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01

STUDY BOOK - 1

ARTIFICIAL INTELLIGENCE ESSENTIAL

FOR CERTIFIED ARTIFICIAL INTELLIGENCE ENGINEER - CAIE™

CAIE™

Certified Artificial Intelligence Engineer

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Packt>

USAII

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Preface

Artificial Intelligence is around since the 1950s, and many attempts have been made in the past to bring in revolutionary changes with multiple tools and technologies for the benefit of the human race. However, it couldn't kick off well due to funding issues, though in 1970, the American computer scientist Marvin Minsky said, "from three to eight years, we will have a machine with the general intelligence of an average human being." Well, even with the basic proof of principle that was available, there was still a long way to go before the end goals of natural language processing, abstract thinking, and self-recognition could be achieved. There was also another problem with the AI projects back then – the DATA. The data creation and storage were less due to inadequate computer systems and machines due to which the process of data mining and analysis was not possible for the best results.

Eventually, in the 1990s and 2000s, a lot was achieved – world chess champion the grandmaster Gary Kasparov was defeated by IBM's Deep Blue, a chess-playing computer system. Similar to Deep Blue, speech recognition programs, *Kismet* – a robot, were developed in the same era.

Everything is changed now, and the struggle AI has gone through has actually become to reality with a lot of awareness created by businesses and experts. Globally, almost everyone is using AI in some form or the other – say your smartphone. However, there is still a lot to achieve, and organizations are bracing up pretty quickly for their AI transformation journey. But, this journey has a problem – **shortage of talent force**. Many organizations globally are facing issues to take the AI projects forward since they do not have the right talent to bring pace to these projects. Professionals with the right AI skills can help the industry grow at a lightning-fast speed. To build in the top AI skills, the pedagogy of AI learning must be better with the latest trends and topics, use cases, and practice projects.

The United States Artificial Intelligence Institute (USAII™) provides the best-in-class certification programs to upskill and reskill the AI talent force in the world. This Study-Book will help you gain the foundational knowledge and concepts of Artificial Intelligence. Every topic in this book is looked for the relevant industry trend and has been matched with the USAII's knowledge framework to give you the best learning possible.

This Study-Book covers the AI essentials under eight modules that include – **Big Data and AI, Artificial Intelligence on the Cloud, Python for Coding, Machine Learning Pipeline, Chatbots, Essential Machine Learning Concepts, Supervised and Unsupervised Learning, Deep Learning Foundations, Tensor Flow, NLP Fundamentals, Computer Vision and the Raspberry Pi, GANs, Reinforcement Learning, Deep Reinforcement Learning.**

Candidates who sign-up with the United States Artificial Intelligence Institute (USAII™) under Certified Artificial Intelligence Engineer (CAIE™) program must know that the contents of this book have been exclusively chosen by our content partner Packt's best-selling database. The content is further carefully vetted and verified by 15 most prominent SMEs of the **USAII's Artificial Intelligence Advisory Board** – these subject matter experts are the influencers of the artificial intelligence domain and are CIOs, CTOs, Data Scientists, technology leaders from Fortune 500 companies. Hence, we are sure that that the content is apt and is future-ready.

Please note, if you are a candidate registered under the CAIE™ program by USAII™, you will be provided with a self-help study kit, which will help you prepare for the CAIE™ certification examination. This study kit includes three books in the eLearning format and can be downloaded from myControlPanel dashboard. Below are the tri-series Study Books:

1. Study Book 1: Artificial Intelligence Essential
2. Study Book 2: Advanced Artificial Intelligence Essential
3. Study Book 3: Artificial Intelligence Essential Reading

The study kit will also include certain other eLearning materials that can be accessed separately as per instructions. These study materials include the latest case studies, workshops, and other important AI events that will help you crack the CAIE™ certification assessment.

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We hope you will find reading this book a great learning experience, and soon, we shall see you adding to the rapidly expanding list of USAII™ certified professionals internationally.

With best wishes,

Research & Authoring Team

United States Artificial Intelligence Institute Editorial Desk

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All About Artificial Intelligence

Module 1: All About Artificial Intelligence

Chapter 1

First Steps in the World of AI

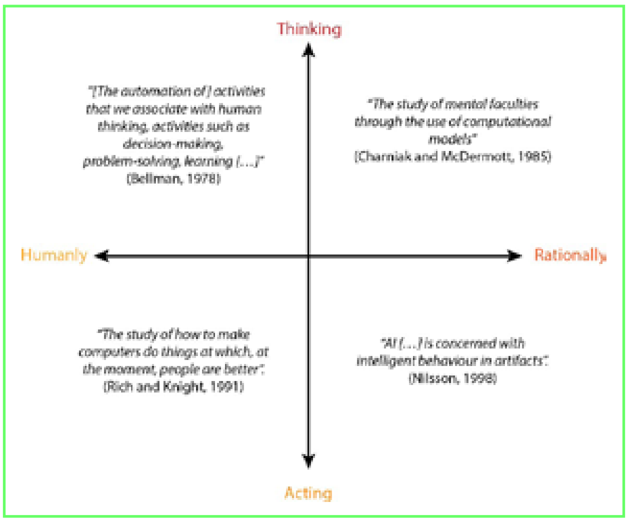
A bit of history

Before venturing on our journey, I believe that having a general overview of the history of AI and AI in games might be beneficial. Of course, you can skip this part if you are a more hands-on type of person who cannot wait to getting down to programming AI.

What is AI?

This is a very interesting question, which doesn't have a unique answer. In fact, different answers lead to different aspects of AI. Let's explore some (of many) definitions that have been given by different scholars (in chronological order).

Actually, Russell and Norvig, in their book, organized these specific definitions into four categories. Here is their schema:



Russell and Norvig's four categories. Top-left: "Systems that think like humans". Top-Right: "Systems that think rationally". Bottom-Left: "Systems that act like humans". Bottom- Right: "Systems that act rationally".

A glance into the past

It might come unexpected to some of you, but the story of AI started well before computers. In fact, even ancient Greeks hypothesized the existence of intelligence machines. A famous example is the bronze giant Talos, who protected the city of Crete from invaders. Another is the golden helpers of Hephaestus, who helped God in his volcano forge along with the Cyclops. In the XVII century, René Descartes wrote about automatons that could think, and believed that animals were do different from machines, which could be replicated with pulleys, pistons, and cams.

However, the core of this story starts in 1931, when the Austrian logician, mathematician, and philosopher Kurt Gödel proved that all the true statements in the first-order logic are derivable. On the other hand, this is not true for higher order logics, in which some true (or false) statements are unprovable. This made first-order logic a good candidate to automate derived logical consequences. Sounds complicated? Well, you can imagine how that sounded to the ears of his traditionalist contemporaries.

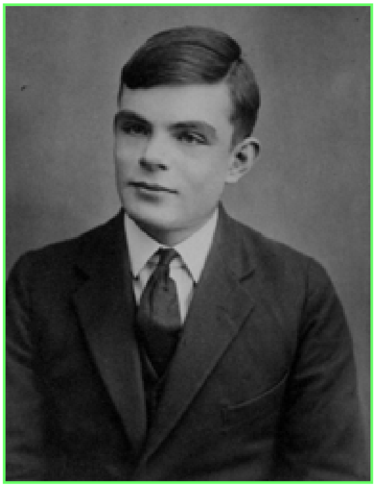


Photo of Alan Turing at the age of 16

In 1937, Alan Turing, an English computer scientist, mathematician, logician, cryptanalyst, philosopher, and theoretical biologist, pointed out some of the limits of "*intelligent machines*" with the halting problem: it is not possible to predict a-priori if a program will terminate unless it is actually run. This has many consequences in theoretical computer science.

However, the fundamental step happened thirteen years later, in 1950, when Alan Turing wrote his famous paper "*Computing Machinery and Intelligence*", in which he talked about the imitation game, nowadays mostly known as "*The Turing Test*": a way to define what an intelligent machine is.

In the 1940s, some attempts were made to emulate biological systems: McCulloch and Pitts developed a mathematical model for a neuron in 1943, and Marvin Minsky created a machine that was able to emulate 40 neurons with 3,000 vacuum tubes in 1951. However, they fell into the dark.

From the late 1950s through to the early 1980s, a great portion of AI research was devoted to "*Symbolic systems*". These are based on two components: a knowledge base made out of symbols and a reasoning algorithm, which uses logical inference to manipulate those symbols, in order to expand the knowledge base itself.

