Artificial Intelligence & Robotics: Industry Report & Investment Case

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The Rise of Intelligent Robots

Artificial intelligence (AI) and robotics, together, is the augmentation and imitation of human activity and behavior to increase output or efficiency. Driven in large by technological advancements and an increase in implementation and demand, these burgeoning fields have both gained a lot of attention in the last few years. However, their underlying sciences have been in development for decades. What is most interesting today is the *intersection* of these two fields, where advancements in both AI and robotics feed on each other, creating a multiplier effect on this intersection.

This is a prime example of the Fourth Industrial Revolution we are in, defined by Klaus Schwab, Founder and Executive Chairman of the World Economic Forum, as a "range of new technologies that are fusing the physical, digital and biological worlds". The fusion and harmonization of fields allows them to grow more rapidly, and AI and robotics are an essential part of this breakthrough. This is one of the reasons why AI and robotics, together, are geared for exceptional growth.

The following analysis will define AI and robotics, explain the elements that are driving growth in the space, illustrate the industry outlook, and then finally show the reasons as to why the product tied to the Nasdaq CTA Artificial Intelligence & Robotics Index (NQROBO), the First Trust Nasdaq Artificial Intelligence and Robotics ETF (ROBT), is poised to capture the trends in this industry.

At-a-Glance

The Nasdaq CTA Artificial Intelligence & Robotics Index provides exposure to the three stages of the global AI and Robotics industry by selecting companies classified as enablers, engagers or enhancers per the Consumer Technology Association (CTA):

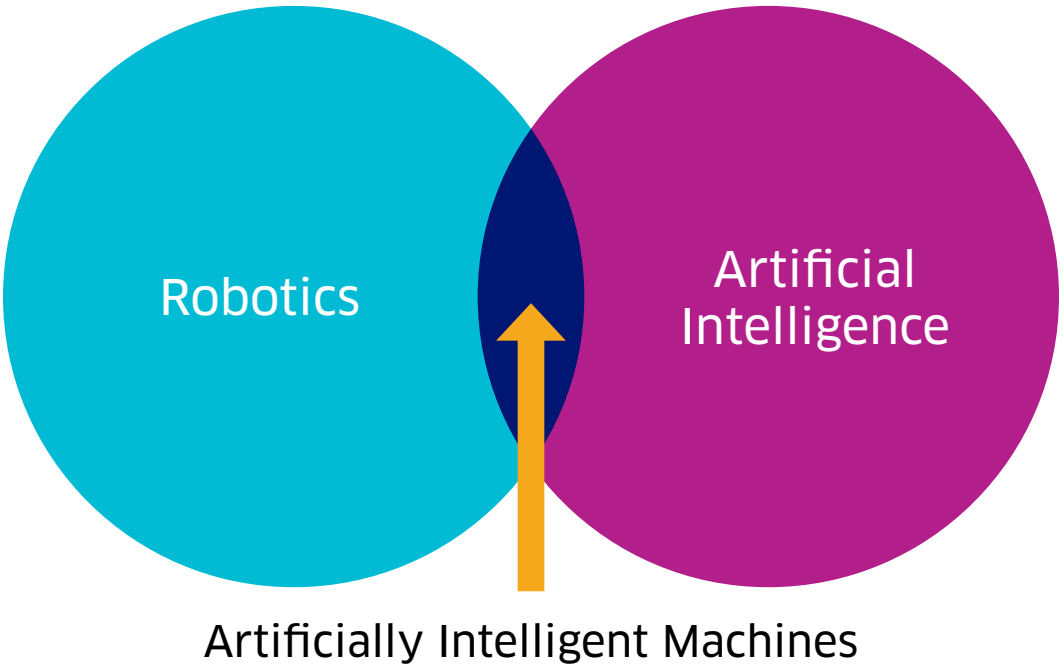
- Enablers (25%): Develop building blocks
- Engagers (60%): Design, create or deliver products, software or systems
- Enhancers (15%): Provide their own value-add

The Index ensures investability, sufficient liquidity and size of the underlying companies.

- Minimum market cap of $250M
- Minimum 3-Month average daily dollar volume of $3M
- Minimum free float of 20%

Defining Artificial Intelligence & Robotics

Separately, AI and robotics are fundamentally different and can be used for a variety of purposes. Robots are programmable machines that can carry out routine tasks semi-or-fully autonomously. Artificial intelligence, on the other hand, is the development of computer models to complete tasks that would otherwise require human intelligence. In other words, artificial intelligence algorithms are generally self-trained to carry out tasks with some level of human behavior (e.g. language understanding capabilities). This shows that the two branches are fundamentally different, in that robots carry out pre-defined and routine tasks while artificial intelligence attempts to mimic "intelligence". There is, however, an intersection of these two branches, which is artificially intelligent machines[1]. Artificially intelligent robots or machines are the bridge between artificial intelligence and robotics. They are machines which are controlled by artificial intelligence programs. This allows robots to not only complete routine tasks but also more complex tasks requiring more "intelligence". These two branches can be summarized with the Venn diagram below[1].



