. In terms of theory, it was in 1847 that George Boole represented logic in a mathematical form understandable to machines, which is what we know as Boolean Algebra. The automated Jacquard loom of 1801 and Babbage's

Difference Engine in 1822 were to play key roles in the future of automated robots. Another significant development was the patenting of a remote controlled robot boat in 1898 by Nikola Tesla, which would form the basis of the wireless control that we see in space exploration robots even today.

In the 1921 play R.U.R (Rossum's Universal Robots), writer Karel Capek used the word 'Robot' to denote automatons in the story. He credits the word to his brother, who derived it from the Czech word 'robota' that means servitude (kind of setting the intent right there). But the word 'robotics' is said to have come into common parlance due to someone else. Asimov's science fiction writing in the 1940s were a major, and perhaps the most significant, cultural phenomenon when it comes robotics. Most importantly, he conceived the three laws of robotics:

- **First Law:** A robot may not injure a human being, or, through inaction, allow a human being to come to harm.
- **Second Law:** A robot must obey the orders given it by human beings except where such orders would conflict with the First Law.
- **Third Law:** A robot must protect its own existence as long as such protection does not conflict with the First or Second Law.

He also added a zero law later:

- **Zeroth Law:** A robot may not harm humanity, or, by inaction, allow humanity to come to harm.

In 1928, Japan's first humanoid robot was designed and built by Makoto Nishimura, a biologist and it was called the Gakutensoku. This was again a mechanoid meant for display purposes as it could change its expression and perform some gestures such as moving its head and hand. Another significant humanoid built by the Westinghouse Electric Corporation somewhere between 1937 and 1938 was Elektro, a robot. This one could blow balloons, speak about 700 words (using a record player), walk by voice command, smoke cigarettes, and

Elektro with Sparko

just like the Gakutensoku, move his head and arms. But a truly beneficial humanoid robot implementation was yet to come and these were still ornamental advancements.

Harder, better, faster, stronger

In 1950, Alan Turing devised the Turing test as a means to determine whether or not a machine has the ability to think for itself. And throughout the decade, Turing and his contemporaries did some remarkable work in computing and artificial intelligence.

The first industrial robot, the Unimate (for 'universal automation') was created by George Devol in 1954 and patented in 1961. The foundation of Unimation, regarded as the world's first robot manufacturing company, by Joseph F. Engelberger and George Devol in 1956 and the patent grant in 1961 is popularly regarded as the foundation of modern robotics. Unimate was actually used by General Motors in a plant in Trenton, New Jersey to lift hot pieces of die cast metal and stack them up.

The 1960s saw a lot of interest in robotics as an academic pursuit, as a consequence of the industrial robotics advancements of the 1950s. The world

Early UNIMATE model

was looking towards robots that did not need to be told what to do. Also, with Artificial intelligence research laboratories being founded at M.I.T., Stanford Research Institute (SRI), Stanford University, and the University of Edinburgh, interest in Artificial intelligence was rife around this time.

And by the end of that decade, the first mobile robot that could comprehend and reason about its surroundings was built by the Stanford Research Institute (now SRI International). The robot was named Shakey and it navigated using a combination of multiple sensor inputs, including laser rangefinders, TV cameras and "bump sensors". In the same decade i.e. 1960, the world was introduced to ELIZA and HAL.

A new robotic hope

Both the PUMA (Programmable Universal Manipulation Arms) and the SCARA (Selective Compliant Articulated Robot Arm) were developed and extensively used in the 1970s. In the decade of the '70s, manufacturing processes were increasingly incorporating robotic arms for dangerous tasks or to increase efficiency.

In this decade, Star Wars, set in a universe where humans and robots coexisted in perfect harmony, inspired many to look at the next level of human-like robots. It turned out to be something significant in the world of robotics that would inspire scientists and engineers for decades to come.

R2D2 and C3PO have sparked countless minds in the world of robotics

From humanoid to humanlike

In 1986, Honda began a research project to develop robots that could interact with humans. Although this project would take almost a decade to bear fruit, its results would be highly significant in the coming years. Their mission goal stated that the robot "should coexist and cooperate with human beings, by doing what a person cannot do and by cultivating a new dimension in mobility to ultimately benefit society."

Honda's P2 would go on to be further refined

ASIMO

So far, robots were being used in space exploration, but the direction of design was to build one big multipurpose robot. In 1989, a research paper changed the direction of rover research. Instead of one big robot, the paper advocated the use of multiple small ones. This would change the way we designed rovers, especially for the Mars mission in the '90s.

The '90s were full of robotic advancements, as if decades of research and study were finally culminating into results. For example, Robots were already invading areas typically reserved for human skill. Cyberknife, a stereotactic radiosurgery robot released in 1994, could treat tumors by using a minimally invasive method, with an accuracy that was comparable to human doctors. The eight-legged walking robot Dante explored Mt. Erebrus in Antarctica. Dante II, a more robust successor, subsequently explored Mt. Spurr in Alaska in 2004.

After almost a decade of research, Honda's P2, the first self regulating bipedal robot, and then P3, Honda's first completely autonomous robot, were ready to be publicly demonstrated.

The millennial robots

The dawn of the new millennium saw robotics reach everyday life and people like never before. ASIMO, the result of Honda's decade and a half worth of robotics research, was introduced to the world and it was the most advanced robot of its kind at that time.

Weighing only 54 kgs, ASIMO (Advanced Step in Innovative Mobility) was capable of communication with humans, running, walking, facial and environmental recognition, interacting with its environment and voice and posture recognition. Estimates in the same year showed that more than 700,000 robots were being used for industrial purposes around the world - and more than half of them in Japan.

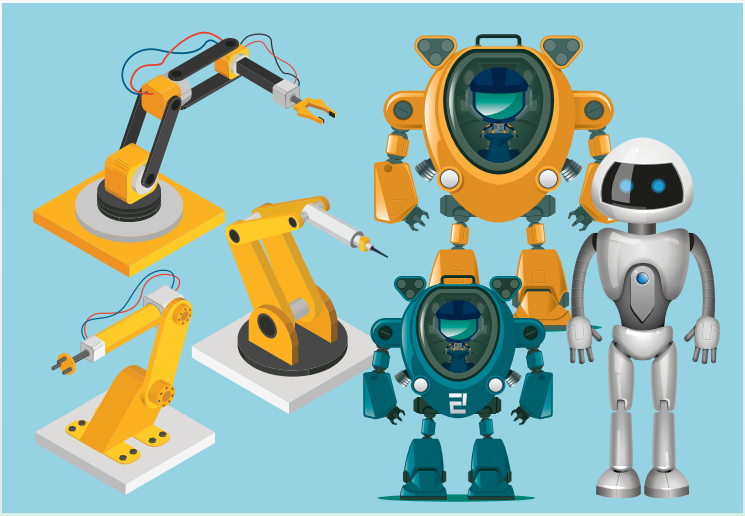
AIBO

Artificial Intelligence Robot, or AIBO, was a robotic dog capable of interacting with humans which also gained popularity around this time. AIBO had several remarkable capabilities like responding to over 100 voice commands and talking in a tonal language, even though it was intended as a consumer market entertainment device.

Behold those who inherit the earth

To most of us, that statement might appear too exaggerated. While we are not claiming otherwise, it would be great if you could look around you and realise how much the world is already dependent on robots. For example, the Roomba automatic vacuum cleaner has sold millions of units, showing how willing we are to welcome robotic technology into our homes. These robots, by the way, are more sophisticated than they have ever been.

On the other side of the power spectrum, there are drones that can navigate the globe by themselves and perform dangerous aerial strikes while the human controller is seated in the safety of their office (or even asleep). In terms of brains, artificial intelligence programs have beaten the world's best at their own games and even learnt how to bluff. If anything, our current state of normalcy with robotics advancement indicates how smooth the transition will be to a world that is completely operated (and perhaps inhabited) by robots.



SIMPLETRON TO MEGATRON

Check out the things that present day robots can actually do - from the amusing to the life changing!

Writers of science fiction seem to be fixated on dystopian futures wherein robots become the masters, or worse, they annihilate humans altogether. It may be too soon to dismiss such scenarios as improbable. But it's also a fact that robots in the present age do some good deeds in service of humans.

So, before we collectively get fixated on a pitiful future in which we are reduced to being slaves to our masters with bloodless eyes, let's take a look at some of the robots in existence today, and what services they render.

The fetching robot

By fetching, if you thought the kind of robot that could play fetch with your dog then you thought different. Fetch Robotics is a company based in California and the robots they create are used for commercial applications including material handling and data collection.

Fetch and Freight by Fetch Robotics

As for material handling in manufacturing units, warehouses, etc., robots are being employed more than ever before. With the price of such devices set to come down in the future, you can expect to see more of them in the work places of tomorrow.

The agri robot

Blue River Technology is based in Mountain View, California. Keeping to their sylvan name, the company developed a robot which seeks to solve a significant issue in agriculture: how to eliminate weeds without applying herbicides on crops or by modifying seeds genetically or by manual methods.

As for the robot that they produced, it makes use of both advanced computer vision and spray technology. Simply put, the robot would be pulled behind a tractor. It has a camera which enables it to peer down at the field. The images the camera collects are processed in mere milliseconds. This enables the robot to determine if a particular plant is a weed or an actual crop. The robot would spray only if it's a weed.

For a greener future

Such a robot could not only help improve health (both for the humans and the environment) it could also help produce food that is more affordable. In fact, if used appropriately, the robotic technology could disrupt the entire pesticide market. In other words, the field is pretty wide at this point.

The barista robot

Everyone loves coffee (or at least, everyone ought to) and anything that makes brewing coffee better should be quickly adopted. And when the technology in question is a robot, all the better!

That's what the food company, Briggo, based in Austin did when they automated the process of brewing coffee.

Coffee brewed, the futuristic way!

The company's robotic barista is modeled on the all too biological barista, Patrick Pierce. The robot can grind coffee to order using a tamper and extract shots using steady water heat to make espresso that are as tasty as they are precise. There's also a steam wand involved, which copies the

angle that's used by Mr. Pierce. It's also said that for the machine, handling a high level of customisation is no big deal. It can, in fact make multiple drinks simultaneously.

The obvious advantage of the robot is that more number of consumers can get gourmet coffee drinks round the clock – assuming you live near a Briggo outlet where the robot serves.

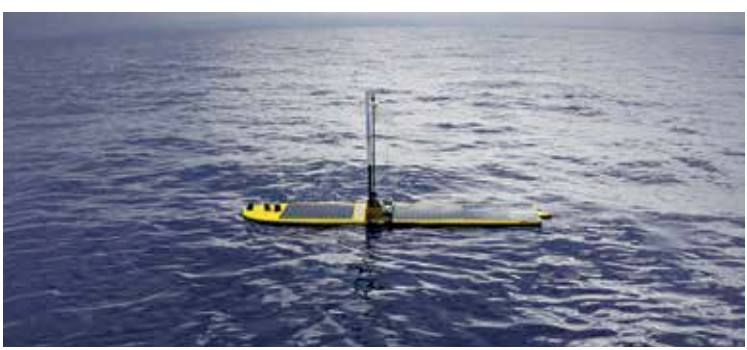
The marine robot

It's said that humans know more about the outer space than we do about our own oceans. That's another way of saying we know next to nothing about the oceans. This means that things such as surveillance services for the oceans make sense scientifically.

Since 2011, the company has seen an annual increase in revenue by 60 per cent, all thanks to selling services and products for ocean surveillance and observation.

The company has a marine robot which goes by the cool name of Wave Glider. It can harness wave energy for propulsion. In fact, the robot even set the world record for mission duration when it crossed the Pacific Ocean all the way from California to Australia. The data which is captured by the robot has multiple uses – from making seismic surveys to strategising underwater warfare. Making things better, it's way cheaper to operate the Wave Glider compared to chartering a ship or using a buoy or even using satellites. At least 180 units are in operation at present.

The Wave Glider is said to be like a floating server rack that's made up of smartphones. It's possible to upgrade the robot in situ and it daisy-chains automatically. This self-swarming mechanism helps get a wider network



More than just skims the surface...

coverage. It demands no human intervention since a potentially unlimited energy is harnessed from the waves.

As for the impact such a technology could have, it could be significant, especially given how climate change has made the weather patterns erratic. The robot gives us a chance to manage the oceans better and help humans afford earlier alerts against phenomena such as tsunamis. It also brings better communication by which ships and fisheries could be managed better.

The bionic suit

Ekso Bionics works out of an old Ford manufacturing unit in California but there's nothing old about the bionic suit that they create. Indeed, it's a wave of the future that helps paraplegics walk again.

The suit was released in February of 2012. Within an year, the company marked about 1 million steps taken with the aid of the suit by some 500 patients. The company hopes to help a million people walking with the suit in a decade. Even though the current cost is less than easy-on-the-pocket: it's $1,10,000, it's hoped that the price would plummet as the demand goes up.

The technology for the suit takes a leaf or two out of the page of load-carrying exoskeleton units which were originally developed for the military. However, Esko's technology uses significantly less power (just 5 watts as opposed to 5,000 watts for the military units). Software and also the sensors included in the hip and knee regions of the device accurately assess when it's safe for the suit to take the next step, based on the wearer's body weight distribution. The suit could be sized to a particular patient in just five minutes. It has an anti-stumbling software – something which ensures at the very least 200 steps for the walkers using it for the first time.

Walk to the future

This robotic technology, if it can be made sufficiently affordable could make the clunky wheelchairs obsolete.

The manufacturer robot

Rethink Robotics is based in Boston, America. There's a significant level of excitement around Rethink's robotic offering and not just because it's owned by Rodney Brook whose first startup has given us the iRobot. Rethink's robot is called Baxter and it's said to be the world's first robot which can work along with people in a manufacturing setup without the use of safety cages.

Baxter is only vaguely shaped like a human and comes equipped with an array of sensors and cameras which the robot uses for adaptive learning. The robot has the ability to avoid collisions, adjust itself to change in the speed of conveyor belts and also recall objects. It can even bring operations to a halt in case of ambiguous conditions or if it has perceived that something outside the desired parameters is underway. The setup for this rather complex robot can be done in under an hour.

Making stuff, following one command at a time

Baxter is said to be considerably more affordable than its more clunky peers. This means that, at least in the US, reduced outsourcing among manufacturers - especially small organizations could be on the horizon.

The medical robot

It's been more than a decade since the California based company, 'In Touch Health' has been creating remote-presence robots catering to the healthcare industry. These robots are already working in at least 700 hospitals and handle physician-patient interactions rather well, going by the reports. The firm's model called RP-VITA became the very first to be cleared by the FDA (Food and Drug Administration) that consists of autonomous navigation technology for telemedicine.