During this period, many brilliant minds made significant progresses. A name worth quoting is McCarthy, who organized a conference in Dartmouth College in 1956, where the term "*Artificial Intelligence*" was first coined. Two years later, he invented the high-level programming language *LISP*, in which the first programs that were able to modify themselves were written. Other remarkable results include Gelernter's *Geometry Theorem Prover* in 1959, the *General Problem Solver* (GPS) by Newell and Simon in 1961, and the famous chat-bot *Eliza* by Weizenbaum, which was the first software that, in 1966, could have a conversation in natural language. Finally, the apotheosis of symbolic systems happened in 1972 with the invention of *PROLOG* by the French scientist Alain Colmerauer.

Symbolic systems led to many AI techniques, which are still used in games, such as blackboard architectures, pathfinding, decision trees, state machines, and steering algorithms.

The trade-off of these systems is between knowledge and search. The more knowledge you have, the less you need to search, and the faster you can search, the less knowledge you will need. This has even been proven mathematically by Wolpert and Macready in 1997.

At the beginning of the 1990s, symbolic systems became inadequate, because they proved hard to scale to larger problems. Also, some philosophical arguments arose against them, maintaining that symbolic systems are an incompatible model for organic intelligence. As a result, old and new technologies have been developed that were inspired by biology. The old Neural Networks were dusted off from the shelf, with the success of Nettalk in 1986, a program that was able to learn how to read aloud, and with the publication of the book "*Parallel distributed processing*" by Rumelhart and McClelland in the same year. In fact, "*back- propagation*" algorithms were rediscovered, since they allow a Neural Network (NN) to actually learn.

In the last 30 years of AI, research took new directions. From the work of Pearl on "*Probabilistic reasoning in intelligent systems*", probability has been adopted as one of the principal tools to handle uncertainty. As a result, AI started to use many statistical techniques, such as Bayesian-nets, Support Vector Machines (SVMs), Gaussian processes, and the Markov Hidden Model, which is used widely to represent the temporal evolution of the states of a system. Also, the introduction of large databases unlocked many possibilities in AI, and a new whole branch named "*Deep Learning*" arose.

However, it's important to keep in mind that, even if AI researchers discover new and more advance techniques, the old are not to be discarded. In fact, we will see how, depending on the problem and its size, a specific algorithm can shine.

Chapter 2

AI in Banking

What is AI?

AI, also known as machine intelligence, is all about creating machines that demonstrate the intelligence that is usually displayed by humans in the form of natural intelligence. John McCarthy coined the term *artificial intelligence* in 1955.

AI has witnessed two winters so far: once in the 1970s with the reduction of funding by the Defense Advanced Research Projects Agency or DARPA (`https://www.darpa.mil/`), then known as ARPA, and another time with the abandonment of an expert system by major IT corporates such as Texas Instruments (`http://www.ti.com/`) and Xerox (`https:// www.xerox.com/`).

In a way, AI aids in the process of transferring decision making from humans to machines, based on predefined rules. In the field of computer science, AI is also defined as the study of intelligent agents. An intelligent agent is any device that learns from the environment and makes decisions based on what it has learned to maximize the probability of achieving its predefined goals.

AI is capable of solving an extremely broad range of problems. These problems include, but are not limited to, simple mathematical puzzles, finding the best route from one location to another, understanding human language, and processing huge amounts of research data to produce meaningful reports. The following is a list of capabilities that the system must have in order to solve these problems along with a brief description of what each means:

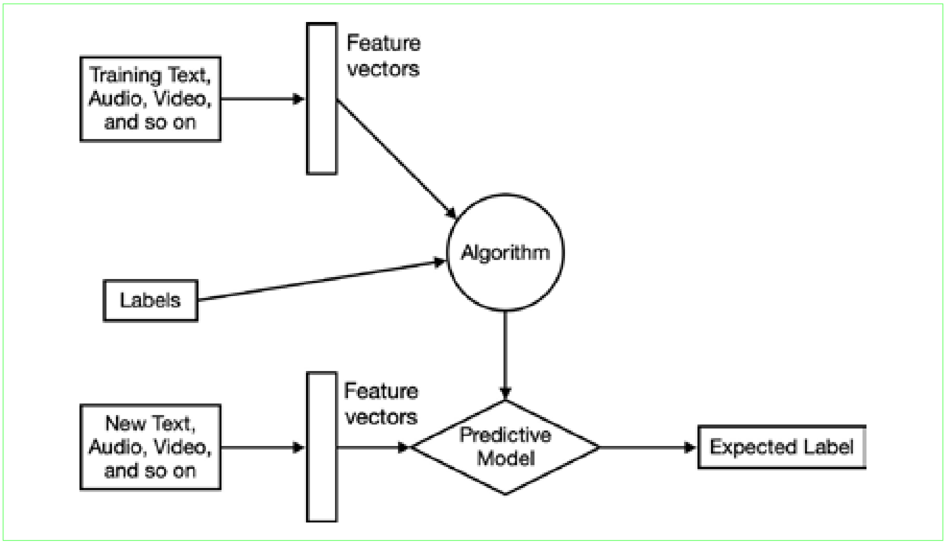
- **Reasoning**: The ability to solve puzzles and make logic-based deductions **Knowledge representation**: The ability to process knowledge collected by researchers and experts
- **Planning**: The ability to set goals and define ways to successfully achieve them
- **Learning**: The ability to improve algorithms by experience
- **Natural Language Processing** (**NLP**): The ability to understand human language

- **Perception**: The ability to use sensors and devices, such as cameras, microphones, and more, in order to acquire enough input to understand and interpret different features of the environment
- **Motion**: The ability to move around

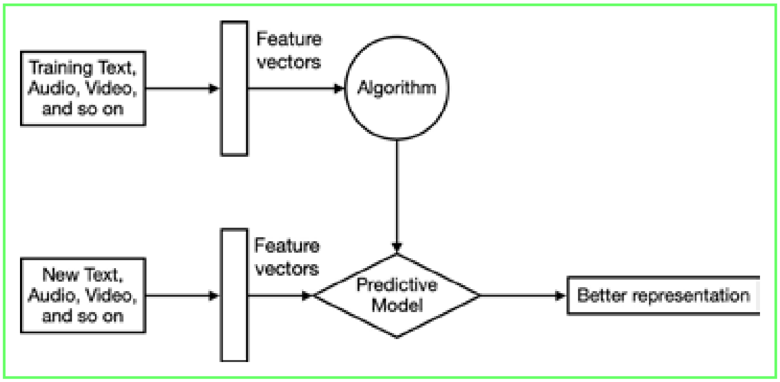
How does a machine learn?

Let's take a quick look at the basics of machine learning. There are three methods that a machine can use in order to learn: supervised learning, unsupervised learning, and reinforcement learning, as described in the following list:

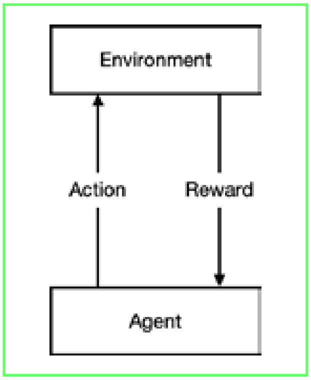
- **Supervised learning** is based on the concept of mining labeled training data. The training data is represented as a pair consisting of the supplied input (also known as a feature vector—this is a vector of numbers that can represent the inputted data numerically as features) and the expected output data (also known as labels). Each pair is tagged with a label. The following diagram illustrates the supervised learning method:



- **Unsupervised learning** is based on a situation where the training data is provided without any underlying information about the data, which means the training data is not labeled. The unsupervised learning algorithm will try to find the hidden meaning for this training data. The following diagram illustrates the unsupervised learning method:



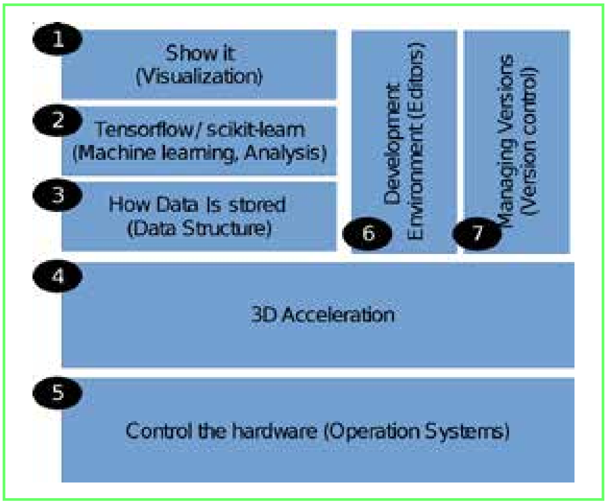
- **Reinforcement learning** is a machine learning technique that does not have training data. This method is based on two things—an agent and a reward for that agent. The agent is expected to draw on its experience in order to get a reward. The following diagram depicts the reinforcement learning method:



Software requirements for the implementation of AI

The open source movement (which will be discussed in the *Importance of accessible banking* section) propels software development. The movement is coupled with the improvement of hardware (for example, GPU, CPU, storage, and network hardware). It is also supported by countless heroes who work on improving hardware performance and internet connectivity. These technicians have developed the AI algorithm to the point where it delivers near-human performance.