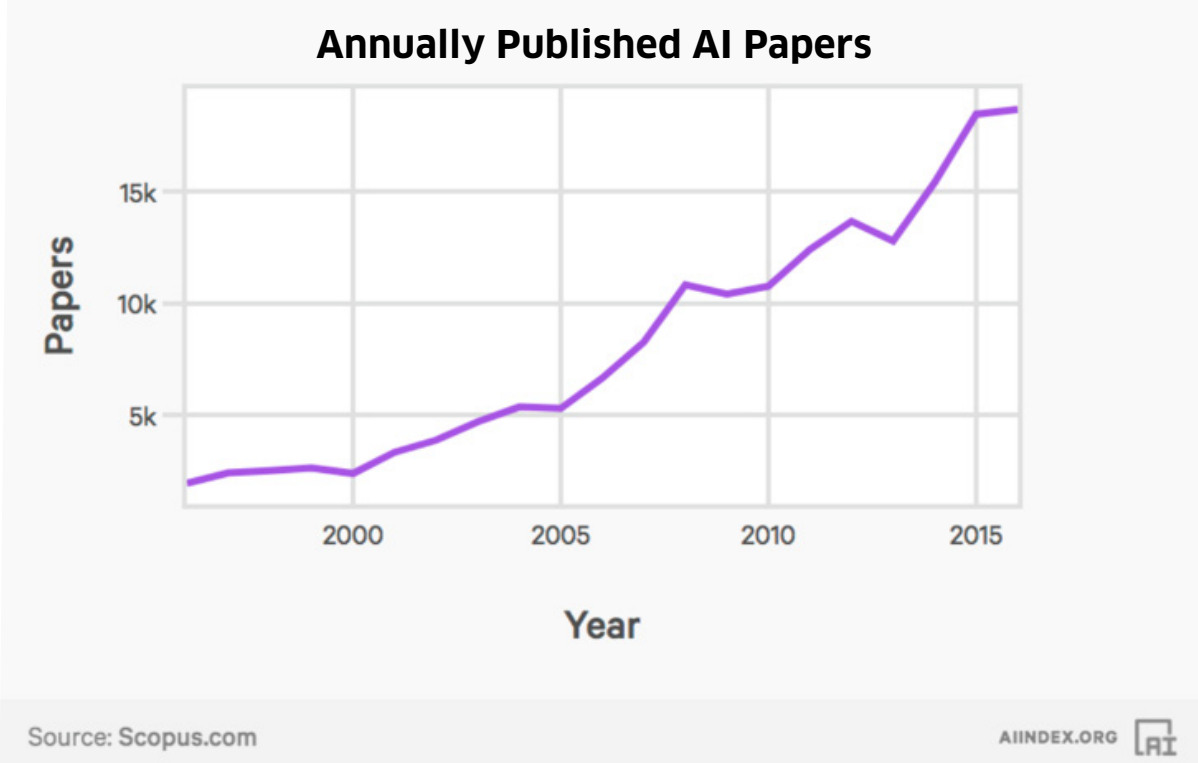
One of the first concepts that come to mind when picturing an example of an artificially intelligent machine is Sophia: a social humanoid robot powered by AI that was developed by Hong Kong-based Hanson Robotics[2]. She is also the first robot in the world to have a nationality after being granted a Saudi Arabian citizenship. Sophia is a human-like robot powered by human-like artificial intelligence—a very intuitive concept.

The reality is, however, that artificially intelligent machines go far beyond humanoid robots; each intelligent robot can take many different forms and can be designed to satisfy a variety of needs. Some examples of AI-enabled robots are disk-shaped robots that vacuum floors, computers that combine eye tracking and speech recognition to replace the keyboard and mouse, unmanned aircrafts, software for analyzing and optimizing designs, and genomics research products.

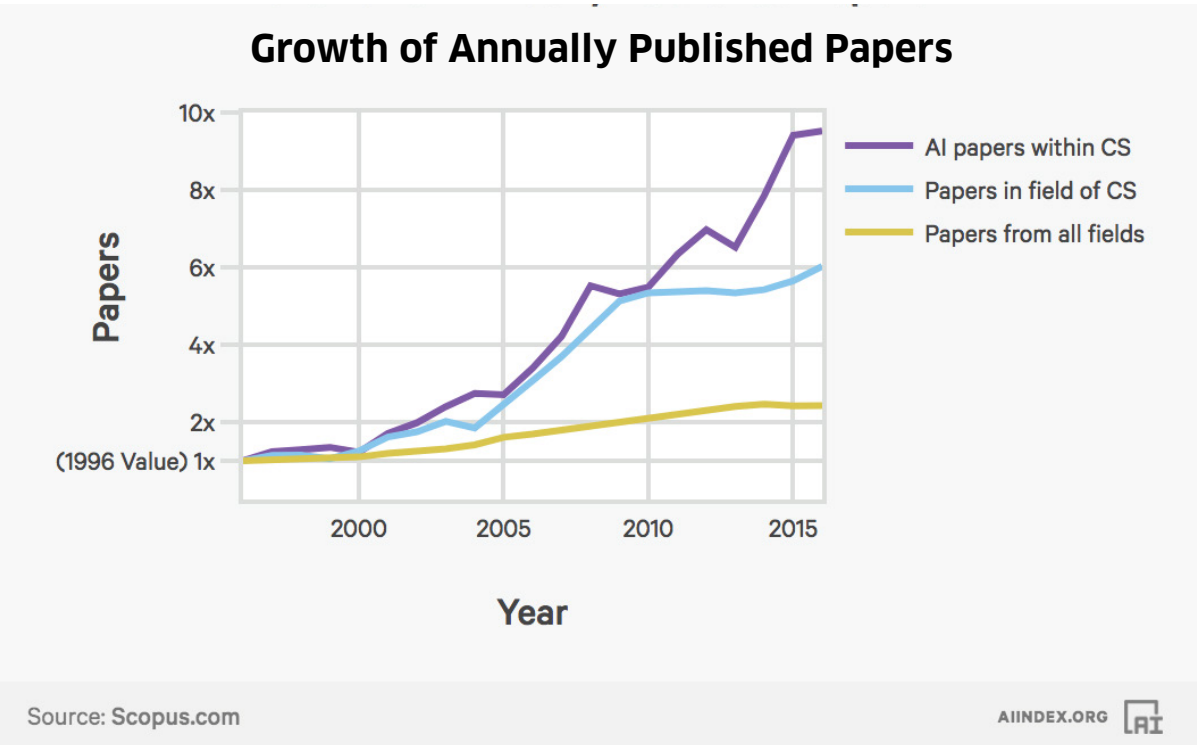
What is Driving the Growth in Artificial Intelligence & Robotics?

AI was formally recognized as an academic field during the Dartmouth conference[3] in 1956 and five years later, the first industrial robot was patented by George Devol[4]. So if AI and robotics have been in development for the past 60 years, one may wonder why it is until now that the field is growing faster than ever before.

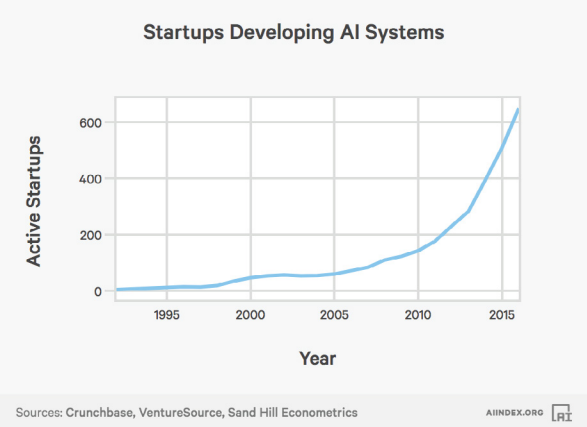
One reason is that AI and robotics, separately, have been exploding. Some of these insights are captured by Stanford University's AI Index report[5], which shows the number of Computer Science research papers that mention "Artificial Intelligence" has grown more than 9 times since 1996.