VITA's development was done by partnering with iRobot. The robot moves around at a reasonable walking pace. Its awareness of its surround-

Healthcare gets a robotic hand!

ings is pretty sophisticated and comes equipped with navigational technology that makes it easier for doctors to direct the robot to different places in the hospital. VITA is said to be very useful in critical care units and the emergency room – places where time as well as access to a specialist (through the aid of video feed) could literally be the difference between life and death. For instance, a doctor at another location (home or another part of the hospital) could direct VITA to a patient's bed if the patient requires urgent attention. The doctor can then advise the medical staff and also the patient in real time.

VITA holds the potential to bring a much needed solution for places where a doctor or a specialist may not be easily at hand – clinics in strife such as war ridden areas, are an example. Of course, the robot also helps bring quality healthcare in everyday situations, that too at a reasonable cost.

The security robot

The company, RoboteX was founded in California in 2007. In a relatively short span of time, the company has gained quite a lot of following, especially after deploying their first fleet of 'robocops' in 2009. Police as well as fire departments across the US now count themselves as clients of the company. Their tactical-use robots could be effectively used in surveillance as well

as hostage situations. It's said that in California alone, almost one-fifth of all SWAT teams own one of these robots.

The base of the robot (which can be controlled remotely) looks like that of a small battle tank. It has multiple add-ons, an example being detachable robotic arms which could search and extract bombs. The robot could bring in supplies and also support negotiations through audio and video feed in hostage situations. The drive system of the robot can address indoor navigation issues pretty effectively. It also has a power system which works with the aid of commodity batteries and also an operating system which has a rather fast feedback loop.

Freeze!

And given how fast innovations are happening, the company has already filed for some 30 odd patents. It's not hard to envision a future in which the robots may end up becoming the norm than the exception.

The solar robot

A robotic system that can improve energy collection at solar farms may just be the thing that's needed in a period of widespread energy crisis. The good news is that Qbotix, a California based company has a worthy solution.

The robots from Qbotix are easy-to-install and hit the market in 2012. The current roster of clients include folks from both America and Japan. The robots are smart and autonomous, and they can work in the middle-of-nowhere on solar farms for decades notwithstanding the high temperatures and winds that are common in such places. The modus operandi involves installing the robots along a monorail track, thereby controlling around 1,200 small solar panels. The robots will rotate each panel towards the sun once every 40 minutes. Collectively, these small solar panels could power 30 homes. They also come equipped with sensors which collect data and track dust buildup on the panels which affects efficiency.

The sun-harvester

It's said that using the robots, up to 40 per cent more energy is generated while bringing down the electricity costs by 20 per cent. Globally, the solar energy industry grows at a rate of 10 to 15 per cent annually. This means, in all probability, these robots are going to be employed at a lot of solar farms across the world.

The thespian robot

RoboThespians are robots that are created by the British company, Engineered Arts. These humanoid robots have abilities which could thrill you- like holding eye contact with you, perform the Frank Sinatra classic, 'Singin' in the Rain' or guess how old you are. And here's the icing on the cake – they can tell jokes, that too in about 30 different languages.

Every year, up to 20 of these robots are bought by museums and universities as well as companies as they make excellent communicators in exhibitions, events and trade shows. Among the esteemed organizations that have the RoboThespians include the Kennedy Space Centre (Florida, USA) and the National Museum of Science, Technology & Space (Israel).

The next stage of the robot's development is said to involve the creation of a 30 kg, 170 cm tall robot that can walk, hop and jump. Professional human entertainers may not have to face stiff competition from their robotic counterparts any time soon. Or perhaps, they might.

Amidst fears of a robotic takeover of the world, thereby relegating humans to the footnotes of history, creations are happening. But as for now, we are seeing some rather interesting, and often useful robots coming out of the modern minds and factories.

WHAT MAKES A ROBOT?

A deeper look at what really constitutes a robot.

What makes a robot?

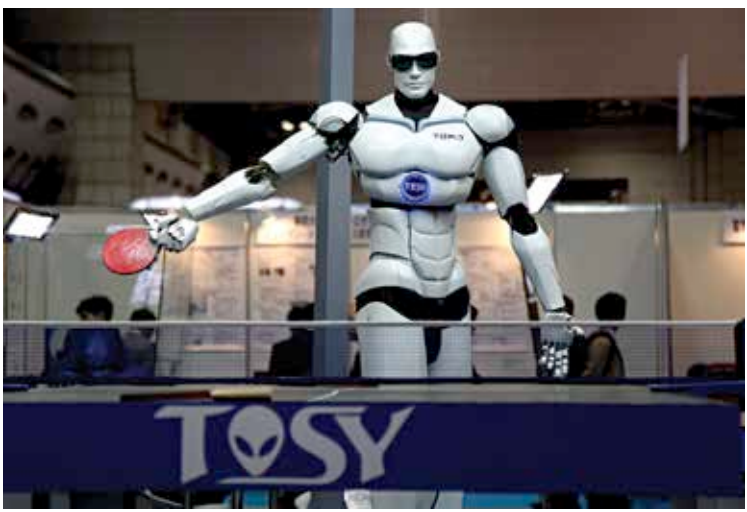
Robots of the 21st century are set to be able to mimic human beings in the most uncanny of ways. Today, we have individual robots that can match and even exceed humans at specific tasks. There are robots that can sort items, process images, navigate obstacles, follow and track down sounds, fly, walk, swim, and even dance! Just as the human body is composed of numerous systems and subsystems, all governed by an inherent structure, so are robots the product of a tenuous design process that pieces together exactly the functionality that was desired, nothing more, and nothing less. Robots are thus the product of a magnificent design cycle - a cycle that in

some humble way, mimics the creation of a real human being. Here from stems theistic quandary of 'Intelligent Design' - must any intelligent, capable being necessarily be the product of design by another, more intelligent, more capable being?

The 'ingredients' of a robot, so to speak, are thus in some sense minimalistic. Factors of safety, precise constraints of space, and the minimum redundancy to balance safety and practicality are the hallmarks of the design process. Even so, robots are actually made of something - and just as the study of human biology can be fascinating enough to lead to entire subfields like medicine, anthropology, cell biology and so on, the study of individual components and subsystems of a robot has matured into a diverse and complex field. The kinds of functionality provided in terms of locomotion, structuring, interactivity, automation, actuation and sensing have all sprung into blossoming branches of research and development. Read on to learn about the immense thought and decades of pioneering that have shaped different subsections of robotic development.

How it looks - the body

The body of a robot is arguably its most defining characteristic. There are anthropomorphic robots that are designed to look like humans and mimic human abilities, but these are often at the frontiers of research and develop-



Source: Wikimedia

The anthropomorphic robot TOPIO, that is designed to play excellent table-tennis.

ment. Most practical robots look like a collection of arms joined together, as pictured. Clearly, this is more like something out of a Mechanix set than what Asimov imagined.

As boring as it may actually sound, practicality is king in the design of almost any robotic body. Often, serious engineering analyses come into the picture. The design team has to account for load-bearing ends, for the structural integrity of the robot, for the available ranges of motion, the speeds that can be sustained - all while trying to minimize the weight, cost, space taken, and complexity of the robot.

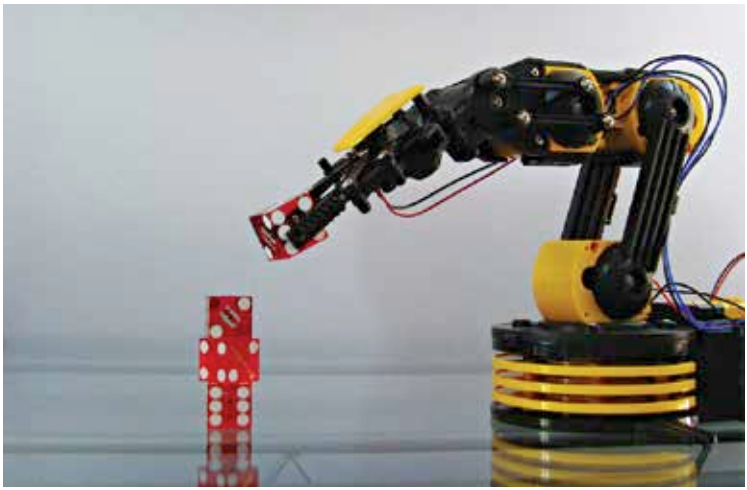
In fact, the design of such robots is often classified in an extremely well-defined scientific way. The final arm, where a task is performed, such as holding a camera or picking up an object, is termed as the actuator, while the initial point of reference which remains stationary with respect to the surroundings is called the ground. The ground is connected to the actuator by a series of links. These may be two-dimensional links in simple cases, such as lifting an object and placing it at some fixed distance away. They may also be three-dimensional links, as in the case of a more complicated process of holding an object, rotating it and placing it on a surface after navigating some obstacles. These links are connected to each other by different types of joints. Some of the common types of joints are the prismatic joint (which allows for relative sliding), the rotatory joint (which allows for relative turning), the cylindrical joint (relative sliding and turning simultaneously) and the helical joint (relative sliding and turning bound by a screw-like constraint).

The lengths of different links and their orientations can actually be solved for given the final ranges of motion that the robot intends to possess, this kind of solution typically involves setting up a complicated equation solver over many iterations to find the best possible solution.

How it moves - actuation

A robot might be extremely pretty to look at, or even extremely functional in its range of motion - but it is little more than a hunk of metal until and unless a suitable mechanism is provided to actually set it in motion in a precise and controllable way. This is the field of actuation - literally, the technology behind getting the actuator to go where we want it to!

At the heart of actuation is the use of motors - it is truly amazing what kinds of motion have been derived from the simple rotational motion of a motor. Advances in motor technology have led to innovations like servo-



Source: https://c1.staticflickr.com

A simple single degree-of-freedom (the clamp can contract or elongate) actuator on a robotic arm.

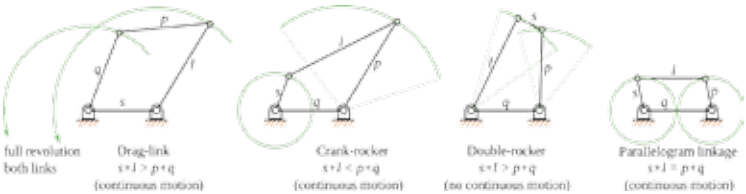
motors and stepper motors, which are extremely precisely controllable motor that offers a limited range of rotation with high accuracy. Gear-belt mechanisms are used to change rotations into translations.

Simultaneously, the fields of pneumatics and hydraulics have also arisen, in which high-pressure air, water or oil are used to set object in motion. Pneumatics offer the huge advantage of being variably powered, easily modified, simple, precise and most importantly - safe. In fact, the actuation in several kinds of heavy machinery like bulldozers and tractors is pneumatic.

How it moves - mechanisms in robotics

Robotics is a field full of hidden delights, and the simplest solution is rarely ever the best one. The field of mechanisms has evolved over the past few centuries, starting with the simple study of piston motion, to produce a host of amazingly simple geometric solutions to various robotic problems.

The overall concept is that the constraints between rods of different lengths can be manipulated to generate a host of different curves. Thus, we find the piston's oscillatory mechanism being simply displayed by a three-bar mechanism - the ground, a short crank that turns round and round, and a connecting rod constrained to move in a line in the same plane.



Simple four-bar mechanisms can be adapted to a wide range of diverse purposes.

Similarly, more complex motions have been developed, such as the crank-rocker mechanism that produces an angular oscillatory push, and the quick-return mechanism that can save time on the return stroke of a power machine.

What it does - functions and end effectors

The ultimate function of most robots is concentrated in a particularly crucial part. This is often an extremity - rarely is a robot found that uses the bulk of its body to perform work, as that would be both inaccurate and clumsy. End-effectors are the tools fixed at the end of a robot's limbs that are used to perform the true function, so to speak, of the robot. Perhaps the most general end-effector is the gripper, which may have zero or more degrees of freedom.

Source: Wikimedia

A six-axis FANUC welding robot with the end effectors clearly visible

A host of varieties of end-effectors are available for diverse applications of robotics. Some robots may have spray paint dispensers, measurement tools, solder guns, glue applicants as end-effectors, others may have welding torches, cutters, CNC wires, machine tools.

The end-effector being a complex being of equipment often requires its own control circuitry, and this may be independent of the rest of the robot, or integrated. The end effector pictured above, with only one degree of freedom, illustrates the complexity that an end-effector may have to accommodate to perform even simple functions. Adding to the complexity, such as the design of a fully functional anthropomorphic human hand (which possesses 14 knuckle joints, and an infinite number of possible ways to grip almost any given object) requires a great deal of optimisation, intelligent programming and intuition for geometry and mechanics.

How it obtains information - sensors

It is fairly common to find robotics applications where a huge amount of power or manoeuvrability is provided by the machinery in a way that needs to be skilfully manipulated by a human being. Consider a digger (also known as an excavator), which has powerful, accurately controlled robotic arms with a huge spade attached at the end. This potent machine still required the expertise of a human being behind the wheel, directing it exactly in the way it needs to move.

Source: https://www.flickr.com

A remote sensing protective glove that integrates tactile, orientation and electrical sensors.

Several robotics applications would become pretty redundant if all robots required the constant supervision of a human being. Consider the post-sorting robots used by the US Postal Service - imagine if a human being had to constantly check that the robotics were not randomly chucking envelopes into different bins!

That's where sensors come in. A good robot designer is able to identify exactly what kinds of information will be most useful to a robot in performing its task. Accordingly sensors of light, heat, proximity, sound, and even chemicals have been developed.

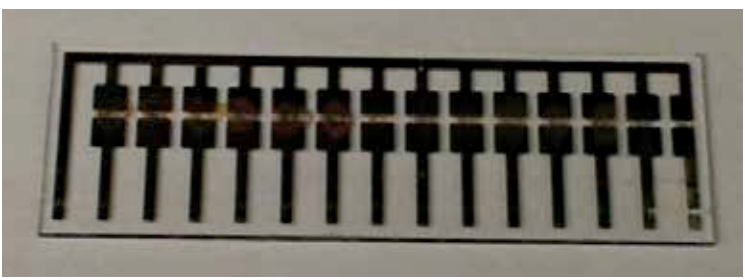
The intelligent use of sensors makes all the difference - it is what transforms a robot from a brute force capable merely of feats of strength or dexterity, into a responsive, interactive agent that can optimally handle a wide range of scenarios. This, coupled with the magic of data science and machine learning, is spurring robotics ahead like never before. In fact, this is precisely what allows the warehouse management robots used by giants like Amazon and Flipkart to accurately manage inventory completely autonomously. Autonomous behaviour - something that is set to save hundreds of thousands of man hours of labour - is what will eventually revolutionise the future of industry, and slowly phase out the working class. It remains to be seen if this will be a move for better or for worse.

How it obtains information - more on sensors

21st century research is ushering a grand new era of sensor technology. Things we never imagined could be converted into noiseless useful data are actually being measured and quantitatively studied for their applications to innovative products. The robotics sector has undoubtedly boosted the interest and funding pumped into research in this direction.