The following diagram depicts the typical technology stack that we should consider whenever we implement software to perform machine learning projects:



The following table breaks down several key technologies that contribute to the different software components mentioned in the preceding diagram:

Serial no.	Components	Software/ package name	Software/package description
1	User interface/ application programming interface	API/Python	API: An application programming interface is a type of interface that allows a program to interact with another program using the internet protocol. In comparison to the UI, the API is meant for a robot. It will be used to pull data from data sources throughout the coding chapters of this book.
2	Machine learning and analysis	TensorFlow, scikit-learn, and ImageNet	Google's TensorFlow (`https://www.tensorflow.org/`) has been one of the most popular frameworks for deep learning since 2017. Scikit-learn (`https://scikit-learn.org/stable/`) is a handy machine learning package that delivers lots of useful functionalities in machine learning pipelines. TensorFlow and Keras (`https://keras.io/`) will be used when we work on deep neural networks, while we will use scikit-learn in less complex networks and data preparation works. ImageNet (`http://www.image-net.org/`) was created by Princeton University in 2009 to aid researchers in testing and building a deep learning model based on a dataset, which led to flourishing research on image recognition using deep learning networks.

Serial no.	Components	Software/ package name	Software/package description
3	Data structure	Pandas and NumPy	Pandas (`https://pandas.pydata.org/`) and NumPy (`http://www.numpy.org/`) are data structures that allow Python to manipulate data. These libraries are one of the key reasons for Python's popularity among data scientists.
4	3D acceleration	Nvidia	The computation performance of Keras-related coding, will be enhanced if 3D acceleration (such as the software and hardware provided by Nvidia (`https://www.nvidia.com/en-us/`)) is used in the backend by TensorFlow. The driver will help to improve certain elements of GPU performance.
5	Operation systems	Ubuntu	This is a free, open source operating system that is compatible with most of the Python libraries. It is arguably the operating system of choice for the AI community.
6	Programming languages and development environment	Python and IDLE	Python programming is the language of AI. Python's existence is due to funding by DARPA in 1999, which was granted in order to provide a common programming language in a plain, readable style. It is open source. IDLE is a development environment that lies within the Python package. It allows programs to be written, debugged, and run. However, there are many more environments available for developers to code in, such as Jupyter Notebook, Spyder, and more. We will use Python and the **Integrated Development and Learning Environment** (**IDLE**) for easier code development (you can find them at `https://docs.python.org/3/library/idle.html`).
7	Version control	GitHub	GitHub is one of the most popular cloud-based collaboration sites. It was made possible because of the proliferation of cloud technologies, which enable scalable computing and storage. This is where our code base will be housed and exchanged.

Deep learning is a special subfield or branch of machine learning. The deep learning methodology is inspired by a computer system that is modeled on the human brain, known as a neural network.

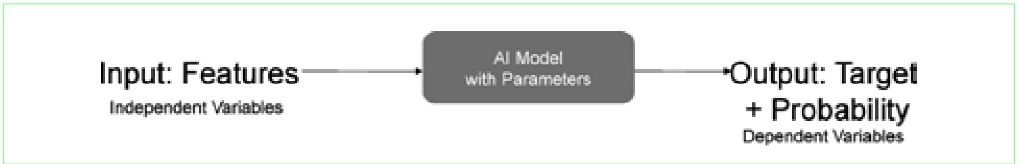
Online customer support by banks via a mobile or web application chatbot is an excellent example of deep learning in banking. Such applications (that is, chatbots) are powerful when it comes to understanding the context of customer requests, preferences, and interests. The chatbot is connected to backend applications that interact with data stores. Based on the customer's inputs or selection of services, the chatbot presents to the customer various alternative sub-services to choose from.

The chatbot or deep learning applications work in layers. It can be compared to learning a language. For instance, once a person masters the alphabet by rigorously learning how to identify each letter uniquely, they will be eligible to move on to the next layer of complexity—words. The person will start learning small words and then long words. Upon mastering words, the person will start forming sentences, understanding grammatical concepts at different layers of complexity. Once they reach the top of this hierarchy of layers of complexity, the person will be able to master the language.

You might have noticed that in each phase or layer of the hierarchy, the learning becomes more complex. Each layer is built based on the learning or knowledge gathered from the previous layer of complexity. This is how deep learning works. The program keeps on learning, forming more knowledge with new layers of complexity based on the knowledge received from the previous layer. The layered complexity is where the word *deep* was taken from. Deep learning is a type of unsupervised learning, so it is much faster than supervised learning.

The major impact of deep learning is that the performance of the model is better as it can accommodate more complex reasoning. We want financial decisions to be made accurately. This means that it will be more cost-effective to give the shareholders of banks a reasonable return while balancing the interests of the bank's clients.

What we expect from a smart machine is as simple as input, process, and output, as shown in the following diagram:



In most financial use cases, we deploy supervised learning, which resembles the process of training an animal—here, you provide a reward for a correct outcome and discourage an incorrect outcome. That's why we need to have the outcome (that is, the target variable) for training to happen.

Hardware requirements for the implementation of AI

While setting the budget for the hardware required by a bank, you need to ensure that it encapsulates the right configurations. This will allow you to deliver the promised results in terms of financial results or time to market, especially now that you are about to start a bank from scratch!

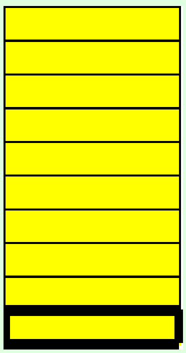
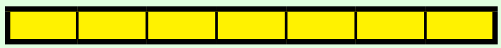
You'd better be sure that every penny works, given that the economic pressures on banks are pretty high. In order to do any of this, we need to understand the contribution that hardware makes to AI in order to ensure we have the right resources.

Graphics processing units

Besides the software and algorithms, the use of a Graphics Processing Unit (GPU) and Solid-State Drive (SSD) helps to speed up machine learning. The use of GPUs and SSDs makes it possible for a computer to think intelligently.

A GPU is a specially designed circuit that can process calculations in a parallel manner. This applies to computer graphic processing, where each of the pixels needs to be processed simultaneously in order to produce a full picture. To visualize this, suppose that there are 10 pixels to be processed. We can either process each of the 10 pixels one by one, or we can process them in 10 processes simultaneously.

The CPU has the unique strength of having a fast processing time per pixel, while the GPU has the strength of multiple threads to handle flat data all at once. Both CPUs and GPUs can do parallel data processing with varying degrees. The following table shows the difference between sequential and parallel data processing:

Sequential data processing	**Parallel data processing**
	
Data comes in sequences, which requires a longer time to complete the computation.	Data comes in parallel, which improves the processing time.

Aside from being great at processing images, a GPU is also leveraged for deep learning. Although deep learning describes the number of layers the neural network has, deep neural networks are often characterized as having a wide record and lots of variables to describe the input.

When used in combination with a GPU, the SSD also improves the speed to read and write data to the CPU/GPU for processing.

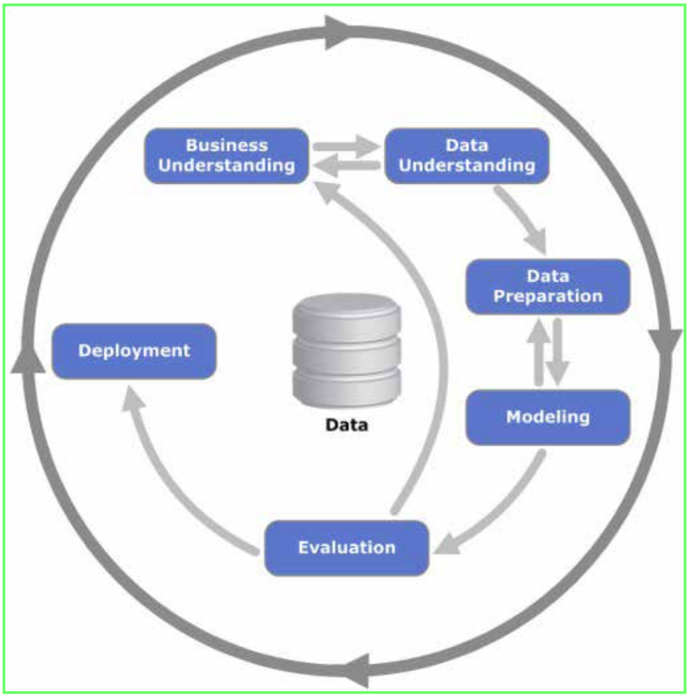
Solid-state drives

Another hardware requirement for machine learning is a storage device called an SSD. The traditional hard disk has a mechanical motor to place the head that reads or writes data at a designated location on the magnetic tape or disk. In contrast to this, the SSD reads and writes data using an electric current on a circuit without the movement of a motor. Comparing the mechanical movement of motors with the electric current onboard, an SSD has a data retrieval speed that is 20 times faster.