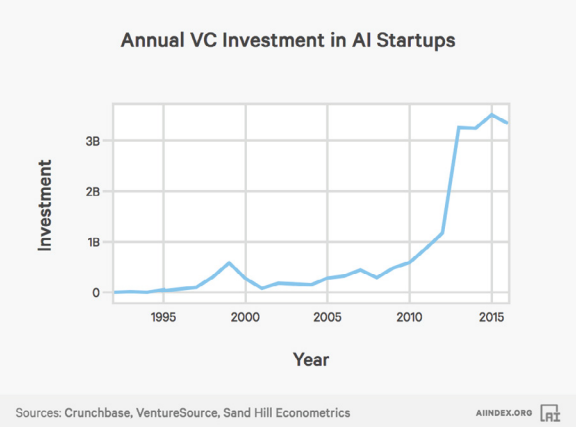


Comparing academic papers from all fields, papers in the field of Computer Science (CS), and AI papers within CS, the Stanford report also found that the annual publishing rate of AI papers within CS has experienced the fastest growth of the three, relative to publishing rates in 1996.

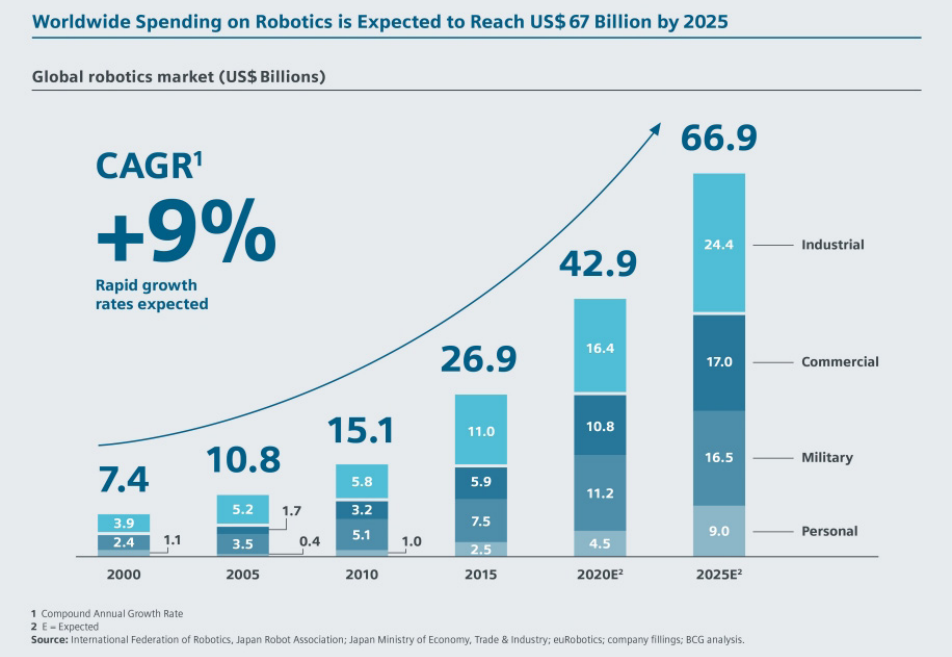


There has also been considerable development and investment in AI, with more startups developing AI systems and more venture capital firms funding them, as shown in the charts below.



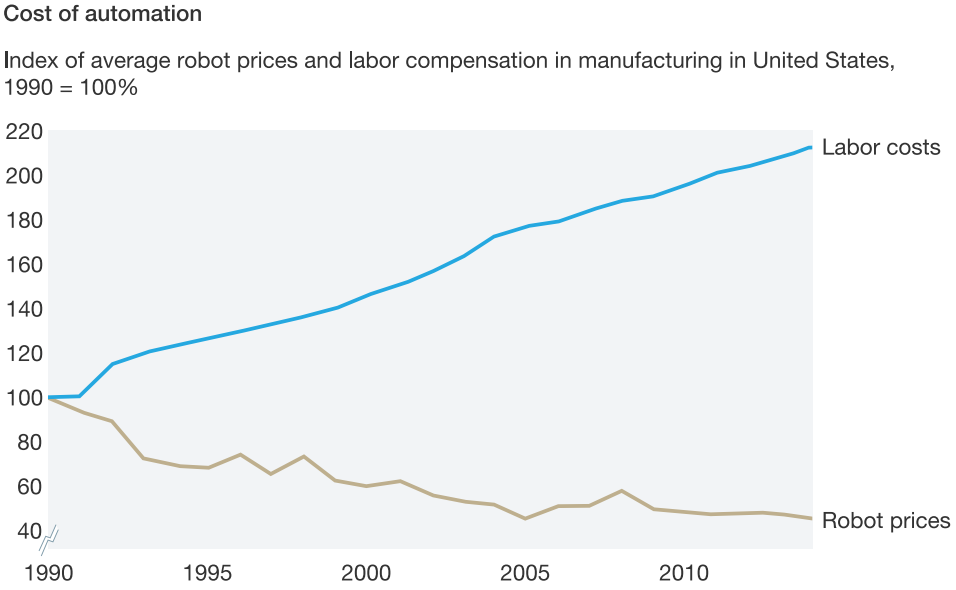


Like the AI field, the robotics industry has also seen fast-paced growth since the year 2000. In fact, according to Siemens (using data from the International Federation of Robotics and others), spending on the global robotics market has grown 2.5 times from 2005 to 2015, and the pace at which the industry is growing is expected to accelerate in future years.[6]



In addition to said growth in the robotics market, there has been a rise in labor costs and drop in robot prices, as one McKinsey & Company analysis showed[7]. These two factors have a direct impact on robot demand: on the one hand, employers are seeking cheaper and more efficient labor given mounting labor costs, particularly in highly-specialized fields where employers have to bid up for top talent; on the other hand, individuals are finding consumer robots more attractive given dropping robot prices.

Robot prices have fallen in comparison with labor costs.