The standard implementations of most sensors are common knowledge - light dependent sensors (based on photodiodes or photovoltaic cells), acoustic sensors (which are just microphones), temperature sensors (implemented efficiently in integrated circuitry) and tactile sensors (starting from push buttons, but having graduated to touch foam and touch screens). The wave of unconventional sensors, on the other hand, begins to look like the technological foundations of a science fiction plot.

- **Sensors that measure distance:** ultrasonic/infrared proximity sensors and laser range-finders (which shoot out beams of light and measure



Source: http://news.mit.edu

This device, based on modified carbon nanotubes, can detect amines produced by decaying meat.

the time taken for return after reflection), stereo cameras (which piece together 3-dimensional information about the environment from a number of photos taken from strategically placed cameras)

- **Sensors that measure orientation and position:** tilt sensors and gyroscopes (that use the principle of conservation of angular momentum to record changes in angular orientation), magnetic direction sensors and Global Positioning System units
- **Sensors that measure electrical properties:** gaussmeters, voltage sensors, current sensors
- **Sensors that measure vibrations, chemical compositions and moisture**
- **Sensors that repair themselves, or that are a nanometer long**

What it runs on - power systems

A robot isn't going anywhere without power. Technological marvels like the Mars Rover are products of a fantastic degree of engineering skill that, among other things, has found reliable and sufficient ways to power the consumptive robotic machinery even 200 million odd kilometres from the earth. It thus becomes of prime importance to take into account the proximity to civilisation (which, in the case of Mars, is not very good), the use cases, duration of use, and type of power consumption - while designing the life's blood that powers any robotic system.

Source: Wikimedia

NASA's Helios, a solar-powered Unmanned Aerial Vehicle (UAV), theoretically capable of infinitely long flight times.

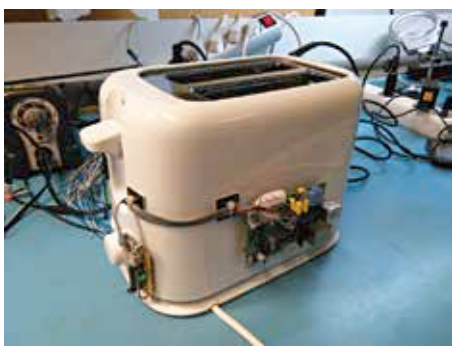
Clearly, in some cases, the solution is trivial. The sorting robots of Flipkart or the US Postal Service don't really need to go anywhere - they can be plugged into the wall, and that will be that. But what about quadcopters, UAVs (unmanned aerial vehicles), exploratory robots that search for oil or underwater ruins? What about satellites, surveillance bots, or even simple high-powered robots that need to work in remote areas?

Batteries have long been the go-to option whenever a power socket or fuel generator was unavailable. Depending on power requirements, weight, and recharge requirements, types of batteries like alkaline, lithium ion and nickel-metal hydride batteries have gone into mass production with a host of diverse applications. Novel methods such as solar cells, biofuels and geothermal power from the ground, or vibrational energy from a superstructure have been harnessed to recharge these batteries on a regular basis. However, in many electrical circuits, a battery is simply not up to the mark - its longevity, power, and consistency are constantly thrown in doubt.

Pneumatic and hydraulic power are the solutions to this quandary, albeit with the limitation of infrastructure. With a fully functional pipeline supplying high-pressure air or water, the possibilities are nearly endless. Nearly any kind of control system can be implemented using pneumatic circuits, the components of which are valves and switches, quite akin to the gates and switches seen in digital circuits.

What controls it - microprocessors

These aren't the clunky valve-transistor relics from the 80s. Nor are they the massive motherboards inside your CPUs from the turn of the millennium. These are slick, robust calculation monsters, designed to fit in areas as small as the palm, with diverse yet powerful I/O, memory management and programming abstractions. Control boards like the Arduino and its various knockoffs, Raspberry Pi, as well as custom boards built by the likes of Intel



Source: Popsci

An automated toaster using a simple microcontroller schema.

and IBM, have found applications in every form of electronics, and robotics are no exception.

The very basic of controllers today - even the ones seen in basic school-yard projects like line-following robots - possess the processing power to sequence traffic, plan efficient routes, and even process high-dimensional data such as video and audio.

How it is controlled - control methodologies classified on basis of human requirement

All methods of controlling a robot involve sensor input, processor runs, and actuator output. Some of the methodologies for robotic control are:

- **Teleoperation** - A skilled human work directs the robot through the required sequence of motions in real time, every time the robot is required for some task.
  - Maximum labour cost, minimum installation cost
  - Requires a human at every stage of operation

Source: http://en.academic.ru

A teleoperated robotic welding arm - though labour costs are high, these are of great use where skilled labour is available, but the working conditions are unsafe.

- **Lead through programming** - A skilled human worker guides the robot through the sequence of motions it is to execute using manual controls. This precise sequence is stored in the memory of the robot with great accuracy and can be repeatedly executed at the touch of a button thereafter.
  - One-time labour cost, high installation cost
  - Requires a human only for the initial training stage of any operation
- **Autonomous control** - The most independent control schema, this is the optimisation of input signal-processing, machine learning and objective maximisation to have control that is completely independent of a human input
  - No labour cost (excluding programming the controller), high development cost
  - Requires significant thought, software design and possible mathematical analysis

How it is controlled - more on autonomous control

Autonomous robots have the incredible burden of needing to be literally 'unplug and play' - they are expected to be fully capable of certain tasks from the first day of operation, with no external training. Further, they're expected to get marginally, if not phenomenally, better at their tasks over time.

Consider the simple example of a simple floor-cleaning robot. It would be expected to figure out the best path around a room so as to cover the entire accessible floor in the smallest time. Further, it may be expected to plan such that the clean parts of the floor are not traversed again by the possibly dirt-carrying robot. It may be further expected to have a particular battery life such that it can clean the whole house with just one charge. Under autonomous control, all of these concerns would have to be appropriately addressed and parametrised into the robot's limited language of signal input, processing and output.

The most common kinds of control 'architecture' used to design autonomous robots are:

- **Top-Down (the brain-first approach) :** The idea is to build the optimal brain after taking a macroscopic design and functional view of the requirements. The argument is that If the brain is built properly, it will be able to process all the expected kinds of input signals to generate useful control output. Such 'proper' building of the brain often entails training the processor on huge and varied datasets, comprehensive program-

Source: Wikimedia

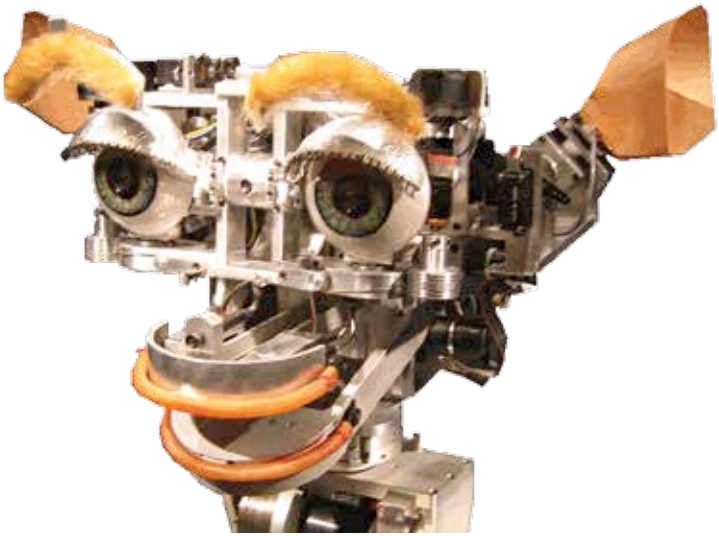
The Curiosity Mars rover is perhaps the best example of a robot that is maximally autonomous - it takes round about half an hour to receive a signal (which may be a distress call!) from Curiosity, process it, and send back appropriate instructions

ming and corner-case testing, and the implementation of at least some degree of machine learning, data processing and artificial intelligence.

- **Bottom-Up (the brain-last approach):** This is a somewhat more ad hoc view of things. One attempts to associate every end-effector with its own sensor, thus identifying an input for every control output, or 'behaviour'. These behaviours, which are nothing but sensor-effector pairs, must then be arranged in a certain order of priority. This priority order can be called a hierarchy. In general, such hard-coding is not going to produce a very efficient or 'intelligent' robot. However, specific sets of parameters can be found that produce very good performance. This, coupled with the ability to dynamically adjust the priority order in realtime, make this method an acceptable ad hoc solution in most cases.

How it learns - the Artificial Intelligence revolution

With the surge in availability of data, sensors, and huge streams of information, a revolution in 'data science' has been born. It poses the question of how to decompose huge volumes of unintelligible information into useful insights or sets of parameters.



Source:Wikimedia

Kismet is a robot at MIT's AI lab that can interpret human body language and inflection of voice in language.

Here, one transcends from the buzzword of the 2000's - machine learning - to the buzzword of the 21st century - 'artificial intelligence'. We are gradually expanding our field of concern from getting good at specific tasks, like identifying good oranges from bad ones, to extremely general, subtle and nuanced problems - speech recognition, noise elimination, audio labelling, body-language parsing, and natural language processing. A classic problem in Artificial Intelligence is to adapt a gained intelligence (or set of parameters, to a computer) to a new form of intelligence, or even to choose better kinds of parameters for existing as well as new kinds of intelligence. Consider a child who has learnt to play table tennis, and wishes to learn tennis - he doesn't start from scratch! Skillsets from his past experiences will aid his picking up of a new skill. A similar concept is being implemented in the realm of artificial intelligence, besides a host of other techniques, to produce remarkably human-like, nuanced and subtle behaviours.

What the future holds - can robots be dangerous?

Everyone's heard the stories. If it's Stephen Hawking today, it's Bill Gates tomorrow, and Elon Musk the day after - all warning us about the potency of machines that can learn and make decisions independently from human

Picture credits: Pexels via QuoteFancy

Nikola Tesla, Asimov, Stephen Hawking and several others have predicted a fundamental restructuring of society in a post-robotic world.

control. At some level, it appears like this would have to be some human error - surely, if we're careful enough about something so important, it's impossible to 'write a bug' that will allows robots to misinterpret human instructions and wreak havoc? Asimov's three rules for a robot, from his short story 'Runaround' (1942) stand solemnly as guide -

1. A robot may not injure a human being or, through inaction, allow a human being to come to harm.
2. A robot must obey orders given it by human beings except where such orders would conflict with the First Law.
3. A robot must protect its own existence as long as such protection does not conflict with the First or Second Law.

The devil, of course, is in the details. It is conceivable that a small oversight somewhere could precipitate into something disastrous (for humans), especially if and when robots develop an intelligence to compete with that of humans. As charted, robots are rapidly developing superior processing abilities than human beings in several small functions - face recognition, path prediction, puzzle solving, chess and Go, just to name a few.

However, what remains to be done is to integrate these functions together into a truly comprehensive 'intelligence'. It is in such a case that serious philosophical questions of ethics, morality and agency will come into play.

Until then, we can still comfortably hook Arduinos up to our toasters so that we can bathe while getting breakfast ready.

What the future holds - the search for the ingredients of true intelligence

Mimicry is perhaps the sincerest form of flattery, but not the best. Our efforts to create robots that can truly match, if not exceed, human beings at the host of incredible processing and actuating abilities that we have are along a long path of understanding, technological and scientific progress, and perhaps even philosophical awakening.

As hardware evolves, robots will become more and more capable of accommodating high-density networks of sensors that can collude to collect never-before-seen volumes of data. Sensor technology itself is already

Source: https://media.npr.org

AI-based AlphaGo beat world champion Lee Sedol at the complicated game of Go - this is a huge step-up from chess, with a severalfold increase in the parameterspace.

burgeoning at breakneck speeds. We're not even sure what to do with new kinds of data such as that collected using electroencephalograms (EEGs) that record neuronal activity.

Data processing will evolve to derive efficient methods to cut out the junk and focus on what's useful - much like the human body knows that the ache of a hungry belly is to be prioritised over a sprained arm or a tired leg. Artificial intelligence will evolve to create learning modules that match the speed and breadth of human learning systems, and perhaps even eclipse them.

Maybe, in some dystopian, or even strangely utopian future - humans will have been outclassed, and rendered purposeless.

THE BRAIN

A robot is essentially software which has been given mechanical limbs. Here's a look into how the robotic brain functions.

The robotic brain

If a robot is expected to mimic and even exceed the complex and intelligent functionality of human beings, it must surely be equipped with a basic decision-making capability. In hardware terms, this translates to a robotic brain - a processing unit that accepts inputs from different kinds of sensors, processes them, and relays the relevant instructions to different actuators.

Definitionally, a robotic brain comprises hardware and software aspects. The hardware deals with the physical mechanisms of processing information, typically implemented as electronic Integrated Circuitry (ICs) with memory, input/output and so on. The software deals with the set of coded instructions that direct the robot on how to behave in various

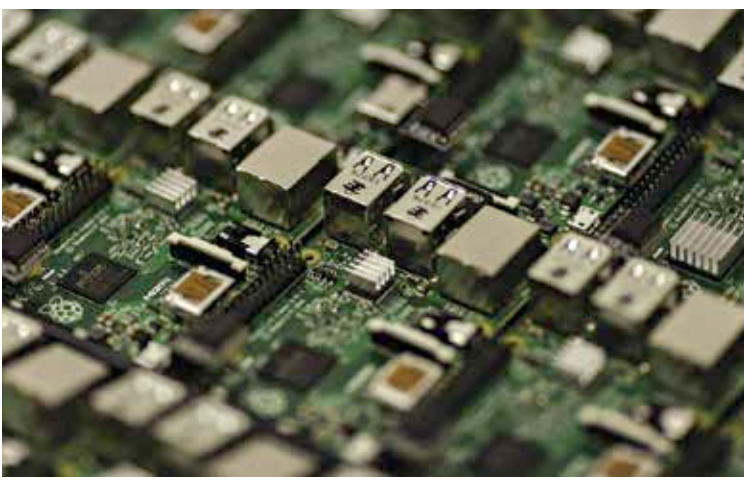
situations. These situations, of course, are identified on the basis of input sensor data.

There are practical considerations of coding and designing the instructions that will govern such a brain - in terms of input signal processing, algorithmic thinking and decision-making, and output directions. Various schema may be used as per the type of application - certain robots require tremendous visual processing capabilites, other require precise signals to output actuators such as stepper motors, while yet others require tremendous computing power to decide optimal courses of action. All of these are being implemented using a host of data science, machine learning and artificial intelligence techniques.

Besides, it is also becoming increasingly relevant to consider philosophical questions surrounding robots and their autonomous ability to make decisions. Concepts such as 'the philosophy of technology', 'ethics of science', the 'robotic soul' and 'algorithmic morality' have come into existence and debate. It may soon become a realistic consideration whether robots deserve 'rights' - a concept that human beings have so far been so arrogant as to attribute to our species alone as 'human rights'!

