

VIEW

Machine Learning: Predictive Software and the Next Wave of Information Technology Innovation

Humans have envisioned a future involving software capable of intelligent behavior since the dawn of the computer age. In fact, the term “artificial intelligence” was first coined in 1955, less than a decade after the first computer was built in 1946. Early computer scientists were profoundly optimistic about the potential for intelligent machines to replicate many tasks undertaken by humans. However, despite remarkable achievements, efforts to encode human thinking into computer logic proved extremely difficult and fell short of expectations in the 20th Century. Even though we remain far from being able to develop machines with full artificial intelligence today, there has been a recent revival of interest in the field. In particular, developments in machine learning, often considered a subset of artificial intelligence, have led to meaningful breakthroughs in the capabilities of software.

Machine learning does not directly seek to replicate human thought processing - it involves the construction of algorithms that can learn from, and make predictions on data, rather than following strictly static program instructions. Machine learning algorithms operate by building a model from a sample of inputs in order to make data-driven predictions or decisions expressed as outputs. Probabilistic methods are used to “train” software as it processes data, until it is able to recognize patterns and reach conclusions that were not programmed in at the outset. Machine learning technology has a broad range of applications including fraud detection, voice and image recognition, virtual agents, search, marketing, medical diagnosis and bioinformatics.

With machine learning at the forefront, artificial intelligence has evolved into a broader term applied to a range of applications involving intelligent computing technologies. For example, Deep Learning, often considered a branch of machine learning, encompasses methods involving artificial neural network software that seeks to emulate the processes of the human brain. Deep Learning works well with complex applications and very large data sets. Robotic learning, another subfield of artificial intelligence, is at the intersection of machine learning and robotics. It involves techniques allowing robots to acquire novel skills or adapt to various environment through learning algorithms. While many people often associate artificial intelligence with

robotics, the technology is relatively slower to develop and can be highly capital intensive. As a result, near term investment opportunities lie predominantly with machine learning applications.

Setting the Stage for The Next Wave of Machine Learning Innovation

Many leaders in the field, including Google CEO Sundar Pichai, believe we may now be at an “exceptionally interesting tipping point,” where a confluence of technological trends is poised to accelerate development in machine learning and artificial intelligence applications. Trends that have set the stage for the next wave of innovation in the space include the following:



Generation of large data sets: It is estimated that there are over 25 billion internet connected devices in the world today, with that number expected to jump to over 50 billion by 2020.¹ Global connectivity has resulted in the generation of unprecedented volumes of data that shows no signs of slowdown. In fact, the amount of data generated, replicated or consumed worldwide every year is anticipated to roughly double every two years between now and 2020.² The “Big Data” phenomenon, still in its early days, goes hand-in hand with machine learning and artificial intelligence as it serves as the basic input for most applications, which typically require access to information about activities, behaviors, preferences, connections and content to be effective.



Increasing computational power at lower costs: Computation processing and storage costs have been declining rapidly while the computation power of processors has been increasing. In fact, computing power available per dollar has increased by a factor of ten roughly every four years in the last 25 years.³ This trend not only makes advanced and powerful machine learning and artificial intelligence applications possible, but also increasingly affordable.

01100 **10110** **11110** **Advanced algorithms and learning systems:** There have been significant improvements in recent years in the design of algorithms and learning systems as well as the architecture and infrastructure that supports them. In particular, deep

¹ Cisco Systems Internet Business Solutions Group (IBSG)

² IDC - 2014 Digital Universe Study

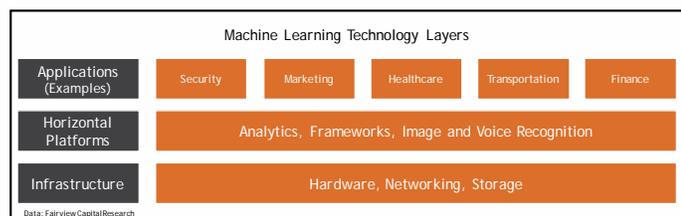
³ Future of Life Institute FLI-RFP-AI1 program

machine learning algorithms have contributed to many recent innovations in software capabilities. For example, Deep Learning architectures called convolution neural networks are so advanced that the software itself can decide which features and characteristics of input data are most important to a given classification problem.



Open sourcing of technology: Large technology companies that have invested heavily in the space, such as IBM, Google, Amazon, Facebook and Microsoft, have all joined a growing movement to make machine learning open source for developers in an effort to improve the quality and agility of their systems. In turn, this has created a stronger community of developers and accelerated innovation and the flow of information in the space.

