The Rise of the Automaton

Robots are here, there, and soon to be everywhere

RATIONAL OPTIMIST SOCIETY
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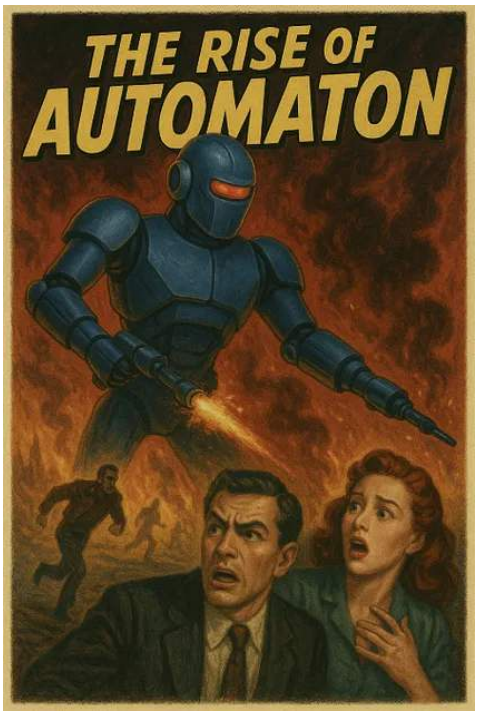
“Robots do not love. They do not desire anything. They do not feel pain. They do not fear death. They are machines.”

— Karel Čapek, R.U.R. (1920)



Dear Rational Optimist,

Having been involved in investment research for over three decades, I’ve heard more than my fair share of big claims.

Which is why I (ROS cofounder David Galland) confess to starting this monthly Deep Dive on the near-future of robotics with a certain amount of skepticism.

After all, despite all the hype about robotics over the years, the global industry is still relatively small and mostly focused on industrial robots made in Japan.

Now, I'm convinced we're in the calm before the storm. The storm being the commercial launch of all-purpose consumer robots.

In a recent speech tech legend Marc Andreessen stated...

"**I think there's a plausible argument, which Elon also believes, that robotics is going to be the biggest industry in the history of the planet.**"

Andreesen's statement made me sit up. He is not known to exaggerate.

If he's right – and for reasons we'll explore, he very well may be – the stakes couldn't be higher.

So what's changed from the past 30 years of slow, incremental growth in robotics?

In short: artificial intelligence.

In the same way rapid advances in AI have supercharged so many technologies, including drones and self-driving cars – basically robots in other forms – innovators are now using it in conjunction with advances in robot mechanics (sensors, motors, and materials) to make robots self-learning, more adaptable, and therefore, more useful across the full range of human endeavors.

In this Deep Dive we'll first explore industrial, medical, and military/law enforcement robots before turning to the world-altering 'space race' underway to develop self-learning humanoid

robots, ready to move into your home and relieve you of your daily chores.

The Age of Robots is Already Here

Today's robots come in all shapes and forms, from humanoid to rolling cylinders, and most commonly, industrial behemoths which can assemble and weld complex machinery with unprecedented speed and precision.

If you need a beast which excels at repetitive tasks like welding, assembly, or material handling with unmatched precision, we've got an industrial robot to fill the bill.

Case in point: starting in the 1960s, the largest US automaker, General Motors, steadily transformed its production lines. Today, they incorporate over 30,000 robots, which handle 90% of the spot welding for car frames and exteriors.

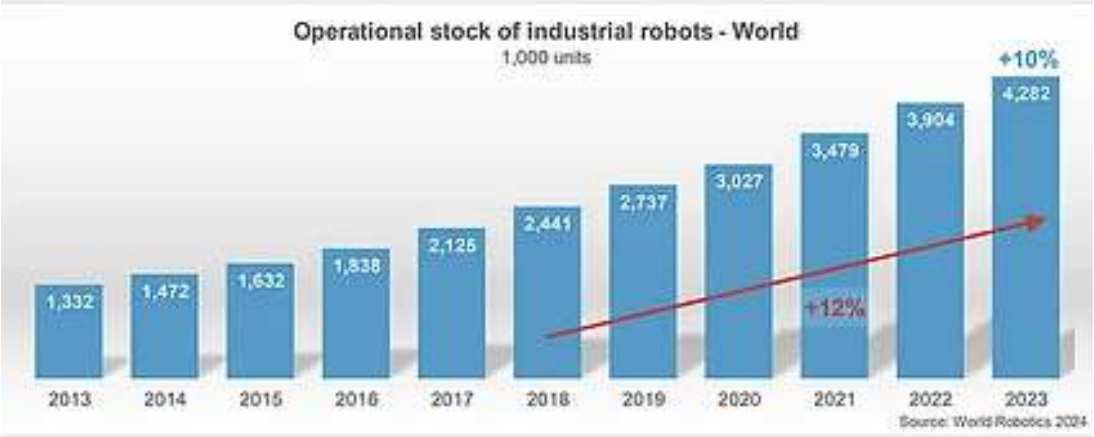
Beyond heavy machinery, **Samsung Electronics** is taking automation to a new level at its display plant in Asan, South Korea, where starting in 2026, more than 10,000 robots will produce over 10 *million* OLED panels annually for flat-screen televisions.

The Asan facility automates over 80% of panel assembly and inspection, slashing labor costs and saving the company hundreds of millions of dollars.

If you were wondering why prices for the popular 55-inch OLED panels have dropped 90% since 2013, wonder no more.