Differences between a human brain and robotic brain

The ultimate goal is to produce a robotic brain that can exactly mimic, if not exceed, the amazing functionality, processing power, memory, speed and



Source: Wikimedia

An inorganic brain that mimics ours

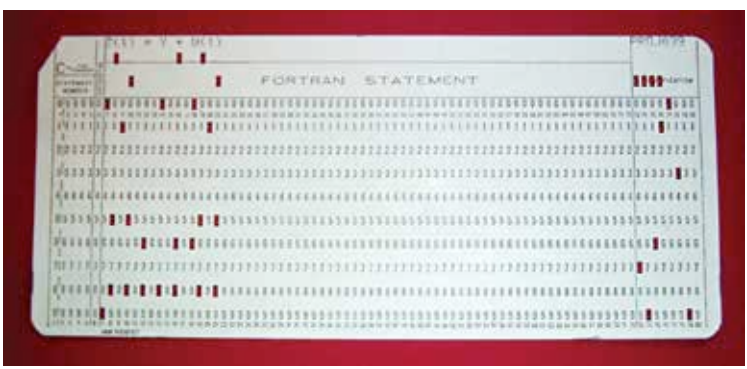
thermodynamic efficiency of the human brain. Ever heard of the human brain overheating because the 'exhaust port was clogged with dust'? In trying to bring one up to par with the other, it is useful to try to understand the contrasting features of the two types of 'brains', notwithstanding their similar labels.

- Brains are analogue, robots work on digital electronics
- The brain uses content-addressable memory, while robots use location-addressable memory
- The brain is a huge, parallel processor machine, while robots are individual, independent, and serial unless explicitly constructed in parallel
- The hardware/software distinction is almost impossible to make for the brain, while it is the fundamental constructive principle for a robotic processor
- Biological synapses and nerves are several times more complex than logic gates

Robotics programming languages - early days

Assembly language has been traditionally used to interface certain commands directly at the level of the microprocessor. This decomposes the entire set of available commands into simple building blocks which can be chained together to perform complicated tasks. Such a set of commands is called an instruction set of the assembly language.

LISP, the world's second oldest programming language (after FORTRAN) is an extremely important language from the robotics point of view. The standard Robotics Operating System (ROS) has been partially written in



Source: Wikimedia

A punch card with FORTRAN code entered into it - a relic from the early days of programming.

LISP. Besides, LISP has tremendous applications in the Artificial Intelligence implementations of various robotics problems. Even today, learning LISP is considered a bonus for any robotics specialist.

Pascal, another early programming language, is often thought of as the industrial roboticist's bread and butter. This language was introduced mainly to inculcate good programming practices, but has stuck on as a powerful and useful language - in fact, it was one of the earliest languages to support pointers. The benefit of learning Pascal is that many Industrial Robot Languages are heavily Pascal based. Hence, even with their individual idiosyncrasies and differences, a knowledge of Pascal serves as a common base from which to learn.

Robotics programming languages - today

Robots as a 20th and 21st century phenomenon have been closely matched, and often surpassed by advances in the field of computer science. It is therefore unsurprising that the bulk of robotic 'code', so to speak, has manifested in established programming languages as and when they have been popular.

Perhaps the most popular language for robotics is C. C is a language that is close to the hardware, and hence is useful for those hardware libraries that are commonly used to direct robotic arms, actuators and motors. Further, C is well-suited to real-time performance of the robot. This has made C (and in modern times, C++), the language of choice for most robotics applications, even though it often takes longer in terms of time as well as code length to implement something in C as compared to Python or MATLAB. C's maturity and robustness have often lent it the moniker of 'the standard language' in robotics circles.

Source: Wikimedia

Simluation of the robot Robotis Darwin using a simulation software

Perhaps the next most powerful languages are Python and

Java - both being interpretive languages, though Python is known for being easier to use. The vast availability of free libraries in Python, and its growing support in electronic systems like Raspberry Pi - coupled with its famed readability and 'Pythonic' simplicity, have lead to an increasing popularity for Python. On the other hand, Java's powerful inheritance structures and reusability of code provided by the Java Virtual Machine have made it a staple in certain applications of robotics.

The next bigwig is MATLAB, developed by Mathworks. Entire robotics systems have been developed with MATLAB alone, especially with the aid of its extremely well-supported and documented Robotics Toolkit. MATLAB's diversity and huge swath of inbuilt functions make it the language of choice in applications that need to process data, generate visuals, or implement advanced control systems.

Besides these, there are several Industrial Robotics Languages as well as Computer Aided Design/Modelling softwares that can be interfaced and used together for the design and simulation processes.

Behind the code - how robots learn

While the entire field of Artificial Intelligence is ultimately concerned with developing an autonomous intellect that can independently control a robot, work in the field is still scattered, albeit very steadily advancing in several interesting directions. Accordingly, as adapted from certain standard machine learning algorithms, there are three basic methodologies for a robot to learn how to behave.

- **Motor Babble:** Much like it sounds, motor babble is the use of a random input to each individual motor, coupled with data from various sensors used to set up a cost function that is then minimised over several iterations of parameters. After a variably lenghty learning period, the robot will be expected to have correlation information between the expected pattern of sensory feedback and the output signal that preceded it. For simpler systems where analytical solutions exist (for example, in inverse kinematical modules), this skip becomes redundant - most of the data is then determinate for various tweaked parameters.
- **Imitation:** Once a robot has a coordinated self-awareness, it can set about trying to imitate useful behaviours. This could be as simple as one robot monitoring the movement of another robot and mimicking it, or even as complicated as a quadcopter trying to ascertain the location of a thrown hoop so as to fly through it.

- **Knowledge acquisition:** Perhaps the most complicated way of deciding actions, this schema allows the robot to explore its environment and collect information relevant to its task, thereby modifying its strategy for exploration, path as well as the types of useful information stored. Algorithms to generate 'curiosity' such as Intelligent Adaptive Curiosity and Category-Based Intrinsic Motivation are used here.

Applications of robotics software - computer vision

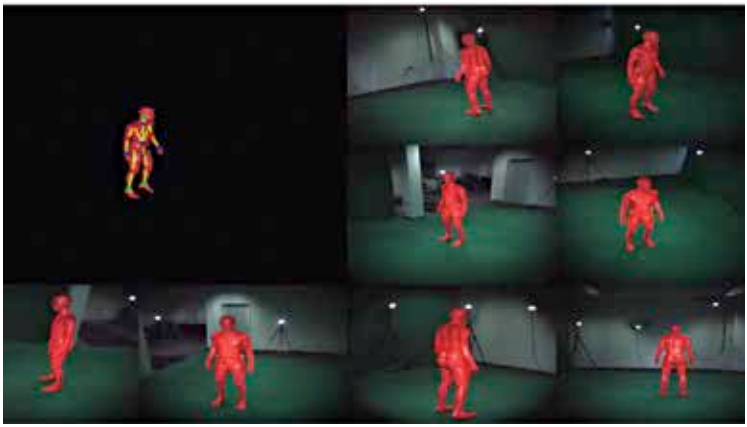
Computer vision is an up-and-coming field wherein visual data, typically from a simple camera, is processed to generate useful information. It's been a typically 'nerdy' weekend project to hook up one's laptop camera to respond to hand gestures - wave one hand to pause a video, swipe to change tabs, and so on. With the integration of satellite data and the development of massively efficient algorithms for data processing and image processing, computer vision has seen a growth like never before.

In fact, as computer vision has so often been associated with the processing of visual data to obtain other information or features, the techniques used to process such data to determine actions of a robotic actuator have come to be known as Robot Vision. Thus, Robot Vision actually uses techniques and analyses of kinematics, references frames and locomotion in conjunction with optical sensory data. Consider the technique of Visual Servoing, which is exclusively a Robot Vision, not a Computer Vision, application. In this technique, the motion of a robot is controlled using the feedback on the robot's present position.

Robot vision has tremendous applications - it has been used in amazing laboratory demonstrations of agile quadcopters which can locate moving obstacles and move to avoid them. Similarly, it can be used by aerial robots to corroborate their location using satellite data, as well as underground or underwater robots to detect leaks, take readings from manual instruments and so on.

Applications of robotics software - control systems

Control systems is simply the field of applying optimal control signals as input to get a desired output. These outputs could be electrical, mechanical, or of any other form. Often, even the most basic of control systems involve the measurement of various input parameters, the prediction of the required next input parameters for the desired output, a measurement of the actual output, and some manner of correction terms. Often, a degree of mathematics



Source: Wikimedia

A robot uses visual data to track the silhouette of a person in the room.

and calculations are required to differing degrees of accuracy. Here's where the software steps in to simplify the entire process.

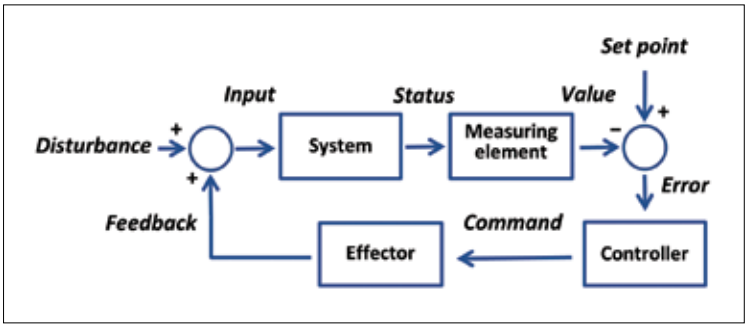
In the past, control systems would often be implemented mechanically, or directly - for example, the axle of a rotating crank would be connected to a flywheel so as to reduce surges in power, and a governor would be attached that used centrifugal force to rise up, reducing the driving power if the shaft rotated too fast. With the advent of microprocessors and control circuitry, it has become possible to implement far more advanced, measurement-based schema for control.

One classic such method is the PID controller - a Proportional (P), Integral (I) and Differential (D) controller. This type of controller makes use of a term proportional to the difference between current and required values, an integral term of error to check the accumulated errors, and a differential term to control the speed of change (for instance, to avoid jerking).

Another application that is easily implemented using software that supports linear algebra is the Kalman filter. This filter makes use of Gaussian distributions and skillful mathematical manipulation to account for diverse kinds of errors, thereby assuring a high-accuracy prediction.

Sensors and software

Different kinds of sensors often require specific kinds of interfacing with the microcontroller so as to actually produce useful signals. For instance, most Arduino boards are compatible with conventional sensors such as



Source: Wikimedia

One of the standard models for implementing a control system

current, voltage, temperature, proximity and optical sensors. However, to be able to effectively use tactile sensors or chemical sensors may require some additional installations onto the processor. The development of such software has become a major focus of modern sensor research.

Further, for multipurpose robots, it becomes necessary to integrate the information provided by various sensors into an aggregated useful form. For instance, there may be a correlation between optical sensor data and measured temperature that proves more useful than either of these measurements alone - consider the example of a welding robot. For such cases, machine learning techniques for high-dimensional data may be used. The principal component analysis algorithm is one such useful algorithm. It works by finding the multidimensional 'directions' of the data that have maximum variance, hence identifying these as the unique directions that determine useful correlations in the data.

A classic example of the use of many kinds of sensors in one application, needing the regulation of well-designed software would be a quadcopter. Accelerometer data, gyroscope data, compass information, optical sensing, proximity sensors and perhaps even more advanced data like geopositioning information may need to be integrated to find the best possible combination of parameters to input for a desired output. The processing and complex mathematics made possible by software are critical to such nuanced predictions and direction.

The three laws of robotics

One of the pioneering thinkers of robotics, Isaac Asimov devised three rules for any robot to follow in order to ensure safe behaviour. These rules are-

Source: Wikimedia

An array of different robotic sensors

1. A robot may not injure a human being or, through inaction, allow a human being to come to harm.
2. A robot must obey orders given to it by human beings except where such orders would conflict with the First Law.
3. A robot must protect its own existence as long as such protection does not conflict with the First or Second Law.

The implications of these laws to a robotic brain are that it must absolutely always be a top priority to protect the life of any identifiable human being. However, this begins to enter shaky territory. What if the robot is simply unable to discern that a human being stands in danger? Several automated production lines lack any kind of check to see if a person has fallen in - it is expected that the vigilance of the person running or supervising the machine will take care of this. Thus, in order for a machine to completely protect human life, it must be at all times aware of all the humans in its vicinity - this may not always be practical.

The next law becomes problematic the moment we give robots the agency to actually take a human life, even in indirect ways. The recent crisis with the Tesla driver who was killed while using autopilot mode on a driverless car prototype stands as a stark example. Clearly, if we are to make robots capable of relatively dangerous tasks like driving cars and piloting planes, there is a the chance that a certain reordering of priorities would make it acceptable to these robots to take human lives. Similarly, the use of unmanned aerial drones for surveillance and warfare in the Middle East has raised serious concerns about the ability of a completely autonomous object to identify and destroy entire villages.

Finally, the third clause too is alarming, as it allows for even greater misinterpretation given the first two. If a robot is able to identify some metric of harm to itself, as compared to the harm to human life - it may effectively be able to put a price on human life, and choose, at some points, to protect itself at the expense of human beings.

The future of the robotic brain

The robotic brain is set to become completely revolutionised by the advent of comprehensive artificial intelligence schema. The underlying technological foundations have already been laid, and more and more ingenious heuristics are being used to make machines more efficient, powerful, and fast. The future will soon undergo a major technological upheaval, as robots enter the arena with far greater processing power, memory, and capacity for sustained work than any human beings.

Source: upload.wikimedia.org

A self-driving car prototype in San Francisco

Such robotic intelligence will undoubtedly usher in momentous change in society and industry. It is expected that several jobs, particularly those in the unskilled sector, will gradually disappear, as robots enter the fray with their enhanced capabilities. Competing socio-political theories predict various kinds of socialist, capitalist, anarchist utopias and dystopias. There is talk of the 'post-work' economy, where all work is done by robots, and human beings are provided with everything they can possibly desire so that the only currency becomes artistic thought and creativity, that robots will perhaps never be able to completely mimic.

Even further into the future, there is talk of a true General Artificial Intelligence that matches and surpasses that of humans. Thus, robots will be the new Sapiens Sapiens, and humans may be outdated, driven extinct, or perhaps just forced to fight for survival against the new superior 'species'. Here, we enter the realm of science fiction - it should be kept in mind, though, that such a future is not nearly as far-fetched as we might think. d

AUTOMATON, WHERE ART THOU?

Do you wonder why those really awesome robots from the movies don't exist as of yet?