Source: Economist Intelligence Unit; IMB; Institut für Arbeitsmarkt- und Berufsforschung; International Robot Federation; US Social Security data; McKinsey analysis

McKinsey&Company

Some recent technological breakthroughs that are driving growth in the AI and robotics field are the following:

- **Unlimited access:** Cloud computing and public data are growing rapidly, enabling a breakthrough in AI computational capability
- **Big Data:** Artificial intelligence feeds on data to analyze it and make strategic "intelligent" decisions. The International Data Corporation predicts that the amount of data in the world will grow ten times by 2025 to 163 zettabytes from the 16.1ZB of data generated in 2016[8]
- **Next Wave Robotics:** The sophistication of robotics has grown significantly reflected in devices like drones or intelligent surgical devices, for instance
- **Machine Cooperation:** One of the greatest advantages of smart robots is that they are able to communicate vast amounts of information very quickly to other robots, and together they have the potential to learn from a pool of shared experiences
- **Knowledge Sharing:** If one intelligent robot learns something, that lesson can be easily distributed to other robots. This allows smart robots to learn significantly faster than humans

Other factors like adoption, demand and investment are also impacting the field:

- **Demand for Augmented Human Function:** Average productivity changes in the nonfarm business sector fell from 2.6% during the 2000-2007 period to 1.2% from 2007-2017[9], according to the Bureau of Labor Statistics, and smart robots that would help increase productivity measures hold promise
- **Adoption Among Professional Services:** Robo-advisors and surgical robots are some examples
- **Government R&D:** The UK announced £ 68 million pounds (about $94.2 million USD) in funding for AI and robotics research on November 8th 2017[10]; China is building an AI research industrial park for $2.1 billion USD[11]; and the US is already leading in AI research funding

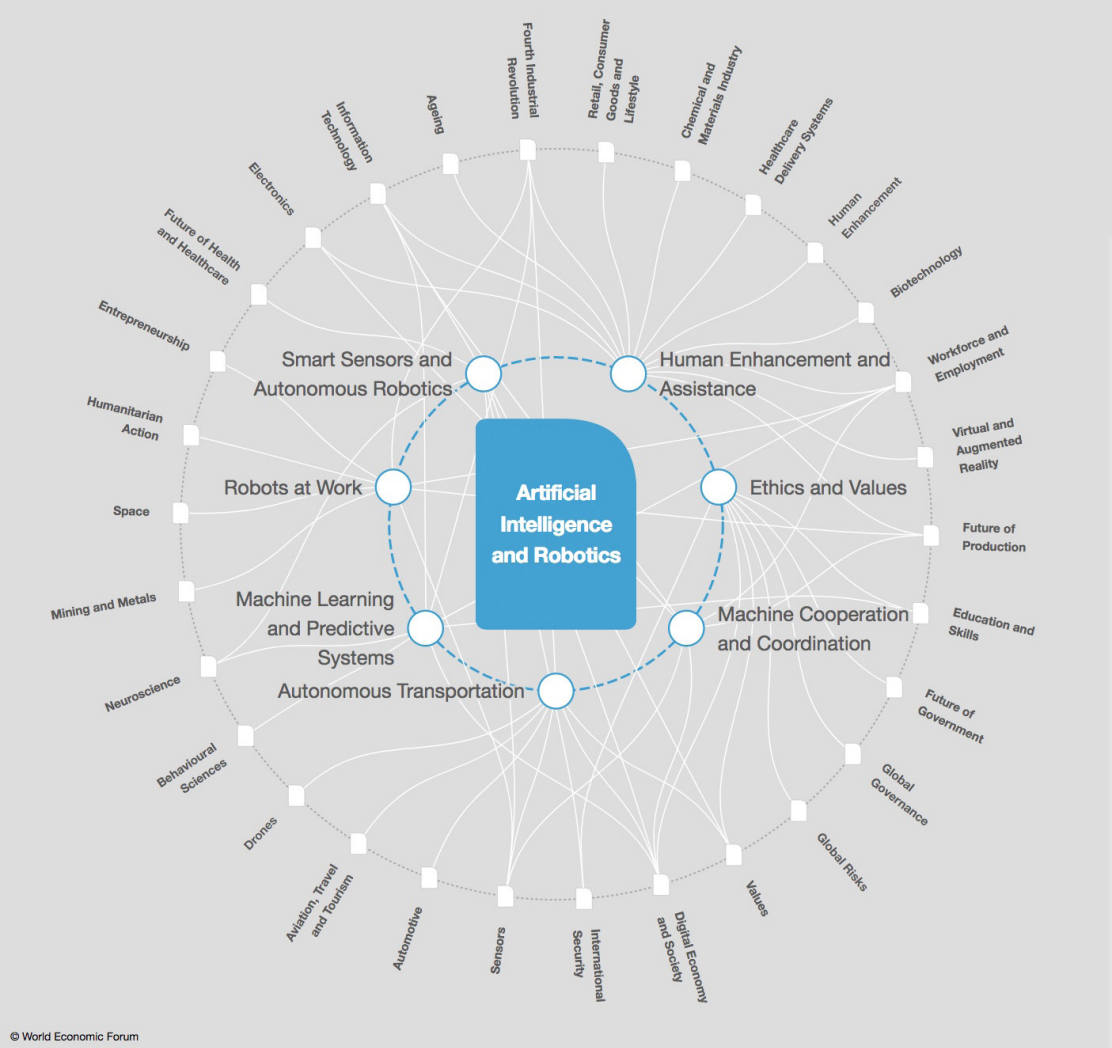
AI and Robotics in the Fourth Industrial Revolution

AI and robotics theory and technology have experienced exceptional growth due to some of the technological advancements in recent history mentioned above. But perhaps more importantly, they have been developed to a point that allows these technologies to be used in fusion, cooperation and harmonization. So the growth in one of these technologies boosts growth in the others because they are interconnected. This multiplier effect is what is driving exponential growth in the AI/robotics field.

From the invention of the steam engine and the birth of the factory during the first industrial revolution to the use of electricity applied to mass production to the digital revolution, the Fourth Industrial Revolution is characterized by a "range of new technologies that are fusing the physical, digital and biological worlds impacting all disciplines, economies and industries, and even challenging ideas about what it means to be human" according to Klaus Schwab, founder of the World Economic Forum (WEF), in his book The Fourth Industrial Revolution.

The Fourth Industrial Revolution is different from the three previous ones for three reasons: velocity, scope and systems impact[12], and intelligent robots are an essential part of this revolution. In fact, Schwab also states that **"robotics, and artificial intelligence generally, are truly at the epicenter of the Fourth Industrial Revolution"**.

An interconnected map by the WEF shows how the AI and robotics field stems from the Fourth Industrial Revolution and impacts numerous concepts and industries across many sectors.[13]



What is the Industry Outlook for Artificial Intelligence & Robotics?