For students in operation research, comparing the two is as simple as identifying the hardware capacity, which is akin to how we design a factory—find the capacity and reduce the bottlenecks as much as possible!

Modeling approach—CRISP-DM

CRISP-DM refers to a **cross-industry standard process for data mining**. Data mining is the process of exploring large amounts of data to identify any patterns to be applied to the next set of data to generate the desired output. To create the models, we will use the CRISP-DM modeling approach. This will help us to maintain a uniform method of implementing machine learning projects. The following diagram depicts the project execution using the CRISP-DM approach in a machine learning project:



As you can see in the preceding diagram, there are various phases of the CRISP-DM approach. We can explain them in detail, as follows:

1. **Business Understanding**: This phase involves defining the business objectives for the project. During this phase, you clarify the queries related to the core business objectives. For example, a core business objective may be to predict when the customers leave a particular website using the historical data of the customer's interaction with the website. The relevant query to clarify might be whether the payment interface currently in place is the reason for customers navigating off the website. Business success criteria are also laid out during this phase of the project execution.
2. **Data Understanding**: This phase involves understanding historical data that is mined in the database or data store. The data is analyzed for its size, format, quantity, number of records, significance in relation to business, fields, source of data, and more.
3. **Data Preparation**: This phase involves raising the quality of the data to the level required for the machine learning algorithms to process it. Examples of data preparation include formatting data in the desired format, rounding the numbers to an acceptable degree of precision, and preparing derived attributes.
4. **Modeling**: This phase involves selecting a modeling technique or algorithm to be applied. A modeling algorithm is used to find a function that, when applied to an input, produces the desired output.
5. **Evaluation**: This phase involves assessing the accuracy of the training model that was built in the previous phase. Any required revisions to the model are made in order to increase efficiency and accuracy.
6. **Deployment**: This phase involves defining a deployment strategy for the training model in the live environment to work on new data. The models are monitored for accuracy.

Where can learning AI take you?

I'd like to motivate you by showing you that you made the right choice to learn AI. To do this, I'll take you on a tour of all the incredible applications AI can and will have in the 21st century. I have a vision of how AI can transform the world, and this vision is structured around 10 areas.

Energy

In 2016, Google used AI to reduce energy consumption in its data centers by more than 30%. If Google has done it for data centers, it could be done for an entire city. By building a smart AI platform using Internet of Things (IoT) technology, the consumption and distribution of energy can be optimized on a large scale.

Healthcare

AI has enormous promise for healthcare. It can already diagnose diseases, make prescriptions, and design new drug formulas. Combining all these skills into a smart healthcare platform will allow people to benefit from truly personalized medical care. This would be amazing for society. The challenges in achieving this are not only present in the technology, but also in getting access to anonymous patient data, which so far is protected by regulations.

Transport and logistics

Self-driving vehicles are becoming a reality. There is still a lot to achieve, but the technology is constantly improving. By building smart digital infrastructures, AI will help reduce the number of accidents and considerably reduce traffic. Also, self-driving delivery trucks and drones will speed up logistic processes, therefore boosting the economy; mostly through one of its bigger engines, the e-commerce industry.

Education

Today, we live in the era of Massive Open Online Courses. Anyone can learn anything online. This is great because the whole world can get access to an education; but it's definitely not enough. A significant improvement would be the personalization of education; everyone learns differently, and at different paces. Some, namely extroverts, will prefer the classroom, while others, introverts, will learn better at home. Some are more visual, while others are more auditory. Taking these and other factors into account, AI is a powerful technology that could deliver personalized training, optimizing everyone's learning curve.

Security

Computer vision has made tremendous technological progress. AI can now detect faces with a high level of accuracy. Not only that, the number of security cameras is increasing significantly. All this could be integrated into a global security platform to reduce crime, increase public safety, and disincentivize people from breaking the law. Besides this, AI and Machine Learning are powerful technologies already used in fraud detection and prevention.

Employment

AI can build powerful recommender systems. We already see platforms of digital recruitment, where AI matches the best candidates to jobs. This not only has a positive impact on the economy, but also on people's happiness, since work makes up more than half of a person's life.

Smart homes and robots

Smart homes, IoT, and connected objects are developing massively. Robots will assist people in their homes, allowing humans to focus on more important activities like their work or spending quality time with their family. They will also help elderly people to live in their home independently, or even allow them to stay active at work, for much longer.

Entertainment and happiness

One downside of technology today is that despite the fact people are so virtually connected, they feel more and more lonely. Loneliness is something we must fight against in this century, as it is very unhealthy for people. AI has a great role to play in this fight, since it is again a powerful recommender system, which can not only recommend relevant movies and songs to users, but also connect people through recommended activities based on their past experiences and common interests.

Through a global smart platform of entertainment, AI technology could help like-minded people to socialize and meet physically instead of virtually.

Another idea to fight loneliness is companion robots, which will be entering homes more and more over the next decade. One branch of AI in the Research and Development phase is emotion creation. This is the branch of AI that will allow robots to show emotions and empathy, and therefore interact more successfully with humans.

Environment

Using computer vision, machines could optimize waste sorting and redistribute the cycles of trash more efficiently. Combining pure AI models with IoT can optimize power and water consumption by individuals. Programs already exist on some platforms that allow people to track their consumption in real time, therefore collecting data. Integrating AI could minimize this consumption, or optimize the distribution cycles for beneficial reuse. Combined with traffic reduction and the development of autonomous vehicles, this will considerably reduce pollution, which will create a healthier environment.

Economy, business, and finance

AI is taking the business world by storm. Earlier, I mentioned the study done by PwC showing how AI could contribute up to $15 trillion to the global economy in 2030 (`https://www.pwc.com/gx/en/issues/data-and-analytics/publications/artificial-intelligence-study.html`). But how can AI generate so much income? AI can bring significant added value to businesses in three different ways: process automation, profit optimization, and innovation. In my vision of an AI-driven economy, I see the majority of companies adopting at least one AI technology, or having an AI department. In finance, we can already see some jobs being replaced by robots. For example, the number of financial traders was significantly reduced after the development of trading robots that perform well on high-frequency trades.

As you can see, the robot world has a lot of great directions for you to take. AI is already in a dynamic place and it's picking up strong momentum as it moves forward. My professional purpose is to democratize AI and incentivize people to make a positive impact in this world thanks to AI—who knows, perhaps your purpose will be to work with AI for the good of humanity. I'm sure that at least one of these 10 applications resonates in you; if that's the case, work hard to become an AI master and you will have the chance to make a difference.

Chapter 3 Use Cases for Artificial Intelligence

In this chapter, we are going to discuss some of the use cases for Artificial Intelligence (AI). This by no means is an exhaustive list. Many industries have been impacted by AI, and the list of those industries not yet impacted gets shorter every day. Ironically, some of the jobs that robots, automation, and AI will not be able to take over are jobs with a low pay rate that require less "brain" power. For example, it will be a while until we are able to replace hair stylists and plumbers. Both of these jobs require a lot of finesse and detail that robots have yet to master. I know it will be a long time before my wife trusts her hair to anyone else other than her current hair stylist, let alone a robot.

Representative AI use cases

From finance to medicine, it is difficult to find an industry that is not being disrupted by Artificial Intelligence. We will focus on real-world examples of the most popular applications of AI in our everyday life. We will explore the current state of the art as well as what is coming soon. Most importantly, maybe this book will spark your imagination and you will come up with some new and innovative ideas that will positively impact society and we can add it to the next edition of our book.