Whenever we hear the word robot, the first thing that comes to our mind is a machine that looks like humans and is either going to kill us all or has come back from the future to stop his other robot brother from killing us all. But the reality is far from fiction. We are surrounded by robots everywhere from intelligent vacuum cleaners to industrial robots working on production

lines making cars, but none of them resemble our first idea of a robot. There are humanoid robots out there, but it is still a developing field with many challenges. Let's take a look at the current generation of humanoids and see why they are nowhere close to what we see in fiction.

Current generation of humanoid robots and their capabilities

A humanoid robot is a robot designed to resemble the human body and has features and functions that effectively resemble ours. There are a number of reasons why humanoids can blend in more easily and are more desirable, especially when considering home settings where they are surrounded by humans. This is not only because they look and feel like humans making them look more familiar and trustworthy, but also because they can interact with various human tools and environments more easily.

There are a number of reasons why Humanoids are a very interesting field for robotics engineer and scientists. Humanoids need researchers to study and understand the details of how exactly the human body works and use the knowledge to make better and stronger humanoid robots.

The focus earlier used to be on using this research to develop better prosthetics for humans but the two fields closely overlap each other and the knowledge has been transferred between the two disciplines leading to faster development of both advanced prosthetics and humanoid robots.

Humanoids are suitable for a number of tasks, specially various desk and clerical job roles that don't require many specific skill sets. The focus of humanoid development has mainly been on developing robots that look, walk, talk and act like humans so they can take up various roles such as become companions for the sick and elderly, sit as receptionists or other similar desk jobs, and take place of a human in dangerous situations. The main advantage of humanoids is that, in theory, since they look like humans and their body is designed like ours, they can take up any task that a human can do, albeit they have been programmed to do so. In theory, a humanoid can be capable enough to replace humans in almost anything they do.

But 'In theory' doesn't translate to 'In reality' every time. Look around you – how many robot receptionists or robot firefighters do you see? The current generation of humanoid robots is nowhere close to replacing all of us everywhere and there are a number of reasons and challenges as to why. Let's take a look at some of the humanoids of the current generation and explore some of these reasons before we look at possible ways to overcome these challenges to making them ubiquitous.

ASIMO has featured in a number of advertisements and press conferences for Honda.

ASIMO

ASIMO stands for 'Advanced Steps in Innovative MObility' and is a 3 foot tall robot by Honda. Resembling a kid in a space suit, ASIMO was one of the first humanoids to gain mass attentions and make skeptics believe that probably humanoid robots can be turned into a reality. Since its first launch in the year 2000, ASIMO has come a long way and garnered a major fan following. The robot has appeared in a number of TV commercials, press conferences and product launches for Honda.

ASIMO's hardware consists of a number of sensors that help it figure its way around a room, interact with its environment, pick up and put down things, and talk to you. The humanoid body has 57 degrees of freedom and was one of the first robots to be able to run, at a pace of 4.3 mph.

But there are a number of reasons why ASIMO couldn't become anything more than a cute publicity gimmick. He still falls on unknown terrains, walks weirdly, and cannot actually help you out in any way, except probably pick up plates from the table and keep them in the kitchen at a slow pace but if you want something more, you gotta wait for some time.

PETMAN

Boston Dynamics was a former DARPA contractor that developed PETMAN (Protection Ensemble Test MANnequin) to test hazmat suits for military. The device doesn't resemble a human completely and lacks hands and

visions. The most advanced thing about PETMAN is it's walking capabilities. The robot can walk over a number of different terrains effectively. It has extraordinary balance and its walk is eerily similar to humans letting it run and hike. This was important for PETMAN as its main job was to emulate human motion on a variety of terrains to stress test hazmat suits in a variety of conditions.

ATLAS

Another remarkable humanoid by Boston Dynamics, ATLAS was an advancement of the PETMAN platform. PETMAN could walk and run on a variety of terrains emulating human motion precisely, but that was pretty much all it could do. The ATLAS robot features hands and a variety of other sensors including rangefinders that help it balance more effectively. It was designed for search and rescue operations, hoping to replace firefighters and medics one day. The company was bought by Google recently and work is still going on, on the project. Let's hope that one day, ATLAS would be out there braving the heat and fire saving lives instead of human firefighters who put theirs at risk.

Robonaut

Robonaut is a robot being designed and developed by NASA to help its astronauts in the space. NASA has been working on a number of robots and

Robonaut 2 is one of the most advanced humanoid right now. It can use most of the tools and tech designed for humans including a smartphone.

many of them have accompanied humans on previous space exploration missions. The Mars Rover is an amazing engineering feat capable of doing a number of things. But NASA realized the importance of humanoid robots as they could not only go on missions where there is a high risk to human life, but could also use all the tools designed for astronauts. NASA began working on Robonauts in 1996, coming out with the first version in the year 2000. The second iteration was developed with joint efforts between NASA and the car manufacturer giant General Motors. Dubbed Robonaut 2 or R2, it became the first humanoid robot to be sent to the International Space Station. Currently the robot is being tested in the environment to determine how well it works. We will still have to wait for some time to see what the future holds for this one.

Famous robots from the big screen

Real Steel

A movie set in a the year 2020, Real Steel shows a world where human boxers are completely replaced by robots. Starring Hugh Jackman, the movie has a predictable plot but the action sequences and visual effects are quite good. The main hero of the movie is a sparring robot called Atom. An underdog, he goes on to fight against the baddest and strongest robot out there in the robot boxing world. Most of the robots in the movie were taller than 12 feet and didn't just stand and move around like humans but also fight as well, with their own signature moves and even dance moves. Atom even had a shadow mode which let it mimic its controller's movements.

I, Robot shows a world where humanoid robots have become a commonplace part of human lives.

I, Robot

Inspired from a sci-fi short written by Isaac Asimov, one of the greatest sci-fi writers of all time, I, Robot is a sci-fi movie set in a futuristic dystopian world. In the year 2035, humanoid robots are everywhere and become a part of our society. But an evil robot takes over all of them and directs them to takeover humans instead. The movie ends with the hero saving the world with the help of one good robot.

The movie portrays a society where humans have developed highly advanced humanoid robots that look, talk and walk like us, and are capable of doing almost everything that we humans can and have replaced humans in many of the day to day roles

Transformers

Transformers are an alien race of robots that used to live on a distant robotic planet called Cybertron. The planet was almost destroyed by a civil war between the 2 factions, Autobots and Decepticons. Years later they somehow reach earth and fight each other again. These robots are not actually humanoids but completely conscious beings made out of 'Cybertronian metal'. They can transform into a variety of other things including cars and planes.

Why are reality and fiction so far away?

The above examples must have made it clear that the reality is far from fiction. A world where robots overthrow humans or worse, kill us all, is far-far away. Robots are too dumb right now to realize their strengths and capabilities and systematically plan a global undertaking. A robot in the future might read this, take offence and decide to eliminate the whole of humanity, but there are still at least a couple of decades to go before that is going to happen and there are plenty of reasons why smart robots are still quite some time away.

There are a number of challenges faced by the robotics industry which include the following:

- Human body is a remarkable feat of engineering. We are capable of walking on a variety of terrains, are highly adaptable, can use tools dexterously with our fingers and hands, think on our feet, learn and grow. Robots are good at doing specific isolated things. Making a robot that is capable of doing even 1/100th of this right now is a difficult task.
- One of the most important characteristics of any robot is its autonomous capabilities. The field of artificial intelligence has progressed quite a

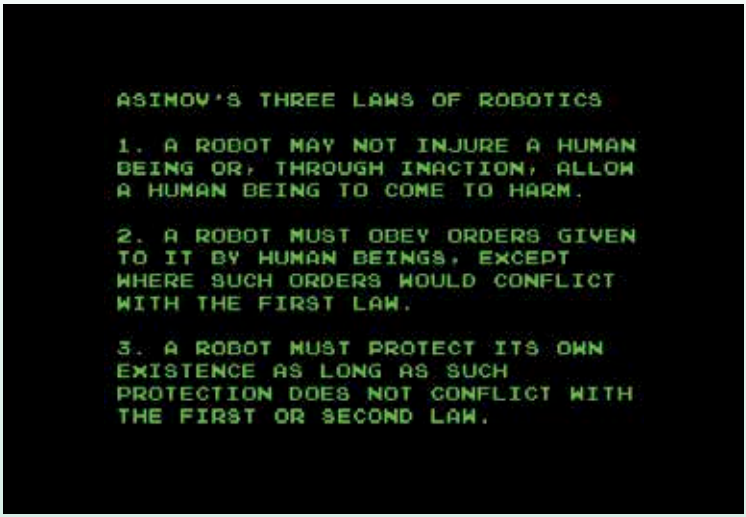
lot in the past few decades. Machine learning has found applications in a variety of new fields and smart personal assistant applications have become almost as common as smartphones. But robots, especially humanoids need strong AI to process, and act on the information they have collected. A smarter AI will mean better human robot interactions, better and faster learning and maybe even conscious robots one day.

- No single common platform exists. There are a number of startups, bigshots as well as individuals in the technology industry who are working in the field of robotics, but none of these projects are compatible with each other. Most of the times technology breakthroughs are not shared within the industry in fear of losing out to their competition.
- Power supply is still a problem. Most of the robots today are powered by heavy batteries that not only need to be recharged quite often but are very heavy leading to many design problems too. Alternate sources of powering up these robots need to be looked into and developed.

There are a number of ethical problems too which need to be looked at – if not right now then sometime soon at least. What things are robots allowed to do? Where exactly can we replace humans with robots? What are the basic rules that every robot should adhere to?

The future of robotics looks exciting and promising. Technology is advancing at a never seen before rate. By the turn of the decade the number of active robots in use in various industries will increase by at least two folds. New industries like logistics, healthcare and utilities will start using more robots in the next 5-10 years to increase their efficiency. All this will also lead to increased job opportunities in the robotics industry and create a dearth of skilled engineers in the field.

All in all, the robotics industry has a bright future and you can expect to have a robot butler or maid to be in your house before the end of the next decade. Just don't ask them to call you Mr. Stark.



THE RULES OF ROBOTICS

Ethics is a boring subject taught in certain universities. But with robotics, it could be what prevents us from going extinct.

While there's plenty of excitement around the very idea of robots – man's ultimate creation, as many term them – there is also the prospect of danger. Some of these dangers, as envisioned in dystopian sci-fi flicks in which the robots have taken over control of the world from us, may seem rather exaggerated.

But then, as many scientists are acknowledging that we may not be able to understand the reasoning style of an artificially intelligent being, our fears may not be all paranoia. Some rules to govern the robots would be handy.

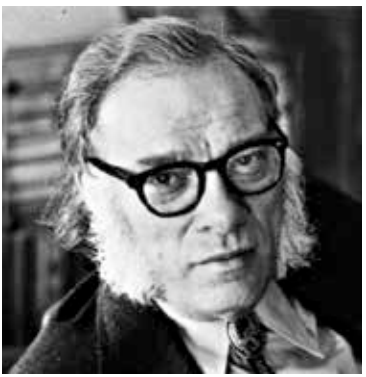
What could such rules be? And have any such rules already been framed? Read on to find out.

Asimov's three laws - are they truly enough?

American science fiction writer, Isaac Asimov, articulated the three laws of robotics, introducing them in a short story in 1942 called "Runaround." Till date, they are considered a benchmark in terms of basic laws, if nothing else, only because nothing better has been devised yet.

The three laws are as follows:

1. A robot may not injure a human being or, through inaction, allow a human being to come to harm
2. A robot must obey the orders given it by human beings except where such orders would conflict with the First Law
3. A robot must protect its own existence as long as such protection does not conflict with the First or Second Law



Will his laws protect us?

Even a casual reading of the laws will give you a feel of how simple and elegant they are. But while simplicity and elegance are great virtues in themselves, would the laws be functional in a real world scenario? That's the million dollar question.

Though a straightforward answer to the question may not be easy, the general perception is that implementing the laws are fraught with troubles.

For one thing, there are matters concerning the interpretation of the language which needs to be taken into account while defining the particular term "harm." For instance, while physically injuring or murdering someone is harming them, does scaring someone also qualify as the same? If yes, what if scaring a person could save them from more vicious harm?

An imaginary scenario involves a robot driver helming a bus with thirty passengers. The bus is going down a road at a high speed and as if from out of nowhere, a human comes onto the road. If the robot brakes hard or swerves the vehicle, it would harm the passengers. Otherwise, it would end up killing the person on the road. In this case, the robot would pit 30 lives against one and save the larger number.

But what if there were just one passenger in the bus? Such scenarios are harder puzzles to solve.

Aside from matters regarding interpretation of language, there is also the issue of conflicts between the laws themselves. For instance, the first and second law could come into conflict in some cases. Like, what if a physician robot knows that a patient who is currently unconscious would harm other people when he awakes? Should the robot not treat the patient?

A conflict also arises whenever a human orders a robot to protect him or her from another human who intends to kill them. If restraint is not a possibility, what route would the robot take?

While self-driving cars are all the talk of the town, we can look at a potential scenario involving a robotic driver. Say, the robot is driving and its human owner is the passenger. To avoid an accident, would the robot swerve off a cliff that would cause the death of the passenger, or do nothing, which could lead to the death of many more people on the road? Going by the logic of numbers, the robot should sacrifice the life of one for saving many. However, if you recall, the passenger is the robot's owner, and isn't it the robot's primary directive to protect its owner's life?

Such dilemmas are just the tip of the iceberg as far as conflicting scenarios involving the three laws of robotics are concerned.

The alternatives

While Asimov's three laws of robotics offer a useful springboard in matters regarding machine ethics, they are by no means the only possibilities that can be explored. Indeed, many people – very smart people – are exploring other models of ethics and rules that can be used in robotics.

How to train your robot in ethics?

Take for instance the case of the commercial toy robot named Nao. The robot got programmed so that it could remind people to take their medicine on time. A simple enough proposition. However, even in this simple scenario, there were ethical challenges. For instance, what if the patient refuses to take the medication? If the robot allows the patient to skip the medicine, it could be

harming her. On the other hand, if it insisted that she take the medicine, the robot would be impinging on the person's autonomy.

To help Nao around such problems, scientists and philosophers provided it with examples – case studies in which such conflicts have been resolved by bioethicists. From these algorithms, patterns were found which could help guide the robot through such situations.

However, there's a catch: the principles that are derived from the algorithm are not written in a computer code. This means that you wouldn't know the reason why a program may tell the robot something is ethically right or not.

Many engineers think that, in such scenarios, it's best to create programs that have the rules clearly formulated, as opposed to asking the robot to derive its own rules. The proponents of the rule-based approach cites one advantage above all else: you are always clear as to why the robot makes a particular choice. It's particularly important in fields like the military, where having a robot drawing its own ethical conclusions on the field could be disastrous.

The machine-learning approach, on the other hand, brings forth the possibility of robots which could learn from experience. This could help create more flexible robots and could be more useful than the strictly programmed variants. Many roboticists believe that the ideal way forward would involve combining both the approaches. But combining the two approaches in a workable way is a challenge that is yet to be met.