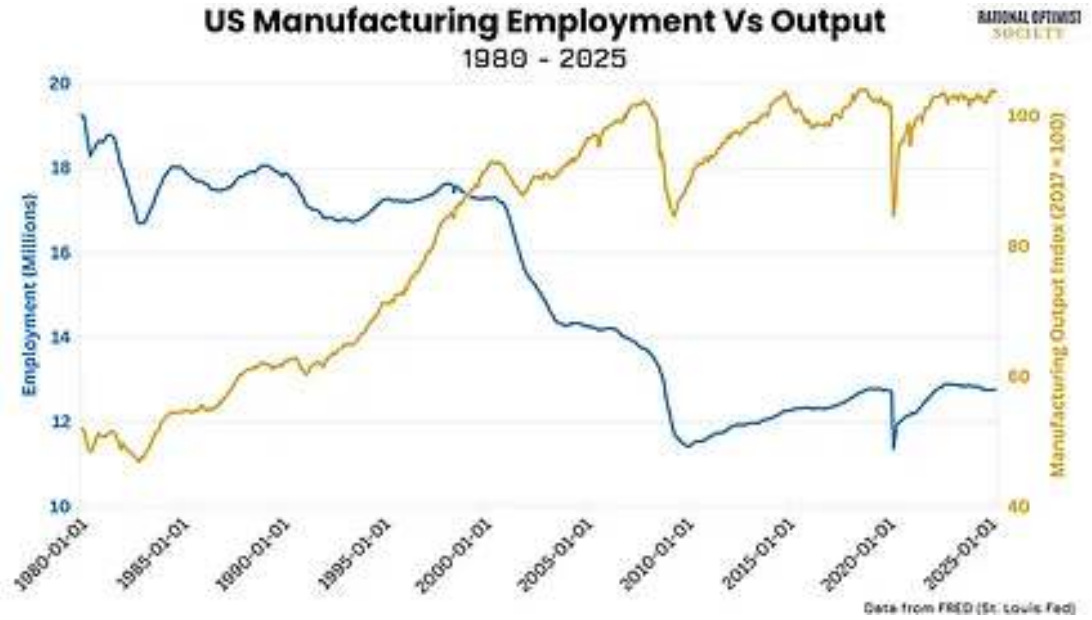
At this point it's safe to say that every manufacturing industry already utilizes robots. The impact of a growing array of

upgraded AI-driven industrial robots will be profound, with factories becoming ever more efficient, lowering costs to consumers.



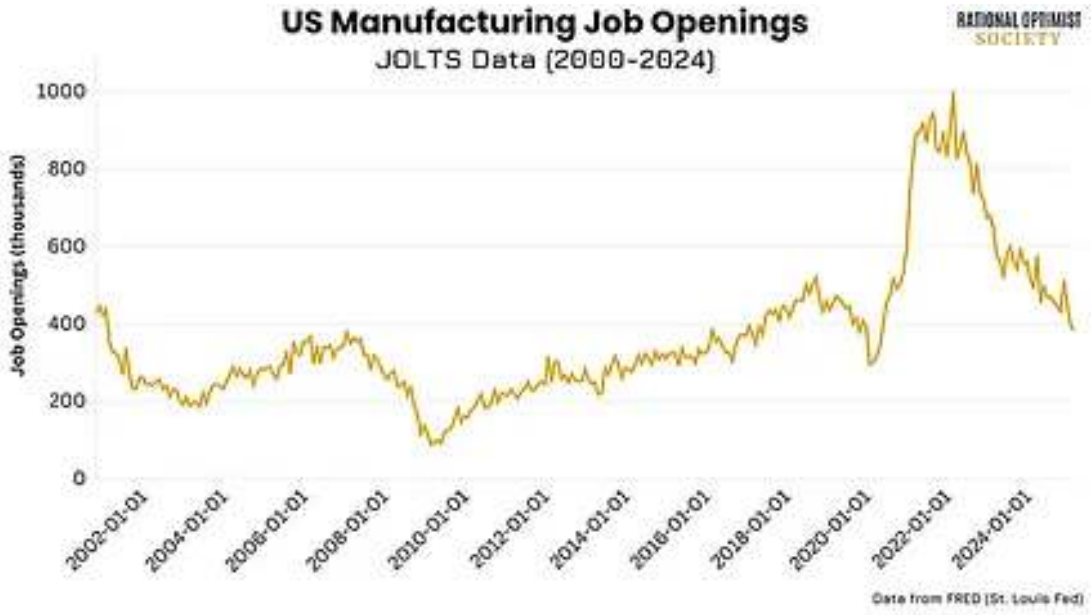
To understand the future, you need only look at the **FANUC** robot factory in Oshino-mura, Japan where the nearly fully automated factory uses robots to produce *other* robots. The factory, which operates 24/7, produces 11,000 sophisticated robots every month. More on FANUC momentarily.

One result of factory automation can be seen in the chart below. Since peaking in the early 1980s, US manufacturing jobs have fallen around 34%.



During the same period, US manufacturing *output* has more than doubled.

Even with offshoring shifting an unknowable number of manufacturing jobs to lower cost countries, hundreds of thousands of US manufacturing jobs have been left unfilled since the Bureau of Labor Statistics began tracking the data in 2000.



Reshoring manufacturing, a US government priority, will only make the job gap worse. Increasingly, those jobs will be filled by

robots.

Industrial Robots

For a simple yet helpful understanding of industrial robots, we'll use the **MOTOMAN** from Yaskawa. Depending on the need, these robots can be big or small and can be configured to suit virtually any manufacturing requirement.

Pictured on the top is a multi-arm robotic MOTOMAN Waterjet cutting system. On the bottom is a far simpler one-arm MOTOMAN model designed for a small manufacturing company.