According to BusinessWire, the global smart robot industry is expected to reach $14.3B by 2023, almost tripling from its $4.9B valuation in 2018 by growing at a CAGR of 23.7% over this five-year time period.[14]

The competitive landscape in this field is currently dominated by large international companies who are able to design, produce or enhance robots and/or artificial intelligence at a low cost and are able to generate revenue both from direct and indirect sales. Some of the largest leading companies in the space are Samsung, Apple, Tencent, Alphabet and Facebook. There are smaller companies, however, like business software company Cloudera and unmanned aircraft company AeroVironment, that are breaking into the space by providing highly specialized AI and/or robotics.

Some of the primary markets that AI and robotics companies are targeting are:

- Autonomous Systems
- Software
- Electronic Equipment
- Industrial Machinery
- Medical
- Manufacturing
- Biotechnology
- Defense
- Automotive

How Can People Invest in Artificial Intelligence and Robotics?

Investors can gain access to the global Artificial Intelligence and Robotics space through the First Trust Nasdaq Artificial Intelligence and Robotics ETF (ROBT) that tracks the Nasdaq CTA Artificial Intelligence & Robotics Index (NQROBO).

The Index is constructed such that the underlying securities represent a robust coverage of the space while ensuring investability, adequate liquidity and size.

Eligibility criteria:

- Minimum market cap of $250M
- Minimum 3-Month average daily dollar volume of $3M
- Minimum free float of 20%
- Classified as an Artificial Intelligence or Robotics company as an enabler, engager or enhancer as determined by Consumer Technology Association (CTA):
  1. Enablers are companies that develop the building block components for robotics or artificial intelligence, such as advanced machinery, autonomous systems/self-driving vehicles, semiconductors, databases used for machine learning
  2. Engagers are companies that design, create, integrate, or deliver robotics and/or artificial intelligence in the form of products, software, or systems
  3. Enhancers are companies that provide their own value-added services within the Artificial Intelligence and Robotics ecosystem, but which are not core to their product or service offering

The top 30 securities (or more inclusive of ties) within each of the three categories – Enablers, Engagers and Enhancers - are selected for a total of 90 (or more inclusive of ties) securities in the Index at the time of the semi-annual evaluations utilizing CTA's AI/Robotics Intensity Rating. This rating is designed to capture the perceived degree of a company's AI/Robotics sector involvement within each respective Engager, Enabler and Enhancer category.

The index employs a modified equal weighting methodology where each category receives the following weights:

- Enablers: 25%
- Engagers: 60%
- Enhancers: 15%

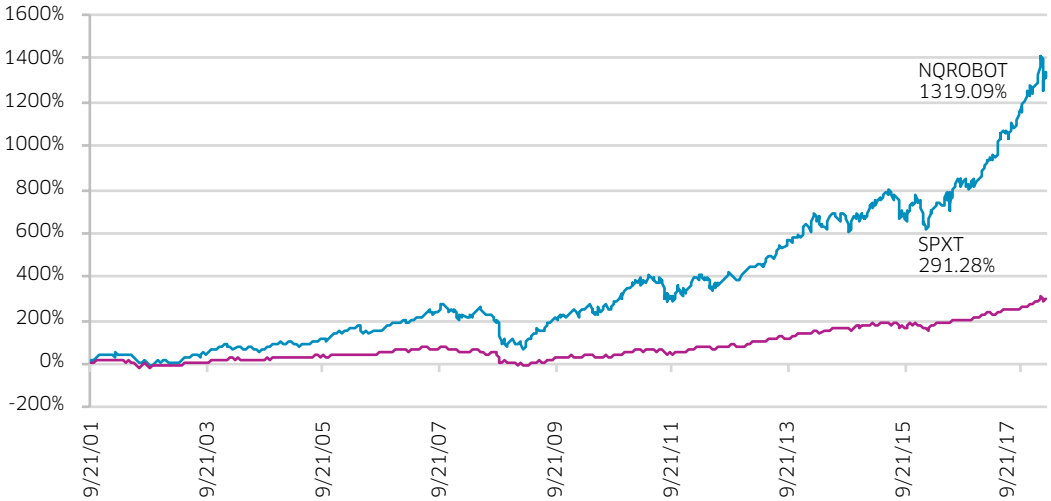
With each category having 30 securities, what that means is that, as of each rebalance, each security classified as an Enabler is assigned a weight of 25%/30 = 0.83%, each Engager is assigned a weight of 2%, and each Enhancer is assigned a weight of 0.5%.

The reasoning behind why a significantly larger weight is assigned to the Engagers category is that AI and robotics products developed, integrated or delivered by companies in this category account for a large portion of the company's revenue. Following a similar logic, companies in the Enablers category receive a significant yet more indirect impact in terms of revenue from AI/robotics products. Last, it is important to capture companies that overlay their own value-added services to devices in the industry, but since these are not the core revenue generating services of the companies in question, the Enhancers category is capped at a lower weight.

The index is evaluated semi-annually in March and September using data through the end of January and July. The results of the semi-annual evaluations go effective after the close of trading the third Friday in March and September. The other two quarters, June and December, have index rebalances, where weights are adjusted to be brought back in-line to the stated weighting methodology of the index (explained further below), but no other review is enacted at those times. Note that these weights are assigned as of the end of February, May, August and November that go effective after the close of trading the third Friday the following month (March, June, September, December).

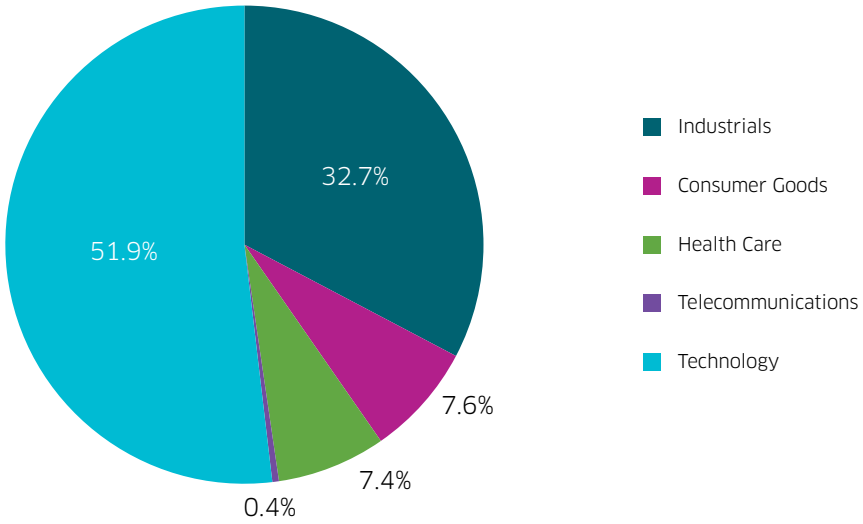
The growth of the companies in the Nasdaq CTA Artificial Intelligence & Robotics Index from a total return standpoint (NQROBOT) is remarkable. Though the live Index officially launched on December 18, 2017, NQROBOT has outperformed the S&P 500 TR Index by more than 1000% since its first day of back-tested history in September 2001 through the end of February 2018.