Artificial Intelligence, cognitive computing, machine learning, and deep learning are only some of the disruptive technologies that are enabling rapid change today. These technologies can be adopted quicker because of advances in cloud computing, Internet of Things (IoT), and edge computing. Organizations are reinventing the way they do business by cobbling together all these technologies. This is only the beginning; we are not even in the first inning, we haven't even recorded the first strike!

With that, let's begin to look at some contemporary applications of AI.

Digital personal assistants and chatbots

Unfortunately, it is still all too common for some call centers to use legacy Interactive Voice Response (IVR) systems that make calling them an exercise in patience. However, we have made great advances in the area of natural language processing: chatbots. Some of the most popular examples are:

- **Google Assistant**: Google Assistant was launched in 2016 and is one of the most advanced chatbots available. It can be found in a variety of appliances such as telephones, headphones, speakers, washers, TVs, and refrigerators. Nowadays, most Android phones include Google Assistant. Google Home and Nest Home Hub also support Google Assistant.
- **Amazon Alexa**: Alexa is a virtual assistant developed and marketed by Amazon. It can interact with users by voice and by executing commands such as playing music, creating to-do lists, setting up alarms, playing audiobooks, and answering basic questions. It can even tell you a joke or a story on demand. Alexa can also be used to control compatible smart devices. Developers can extend Alexa's capabilities by installing skills. An Alexa skill is additional functionality developed by third-party vendors.
- **Apple Siri**: Siri can accept user voice commands and a natural language user interface to answer questions, make suggestions, and perform actions by parsing these voice commands and delegating these requests to a set of internet services. The software can adapt to users' individual language usage, their searches, and preferences. The more it is used the more it learns and the better it gets.
- **Microsoft Cortana**: Cortana is another digital virtual assistant, designed and created by Microsoft. Cortana can set reminders and alarms, recognize natural voice commands, and it answers questions using information.

All these assistants will allow you to perform all or at least most of these tasks:

- Control devices in your home
- Play music and display videos on command
- Set timers and reminders
- Make appointments
- Send text and email messages
- Make phone calls
- Open applications
- Read notifications
- Perform translations
- Order from e-commerce sites

Some of the tasks that might not be supported but will start to become more pervasive are:

- Checking into your flight
- Booking a hotel
- Making a restaurant reservation

All these platforms also support 3rd party developers to develop their own applications or “skills” as Amazon calls them. So, the possibilities are endless.

Some examples of existing Alexa skills:

- **MySomm**: Recommends what wine goes with a certain meat
- **The bartender**: Provides instructions on how to make alcoholic drinks
- **7-minute workout**: Will guide you through a tough 7-minute workout
- **Uber**: Allows you to order an Uber ride through Alexa

All the preceding services listed continue to get better. They continuously learn from interactions with customers. They are improved both by the developers of the services as well as by the systems taking advantage of new data points created daily by users of the services.

Most cloud providers make it extremely easy to create chatbots and for some basic examples it is not necessary to use a programming language. In addition, it is not difficult to deploy these chatbots to services such as Slack, Facebook Messenger, Skype, and WhatsApp.

Personal chauffeur

Self-driving or driverless cars are vehicles that can travel along a pre-established route with no human assistance. Most self-driving cars in existence today do not rely on a single sensor and navigation method and use a variety of technologies such as radar, sonar, lidar, computer vision, and GPS.

As technologies emerge, industries start creating standards to implement and measure their progress. Driverless technologies are no different. SAE International has created standard J3016, which defines six levels of automation for cars so that automakers, suppliers, and policymakers can use the same language to classify the vehicle’s level of sophistication:

Level 0 (No automation)

The car has no self-driving capabilities. The driver is fully involved and responsible. The human driver steers, brakes, accelerates, and negotiates traffic. This describes most current cars on the road today.

Level 1 (Driver assistance)

System capability: Under certain conditions, the car controls either the steering or the vehicle speed, but not both simultaneously.

Driver involvement: The driver performs all other aspects of driving and has full responsibility for monitoring the road and taking over if the assistance system fails to act appropriately. For example, Adaptive cruise control.

Level 2 (Partial automation)

The car can steer, accelerate, and brake in certain circumstances. The human driver still performs many maneuvers like interpreting and responding to traffic signals or changing lanes. The responsibility for controlling the vehicle largely falls on the driver. The manufacturer still requires the driver to be fully engaged. Examples of this level are:

- Audi Traffic Jam Assist
- Cadillac Super Cruise
- Mercedes-Benz Driver Assistance Systems
- Tesla Autopilot
- Volvo Pilot Assist

Level 3 (Conditional automation)

The pivot point between levels 2 and 3 is critical. The responsibility for controlling and monitoring the car starts to change from driver to computer at this level. Under the right conditions, the computer can control the car, including monitoring the environment. If the car encounters a scenario that it cannot handle, it requests that the driver intervene and take control. The driver normally does not control the car but must be available to take over at any time. An example of this is Audi Traffic Jam Pilot.

Level 4 (High automation)

The car does not need human involvement under most conditions but still needs human assistance under some road, weather, or geographic conditions. Under a shared car model restricted to a defined area, there may not be any human involvement. But for a privately-owned car, the driver might manage all driving duties on surface streets and the system takes over on the highway. Google's now defunct Firefly pod-car is an example of this level. It didn't have pedals or a steering wheel. It was restricted to a top speed of 25 mph and it was not used in public streets.

Level 5 (Full automation)

The driverless system can control and operate the car on any road and under any conditions that a human driver could handle. The "operator" of the car only needs to enter a destination. Nothing at this level is in production yet but a few companies are close and might be there by the time the book is published.

We'll now review some of the leading companies working in the space:

Google's Waymo

As of 2018, Waymo's autonomous cars have driven eight million miles on public roads as well as five billion miles in simulated environments. In the next few years, it is all but a certainty that we will be able to purchase a car capable of full driving autonomy. Tesla, among others, already offers driver assistance with their Autopilot feature and possibly will be the first company to offer full self-driving capabilities. Imagine a world where a child born today will never have to get a driver's license! The disruption caused in our society by this advance in AI alone will be massive. The need for delivery drivers, taxi drivers, and truckers will be obviated. Even if there are still car accidents in a driverless future, millions of lives will be saved because we will eliminate distracted driving and drunk driving.

Waymo launched the first commercial driverless service in 2018 in Arizona, USA with plans to expand nationally and worldwide.

Uber ATG

Uber's Advanced Technology Group (ATG) is an Uber subsidiary working on developing self-driving technology. In 2016, Uber launched an experimental car service on the streets of Pittsburgh. Uber has plans to buy up to 24,000 Volvo XC90 and equip them with their self-driving technology and start commercializing them in some capacity by 2021.

Tragically, in March 2018, Elaine Herzberg was involved in an incident with an Uber driverless car and died. According to police reports, she was struck by the Uber vehicle while trying to cross the street, while she was watching a video on her phone. Ms. Herzberg became one of the first individuals to die in an incident involving a driverless car. Ideally, we would like to see no accidents ever happen with this technology, yet the level of safety that we demand needs to be tempered with the current crisis we have with traffic accidents. For context, there were 40,100 motor vehicle deaths in the US in 2017; even if we continue to see accidents with automated cars, if this death toll was slashed by say, half, thousands of lives would be saved each year.

It is certainly possible to envision a driverless vehicle that looks more like a living room than the interior of our current cars. There would be no need for steering wheels, pedals or any kind of manual control. The only input the car would need is your destination, which could be given at the beginning of your journey by “speaking” to your car. There would be no need to keep track of a maintenance schedule as the car would be able to sense when a service is due or there is an issue with the car’s function.

Liability for car accidents will shift from the driver of the vehicle to the manufacturer of the vehicle doing away with the need to have car insurance. This last point is probably one of the reasons why car manufacturers have been slow to deploy this technology. Even car ownership might be flipped on its head since we could summon a car whenever we need one instead of needing one all the time.

Shipping and warehouse management

An Amazon sorting facility is one of the best examples of the symbiotic relationship that is forming between humans, computers, and robots. Computers take customer orders and decide where to route merchandise, the robots act as mules carrying the pallets and inventory around the warehouse. Humans plug the “last mile” problem by hand picking the items that are going into each order. Robots are proficient in mindlessly repeating a task many times as long as there is a pattern involved and some level of pretraining is involved to achieve this. However, having a robot pick a 20-pound package and immediately being able to grab an egg without breaking it is one of the harder robotics problems.

Robots struggle dealing with objects of different sizes, weights, shapes, and fragility; a task that many humans can perform effortlessly. People, therefore, handle the tasks that the robots encounter difficulty with. The interaction of these three types of different actors translates into a finely tuned orchestra that can deliver millions of packages everyday with very little mistakes.