In both cases, the robots take quite a bit of set up and programming. In this video, you can watch as the author fumbles through the initial set-up of the single-arm MOTOMAN above. The video is long, and you'll want to skim through it, but it will give you an idea of the initial hassle involved.

Once set up, however, the payoff is huge, as the robots are capable of cranking out the goods repetitively, 24/7, with little to no human intervention. No coffee breaks, no unions, no overtime, no HR interactions, no lunchtime birthday parties.

For anyone who has worked with a large (or even small) number of employees – or signed the payroll checks – it's a compelling

proposition.

Of the top ten industrial robot companies by revenue, Europe claims two of the top ten spots, while Japan, an early leader in the field, holds the remaining eight positions.

Here are the current top five.

FANUC Corporation (Japan)

World's largest

With annual revenues topping $5.5 billion, FANUC is the global leader in factory automation, producing a wide range of industrial robots and associated CNC systems (Computer Numerical Control – the digital brains which control robots).

FANUC is the "go to" manufacturer for high-quality robots able to be customized to suit the various industries where you'd expect robots to play a big role: automotive, electronics, and metalworking.

ABB Ltd. (Sweden/Switzerland)

Operates the largest robot factory in China

The *Robotics & Discrete Automation* division of this globally diversified conglomerate offers a comprehensive portfolio of industrial robots and modular manufacturing systems, generating revenues of approximately USD $4.5 billion.

Importantly, in response to rising demand from Chinese manufacturers for more sophisticated robots, ABB opened a robot 'mega factory' in Shanghai in 2022 – the largest in China

and reportedly the most advanced fully automated robot production facility in the world.

KUKA AG (Germany)

German-based, Chinese owned

To offset the fact that Chinese robot manufacturers have historically lagged global leaders in advanced robotics, Chinese firms have acquired large and controlling interests in a number of foreign companies—including Germany's KUKA AG, acquired by China's Midea Group in 2016.

KUKA's factories in Germany and, increasingly, China, now generate approximately USD $4.4 billion in annual revenue from a broad range of robots serving the automotive, aerospace, and consumer goods industries.

Yaskawa Electric Corporation (Japan)

Motion-control pioneer

Well before Yaskawa began producing robots, it had a global reputation as a pioneer in motion-control components, the servo motors, drives, and automation which are the hallmark of modern robotics. It then leveraged that technical expertise by creating the MOTOMAN series mentioned a moment ago.

With estimated revenue of about $3.7 billion, the company's robots are known for exceptional flexibility which makes them useful for both large and small manufacturers.

Kawasaki Heavy Industries (Japan)

Japan's First Robot Maker

With revenues just under USD $2 billion, Kawasaki has been a pioneer in industrial robotics since the early 1960s, when it produced Japan's first domestically built robot, the **Kawasaki-Unimate**, marking the beginning of Japan's robotics industry.

More recently, Kawasaki has expanded into specialized medical and pharmaceutical automation, developing robots for tasks such as sterile drug preparation, surgical support, and lab automation.

Material Handling

When it comes to material handling, **Amazon Robotics** – born out of the company's acquisition of Kiva Systems in 2012 – is the undisputed Robot King, currently deploying over 750,000 robots. For comparison, Walmart's fleet of robots totals only about 50,000.

Driven by the need to handle 26 million individual products each day, Amazon is constantly seeking new ways to automate inventory management and streamline the tedious picking and packing process.

Expect more robotic breakthroughs from Amazon.

Competing with Amazon – or perhaps trying to gain enough traction to become an acquisition target – are companies such as **RightHand Robotics** and **Locus Robotics**, among many others. They are deploying computer vision along with various suction devices and tactile "fingers" to move products from bins into packages. The robot shown here is designed specifically to load and unload trucks, a growing use case.

Given the size of the opportunity, the use of robots in manufacturing and material handling is set to improve dramatically in both scale and sophistication.

A Word About China

While native Chinese companies now manufacture more robots by *volume* than any other country in the world, they greatly lag the world when it comes to manufacturing sophisticated, high-value robots.

Consider **Siasun**, China's largest robot manufacturer, which generates annual revenues of around US$500 million. That pales in comparison to industry leaders such as FANUC, whose sales run into the billions.

Yet, with China the world's leading consumer of industrial robots, the situation is changing.

Launched in 2015, the Chinese government's ***Made in China 2025*** initiative identified robotics as a core industry, unlocking billions in research funding and local incentives. The same

initiative also drove China's rise to dominance in 'flying robots'—better known as drones.

According to the International Federation of Robotics:

> *"In China, robotics and automation are penetrating all levels of production. This is evidenced by its high robot density of 470 robots per 10,000 employees in manufacturing - the third highest in the world, surpassing Germany and Japan in 2023. The United States, on the other hand, ranks only tenth among the world's most automated manufacturing countries with a robot density of 295 robots per 10,000 employees."*

FYI, the two leaders in robot density are **South Korea** with 1,012 robots per 10,000 employees, and **Singapore** with 770 robots per 10,000 employees, so there is a *lot* of room for growth in China, and even more in the US.

To meet the government's goals, Chinese companies such as **Siasun**, **Estun**, and **Efort** are growing quickly organically, and through global acquisitions such as the Midea Group's acquisition of KUKA AG, noted earlier.

And they are quickly moving up the sophistication scale. Pictured below is the **Iron** robot from Chinese company **XPENG**. It is already being deployed in factories, and is now being tested in households. Keep **Iron** in mind as we discuss the heated competition for humanoid robots a bit further on.

Iron, the humanoid robot (XPENG)

Medical Robots

For medical robots, one company stands head and shoulders above the rest: **Intuitive Surgical** (NASDAQ: ISRG), maker of the **da Vinci Surgical System**.