The machine learning landscape can be thought of existing in three “layers”: infrastructure, horizontal platforms and vertical applications. Much of the advanced infrastructure (such as storage and networks) is in place, though it will certainly continue to evolve and improve. There have been many advancements in the horizontal layer where companies are capable of providing analytics and other services that can usefully process large sets of complex data (including image and voice recognition). This has set the stage for applications, including predictive applications, to be built on top. Applications that leverage machine learning can be deployed in a very wide range of industry verticals, addressing many needs and allowing for transformative new companies to be built.



The Role of Technology Leaders

Large technology companies have helped pave the path forward for machine learning and artificial intelligence applications, and almost without exception, all believe the technology will shape the future of their business. Google has dedicated significant resources to developing machine learning technology, which is at the core of many internal initiatives, including its well-known self-driving car unit. Google has also recently launched TensorFlow, an open source software library for machine learning. IBM’s Watson computer system, which famously beat top *Jeopardy!* contestants in 2011, is being evolved into a broad technology platform that uses machine learning to reveal insights from large amounts of

unstructured data to serve a range of business customers, particularly in the healthcare space. Facebook has established an Applied Machine Learning Group and Mark Zuckerberg has stated publicly on many occasions that the company plans to push the envelope with regards to machine learning and artificial intelligence technology. Amazon, through Amazon Web Services, launched Amazon Machine Learning last year to provide developers access to visualization tools and wizards that guide them through the process of creating machine learning models. Finally, Microsoft recently opened up its Azure Machine Learning platform to developers with the goal of democratizing machine learning.

A critical input for machine learning technology is data. This is one area where incumbent technology firms and other large corporations may currently have an advantage over startups. Access to large and high quality data sets allows for the development of more precise and robust machine learning solutions. One way startups in the machine learning space can overcome shortcomings on this front is by forming data partnerships with the incumbents. Some startups have already built successful businesses by implementing this model. If large and high quality data sets cannot be accessed, startups will have to compete by developing proprietary algorithms or building algorithms that can learn from limited data sets.

While innovation is occurring across the landscape, startups, in many ways, remain uniquely positioned to capitalize on the coming propagation of machine learning and artificial intelligence applications. They can be more inventive, focused, nimble and attract top talent. Large corporations have recognized this fact and in response have been active as investors through corporate venture capital arms, and as acquirers of startups. Startup funding rounds for machine learning and artificial intelligence companies involving corporate venture capital investors saw a 15x increase between 2010 and 2015.⁴ Already, over 30 companies in the artificial intelligence space have been acquired in the past three years by large corporations.⁵ Google has led the way with five acquisitions but IBM, Amazon, Salesforce, Cisco, Microsoft, Facebook, Yahoo, Intel, Dropbox, LinkedIn, Pinterest, and Twitter have all also acquired companies in the space. As vertical-specific machine learning companies mature and the technology becomes more critical to doing business, acquirers are likely to include companies outside of the technology space - such as insurance, finance and healthcare companies.

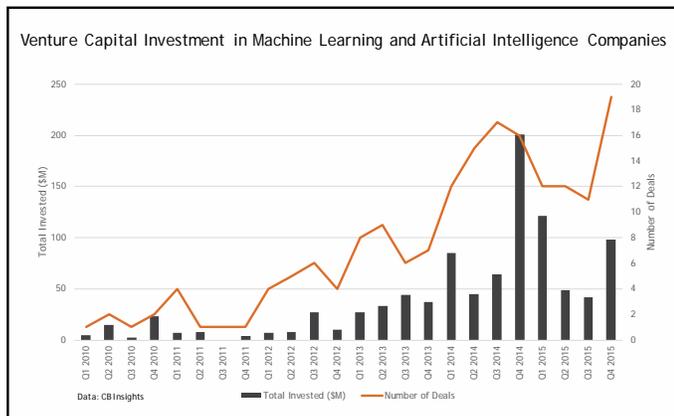
Venture Capital Investment in Artificial Intelligence and Machine Learning

The innovation and level of interest in machine learning and artificial intelligence technology companies has been closely monitored by venture capitalists. The space

⁴ CB Insights - Analyzing the AI Investment Landscape, February 2016

⁵ Fairview Capital Research, CB Insights

represents a natural shift for many venture capital firms and the types of transformative companies serving large addressable markets through viable and attractive business models fits venture investing very well. Close to \$1 billion has already been invested in artificial intelligence related companies by venture capitalists since 2010 and annual funding to companies in the space has increased seven-fold since 2010.⁶ Many venture capital firms have already begun reaping the benefits of investing in the space as over two-thirds of artificial intelligence companies acquired in the past three years have been venture-backed.⁷



Venture firms have taken a range of approaches to investing in machine learning and artificial intelligence companies. Many firms have roots investing in software, IT infrastructure and “big data” companies as well as applications across many industry verticals. While there are certainly differences when it comes to investing in machine learning and artificial intelligence companies, often the skill sets, networks and technical knowledge required translate well. To bolster their capabilities to invest in the space, some firms have hired experts to augment their teams such as data scientists, or have developed advisory boards or networks comprised of leading researchers, academics or operators in the field. Recently, there has also been the formation of new firms with a primary focus on investing in machine learning and artificial intelligence companies.