Even Scott Anderson, Amazon’s director of robotics fulfillment acknowledged in May 2019 that a fully automated warehouse is at least 10 years away. So, we will continue to see this configuration in warehouses across the world for a little longer.

Human health

The ways that AI can be applied in health science is almost limitless. We will discuss a few of them here, but it will by no means be an exhaustive list.

Drug discovery

AI can assist in generating drug candidates (that is, molecules to be tested for medical application) and then quickly eliminating some of them using constraint satisfaction or experiment simulation. In a nutshell, this approach allows us to speed up drug discovery by quickly generating millions of possible drug candidates and just as quickly rejecting them if the candidates do not satisfy certain predetermined constraints.

In addition, in some cases we can simulate experiments in the computer that otherwise would be much more expensive to perform in real life.

Furthermore, in some instances researchers still conduct real-world experiments but rely on robots to perform the experiments and speed up the process with them. These emerging fields are dubbed high throughput screening (HTS) and virtual high throughput screening (VHTS).

Machine learning is starting to be used more and more to enhance clinical trials. The consulting company of Accenture has developed a tool called intelligent clinical trials (ITP). It is used to predict the length of clinical trials.

Another approach that can surprisingly be used is to apply to drug discovery is Natural Language Processing (NLP). Genomic data can be represented using a string of letters and the NLP techniques can be used to process or “understand” what the genomic sequences mean.

Insurance pricing

Machine learning algorithms can be used to better price insurance by more accurately predicting how much will be spent on a patient, how good a driver an individual is, or how long a person will live.

As an example, the *young.ai* project from Insilico Medicine can predict with some accuracy how long someone will live from a blood sample and a photograph. The blood sample provides 21 biomarkers such as cholesterol level, inflammation markers, hemoglobin counts and albumin level that are used as input to a machine learning model. Other inputs into the model are ethnicity and age, as well as a photograph of the person.

Interestingly, as of now, anyone can use this service for free by visiting young.ai (`https://young.ai`) and providing the required information.

Patient diagnosis

Doctors can make better diagnosis on their patients and be more productive in their practice by using sophisticated rules engines and machine learning. As an example, in a recent study at the University of California in San Diego conducted by Kang Zhang

[1], one system could diagnose children's illnesses with a higher degree of accuracy than junior pediatricians. The system was able to diagnose the following diseases with a degree of accuracy of between 90% and 97%:

- Glandular fever
- Roseola
- Influenza
- Chicken pox
- Hand, foot, and mouth disease

The input dataset consisted of medical records from 1.3 million children visits to the doctor from the Guangzhou region in China between 2016 and 2017.

Medical imaging interpretation

Medical imaging data is a complex and rich source of information about patients. CAT scans, MRIs, and X-rays contain information that is otherwise unavailable. There is a shortage of radiologists and clinicians that can interpret them. Getting results from these images can sometimes take days and can sometimes be misinterpreted. Recent studies have found that machine learning models can perform just as well, if not better, than their human counterparts.

Data scientists have developed AI enabled platforms that can interpret MRI scans and radiological images in a matter of minutes instead of days and with a higher degree of accuracy when compared with traditional methods.

Perhaps surprisingly, far from being concerned, leaders from the American College for Radiology see the advent of AI as a valuable tool for physicians. In order to foster further development in the field, the American College for Radiology Data Science Institute (ACR DSI) released several AI use cases in medical imaging and plans to continue releasing more.

Psychiatric analysis

An hour-long session with a psychiatrist can costs hundreds of dollars. We are on the cusp of being able to simulate the behavior with AI chatbots. At the very least, these bots will be able to offer follow-up care from the sessions with the psychiatrist and help with a patient's care between doctor's visits.

One early example of an automated counselor is Eliza. It was developed in 1966 by Joseph Weizenbaum. It allows users to have a "conversation" with the computer mimicking a Rogerian psychotherapist. Remarkably, Eliza feels natural, but its code is only a few hundred lines and it doesn't really use much AI at its core.

A more recent and advanced example is Ellie. Ellie was created by the Institute for Creative Technologies at the University of Southern California. It helps with the treatment of people with depression or post-traumatic stress disorder. Ellie is a virtual therapist (she appears on screen), responds to emotional cues, nods affirmatively when appropriate and shifts in her seat. She can sense 66 points on a person's face and use these inputs to read a person's emotional state. One of Ellie's secrets is that she is obviously not human and that makes people feel less judged and more comfortable opening up to her.

Smart health records

Medicine is notorious for being a laggard in moving to electronic records. Data science provides a variety of methods to streamline the capture of patient data including OCR, handwriting recognition, voice to text capture, and real-time reading and analysis of patient's vital signs. It is not hard to imagine a future coming soon where this information can be analyzed in real-time by AI engines to take decisions such as adjusting body glucose levels, administering a medicine, or summoning medical help because a health problem is imminent.

Disease detection and prediction

The human genome is the ultimate dataset. At some point soon, we will be able to use the human genome as input to machine learning models and be able to detect and predict a wide variety of diseases and conditions using this vast dataset.

Using genomic datasets as an input in machine learning is an exciting area that is evolving rapidly and will revolutionize medicine and health care.

The human genome contains over 3 billion base pairs. We are making progress on two fronts that will accelerate progress:

- Continuous advancements in the understanding of genome biology
- Advances in big data computing to process vast amounts of data faster

There is much research applying deep learning to the field of genomics. Although it is still in early stages, deep learning in genomics has the potential to inform fields including:

- Functional genomics
- Oncology
- Population genetics
- Clinical genetics
- Crop yield improvement
- Epidemiology and public health
- Evolutionary and phylogenetic analysis

Knowledge search

We have gotten to a point where, in some cases, we don't even realize we are using artificial intelligence. A sign that a technology or product is good is when we don't necessarily stop to think how it's doing what it is doing. A perfect example of this is Google Search. The product has become ubiquitous in our lives and we don't realize how much it relies on artificial intelligence to produce its amazing results. From its Google Suggest technology to its constant improvement of the relevancy of its results, AI is deeply embedded in its search process.

Early in 2015, as was reported by Bloomberg, Google began using a deep learning system called RankBrain to assist in generating search query responses. The Bloomberg article describes RankBrain as follows:

> *"RankBrain uses artificial intelligence to embed vast amounts of written language into mathematical entities — called vectors — that the computer can understand. If RankBrain sees a word or phrase it isn't familiar with, the machine can make a guess as to what words or phrases might have a similar meaning and filter the result accordingly, making it more effective at handling never-before-seen search queries."*
>
> *— Clark, Jack [2]*

As of the last report, RankBrain plays a role in a large percentage of the billions of Google Search queries. As one can imagine, the company is tight lipped about how exactly RankBrain works, and furthermore even Google might have a hard time explaining how it works. You see, this is one of the dilemmas of deep learning. In many cases, it can provide highly accurate results, but deep learning algorithms are usually hard to understand in terms of why an individual answer was given. Rule-based systems and even other machine learning models (such as Random Forest) are much easier to interpret.

The lack of explainability of deep learning algorithms has major implications, including legal implications. Lately, Google and Facebook among others, have found themselves under the microscope to determine if their results are biased. In the future, legislators and regulators might require that these tech giants provide a justification for a certain result. If deep learning algorithms do not provide explainability, they might be forced to use other less accurate algorithms that do.

Initially, RankBrain only assisted in about 15 percent of Google queries, but now it is involved in almost all user queries.

However, if a query is a common query, or something that the algorithm understands, the RankBrain rank score is given little weight. If the query is one that the algorithm has not seen before or it does not know its meaning, RankBrain score is much more relevant.

Recommendation systems

Recommendation systems are another example of AI technology that has been weaved into our everyday lives. Amazon, YouTube, Netflix, LinkedIn, and Facebook all rely on recommendation technology and we don't even realize we are using it. Recommendation systems rely heavily on data and the more data that is at their disposable, the more powerful they become. It is not coincidence that these companies have some of the biggest market caps in the world and their power comes from them being able to harness the hidden power in their customer's data. Expect this trend to continue in the future.

What is a recommendation? Let's answer the question by first exploring what it is not. It is not a definitive answer. Certain questions like "what is two plus two?" or "how many moons does Saturn have?" have a definite answer and there is no room for subjectivity. Other questions like "what is your favorite movie?" or "do you like radishes?" are completely subjective and the answer is going to depend on the person answering the question. Some machine learning algorithms thrive with this kind of "fuzziness." Again, these recommendations can have tremendous implications.