In May 1998, a doctor using a da Vinci prototype performed the world's first documented robotic-assisted surgery (**RAS**) at the Leipzig Heart Center in Germany. After gaining FDA approval in 2000, the system quickly became the gold standard for minimally invasive soft tissue procedures, including prostate, bladder, and uterine surgeries.

In 2024 alone, da Vinci systems were used in over 2.7 million procedures globally. In the United States, more than 80% of all prostatectomies are now performed with the assistance of a da Vinci robot.

Demand for Intuitive Surgical's systems continues to surge, with the company's revenues nearly doubling over the past five years.

The introduction of the **da Vinci 5**, launched in 2024, is helping to drive that growth. Leveraging AI, this next-generation platform offers 10,000 times more computing power than previous models and even enables tactile feedback, allowing surgeons to 'feel' tissue resistance during surgery, a previously missing element critical to reducing tissue trauma.

Today's RAS process is highly sophisticated and usually begins with MRI or CT scans that are used to build 3D digital models of the patient's anatomy. These models help the surgical team plan and even virtually rehearse the optimal approach before any incision is made.

Once finalized, the plan is uploaded into the robot's system, guiding the procedure with digital "guardrails" that eliminate hand tremors and enhance accuracy for tasks like incisions, cauterization, resection, and suturing.

During a RAS procedure, the surgeon operates from a seated console, using hand and foot controls to direct the robotic arms according to the pre-determined surgical plan. This setup reduces surgeon fatigue and enables movements that are far more stable and precise than the human hand can typically achieve.

For hard-tissue surgeries such as hip and knee replacements, **Stryker** (NYSE: SYK) leads the field with its **Mako** *SmartRobotics* system. A physical therapist I know here in the UK recently told me one of her patients had a knee replaced using the Mako system and 3D-printed implants. He was able to walk out of the hospital the same day as his surgery.

The new **Mako 4**, launched in 2025, improves setup speed and expands into the specialized area of spinal procedures, giving Stryker a foothold in a space long dominated by UK-based **Medtronic** (NYSE:MDT).

Given the complexity of spinal operations, and the potential for a devastating outcome should something go wrong, the control offered by robots represents a huge step forward.

Typically, the robotic medical systems cost well over a million dollars per unit. But the cost is offset by gains in precision, efficiency, reduced fatigue, and fewer medical errors, which can be both costly and legally risky for hospitals.

Consider this: up to 16% of patients undergoing traditional prostatectomies suffer potentially life-altering complications. As robotic surgery becomes more refined and globally adopted, that rate is expected to drop dramatically.

Of course, like all transformative tech, surgical robots are riding the experience curve: over time, costs will come down, quality will go up, and access will expand.

The Innovators

The innovation in medical robots – and all robotics, for that matter – is happening so fast and furious that by the time this Deep Dive is finished, the information is likely to be out of date.

Even so, I'll quickly mention a few innovations you're likely to hear more about.

- **Nanomedical Robots.** Nanomedical robots—nanoscale devices ranging from 1 to 100 nanometers—are currently in pre-clinical development. Pioneered by academic institutions such as **MIT** and **ETH Zurich**, and supported by startups like **Galen Data**, these tiny machines aim to deliver drugs directly to targeted cells (such as cancer tumors) or perform precise tasks within the body, such as clearing arterial plaques or assisting in neural repair. While high research and development costs and significant regulatory challenges have slowed progress, the potential to transform fields like oncology and neurology continues to attract investment.
- **Remote Surgeries.** The first fully remote tele-surgery, known as *Operation Lindbergh*, was performed on September 7, 2001, when a surgeon in New York used a

custom-built high-speed fiber-optic connection to operate on a patient in France. While the feasibility of remote surgery continues to be tested, particularly in countries like China, these procedures remain rare due to legitimate concerns about latency and connection stability: a momentary internet disruption could have serious consequences. As the reliability of high-speed internet connectivity improves, long-distance surgery becomes more viable and maybe even routine.

- **General Hospital Support. Moxi** from Diligent Robotics is already deployed in over 30 hospitals, saving nurses time by fetching and delivering various supplies, including drugs. Moxi utilizes AI to expedite learning, and sensors to avoid running into people and clutter found in hospital hallways. It can use elevators and open and close doors on its own.

- **Neuralink's R1 Robot**: After a surgeon removes the top portion of the patient's skull, the purpose-built R1 Robot uses a 3D model of the brain to precisely insert the

> company's N1 implant—roughly the size of a quarter—along with more than 1,000 ultra-thin wires into targeted areas of the brain. Once operational, the implant's sensors capture brain signals, which are processed to help restore speech and some degree of motor function. *[Read more]*

"Follow the money" is a time-tested adage in both investing and forecasting the adoption of new technologies. In 2024, the global surgical robotics market was valued at approximately $7–10 billion annually. Based on current growth trajectories and industry forecasts, that figure is expected to double or even triple in the next five years, reaching $20–30 billion by 2030.

The biggest beneficiaries of this rapidly evolving technology are aging populations, whose need for surgical interventions is rising, just as a growing shortage of surgeons is projected. According to a recent report by the *Association of American Medical Colleges*, the US could face a shortfall of up to 19,000 surgeons by 2036.

At first glance that shortall may not seem catastrophic, but 19,000 surgeons performing an average of three surgeries a day, five days a week for 42 weeks a year, equals an annual shortfall of 11.97 million operations.

Medical robots are not a luxury, but a hard necessity. In the quest to make surgeons more efficient (and effective), expect to see the full automation of select surgical tasks, starting with fully automated suturing. Those robots are already in development.