Index Performance



From an ICB Industry perspective, it's not surprising to see more than half of the companies fall in the Technology industry.

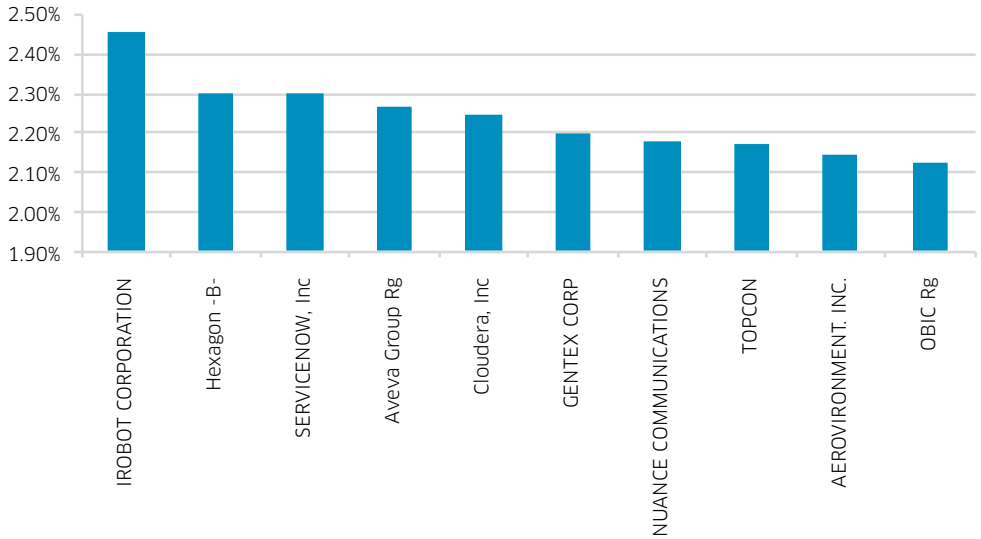
ICB Industry Classification (1/31/2018)



While it's helpful to see the way in which securities are classified within a classification framework such as ICB, it's important to note that the diversification element within this Index is truly driven by the different types of AI and Robotics companies: Engagers, Enablers, and Enhancers. As such, that is why the Index has the cap at 30 securities within each category.

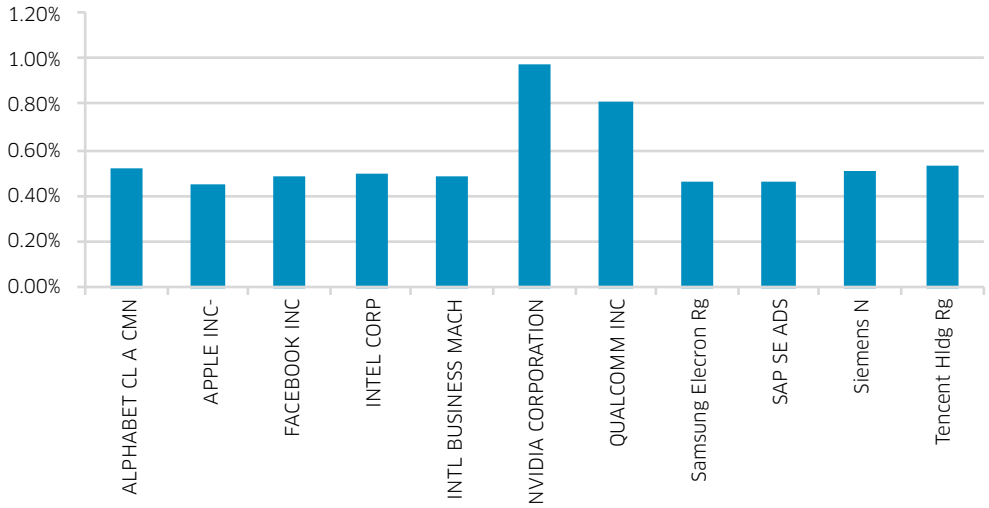
The top ten holdings as of January 31, 2018, are shown here. The average market cap of securities in the top ten is $7.8B.

Top Ten Holdings in NQROBO (1/31/2018)



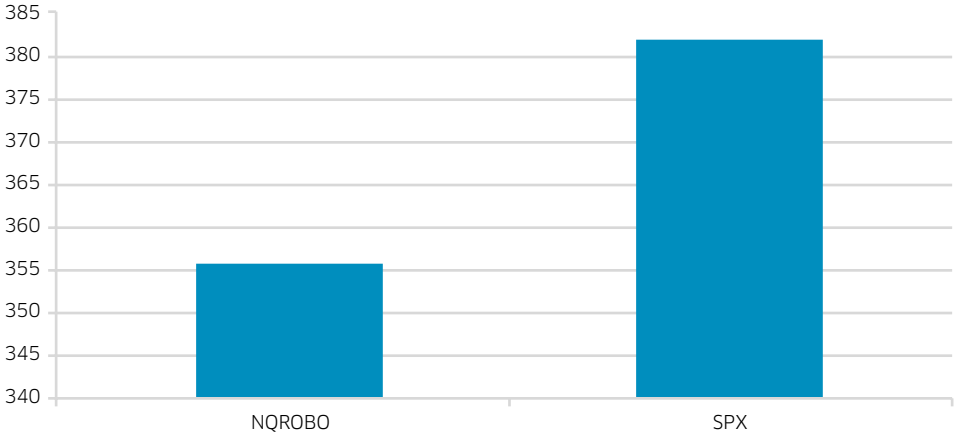
Not included in the top ten but in the Index are eleven mega cap companies whose market cap was over $100B as of January 31, 2018. They are shown in the chart with their respective Index weights. Their lower weights indicate that they were not classified as Engagers but rather as Enhancers or Enablers. This shows that, while the mega cap companies are certainly represented in this Index as Enhancers and Enablers, much larger exposure is given to the types of companies that directly offer products and services related to this space.