Think of the consequences of Amazon constantly recommending a product versus another. The company that makes the recommended product will thrive and the company that makes the product that was not recommended could go out of business if it doesn't find alternative ways to distribute and sell its product.

One of the ways that a recommender system can improve is by having previous selections from users of the system. If you visit an e-commerce site for the first time and you don't have an order history, the site will have a hard time making a recommendation tailored to you. If you purchase sneakers, the website now has one data point that it can start using as a starting point. Depending on the sophistication of the system, it might recommend a different pair of sneakers, a pair of athletic socks, or maybe even a basketball (if the shoes were high-tops).

An important component of good recommendation systems is a randomization factor that occasionally "goes out on a limb" and makes oddball recommendations that might not be that related to the initial user's choices. Recommender systems don't just learn from history to find similar recommendations, but they also attempt to make new recommendations that might not be related at first blush. For example, a Netflix user might watch "The Godfather" and Netflix might start recommending Al Pacino movies or mobster movies. But it might recommend "Bourne Identity," which is a stretch. If the user does not take the recommendation or does not watch the movie, the algorithm will learn from this and avoid other movies like the "Bourne Identity" (for example any movies that have Jason Bourne as the main character).

As recommender systems get better, the possibilities are exciting. They will be able to power personal digital assistants and become your personal butler that has intimate knowledge of your likes and dislikes and can make great suggestions that you might have not thought about. Some of the areas where recommendations can benefit from these systems are:

- Restaurants
- Movies
- Music
- Potential partners (online dating)
- Books and articles
- Search results
- Financial services (robo-advisors)

Some notable specific examples of recommender systems follow:

Netflix Prize

A contest that created a lot of buzz in the recommender system community was the Netflix Prize. From 2006 to 2009, Netflix sponsored a competition with a grand prize of one million US dollars. Netflix made available a dataset of 100 million plus ratings.

Netflix offered to pay the prize to the team that offered the highest accuracy in their recommendations and was 10% more accurate than the recommendations from Netflix's existing recommender system. The competition energized research for new and more accurate algorithms. In September 2009, the grand prize was awarded to the BellKor's Pragmatic Chaos team.

Pandora

Pandora is one of the leading music services. Unlike other companies like Apple and Amazon, Pandora's exclusive focus is as a music service. One of Pandora's salient service features is the concept of customized radio stations. These "stations" allow users to play music by genre. As you can imagine, recommender systems are at the core of this functionality.

Pandora's recommender is built on multiple tiers:

- First, their team of music experts annotates songs based on genre, rhythm, and progression.
- These annotations are transformed into a vector for comparing song similarity. This approach promotes the presentation of "long tail" or obscure music from unknown artists that nonetheless could be a good fit for individual listeners.
- The service also heavily relies on user feedback and uses it to continuously enhance the service. Pandora has collected over 75 billion feedback data points on listener preferences.
- The Pandora recommendation engine can then perform personalized filtering based on a listener's preferences using their previous selections, geography, and other demographic data.

In total, Pandora's recommender uses around 70 different algorithms, including 10 to analyze content, 40 to process collective intelligence, and about another 30 to do personalized filtering.

Betterment

Robo-advisors are recommendation engines that provide investment or financial advice and management with minimal human involvement. These services use machine learning to automatically allocate, manage, and optimize a customer's asset mix. They can offer these services at a lower cost than traditional advisors because their overhead is lower, and their approach is more scalable.

There is now fierce competition in this space with well over 100 companies offering these kinds of services. Robo-advisors are considered a tremendous breakthrough. Formerly, wealth management services were an exclusive and expensive service reserved for high net worth individuals. Robo-advisors promise to bring a similar service to a broader audience with lower costs compared to the traditional human-enabled services. Robo-advisors could potentially allocate investments in a wide variety of investment products like stocks, bonds, futures, commodities, real estate, and other exotic investments. However, to keep things simple investments are often constrained to exchange traded funds (ETFs).

As we mentioned there are many companies offering robo-advice. As an example, you might want to investigate Betterment to learn more about this topic. After filling out a risk questionnaire, Betterment will provide users with a customized, diversified portfolio. Betterment will normally recommend a mix of low-fee stock and bond index funds. Betterment charges an administration fee (as a percentage of the portfolio) but it is lower than most human-powered services. Please note that we are not endorsing this service and we only mention it as an example of a recommendation engine in the financial sector.

The smart home

Whenever you bring up the topic of AI to the common folk on the street, they are usually skeptical about how soon it is going to replace human workers. They can rightly point to the fact that we still need to do a lot of housework around the house. AI needs to become not only technologically possible, but it also needs to be economically feasible for adoption to become widespread. House help is normally a low-wage profession and, for that reason, automation to replace it needs to be the same price or cheaper. In addition, house work requires a lot of finesse and it comprises tasks that are not necessarily repetitive. Let's list out some of the tasks that this automaton will need to perform in order to be proficient:

- Wash and dry clothes
- Fold clothes
- Cook dinner
- Make beds
- Pick up items off the floor
- Mop, dust and vacuum
- Wash dishes
- Monitor the home

As we already know, some of these tasks are easy to perform for machines (even without AI) and some of them are extremely hard. For this reason and because of the economic considerations, the home will probably be one of the last places to become fully automated. Nonetheless, let's look at some of the amazing advances that have been made in this area.

Home Monitoring

Home monitoring is one area where great solutions are generally available already. The Ring video doorbell from Amazon and the Google Nest thermostat are two inexpensive options that are widely available and popular. These are two simple examples of smart home devices that are available for purchase today.

The Ring video doorbell is a smart home device connected to the internet that can notify the homeowner of activity at their home, such as a visitor, via their smartphone. The system does not continuously record but rather it activates when the doorbell is pressed, or when the motion detector is activated. The Ring doorbell can then let the home owner watch the activity or communicate with the visitor using the built-in microphone and speakers. Some models also allow the homeowner to open the door remotely via a smart lock and let the visitor into the house.

The Nest Learning Thermostat is a smart home device initially developed by Nest Labs, a company that was later bought by Google. It was designed by Tony Fadell, Ben Filson, and Fred Bould. It is programmable, Wi-Fi-enabled, and self-learning. It uses artificial intelligence to optimize the temperature of the home while saving energy.

In the first weeks of use you set the thermostat to your preferred settings and this will serve as a baseline. The thermostat will learn your schedule and your preferred temperatures. Using built-in sensors and your phones' locations, the thermostat will shift into energy saving mode when no one is home.

Since 2011, the Nest Thermostat has saved billions of kWh of energy in millions of homes worldwide. Independent studies have shown that it saves people an average of 10% to 12% on their heating bills and 15% on their cooling bills so in about 2 years it may pay for itself.

Vacuuming and mopping

Two tasks that have been popular to hand off to robots are vacuuming and mopping. A robotic vacuum cleaner is an autonomous robotic vacuum cleaner that uses AI to vacuum a surface. Depending on the design, some of these machines use spinning brushes to reach tight corners and some models include several other features in addition to being able to vacuum, such as mopping and UV sterilization. Much of the credit for popularizing this technology goes to the company (not the film), *iRobot*.

iRobot was started in 1990 by Rodney Brooks, Colin Angle, and Helen Greiner after meeting each other while working in MIT's Artificial Intelligence Lab. iRobot is best known for its vacuuming robot (Roomba), but for a long time they also had a division devoted to the development of military robots. The Roomba started selling in 2002. As of 2012 iRobot had sold more than eight million home robots as well as creating more than 5,000 defense and security robots. The company's PackBot is a bomb-disposal robot used by the US military that has been used extensively in Iraq and Afghanistan. PackBots were also used to gather information under dangerous conditions at the Fukushima Daiichi nuclear disaster site. iRobot's Seaglider was used to detect underwater pools of oil after the Deepwater Horizon oil spill in the Gulf of Mexico.

Another iRobot product is the Braava series of cleaners. The Braava is a small robot that can mop and sweep floors. It is meant for small spaces like bathrooms and kitchens. It sprays water and uses an assortment of different pads to clean effectively and quietly. Some of the Braava models have a built-in navigation system. The Braava doesn't have enough power to remove deep-set stains, so it's not a complete human replacement, but it does have wide acceptance and high ratings. We expect them to continue to gain popularity.

The potential market for intelligent devices in the home is huge and it is all but certain that we will continue to see attempts from well established companies and startups alike to exploit this largely untapped market.