Military and Law Enforcement Robots

Outside of drones, at this point most robots being deployed by the military and police are used for remote surveillance and bomb disposal.

If you want to understand the core value proposition for first responders, check out the video showing the **Spot** robot dog from **Boston Dynamics** opening a door.

Equipped with cameras, heat sensors, chemical sniffers, communication devices and more, these robots are being sent into dangerous situations ahead of humans, greatly reducing risk.

While a bit silly looking, units such as those offered by **Knightsbridge**, shown here, are supplementing human patrol officers.

The robot is equipped with cameras and a two-way speaker system, allowing it to deter crime simply by following a suspect around and notifying them they're being recorded and that police are enroute.

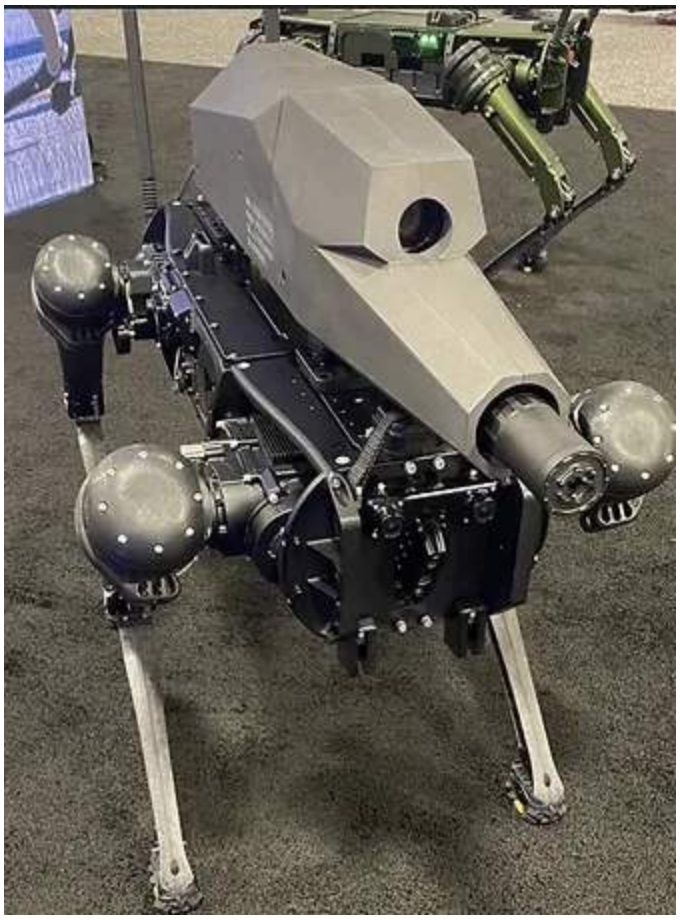
According to the company, the presence of these units on premise reduces crime by almost 50%.

The Chinese are taking a different approach to the patrol function, deploying the ball-like 126 kilo (277 lb) **RT-G robot** from **Logon Technology**. According to the company, it's capable of chasing down perps at speeds of up to 35 k/hr across land, up stairs, or even across water.

The RT-G is loaded with facial recognition software and can be kitted out with non-lethal gear from tear-gas to net guns. A sound-wave dispersion device comes as an optional feature, able to disperse unruly crowds with painful sonic bursts.

Though purposely downplayed due to ethical concerns, there are also a number of companies working on lethal robots.

The appropriately named **Ghost Robotics** is advancing a robotic dog that looks a lot like **Spot**, (so much so Boston Dynamics filed a lawsuit against the company in 2022) but which offers a platform designed to be easily modded with machine guns, grenade launchers and more.



The Ghost Robot shown here has a special gun designed by **SWORD Defense Systems** mounted on its back.

The US government is actively investing in these new automated warfighting technologies, including efforts to replace the long-serving **Bradley Fighting Vehicle** with a next-generation platform known as the **XM30 Mechanized Infantry Combat Vehicle**.

This new vehicle is being designed with "optionally manned" capabilities, meaning it can operate with a crew onboard or be controlled remotely under certain conditions. While full autonomy is not the current standard, the integration of increasingly autonomous features will expand over time as the technology matures.

As demonstrated by the deployment of drones, it's a safe bet fully automated killer robots will appear on battlefields, probably within the next decade.

Civilized society will need to determine the rules of engagement for these robots. Perhaps the optimal solution is to have them serve as mobile, intelligent sentinels, akin to smart landmines. If attackers wish to cross into their field of fire, so be it.

If there's a silver lining it may be that, unlike landmines which can torment a population for decades following a conflict, robots can be easily decommissioned and returned to the warehouse.

Moving along, let's cross back over to the sunny side of the street with a look at the rapidly evolving robotic technologies Marc Andreessen, Elon Musk, Cathie Wood, and other serious tech minds believe will soon fundamentally alter the world.

Household Robots

1X Technologies

Of course, household robots are already prolific.