Mega Cap Holdings in NQROBO (1/31/2018)

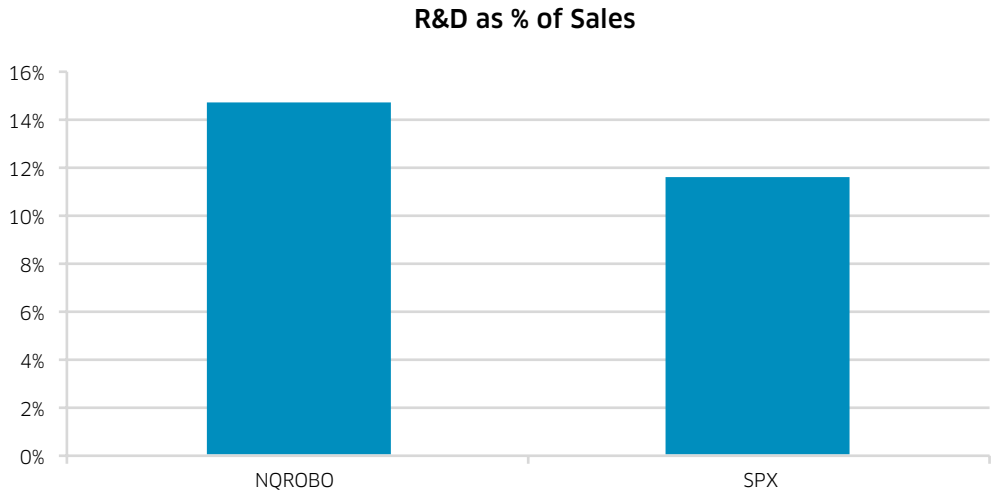


Interestingly, as of January 31, 2018, the average market cap of all companies in the Nasdaq CTA Artificial Intelligence & Robotics Index was higher than the S&P 500 at $55.6B vs $49.6B. However, at a weighted average market cap perspective (index weight of each security times its respective market cap) it follows that the S&P 500 is higher because the Nasdaq CTA Artificial Intelligence & Robotics Index gravitates towards having smaller cap names in the Engager category (weighted average market cap chart shown with data as of January 31, 2018).

Weighted Average Market Cap ($M)



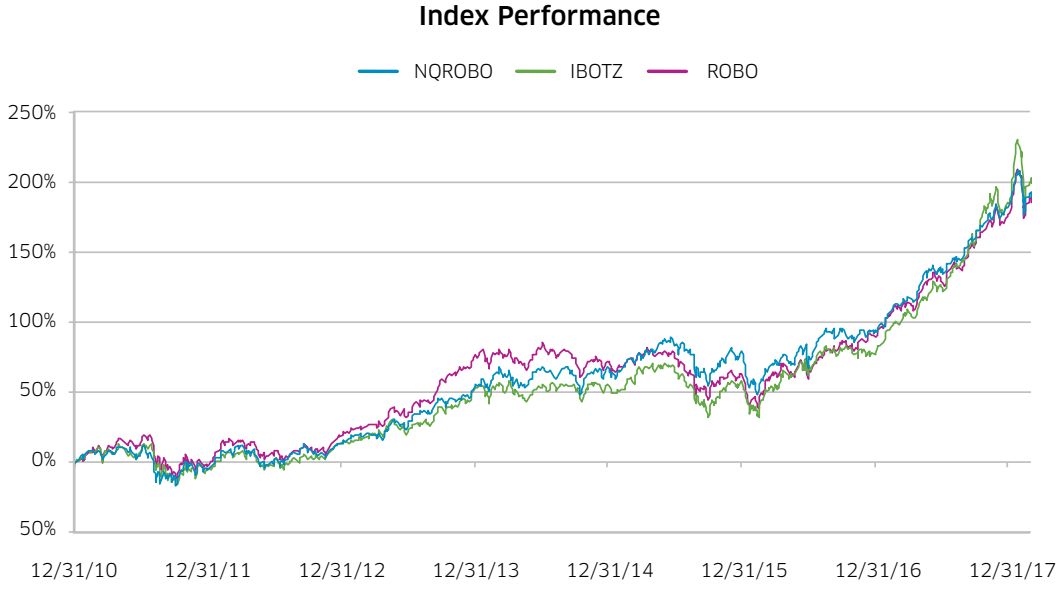
Given the nature of the Artificial Intelligence and Robotics industries, it follows that there is a strong focus on research and development. Taking that in proportion to sales, the Nasdaq CTA Artificial Intelligence & Robotics Index has a higher figure, on average, than the S&P 500.



Comparison to other Artificial Intelligence and Robotics Indexes

The First Trust Nasdaq Artificial Intelligence and Robotics ETF (ROBT), which tracks Nasdaq CTA Artificial Intelligence & Robotics Index (NQROBO), came to market after two predecessors in the space: the Robo Global Robotics & Automation Index ETF (ROBO) launched in October 2013 and the Global X Robotics & Artificial Intelligence ETF (BOTZ) launched almost three years after that in September 2016.

Since year-end 2010 to the end of February 2018, the underlying price return indexes, the Nasdaq CTA Artificial Intelligence & Robotics Index (NQROBO), the ROBO Global® Robotics and Automation Index (ROBO) and the Indxx Global Robotics & Artificial Intelligence Thematic Index (IBOTZ), which do not account for dividends, have performed fairly similarly. (Price return values are shown below since IBOTZ does not have a publically available total return index).



Additionally, annualized volatility figures of the three indexes are summarized below. The table shows that in recent periods, NQROBO's volatility has generally been fairly close to ROBO and lower than IBOTZ.

VOLATILITY AS OF 2/28/2018	NQROBO	IBOTZ	ROBO
YTD	18.34%	20.58%	18.06%
6-Month	12.43%	15.61%	12.83%
1-Year	11.47%	12.82%	11.12%
3-Year	13.93%	14.82%	13.18%
5-Year	13.48%	14.35%	12.51%

Despite similarities in terms of past performance and somewhat similar volatility figures, the underlying baskets of the three indexes vary widely. Since these three indexes were designed to provide a global exposure to the AI, robotics and automation fields, one would assume that in such a niche space, these would track fairly similar baskets. But as one recent Bloomberg Intelligence research piece by Psarofagis and Balchunas compared, out of 142 unique holdings across the ETFs, only 15 exist in all three.[15]

Overlapping Index Companies (1/31/2018)

TICKER	COMPANY NAME
ABBN	ABB RG
AVAV	AEROVIRONMENT, INC.
6383	DAIFUKU RG
6954	FANUC RG
ISRG	INTUITIVE SURG, INC.
IRBT	IROBOT CORPORATION
JBT	JOHN BEAN TECH CORP
6861	KEYENCE CORP RG

TICKER	COMPANY NAME
6503	MITSUBISHI ELECT RG
NVDA	NVIDIA CORPORATION
6645	OMRON CORP RG
6273	SMC CORP RG
TECN	TECAN GRP N
TRMB	TRIMBLE INC.
6506	YASKAWA ELECTRIC RG

The disparity in the underlying baskets stems from the different approaches in their methodologies and weighting schemes.