The opportunity for value creation for venture firms is strong as the technology will be able to address a wide range of large markets with further advancements in the technology almost certain to come at all layers.

Examples of venture-backed machine learning and artificial intelligence companies in the Fairview portfolio include the following:

AYASDI Ayasdi offers a machine intelligence software platform and applications

to organizations looking to analyze high volume or highly dimensional data sets. Organizations and governments have deployed Ayasdi's software across a variety of use cases, including the development of clinical pathways for hospitals, fraud detection, trading strategies, customer segmentation, oil & gas well development, drug development, disease research, information security, anomaly detection and national security applications. The company's software has revealed genetic traits of cancer survivors, discovered six distinct subtypes of Type II Diabetes patients, and even helped the Institute for the Study of War map terrorist behavior. The customer base is exclusively Fortune-1000 type companies, many of which feature sizable seven-figure deals. Ayasdi was founded out of 12 years of research and development at Stanford University. Venture capital investors include FLOODGATE, Khosla Ventures, Institutional Venture Partners, and Kleiner Perkins Caufield & Byers.

Dataminr Dataminr is an information discovery company that leverages proprietary machine learning algorithms to instantly analyze tweets and other publicly available data. The company's technology can identify, classify, and determine the significance of real-time information and deliver relevant signals and contextual analytics as high-value applications. In finance, many hedge funds and investment banks utilize Dataminr to take action on early market moving information. Other large corporations utilize Dataminr for corporate security and crisis management watch centers that warn about emerging threats and crises. The company was founded in 2009 and now has over 150 employees. It is backed by Venrock, Institutional Venture Partners, Fidelity, Wellington and Credit Suisse.

MetaMind MetaMind is a Deep Learning platform designed to predict outcomes for language, vision and database tasks. The company's core technology is neural network software that can reportedly answer everything from specific queries about snippets of text to the sentiment of that text. MetaMind also has developed one of the best image recognition capabilities in the market. The company was launched in 2014 and has raised venture capital funding from Khosla Ventures. In April of 2016, MetaMind was acquired by Salesforce. Salesforce plans to use its technology to “further automate and personalize customer support, marketing automation, and many other business processes.” The acquisition is expected to extend Salesforce's data science capabilities by embedding Deep Learning within the Salesforce platform.

X.ai X.ai's first product, currently in beta testing, uses artificial intelligence to schedule meetings for people. The service features an artificial

⁶ CB Insights - Analyzing the AI Investment Landscape, February 2016

⁷ Fairview Capital Research, FirstMark Capital, CB Insights

intelligence-powered assistant that analyzes not only requests for meetings, but also entire email conversational threads in order to determine a time and location that works for all parties involved. Users simply interact with the assistant via e-mail as they would any other person by including the e-mail address as a carbon copy. There is no need to install an application or download any software. The service will know your schedule and preferences and also automatically deal with the back and forth of scheduling. X.ai was founded in 2014 and has raised venture funding from IA Ventures, FirstMark Capital, SoftBank Capital and Two Sigma Ventures.

Fairview's Investment Activity in Machine Learning and Artificial Intelligence

 Fairview has actively monitored, and participated as an investor in, much of the innovation and value creation that has led to the foundation for the next generation of machine learning and artificial intelligence driven companies. In addition, Fairview's venture capital portfolios have already featured investments in many leading machine learning and artificial intelligence companies at all layers - infrastructure, analytics and applications. Looking ahead, we are particularly optimistic about the wide range of new business opportunities that will be generated by machine learning and artificial intelligence applications. Many industries are poised to be transformed by the technology. Incumbents will be investing in the technology and new entrants will have the opportunity to create significant value.

Fairview believes the best way to invest in machine learning and artificial intelligence companies is through venture capital firms with the expertise, talent and networks to effectively address the opportunity set. We expect our venture portfolios to develop greater exposure to machine learning and artificial intelligence-related companies in the future.

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