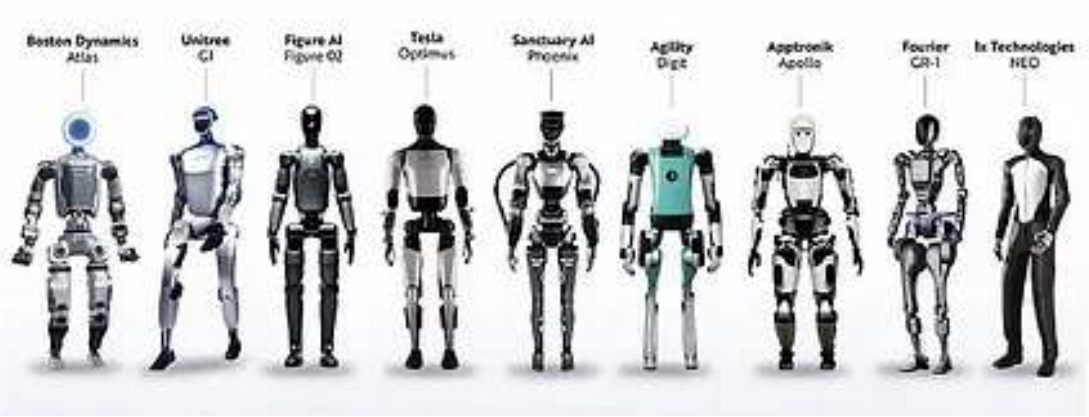
Dishwashers wash our dishes and robotic floor cleaners, like **iRobot's Roomba**, the **Matic from Matic Robots** are tidying up and saving people time. Robot lawnmowers are increasingly freeing up our weekends.

If the techies are right, things are about to get *very* interesting with AI-powered humanoid robots designed to free humans from the tedium of most household tasks.

When you think about it, the humanoid shape for these robots makes sense because virtually *everything* we interact with in our daily routine – from doorknobs to drinking glasses – are optimally designed for the human form.

As mentioned, I started this Deep Dive fairly skeptical a humanoid robot capable of performing virtually any household task on command would be perfected any time soon.

Yet… yet… tech giants like Amazon, Google, Tesla, and NVIDIA are pouring billions into the race to be first to market with exactly that kind of robot. Toss into the mix dozens of well-financed start-ups and Asian robotics companies supported by their respective governments, and you have the equivalent of a space race.



What do these enterprises, and their backers, know about the technology that makes them so confident?

Perhaps it's the impending perfection of AI-powered "brains" – like those being developed by **Physical Intelligence**, a company backed by Jeff Bezos and some of the world's leading tech venture capitalists – that allow robots to learn new tasks simply by observing.

Their flagship product, π0 (Pi-Zero), is designed to enable a robot's AI-driven physical intelligence to be continuously updated and improved simply by observing, with the knowledge shared via regular updates to all the robots in the same eco-system.

Pi-Zero robots are already able to execute up to 50 motor commands per second. That's pretty close to operating in real-time (i.e. without clumsy pauses).

As mentioned, this progress is only possible thanks to the exponential gains being made in artificial intelligence. You'll notice this as a constant theme in the development plans of leading contenders in the crowded race to perfect a functional humanoid robot – a small sampling of which follows.

Reviewing the list, keep in mind that **if one wins, many will win**. More on that shortly.

1X Technologies

Home-friendly humanoids powered by NVIDIA-backed learning

Based in Palo Alto, California, **1X Technologies** is the maker of the **NEO** robot, shown here with NVIDIA founder Jensen Huang.

The company's collaboration with NVIDIA gives it a meaningful edge as NEO uses NVIDIA's onboard GPU alongside a vision-language transformer system (Redwood) that enables real-time object recognition and manipulation. In other words, it's learning to do what we do, simply by observing us do it in the real world.

I've watched NEO tackle everything from cooking to household chores and the results are impressive. NEO isn't some clunky lab prototype; it's increasingly nimble and purpose built to live safely among us.

Tesla

Tesla's AI ecosystem offers a major advantage

Tesla's **Optimus** robot is emerging as a top contender, largely due to its potential for full integration within the broader Elon Musk ecosystem. This ecosystem includes access to vast real-world training data, particularly from millions of camera-equipped Tesla vehicles operating autonomously in diverse environments. Optimus, like Tesla's self-driving system, is based on a vision-centric AI model.

Additional potential advantages could include connectivity via the Starlink satellite network and broader AI development insights from access to user behavior on X (formerly Twitter).

Like Physical Intelligence's Pi-Zero, Optimus is now capable of learning tasks simply by observing humans or watching videos. In this video, Optimus is shown performing everyday tasks: tossing trash in a bin, stirring a pot, vacuuming the floor. With each iteration, its movements grow smoother and more natural, true of all of the robot race leaders.

Apptronik

Warehouse workhorse: lifting 55 lb with human-like ease

Born out of the *Human Centered Robotics Lab* at the University of Texas at Austin, **Apptronik** has been quietly working on humanoid robotics since 2016.

Its flagship robot, **Apollo**, is all about real-world applications – with a current focus on logistics. Standing 5'8" and weighing about 160 lb, Apollo can lift up to 55 lb. Apollo is already being tested for tasks like unloading trucks (shown here), palletizing goods, and navigating factory floors. When you compare this image with that of the bulky box handling machine shown earlier, the humanoid has a clear advantage.

The company, still privately held, recently raised over $350 million from backers including Google's Gradient Ventures and Jabil. Apollo can run for up to four hours on a swappable battery, and its modular design – where key components can be easily upgraded, replaced, or customized – makes it easier and more cost-effective to mass-produce, maintain, and adapt for different tasks. This flexibility is a key advantage when scaling up production or deploying the robot across varied industries.

Figure AI

AI-driven humanoids able to listen, think, and do

Figure AI, founded by Brett Adcock—founder of Archer Aviation—raised $675 million in funding from Microsoft,

OpenAI, NVIDIA, Jeff Bezos, and others. With a current valuation of $2.6 billion, the company is aggressively pursuing large-scale deployment of general-purpose robots.

Figure's main advantage is that its robots are built around artificial intelligence from the ground up. They're designed to see, understand, and respond to the world using powerful AI tools developed with help from OpenAI and powered by NVIDIA's advanced computer systems.