	NQROBO	ROBO	IBOTZ
NUMBER OF COMPONENTS	**88**	**88**	**29**
Methodology	Selects companies in artificial intelligence and robotics that are classified as either enablers, engagers or enhancers as determined by the Consumer Technology Association (CTA) with the purpose of capturing players at the three stages of involvement in the AI and robotics space	Includes "bellwether" companies (established leading players whose core business is directly related to Robotics and Automation) and "non-bellwether" companies (those players with a distinct portion of their business and revenue in Robotics and Automation and that have the potential to grow through innovation and market adoption of their products and services).	Tracks companies in robotics and AI including those involved with industrial robotics and automation, non-industrial robots, and autonomous vehicles
Weighting	Equal Weight within each category: • Enablers (25%) • Engagers (60%) • Enhancers (15%)	Equal Weight within each category: • Bellwether (40%) • Non-Bellwether	(60%) Market Cap Weighted

Number of Companies only in NQROBO	
Enabler	8
Engager	17
Enhancer	23
Total	48

To show which companies are unique to NQROBO when compared to its peers, out of 48 companies (from a total of 88 index components) that do not appear in the other two indexes, almost half are classified as Enhancers, followed by Engagers and finally Enablers.

The important difference about NQROBO when compared to the other two indexes in AI/Robotics is that its tiered methodology is designed to track the three levels of the AI and robotics industry involvement. While IBOTZ and ROBO include companies that either serve as building blocks or are directly involved in creating products or services, these indexes generally overlook companies that leverage artificial intelligence and robotics to make these products or services more valuable. Examples of these "enhancer" companies in NQROBO that not appear in IBOTZ or ROBT are shown below.

Enhancers:

- **Tesla** Inc. designs, manufactures, and sells high-performance electric vehicles and electric vehicle powertrain components.
- **Facebook**, Inc. is a social networking website that allows people to communicate with friends, family and coworkers.
- **Tencent** Holdings Limited, an investment holding company, provides Internet and mobile value-added services (VAS), online advertising services, and e-commerce transactions services.

In addition to this important difference, the three indexes in the space provide quite distinct country and industry exposures despite the fact that in theory these all provide global exposure to the AI and robotics space.

In the table below, NQROBO assigns the highest weight to companies domiciled in the USA (56%) followed by ROBO (42%), while IBOTZ tilts more heavily towards Japan (50%).

COUNTRY	NQROBO	IBOTZ	ROBO
USA	55.8%	28.7%	41.9%
Japan	14.4%	49.7%	26.6%
United Kingdom	8.6%	4.3%	0.9%
Sweden	4.9%	–	2.1%
Switzerland	4.5%	7.8%	4.5%
Germany	2.7%	0.6%	8.9%
France	2.5%	–	1.9%
Brazil	2.1%	–	

COUNTRY	NQROBO	IBOTZ	ROBO
China	1.8%	–	1.7%
Taiwan	0.9%	–	5.5%
Netherlands	0.8%	–	0.9%
Canada	0.5%	0.8%	1.0%
South Korea	0.5%	5.0%	1.3%
Finland	–	2.1%	0.9%
Israel	–	1.0%	1.8%

When comparing the industry breakdown of the three indexes in question, NQROBO provides the highest exposure to the Technology sector (52%) when compared to IBOTZ (10%) and ROBO (19%). The other big difference is that IBOTZ and ROBO both assign the highest weight to Industrials (77% and 65%, respectively), while NQROBO allocates a lower weight (33%) to this sector.

INDUSTRY	NQROBO	IBOTZ	ROBO
Technology	51.9%	9.9%	18.9%
Industrials	32.7%	76.5%	65.5%
Consumer Goods	7.6%	1.6%	3.9%

INDUSTRY	NQROBO	IBOTZ	ROBO
Health Care	7.4%	12.0%	9.1%
Telecommunications	0.4%	–	–
Oil & Gas	–	–	2.7%

This analysis shows that while NQROBO, IBOTZ and ROBO all perform similarly and share the common themes of global AI, robotics and automation, their underlying components can vary greatly from one index to another. Specifically, the Nasdaq CTA Artificial Intelligence & Robotics Index includes companies in a tiered approach, indicating that this index is poised to provide investors with exposure to companies that are involved in all stages of the artificial intelligence and robotics market.

Conclusion

This analysis illustrates how technological advancements and increasing implementation and demand of artificial intelligence and robotics products, as well as the possibility of merging these fields as shown by the Fourth Industrial Revolution, have caused the AI/Robotics field to grow exponentially. The impact of AI and robotics growth spans various industries from tech and industrials to healthcare and consumer products. The Nasdaq CTA Artificial Intelligence & Robotics Index (NQROBO) offers investors a robust exposure to the global AI and robotics market while ensuring investability, sufficient liquidity and size. As a result, NQROBO's methodology, which includes Enablers, Engagers and Enhancers, captures companies at the three stages of the AI and Robotics field.

Investors looking to get exposure to the artificial intelligence and robotics industries can invest in the product tied to NQROBO, the First Trust Nasdaq Artificial Intelligence and Robotics ETF (ROBT).

Data as of January 31, 2018, unless otherwise stated.

Footnotes:

1. https://blog.robotiq.com/whats-the-difference-between-robotics-and-artificial-intelligence
2. http://www.hansonrobotics.com/robot/sophia/
3. http://www.independent.co.uk/news/obituaries/john-mccarthy-computer-scientist-known-as-the-father-of-ai-6255307.html
4. https://www.theatlantic.com/technology/archive/2011/08/unimate-the-story-of-george-devol-and-the-first-robotic-arm/243716/
5. http://cdn.aiindex.org/2017-report.pdf
6. https://www.siemens.com/innovation/en/home/pictures-of-the-future/digitalization-and-software/autonomous-systems-facts-and-forecasts.html
7. https://www.mckinsey.com/business-functions/operations/our-insights/automation-robotics-and-the-factory-of-the-future
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