Notwithstanding the manner in which the issue would be tackled, it looks more and more as though a workable solution wouldn't be confined to the three laws that Asimov put forward. The reality, as it's turning out, could be far more complex than anyone ever imagined.

The BS8611 Robots and robotic devices

The British Standards Institute(BSI) issued a document called BS8611 Robots and robotic devices. Drafted in a language that's a bit too dry, it's a health and safety manual for manufacturers of robots. Notwithstanding its colourless language, the manual covers a whole lot of topics that could have been taken from science fiction. Topics like robot deception, robot addiction, and even the possibility of self-learning mechanisms exceeding their limits, falls under 'hazards which should be considered by the manufacturers.'

It's probably the first ever published guideline for the ethical design of robots. Some consider it the first step in inculcating ethics in robots.

The document opens with broader ethical considerations like not designing a robot for the sole purpose of killing or harming humans. It's also mentioned in the guideline that humans are the responsible agents and not robots and that it should be possible to discover who is responsible for a robot and its behaviour.

Other, more abstract issues as also highlighted – like the question of whether establishing an emotional bond with a robot is a good idea, especially if the robot is meant to interact with children and the elderly.

British Standards Institute: forerunner in framing rules

The code also recommends that transparency be something that designers should aim for. However, scientists are of the opinion that making that a reality could be hard. This opinion stems from the fact that you cannot know why the current AI(Artificial Intelligence) systems – particularly the deep learning systems – make the decisions that they do.

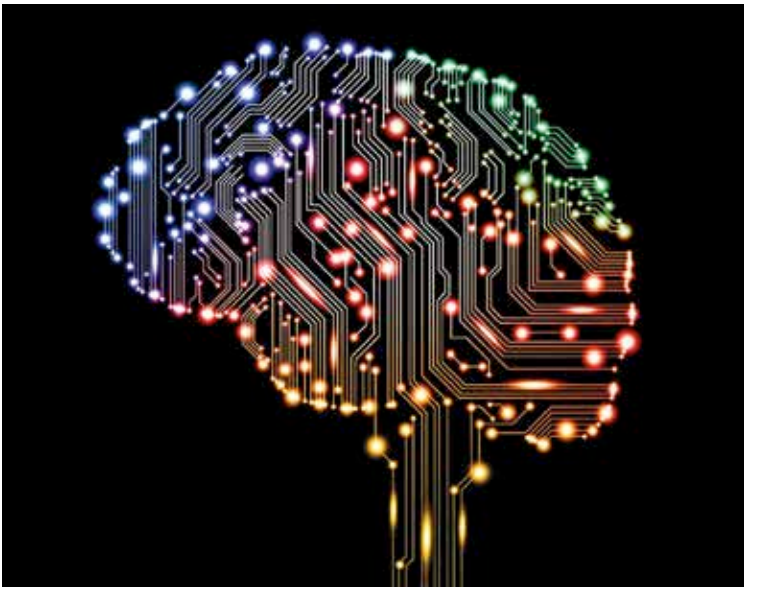
For instance, deep learning agents aren't programmed to do a particular task in a predefined manner. They learn to do a task by literally attempting it millions of times. After a series of trials they come up with a successful strategy. The curious fact is that sometimes, the successful strategy is something that its human creators didn't anticipate or don't even understand.

The BSI's guidance even points to the prospect of racist or sexist robots. A warning is provided against "lack of respect for cultural diversity or pluralism."

Finally, is an intelligence actually fully controllable?

While the question of efficient robotics is all about balance – allowing the robot enough intelligence to perform the tasks it's supposed to do while limiting the intelligence enough to prevent it from going rogue or worse, one curious(or not) argument that many experts make is that intelligence can't be completely controlled in the first place.

The basic argument goes something like this: In almost every field of human endeavour, from science to music, great leaps have been made by individuals who constantly practice their vocation and learn from it. Examples of such individuals are Einstein and Mozart. Now, as far as machine learning goes, it not only involves consistent learning, it could also rewrite



Intelligence: Hard to define, harder to control?

its brain. In other words, it's way more intelligent and adaptable than the smartest of humans. How then can we hope to control such machines?

At this point, there exists no clear indication as to the nature of the laws that we would need for robots. The sheer unpredictability of it all makes it rather hard to foresee such laws. But the first steps towards the framing of efficient laws have been taken. Hopefully, they will lead us to a future where man and robot can coexist.

ROBOTS vs HUMANS

Will robots surpass humans in intelligence? Are autonomous systems taking over our jobs? A look into a future that's filled with potential landmines.

So it's come down to a showdown: between humans and robots. One trying to prove it's better than the other. If the robots are better at a job than humans, then they obviously get the job! At least, this is a scenario which many people fear will happen, or is already happening.

But is such a fear valid? Will it ever come to a point where working class humans are rendered completely irrelevant, a world in which robots

are more than enough to perform all the jobs which we once thought only humans could do?

Let's investigate, starting by looking at one of the more basic concepts regarding AI superseding humans: singularity.

Singularity – When they begin to really think for themselves

Singularity

Singularity refers to the moment when a civilization changes so much that the rules and technologies that they give rise to are not comprehensible to the generations before it. Many think that the singularity will be brought about by the hyper-rapid changes in technology and science. Such aspects would be so fast that every facet of society – from human bodies, to families, and forms of governments, it would all be altered.

Another side to the theory of singularity is the point when all collective artificial intelligence supersedes the collective human intelligence. After all, once such a thing happens, it stands to reason that everything we know will change forever. But what exactly the nature of the changes would be once the singularity is achieved are not easily definable. Will the AI, with their superior intelligence, think that humans have run out of their shelf life and are no more of use to them? Or would they be ethical and respect our will to survive – after all, we are what gave birth to them!

Singularity in pop culture

It was science fiction writer, Vernor Vinge who popularized the concept of singularity in his 1993 essay titled "Technological Singularity." As per his definition, it's a point from which "a new reality rules." So, we would have to discard our old models. He says that as we gets closer to the point, it'll loom ever vaster over human affairs until the notion itself seems commonplace. However, says Vinge, when it finally happens, the singularity would still be a huge surprise and "a greater unknown."

Vinge correlated the singularity with the emergence of AI. He, in fact, compared the emergence to the rise of human life on the Earth. The precise

The future's bleak, says pop culture

cause of the change, he said, is the imminent creation by technology of entities with greater than human intelligence.

Though people rarely get to read about things such as the singularity in mainstream media, it makes frequent appearances in pop culture. Perhaps the most famous is its presence in the 'Terminator' movie franchise. In the 'Terminator' universe, the robots have become intelligent enough to wage war against humans.

Taking things further, in 'The Matrix' franchise, the AI has turned intelligent and managed to trap us all in a virtual reality.

2100 - The year robots overtake us?

Some experts think that 2100 will be the year when robotic intelligence will surpass human intelligence. However, there doesn't seem to be a consensus, even among the experts, regarding the date.

For instance, the futurist, Ray Kurzweil predicted in his book, 'The Singularity is Near: When Humans Transcend Biology' that computers would become as smart as humans by 2029. He also predicted that by 2045 computers would be billions of times more powerful than unaided human intelligence.

On the other hand, Bill Hibbard, a renowned computer scientist at the University of Wisconsin-Madison in America isn't too sure about the dates Kurzweil predicts. He is confident that AI will gain human-level intelligence some time in the 21st century itself. According to him, going even by his

Year 2100 - what kind of future are we in for?

most pessimistic guess, it's going to happen in the lifetime of those who are already born.

At the opposite end of the pole to scientists like Hibbard are the skeptics – one among whom is Ernest Davis, a computer scientist at New York University. Davis acknowledges that AI could give even the best chess players a run for their money but compared to the average 7 year old who holds abilities such as common sense, vision, language and also intuition about how the physical world functions, it's still light years behind.

Will robots take over our jobs?

It's no secret that the level of automation across sectors has increased highly in the past few decades. In this context, two streams of thought become significant, raising two different questions: 1)Will new technology give rise to mass unemployment as robots take jobs away from humans? 2)Will robots create demand for new types of jobs for humans?

Put another way, the question is this: are the modern technological innovations similar to those of the past – the kind which made the job of manufacturing horse carts obsolete, but generated the job of an automobile manufacturer? Or are present day innovations different in some fundamental manner?

Such a concern isn't entirely new. At least since the Luddites of the 19th century in Britain, new technologies have been a cause for fear due to the changes they bring.

In with the robot, out with the job?

American economists, Jeffrey Sachs and Laurence Kotlikoff are two experts who feel that such concerns are not without relevance in the present day. They ask a significant question: What if machines are getting so smart that they no longer need unskilled labour to operate?

They point out how smart machines are already doing jobs which have been entirely human domains until recently – like collecting highway tolls, checking customers out at stores, taking blood pressure, giving directions, answering phones, printing documents, flying planes, and teaching kids among other things. They also point out how this list is not at all exhaustive.

Looking at the economic metrics in America, some people – like Eric Brynjolfsson and Andrew McAfee of the Massachusetts Institute of Technology(MIT) think that the concern could be justified.

They point out how the economic statistics that people care about the most rose together in America for decades after the second World War. The Gross Domestic Product(GDP) grew alongside productivity. Literally millions of jobs were created – many of these jobs were suited for those without a degree even. But then, the productivity growth and employment growth began to decouple from each other.

The decoupling data reveals that the US economy has been doing rather poorly for the bottom 90 percent of Americans for the last 4 decades. Technology has been improving productivity greatly during these decades which in turn resulted in a growing economy. However, most people don't get to benefit from the growth. Though the American economy still creates

How long before robots take over your job?

jobs, it's not creating enough of them. In fact, statistics show that the active percentage of the labour force has been coming down since the late 1990s.

It's been found that currently, the manufacturing output is at an all-time high. However, the creation of employment today is lower than in the later 1940s. The income for non-supervisory employees have stagnated since the late 1960s. As for the wages-to-GDP ratio, it's been coming down since 1970. Long-term unemployment is a trend that's going upwards.

Though a clear analysis would require even more data, it's clear enough that higher automation has had an adverse effect in terms of job creation in the world's biggest economy.

Even more shocking is the finding that mortality among white middle-age Americans has been on the rise for the last 25 years because of suicides and afflictions based in substance abuse. The finding was made by Anne Case, the winner of the 2015 Nobel Memorial Prize in Economic Science.

It's more than a probability that rapid progress in artificial intelligence and robotics is a major reason for the economic decline among the working class Americans.

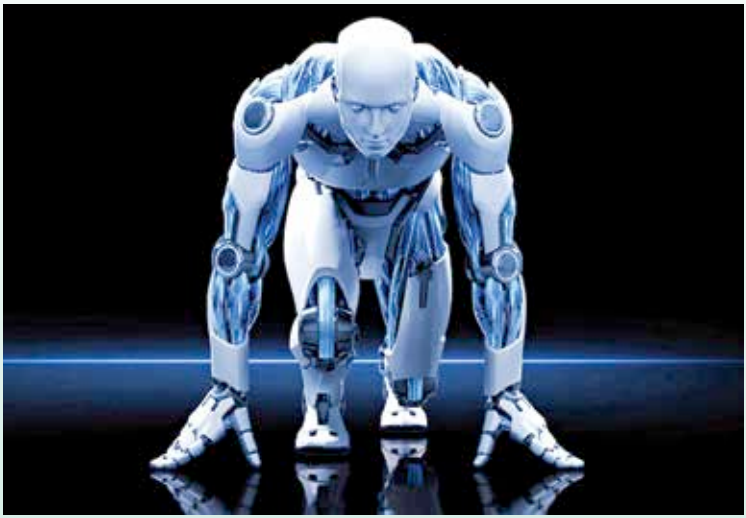
Yes, there could be other factors at play – like deregulation and globalization. However, a poll conducted by the Chicago Initiative on Global Markets among leading academic economists in 2014 showed that 43 percent of the respondents agreed to a statement that the main reason for stagnant median

wages in the US for more than a decade in spite of rising productivity was technological progress. Just 28 percent disagreed with the statement.

Also, there exists a 2015 study by the International Monetary Fund which cites technological progress as a key reason for inequality over the past decades.

All this paints a less than pretty picture – automation does indeed eliminate many jobs in the economy which were once done by people, and there's no proof that new technologies in recent years create an equal number of jobs to compensate for this.

Though precise data for countries like India are not available, widespread automation is a fact of life in developing countries as well. However, whether countries like India will also face a job crisis which developed nations like the US are currently going through remains an open question. But judging from how things are going elsewhere, a certain sense of apprehension wouldn't be without justification.



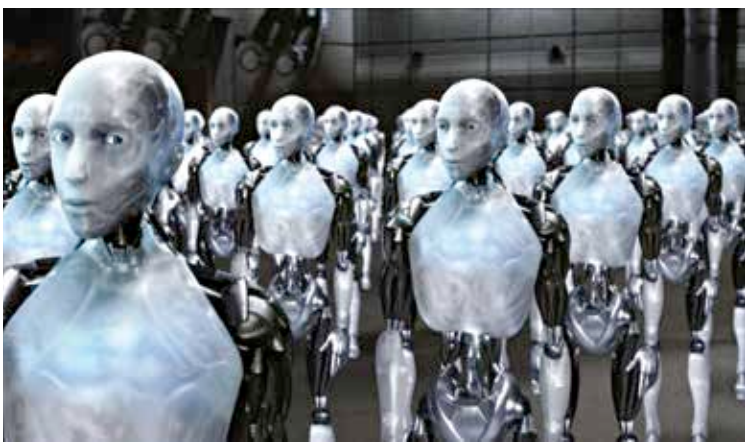
THE FUTURE OF ROBOTICS

From those bound in eternal servitude to those who could dominate mankind, the future or Robotics holds many possibilities.

The tin man from the Wizard of Oz would probably have a lot of company in today's world. Robotics has become an open source art and people are voraciously finding new ways in which robots can help make our lives easier and better. Be it in the field of education, entertainment or healthcare, the possibilities really are endless. Some of the prototypes out there today seem to be straight out of sci-fi movies. We truly have come a long way when it comes to robotics, and the growth has been

extraordinary in the last few years. With the idea of artificial intelligence making rounds and computers now capable of storing huge amounts of data, scientists are asking the same question all over the world: is it possible that we could someday create a sentient being? It certainly seems that we are heading in that direction.

The term 'robot' although easily defined as 'a machine capable of carrying out a complex series of actions automatically, especially one programmable by a computer', is becoming a rather vague and abstract term. It is difficult to categorize all smart technology under the same umbrella. We shall take a look at some of the whacky technologies that could well become commonplace in the next few years. Then we shall look at the future of robotics and some predictions for the near future. Finally, we shall answer an important question.