In a recent demo video (watch here), two humanoid robots are shown working together to accomplish a task they've never encountered before. After receiving a verbal command delivered in natural, conversational English, they collaborate to complete the job.

They appear to be interpreting the scene using advanced computer vision and real time reasoning. If this wasn't a remote-operated demo (and Figure claims it wasn't), it's one of the most compelling displays of embodied AI to date.

Figure's robots are already being tested in real-world environments, including in a BMW factory. And the company is in talks with UPS to test Figure robots for delivering packages.

Adcock has stated the company aims to ship tens of thousands of humanoid robots over the next few years, scaling production through its newly unveiled manufacturing facility, **BotQ**, located in San Jose, California. Designed to eventually produce up to 12,000 robots annually, the factory is part of a broader robot campus where some assembly work will be performed by Figure's own humanoids. While it's still early days, Figure is well-funded, well-connected, and moving fast.

Boston Dynamics

Decades ahead in agility

No discussion of the robot race is complete without mentioning **Boston Dynamics**, a pioneer in the field since 1992 when it was spun out of **MIT**.

The company's flagship humanoid robot, **Atlas**, has repeatedly set the bar for robotic agility and is capable of running, leaping, flipping, and even performing parkour.

Though not yet aimed at commercial applications, Atlas is influencing the development of humanoid robotics by pushing the boundaries of balance, coordination, and real-world dexterity. In a race where many robots are still learning to walk, Atlas is already crossing the finish line.

As part of its strategy to become a diversified "smart mobility solution provider," **Hyundai Motor Group**, the South Korean automaker, acquired an 80% stake in Boston Dynamics in 2021. Simply put, Hyundai is expanding beyond traditional automobiles, focusing on autonomous driving, artificial intelligence, electric vertical take-off and landing vehicles (**eVTOL**), smart factories, and, with Boston Dynamics, robotics.

It’s a bold move, sure to have caught the attention of other automakers.

A moment ago, I stated 'if one wins, many win.' By that, I mean that once we have a working humanoid robot capable of performing a wide range of household, factory and service tasks, the river of investment into the sector will turn into a flood.

That influx will allow other serious contenders to quickly catch up, sparking competition, accelerating improvements in utility, and driving down costs. Maybe I’ll own an Optimus, and you’ll own a NEO, and we can have them compete in a footrace around the backyard.

An Important Aside: Operators vs. AI

1X Technologies, Tesla, and others openly acknowledge that in many of their demonstration videos, humanoid robots are being remotely operated by humans. Technically speaking, that makes them more like puppets than autonomous machines.

The robotic companies are unapologetic about what some might call sleight of hand.

Why?

Because once the AI-control software and interfaces now in development reach the necessary level of sophistication, switching from human input to full AI control will be relatively straightforward. One day, it’s a human operator. The next, it’s AI.

It’s a valid point and worth keeping in mind as the technology evolves.

Use Cases

In addition to household chores, what roles might these humanoid robots play in the reasonably near future?

Physical Labor. As billionaire Marc Andreessen recently commented “We shouldn’t be screwing screws by hand on rubber mats for 10 hours.”

According to numbers provided by Figure, 50% of global GDP – about $42 trillion worth – is generated by human physical labor.

That represents a massive market for humanoid robots, whether unloading boxes from trucks, collecting garbage, doing repetitive manufacturing jobs, cleaning offices, waiting tables or, or…

In the future, if a robot can do the job, and the cost/value proposition is right, the robot will get the job.

Elder Care. Also according to data provided by Figure, there are now close to a billion elderly people worldwide needing some form of home assistance. Properly designed, a robot could provide a range of useful functions, including:

- **Companionship**. AI chatbots built into care robots will be able to interact on multiple levels, from providing a gentle wake-up call in the morning, to providing the news, playing games to help maintain mental acuity, recording and delivering messages to and from family members, projecting media onto walls, or just engaging in a friendly chat. The robot need not have a humanoid shape to provide companionship. This cute little fella is the **TomBot**, a robotic dog that responds to touch in much the same way a real dog does.

But why stop there? Robotic cats? Cuddly walking, talking Pooh Bears? Why not?

- **Medical support**. Monitoring activity – or lack thereof – to prevent "I've fallen and can't get up scenarios," and to call for medical intervention when necessary, are a function these robots can already provide.

As would be delivering medicines, in the right dosage, on a set schedule. Engaging in dialogue to gauge mental capabilities, or follow-ups after doctor's visits would be logical.

- **Physical support.** Properly designed, a care robot could assist a person out of bed, in and out of wheelchairs, or when using the bathroom. Units such as this are already in development.
  In our recent Rational Optimist Podcast interview with **Noland Arbaugh**—the first Neuralink recipient—he shared what life is like living paralyzed from the shoulders down. Unable to perform most daily tasks without a caregiver, Noland has found new independence through Neuralink, which now allows him to operate a computer using only his mind.
  During our conversation, he expressed hope that one day he might be able to control a Tesla Optimus robot with his thoughts. Imagine the possibilities: telepathically instructing Optimus to help him eat, get dressed, or perform the countless everyday tasks he currently cannot do on his own. Providing one-on-one human support is expensive, and so we can expect well-funded hospitals to be early adopters. Then, as the price of the robots fall, to see them adopted in assisted living homes and, finally, private homes, probably on a lease basis.

In the interest of time, I will move on, leaving it to you to imagine all the many ways a fully teachable and functional humanoid robot might be pressed into service. The list is pretty much infinite.

(For those of you interested, in an addendum to this Deep Dive, I include other examples of the functions robots might provide.)

Remaining Hurdles

Other than the obvious technical hurdles, there's another important consideration in the robotization of Planet Earth: privacy.