'A still from the movie iRobot'

Straight From A Mad Scientist

These technologies took time to develop and to be synthesised. These are right there at the cliff of extraordinary and at the edge of bizarre. Some of them might still seem like a distant dream but it won't be surprising to see these in every household in the years to come. So let's take a look at some of these futuristic concepts

1. Robot Teachers

This one is straight out of the Jetsons. Some schools in Korea have already

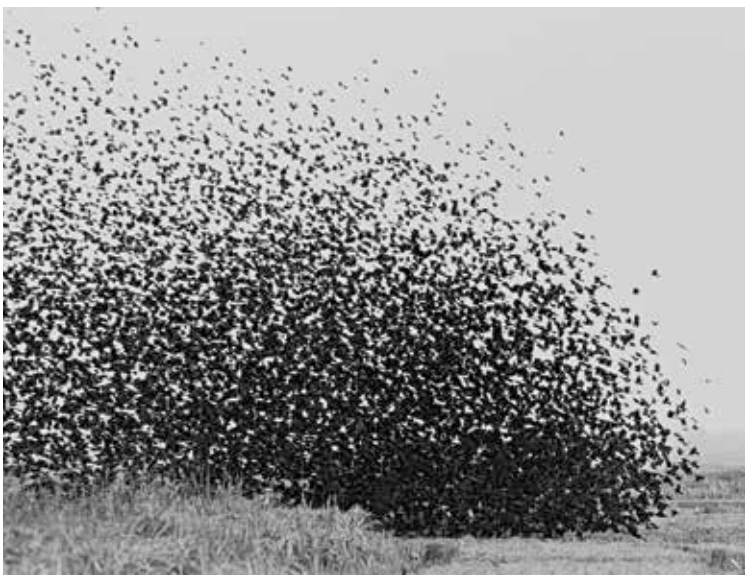
employed this technique of having the virtual presence of a teacher to help children learn English. The 'teacher' is a huge egg shaped robot with a display for the head on which the teacher's face is visible. The teacher can communicate with the class via live streaming through the robot. The robot is locomotive and is a cheaper way of getting teachers who are fluent in English to teach in distant places. This is a rather unique and helpful method and in the future, this could be used to provide education in countries which are hard to reach. Quality education would no

'Hello class, I am Mr. Gears and I will be your substitute human psychology teacher'

longer be limited by location. Truly a big step towards a more connected, globalized world.

2. The Wi-Fi 'cloud'

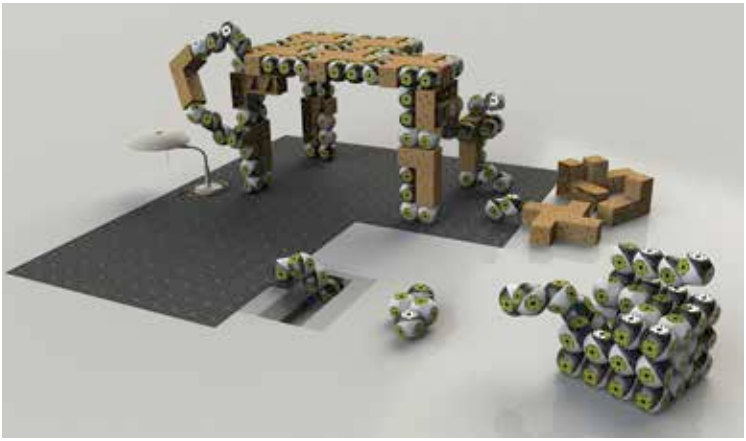
Nothing could ever totally go wrong with this. Well, bizarre as it may seem, Swiss Federal Institute of Technology believe that in times of critical emergency situations, networking might be shut down. That means no high speed Wi-Fi. But on a more serious note, this might be a legitimate threat and to tackle this, they came up with the idea of a Wi-Fi 'swarm' that would have thousands of flying bug-like robots with a Wi-Fi module attached to them. The swarm would behave as a whole and would provide a flying Wi-Fi network. It is easy to see how important the application of this technology might be. Everything needs to be interconnected now. All the robots need the internet to function. So maybe this swarm is a useful alternative to help them stay connected in places with no steady internet connection.



'Nice router you got there'

3. Robot Furniture

Now this is something we could all get behind. Swiss designers and innovators have come up with the idea of smart 'RollBots' that can take the shape



'Concept depiction of a RollBot Arrangement'

of a desired piece of furniture as per the user's requirement. This truly is the spiritual successor to IKEA and helps take furniture customisation to a whole new level. When not in need, the RollBots will fold back into a wall, thus saving space. This is a very interesting concept and it might not be too late before we see technology like this in the future smart houses.

4. WR-07

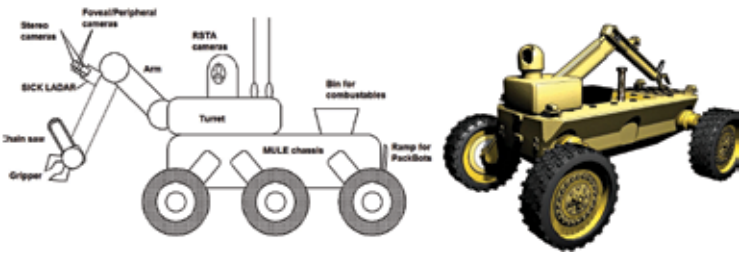
Are you a fan of the transformer series? Does the fact that your car is just a car bother you? Say no more. Hemji Soft Japan has created the first ever, real transformer, which transforms from a robot to a car that can be driven. Applications of this concept are still yet to be tapped into but who cares about all that when you can have an autobot parked in your garage! The future is going to be fun.

'"I'll just be waiting in the garage for deployment"'

5. EATR

Back in 2009, Cyclone power technologies came up with the idea of a robot that wouldn't need petrol or

other conventional fuels. It would power itself – by feeding on vegetation and biomass like dead trees – on endurance missions, where it could not be charged by humans. The idea had huge possibilities in the war industry and it did not come without concerns; the media went as far as making everyone believe that it would feed on humans and this would be the first step towards apocalypse. Disregarding all such speculations, the EATR runs on a solid idea and it may find applications in search and exploration missions in the future.



'The idea behind EATR robot'

6. The A-Pod

This creepy looking robot is inspired by the movement of spiders. It has a unique 3DOF (3 degree of freedom) design that allows it to walk in any direction. Because of this, it has a variety of functions and can perform jobs like climbing ropes, walking on glass and even pouring a glass of water with ease. The Hexapod has a variety of implementations in many fields, especially exploring where humans can't easily reach. These types of hexapods also find their application in surveillance and defence, maybe because they look like something straight out of a metal gear game. Be prepared to see a whole lot of such robots in the future and if you have arachnophobia, God help you.

The robotics industry is constantly trying to change the approach to making robots. One such example is Bio-robots, which use muscles and electrical signals to move and do other functions. Scientists predict that in the next 50 years robotics will take over the world with robots taking up as much as 50% of our jobs by 2050.

Here are a few predicted fields of application that robots are expected to take over in the not so distant future:

'Its unique design gives it freedom to move in all directions'

1. Security

It is predicted that in the next 5 years, robots will take over a majority of the security and peace keeping positions. Robots are already seen guarding malls in the Silicon Valley. Surveillance robots have been used by the police for a long time now, and there's even more efficient prototypes available at your disposal nowadays. This is a field the government is investing heavily in to reduce the risk to human life.

2. The Sentient Ones

There has been a shift in developing software based robots over the past few years. The difference is that these robots are able to sync to the cloud and as and when that happens, the possibilities truly become endless. The robot building community is pretty much open source and this is leading to the genesis of a robotics software based marketplace. Imagine, in the times to come, the basic robot will become what the Arduino was a few years ago. You'd be able to buy a simple robot arrangement and then program it to your requirement by getting software from the cloud. This is exactly how the robotics community is shaping out to be.

3. The DIY aspect

Like we discussed in the last part, the robotics community is generous and

'How long till a real Westworld themed park opens for the public?'

largely open source. Blueprints of innovative ideas are shared with the community so that they can be improved upon. 3D printers provide the perfect platform to materialize these creations.

4. Healthcare

This is probably the biggest application of robotics to date. The possibilities are so many; let's try to cover all of them.

'Jump higher, run faster'

a. Exoskeletons

Walking sticks and wheelchairs will be a thing of the past. People with disabilities will have the option of choosing from a plethora of prosthetics which could be metallic or 3D printed. The exoskeleton concept takes this one step further. These exoskeletons would not only help people with disabilities but could even enhance normal human capabilities. These systems can even help paralysed patients walk. However, the major drawback of this concept is that it isn't available to everyone

due to being highly expensive. Advances will need to be made in order to bring down the cost of production and make them accessible to everyone, especially those in need.

b. Ingestible Origami Robots

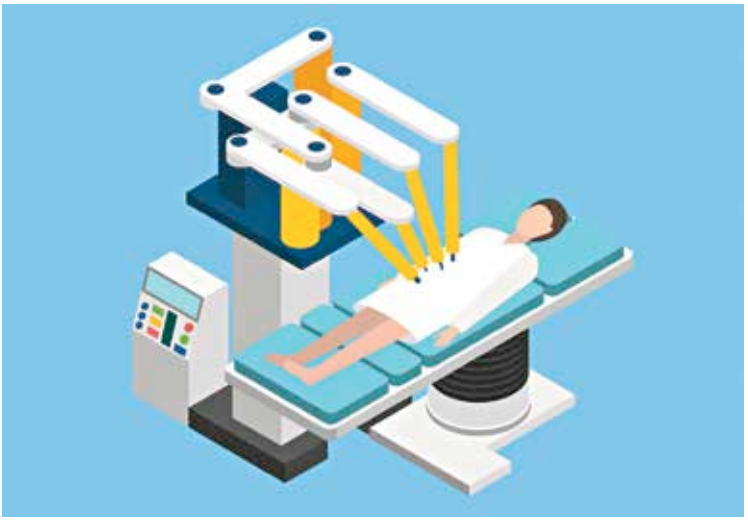
Yes, you read that right. Scientists have now come up with tiny ingestible foldable pieces of equipment that can be swallowed by patients. On reaching the stomach, these robots dissolve and unfold themselves, to be controlled by magnetic waves by a technician and perform surgeries from

'Ingestible technology'

the inside. Talk about a tiny Trojan horse. These micro-bots can be sent to various organs to perform required surgery and after the job is done, they are excreted by the body harmlessly.

c. Surgery

Surgery is a protocol that is followed by a surgeon with an iron grip and nerves of steel. If done right, it could pretty much bring a person back from the brink of death. However, it is a protocol and protocols can be followed to a T by a robot if programmed correctly. It all comes down to whether you would trust a lifeless machine to operate on your body. Turns out robotic arms are pretty precise in carrying out such surgeries. In the times to come, surgeries could probably be performed entirely by robots. As a matter of



'Robots could be performing 100% of the surgeries in the future'

fact, these robots have great precision and can perform very fine incisions and have a great application.

3. Robot Laws

Scientists predict that the times to come will witness new laws being formulated, especially in the fields of space travel and robotics. We all know the three basic laws of robotics from the previous chapter. But other than those, there are a lot of gray areas where the laws are still not defined. For example, scientists predict that by 2050, we will witness the first human robot marriage! Also, if you have a pet robot, do you buy an airline ticket for it? There are many such unanswered questions, simply because there hasn't been a need to answer them yet.

4. E-commerce

Robots will find huge application in the manufacturing and development aspects of commerce. Complex machines have been used for a while now to make the process of manufacturing easier for humans. These machines are constantly improving and can now be programmed to function with zero human input. Imagine a factory run entirely by robots and machines. You would no longer need to worry about human error and only resources

'Robots already do all the heavy lifting in the high end factories'

would factor in when calculating output efficiency. It is predicted that robots would take up more than 50% of human jobs by 2050.

Let us take a look at some of the jobs that future robots would be good at replacing us with:

1. Pilots, Drivers

Smart cars are already a thing. There is a complex algorithm which measures the risks involved while driving a vehicle and drives it accordingly. Tesla is the flagship company for this technology. Robots could even replace the jobs of commercial pilots and we would never have to worry about our flights getting delayed. It is kind of scary in a way, to imagine a world where jobs as important as running trains and flying planes are done by robots.

2. Teachers

As we saw with the TeacherBot before, teaching with the help of robots not only makes education cheaper, it also makes it more accessible. Teacher bots would be a good alternative to the traditional teaching method. It involves interaction with the class and it just might be the direction that schools of tomorrow are headed to.

3. Soldiers

This might be one of the most hard hitting after effects of the great robot age. The great Mark Twain once said, "I do not know what the third world war will be fought with, but the fourth world war will be fought with sticks and stones." As warfare becomes more advanced, it is impossible for countries not to want to harness robots. After all, you'd rather send a lifeless machine to war than an actual living being. There have already been a lot of prototypes of battle bots. Governments spend a tonne of money on developing technology to make killer machines which will rain terror on their opponents. This is not an outcome any true lover of robotics would want, for robots to become lifeless killing machines. But history is proof that war is inevitable.

'It's all fun and games until this guy shows up'

4. Lab Rats

Robots are already replacing humans in pharmacies in the UK. Robots are being used to conduct and take readings for laboratory experiments. A busy pharmacy can be run by a single robot, which can give customers the right medication via a conveyor belt based on their prescriptions. Robots are also great for taking precise measurements and calculating errors. For these reasons, they make for amazing lab assistants. Add a nice Siri-like A.I. to the robot and BOOM! You've got your own pharmacist Jarvis.

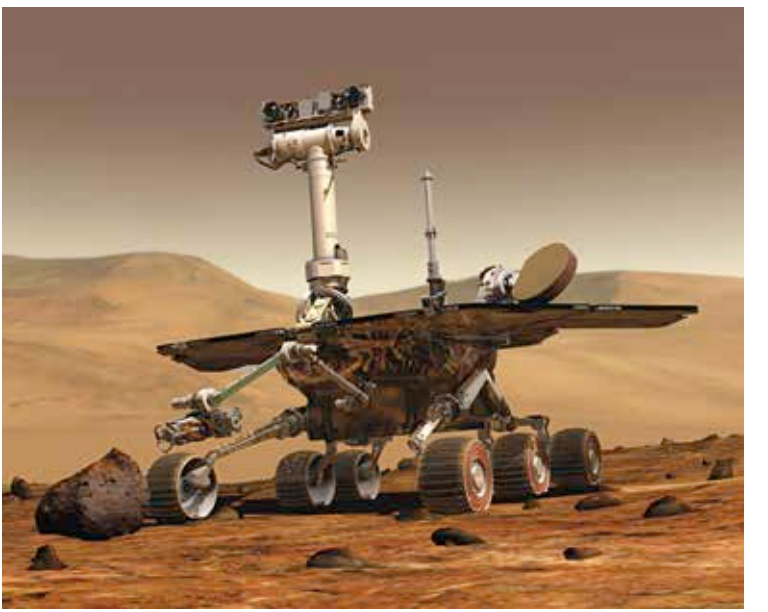
5. Home Bots

General purpose home bots are most likely to appear in markets in the next two-three years. Smart vacuum cleaners and guard robots are already available in the market. The more interesting ones are the kind that tell stories to kids and are able to remember user preferences and help build a smart house network. It is predicted that most homes would be smart homes in the next ten years.

Home bots could be perfect babysitters and provide care for the elderly. There are a lot of companies working to create the perfect robot for the job. The robots available right now, like Asimo, are very expensive. If somehow, they were to be made accessible, I don't know anyone who wouldn't want their own Chappie.

6. Explorers

We have already seen examples of robots that can reach nooks and crannies us humans can not. Robots may perhaps find their most important application in the field of exploration, especially space exploration. Robots have a huge advantage over us in that they don't have any biomedical require-



One small step for man, one giant leap for robotics

ments. They can survive the most deadliest of environments as long as their circuits don't fry and the heat and weather conditions do not damage their exterior. The Explorer probes sent to planets like mars and Jupiter are perfect examples of how robots are of great use to mankind. The first thing to set foot on mars was not a human, but a robot designed by us. Robots are, in a way, an extension of humanity itself. The bond between robotics and humanity will yet take us to places we have never been to before.

Robots for Change

The world is constantly changing and we can only imagine how much more it will have changed in the coming 50 years, or even the next 200 years. Like the turn of the industrial revolution, or the beginning of the Bronze Age, we as a civilization stand at the threshold of something grand. Machines are taking over our lives in newer ways and we depend on them heavily to live our lives. If someone was to turn all the machines off, we would be pushed back to the Stone Age. The use of robots comes with a few alarming questions as well. How much can you depend on something to get a job done? How long till Robots start writing songs and directing plays? The world has been on its toes since the nuclear bombs came around. We always seem to make newer more punishing weapons of mass destruction. So we can't overlook the humane aspect of things when it comes to robotics. We have to teach the more complex ones all the good things that make us human (and maybe prevent judgement day while we are at it?).

THE ONES THAT ARE AND THOSE THAT SHALL BE

The era of robots is no longer a distant future. We are there already. Sure, we're only at beginning, still there's enough to be excited about. Read on...

The design and engineering legions have been at work on creating robots for a while. But we've never witnessed such a mainstream utilization of robotics. From robots that manage your whole house to the ones which allow its users to make their own robots. From those that can traverse almost any type of terrain to the one that is looking for life outside our world. As of now, there are a staggering amount of robots at play. So here's a curated collection of the ones that should definitely be on your radar. Some of them are being developed right now and some are already enjoying the company of their owners.

The ones at our homes

Those that are

Cozmo by Anki

After watching Disney's Wall-E, if you had a desire to own a cute little robot of your own, Anki's Cozmo is something that might just interest you. It's a robot with character. With the help of a team of character designers and animators, Cozmo was packed with animations for his digital eyes, body and even voice. He reacts to his surroundings, to what you say and even has some mischief programmed into him. For example, if it detects a drop ahead of him, it will react with a little scream, change his expressions and scurry back raising of his arms out of terror. This little guy seems straight out of an animation flick. The digital set of eyes are extremely expressive and combined with the voice and actions, Cozmo becomes a charm to watch. It even comes with cubes which can be used to play games. And yes if you beat Cozmo, he will become sad. Straight out of the box it'll start exploring its surroundings and identifying people. It learns and improves on its own or by interacting with people. What is its utility? Nothing other than being a toy. Cozmo was built to be a quirky robot companion. Much like a pet.

Toys are a great use of robotics, but if you imagine robots to help you get things done, a company called Autonomous has got you covered. Their

Personal Assistant robot can move around, recognise people and interact with IoT ecosystems. It's like a smartphone on wheels; except it has a face and voice recognition. It's proficient at things like waking you up, reminding you of things, dictating information, keeping track of health, giving status updates about its environment and people are present. Apart from theses, the Personal Robot can be fed with a bunch of data, which it can analyse for you. Once it knows the database, you can ask it questions as if you would ask a normal person. This makes the robot a great choice for office environments too. Because of its ability to move and stay connected to the internet, you can use your smartphone and ask the robot to go around the house or workspace for you to keep a check on the area. Now obviously it's not like Jarvis, it's quite rough around the edges. Often it could take some time to understand what you say and well you can imagine what would happen if you leave the bot with a pet.

There's also a lot happening in DIY segment, especially the open source segment. **BQ's Zowi** is one such playful member of the DIY Robotics community. Zowi bots are easy to assemble and are mostly targeted towards students. But of course there's nothing stopping adults from indulging as well. After all who doesn't like 3D printing and modding?

RoboEve Xpider is another easy to grasp DIY kit. A little more complex than Zowi in terms of hardware. It comes with 26 different designs and 40 parts each. But it is powered by the software SmartNode which provides an easy drag and drop interface to program the robot.

Another kit with the complexity upped is the Poppy Humanoid. Don't expect to get done with a Poppy Humanoid over a single weekend. It's a great way for anyone who wants to enter the robotics industry professionally.

And finally, we have the **InMoov**. This guy has been around since 2012 when its arm became the first 3D printed open-source robotics project. InMoov is incredibly complex. You're basically given a space to create a human-like being. There are guidelines available, but the creator of this project expects its users to figure out what to do. Although it is recommended that you start with the arm if you do not have prior experience with creating programmed hardware.

Those that shall be

What if someone would fuse the utility of the Personal Assistant with the charm of Cozmo? Well, some people did just that. **Jibo** is a home assistant with skillsets very similar to the Personal Assistant. Although it doesn't

move around, it's small and can be easily moved around in the house. There are playful eye animations and audio cues similar to Cozmo. It has a minimalistic and adorable form factor. Although unlike Personal Assistant it cannot analyze data or act in home security. Again it's a smartphone with an AI installed that can change its expressions and take care of your home.

Even LG has entered the robotics market with its own line of products. One of them is a central hub for your home called Hub Robot. Works and looks very similar to Jibo. But comes with the massive collaborations and quality assurance of LG. There is also a robot in development specifically to act as a guide on airports. And another one clean airports, or other large spaces.

Moley can make your favourite dishes

Ok now that we have our house covered all we need is food! Yep, there's an upcoming robot just for that. Meet **Moley**. This set of two arms inside a cooking chamber can be installed in homes and asked to make your food. It learns to cook by watching others. Then it uploads that learning on the internet for all other Moleys to learn as well. Anyone would be able to teach it cooking. The creators have even expressed interest in creating a marketplace for recipes.

Arm based robots are the most popular forms of bots especially in the industrial context. So someone thought, why not scale them down and put them on desks or other flat surfaces. UFactory is working on a product called UArm Swift, which is a programmable and moddable arm. The point of focus here is the end of the arm. An assorted variety of attachments can be put there to do things like drawing, picking and even laser cutting. It is

actually an advanced version of the company's previous product UArm Metal. UArm swift comes in two versions, vanilla and pro. The upgrade in pro comes with a more precise repeatability. The best part? It's open source.

Another upcoming member of the open source field is **Ziro**. A robotics kit which is controlled by a glove. At its core, Ziro is a set of motors. You craft your robot around these motors and then programme hand gestures to movements of the motors. This can be done through a simple smartphone app. What is the robot made of? Anything. The creators presented Ziro with robots made out of cardboard, so you know there's a large pool of possibilities.

The ones for transportation

Those that are

Robotics in transportation is still in its infancy, most of the technologies are in development. But one robot has already been doing its job for over four years now. NASA's Curiosity Rover has been at work on Mars since August 2012. More than being a tool for consumers, Curiosity is actually a tool for the whole of humanity. It was the first to find out the most promising clues to the origins of the red planet. It constantly studies the atmosphere, digs up holes to collect and study rocks and dirt and sends the data from these studies back to Earth. As of the time of writing, the rover is planned to stay for an additional two years on the red planet.

Special mention

Hate them or not, autonomous vehicles are now the main act unfolding in the robotics theatre. Even if you despise a machine taking over your controls, you cannot underestimate the size of this new wave. Many large automobile companies and startups all over the world are engaged in making autonomous vehicles a reality. Companies like Tesla, Ford, Mercedes and Google have been an active part of this segment. Apart from these, there are a plethora of startups too. NEXT Future Transportation and Otto are working on large autonomous road vehicles. Faraday Future and LeEco have partnered together to work on cars. Then there are companies like AdasWorks, Cruise, DriveAI, Nauto and Princeton Lightwave are just examples of the many small companies working on AI systems. So despite being 'unorthodox', it would be interesting to see what these companies bring up. In the end, we are going to be the users and therefore we can decide, what works and what doesn't.

Those that shall be

As of now the most recent future in transportation robotics is luggage. Cowa Robot, Starship Technologies and Piaggio have announced their luggage robots and would be launching them soon. Cowa Robot takes a more conventional route by fitting AI into existing bag design. Starship's robot looks like a scaled down version of a bathtub with a lid on top. Piaggio's design is as playful as their Vespas. They're shaped like a wheel with a lid on top and would be sold in a variety of vibrant colours. What would these robots help in? Delivery is a highly common projected use, even Amazon is working on its own delivery robots. Other than delivery they could hold equipment of different professionals while they move around doing their job.

These Starship bots might just deliver your next Pizza

In a little distant future lies Agility Robotics' **Cassie**. It's the most successful bipedal robot. Able to traverse a variety of terrain types and even rebalance itself after being hit by a force. The reason why legs are a better solution on robots than wheels is the same reason why it's the preferred form of locomotion in the animal kingdom. It allows for a larger variety of traversals. Being able to go to more places in itself is a big achievement. Some examples of Cassie's uses include sending it inside a burning building to spot people trapped inside, without risking the lives of the firemen. In search and rescue operations, especially areas where it would take extremely long for humans to reach. And even in homes and workspaces, Cassie would be able to better perform by being able to climb stairs.

For average humans, bats have been an element of horror, but for scientists, they've been a marvel of movement. Their hyper responsive and agile maneuverability has fascinated scientists for long. And until

now, due to difficulty in making tiny programmable parts, bats have never been replicated to their scale. Researchers from Caltech and the University of Illinois at Urbana-Champaign have developed a prototype of a bat robot. Compared to a flying drone, a bat robot with its flexible wings would be able to fly through much more complex areas and even be able to recover after hitting something. As of the time of writing, the robot is still in its early stages. It's not completely autonomous and cannot fly for long. But there are people hard at work to one day make our nightmares rescue us.

The ones in medical industry

Those that are

BeWell has made a kiosk that will test your blood pressure, pulse, weight and maintain a database of the same. It is being developed to quickly check your vitals before a professional takes over. Usually, this job is done by a nurse, but it takes that nurse a long time to test all the vitals and update them to a database. The **WellPoint**, as it is called, does all of the testing much quicker and also instantly updates the database. It even keeps a tab on results of previous check-ups. Patients can remotely access their information as well. In addition to testing vitals, a touch screen on the machine would even request the patients to fill up important forms related to medical history. In future, BeWell would be adding more diagnostics option into the robot, something like a connection to blood sugar monitor to record the data.

Those that shall be

An important topic of technological debate is that most of our advancements are catered towards normal people and those with any kind of disabilities are being left behind. **Leka** is a robot toy which is designed for people with autism. Due to the difficulty faced by people in interpreting and expressing emotions, it becomes a challenge for them to interact with other people. Leka's simple visual cues make it much easier to understand emotions. Things like lights, vibrations, playful movements and simple images of expressions. The robot would be programmed to play easy to grasp games utilising the visual cues. It would react joyfully to the victory of its player. And behind the scenes, Leka also keeps recording behavioral information of its users. This information can then be used by a doctor to analyse and find out patterns to create better solutions for the patient.

A research team at Philips was able to magnetically control a swarm of screws and then superimposing more magnetic fields to individually control those screws. This new technology would allow doctors to perform targeted medications inside human bodies. Like opening cancer treating radioactive pills only at the area of the tumor while preventing exposure to the healthy parts. Another possible use could be in medical implants, where the shape of the implant could be altered based on the amount of healing done by the patient or vice versa.

Harvard University and Boston Children's Hospital have together developed a soft robot which can be wrapped around the heart to assist in its beating. Unlike existing methods to assist beating of the heart, the soft robot sleeve doesn't contact blood directly. This reduces chances of clotting, which in turn prevents patients from using blood thinners. The thin silicone sleeve is attached by pneumatic actuators to twist and compress the heart, mimicking its beating. These actuators are powered by an external air pump. The sleeve itself is attached to the heart using a combination of a suction device, sutures, and a gel interface to reduce the friction. The sleeve can also be customised for different patients depending on specific weak areas.

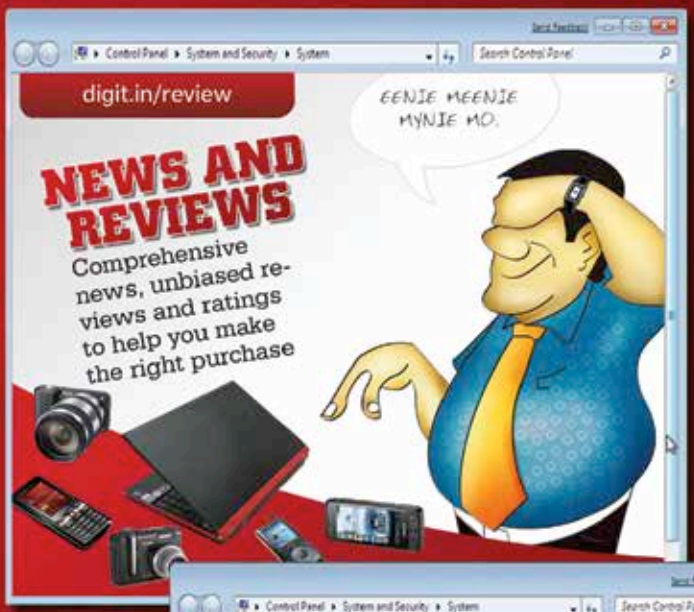
The Leka bot

Wrapping up

Even though the pop culture might have scared us about our future with robots, there is ample work going on to make them safe. Regulatory agencies are conducting strict tests and are controlling the development with guidelines. Plus, even the companies themselves have understood the fear in masses and have started taking steps to improve their technologies and also spread awareness about safe usage of robotics. As it was mentioned earlier, we're just at the gateway of this technology. There's a lot humans

need to experience and learn. What surprises us today will become normal tomorrow and something else would surprise us instead. Robots like Cozmo and Leka are great examples to show the caring nature we can develop into our machines. The Curiosity Rover and the Swarm of Magnetic Robots show their potential to reach both far out and deep inside our lives. Open source kits have brought in another league of developers and designers to create delightful experiences that inspire them and everyone.

Yes, there is a threat of us ending up lazy and weak because of over dependency on these machines. But the fear of fire and electricity never stopped us from developing. Neither will the fear of robots.



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