Even **Samsung's** adorable **Ballie** is, at its core, an information vacuum. To function as your home assistant, it must map your house, listen to conversations, record video, and interface with your internet accounts, smart devices, and cloud services.

If such a system were to be hacked – which, without airtight security protocols, is a near certainty – it wouldn't just be a data breach. Your life would be downloaded, exposing your habits,

routines, voiceprints, passwords, relationships, conversations, and personal spaces.

But privacy is just one layer. A deeper challenge is psychological: many people harbor an instinctive fear of robots, particularly those that appear too human. This is known as the “uncanny valley” effect – a sense of unease when a robot looks and moves almost like a person, but not quite. It triggers discomfort, suspicion, and even fear.

There’s also concern about job displacement, government surveillance creep, and the broader implications of machines that don’t just serve us, but watch, record, and adapt to us. Who owns the data they collect? What rights do you have when a robot logs your child's first words, your daily routines, or your intimate conversations?

Fortunately, we humans are good at problem-solving. We’ve done it before with smartphones, smart homes, and AI assistants. So, I’m convinced we’ll do it again with robots.

The Potential

While the timing is uncertain – Musk’s plans for the 2026 commercial launch of Optimus seem optimistic – the overarching fact is that, heavily aided by AI and a lot of cash, the pioneers in this burgeoning field are making serious inroads.

We already have robots capable of seamlessly moving like humans (or, going one better, doing backflips) and manipulating the smallest and most fragile of items. Pretty much all that’s needed now is for the operational software to catch up. And if

there's one thing we humans are really good at in this digital age, it's software.

While the idea of humanoid robots is kind of fun, fun is not what's driving the race to tomorrow. It's money.

Marc Andreessen, quoted earlier, has also gone on record that he sees a future with "billions, perhaps tens of billions" of robots.

According to the **2025 Big Ideas** report produced by tech investor Cathy Wood of ARK Investment Management, "Generalizable robotics could generate over $26 *trillion* in annual revenue, created evenly between household and manufacturing robotics."

Cathy Wood's exuberance was echoed in a recent speech by NVIDIA Founder Jensen Huang who agreed robots were the next multi-trillion industry.

While it is rational to meet projections involving billions of robots and trillions of dollars with a healthy dose of skepticism, it's notable that some of the nation's leading tech investors are bandying about these sorts of numbers.

Though still "cautious," I am now considerably more inclined to believe we are on the verge of the New Age of Robotics.

For those of you still skeptical, let's play a simple mind game. Imagine the world 100 years from now. Do you think virtually all heavy manufacturing and material handling will be fully automated? The answer is clearly yes.

Do you think humanoid robots, already within throwing distance of being fundamentally useful, will be a part of most households in 100 years? Again, I think the answer is yes.

Which begs the question, “When?”

As we often reflect upon in our weekly Rational Optimist Society communiques, after years where progress seemed confined to the virtual realm, the innovators are once again shaping the physical world with bold inventions and ingenuity.

We’re curing diseases once thought incurable. We’re building cars that drive themselves. And we’re catching skyscraper-sized rockets – midair – with precision-engineered robotic arms.

With exponential advances in artificial intelligence now transforming, well, everything… isn't it rational to believe we are living in the era when the breakthrough in humanoid robots will finally occur?

I now believe it is.

What do you think? Would you let a robot operate on you? Would you buy a humanoid robot? How soon will manual labor as we know it be a thing of the past?

Let us know your thoughts by dropping me a line at Galland@rationaloptimistsociety.com or by leaving a comment below.

Until next time…

David Galland

Addendum: Other Possible Robot Uses

Just for fun, and to gain a fuller sense of what we might expect from robots, here are some creative, and useful, ways entrepreneurs are either already using robots, or may soon be.

General Household Management

Samsung Electronics has been hard at work perfecting their **Ballie** robot, an AI-driven home assistant and monitor, shown a minute ago.

Basically, it's an Alexa device on wheels, but with some added features such as being able to project media onto a wall. It can interact with smart home tech to monitor the temperature, make you a cup of coffee, turn the lights on, etc.

It also learns to recognize you and your family members, and to patrol your home and alert you if someone it doesn't recognize appears on the scene.

Samsung is preparing for a summer 2025 launch, at a price estimated in the $1,500 range. Pick one up while waiting for your NEO delivery?

PetCare

Though most people don't realize it, the pet care industry is massive. In fact, globally it is more than four times bigger than the personal computer industry.

Which explains why a number of robot makers are focused on building companion robots for pets, with a focus on those who are left at home while the owner works.

The **Pumpkii**, shown here, will interact with your pet, allow you to talk to it in your voice, and on your remote instructions, provide it with a treat while taking a photo to send to you.

There's a lot of room for improvement, and with the size of the market, there will be.

House Building Bots

In our discussion of industrial robots, I mentioned they can be configured to serve pretty much any purpose. How about building your next house?

After working with clients to create a detailed 3D model for a house, BotBuilt uses industrial robots to prefab the frames which are then transported to the building site and assembled, saving a tremendous amount of time and labor, and therefore costs.

The founder claims a single teenager can run the entire robotic framing process. In addition, robotic precision means the framing is built right the first time, even with a teenager in charge.

Restaurants

One can easily imagine robot *maîtres* or Optimus waiters. There are already an increasing number of specialized robots being used in the kitchen, including the **BurgerBot** shown here.

After a human chef cooks the burger, the robot assembles it – adding condiments according to the order – then boxes it up and pushes it onto a conveyor belt. It's all a bit silly, if you ask me, but it's a clever marketing ploy as guests get to watch it work, and probably saves the cost of a line cook or two.