Picking up your mess

As we learned in the shipping use case, picking objects of different weights, dimensions, and shapes is one of the most difficult tasks to automate. Robots can perform efficiently under homogeneous conditions like a factory floor where certain robots specialize in certain tasks. Picking up a pair of shoes after picking up a chair, however, can be immensely challenging and expensive. For this reason, do not expect this home chore to be pervasively performed by machines in a cost-effective fashion any time soon.

Personal chef

Like picking up items off the floor, cooking involves picking up disparate items. Yet there are two reasons why we can expect “automated cooking” to happen sooner:

- Certain restaurants may charge hundreds of dollars for their food and be paying high prices for skilled chefs. Therefore, they might be open to using technology to replace their high-priced staff if this should work out to be more profitable. An example for this is a five-star sushi restaurant.
- Some tasks in the kitchen are repetitive and therefore lend themselves to automation. Think of a fast food joint where hamburgers and fries might have to be made by the hundreds. Thus, rather than having one machine handle the entire disparate cooking process, a series of machines could deal with individual repetitive stages of the process.

Smart prosthetics are great examples of artificial intelligence augmenting humans rather than replacing them. There are more than a few chefs that lost their arm in an accident or were born without a limb.

One example is chef Michael Caines who runs a two Michelin star restaurant and lost his arm in a horrific car accident. Chef Caines was head chef of Gidleigh Park in Devon in England until January 2016.[3] He is currently the executive chef of the Lympstone Manor hotel between Exeter and Exmouth. He now cooks with a prosthetic arm, but you’d never know it given the quality of his food.

Another example is Eduardo Garcia who is a sportsman and a chef – both of which are made possible by the most advanced bionic hand in the world.

On October 2011, while bow-hunting elk he was electrocuted in the Montana backcountry. Eduardo was hunting by himself in October 2011. He was in back country when he saw a dead baby black bear. He stopped to check it out, knelt, and used his knife to prod it.

While doing so, 2,400 volts coursed through his body – the baby bear had been killed by a buried, live electrical wire. He survived but lost his arm during the incident.

In September 2013, Garcia was fitted by Advanced Arm Dynamics with a bionic hand designed by Touch Bionics. The bionic hand is controlled by Garcia's forearm muscles and can grip in 25 different ways. With his new hand, Garcia can perform tasks that normally require great dexterity. His new hand still has some limitations. For example, Garcia cannot lift heavy weights. However, there are things that he can perform now that he couldn't before. For example, he can grab things out of a hot oven and not get burnt and it is impossible to cut his fingers.

Conversely, rather than augmenting humans, robots may replace humans in the kitchen entirely. An example of this is Moley, the robotic kitchen. Moley is not currently in production but the most advanced prototype of the Moley Robotic Kitchen consists of two robotic arms with hands equipped with tactile sensors, a stove top, an oven, a dishwasher, and a touchscreen unit. These artificial hands can lift, grab, and interact with most kitchen equipment including knives, whisks, spoons, and blenders.

Using a 3D camera and a glove it can record a human chef preparing a meal and then upload detailed steps and instructions into a repository. The chef's actions are then translated into robotic movements using gesture recognition models. These models were created in collaboration with Stanford University and Carnegie Mellon University. After that Moley can reproduce the same steps and cooks the exact same meal from scratch.

In the current prototype, the user can operate it using a touchscreen or smartphone application with ingredients prepared in advance and placed in preset locations. The company's long-term goal is to allow users to simply select an option from a list of more 2,000 recipes and Moley will have the meal prepared in minutes.

Gaming

There is perhaps no better example to demonstrate the awe-inspiring advances in Artificial Intelligence than the progress that has been made in the area of gaming. Humans are competitive by nature and having machines beat us at our own games is an interesting yardstick to measure the breakthroughs in the field. Computers have long been able to beat us in some of the more basic, more deterministic, less compute-intensive games like say checkers. It's only in the last few years that machines have been able to consistently beat the masters of some of the harder games. In this section we go over three of these examples.

StarCraft 2

Video games have been used for decades as a benchmark to test the performance of AI systems. As capabilities increase, researchers work with more complex games that require different types of intelligence. The strategies and techniques developed from this game playing can transfer to solving real-world problems. The game of StarCraft II is considered one of the hardest, though it is an ancient game by video game standards.

The team at DeepMind introduced a program dubbed AlphaStar that can play StarCraft II and was for the first time able to defeat a top professional player. In matches held in December 2018, AlphaStar whooped a team put together by Grzegorz "MaNa" Komincz, one of the world's strongest professional StarCraft players with a score of 5-0. The games took place under professional match conditions and without any game restrictions.

In contrast to previous attempts to master the game using AI that required restrictions, AlphaStar can play the full game with no restrictions. It uses a deep neural network that is trained directly from raw game data using supervised learning and reinforcement learning.

One of the things that makes StarCraft II so difficult is the need to balance short- and long-term goals and adapt to unexpected scenarios. This has normally posed a tremendous challenge for previous systems.

While StarCraft is just a game, albeit a difficult one, the concepts and techniques coming out of AlphaStar can be useful in solving other real-world challenges. As an example, AlphaStar's architecture is capable of modeling very long sequences of likely actions – with games often lasting up to an hour with tens of thousands of moves – based on imperfect information. The primary concept of making complicated predictions over long sequences of data can be found in many real-world problems, such as:

- Weather prediction
- Climate modelling
- Natural Language Understanding

The success that AlphaStar has demonstrated playing StarCraft represents a major scientific breakthrough in one of the hardest video games in existence. These breakthroughs represent a big leap in the creation of artificial intelligence systems that can be transferred and that can help solve fundamental real-world practical problems.

Jeopardy

IBM and the Watson team made history in 2011 when they devised a system that was able to beat two of the most successful Jeopardy champions.

Ken Jennings has the longest unbeaten run in the show's history with 74 consecutive appearances. Brad Rutter had the distinction of winning the biggest prize pot with a total of $3.25 million.

Both players agreed to an exhibition match against Watson.

Watson is a question-answering system that can answer questions posed in natural language. It was initially created by IBM's DeepQA research team, led by principal investigator David Ferrucci.

The main difference between the question-answering technology used by Watson and general search (think Google searches) is that general search takes a keyword as input and responds with a list of documents with a ranking based on the relevance to the query. Question-answering technology like what is used by Watson takes a question expressed in natural language, tries to understand the question at a deeper level, and tries to provide the precise answer to the question.

The software architecture of Watson uses:

- IBM's DeepQA software
- Apache UIMA (Unstructured Information Management Architecture)
- A variety of languages, including Java, C++, and Prolog
- SUSE Linux Enterprise Server
- Apache Hadoop for distributed computing

Chess

Many of us remember the news when Deep Blue famously beat chess grand master Gary Kasparov in 1996. Deep Blue was a chess-playing application created by IBM.

In the first round of play Deep Blue won the first game against Gary Kasparov. However, they were scheduled to play six games. Kasparov won three and drew two of the following five games thus defeating Deep Blue by a score of 4–2.

The Deep Blue team went back to the drawing board, made a lot of enhancements to the software, and played Kasparov again in 1997. Deep Blue won the second round against Kasparov winning the six-game rematch by a score of 3½–2½. It then became the first computer system to beat a current world champion in a match under standard chess tournament rules and time controls.

A lesser known example, and a sign that machines beating humans is becoming common place, is the achievement in the area of chess by the AlphaZero team.

Google scientists from their AlphaZero research team created a system in 2017 that took just four hours to learn the rules of chess before crushing the most advanced world champion chess program at the time called *Stockfish*. By now the question as to whether computers or humans are better at chess has been resolved.

Let's pause for a second and think about this. All of humanity's knowledge about the ancient game of chess was surpassed by a system that, if it started learning in the morning, would be done by lunch time.

The system was given the rules of chess, but it was not given any strategies or further knowledge. Then, in a few hours, AlphaZero mastered the game to the extent it was able to beat Stockfish.

In a series of 100 games against Stockfish, AlphaZero won 25 games while playing as white (white has an advantage because it goes first). It also won three games playing as black. The rest of the games were ties. Stockfish did not obtain a single win.

AlphaGo

As hard as chess is, its difficulty does not compare to the ancient game of Go.

Not only are there more possible (19 x 19) Go-board positions than there are atoms in the visible universe and the number of possible chess positions is negligible to the number of Go positions. But Go is at least several orders of magnitude more complex than a game of chess because of the large number of possible ways to let the game flow with each move towards another line of development. With Go, the number of moves in which a single stone can affect and impact the whole-board situation is also many orders of magnitude larger than that of a single piece movement with chess.

There is great example of a powerful program that can play the game of Go also developed by DeepMind called AlphaGo. AlphaGo also has three far more powerful successors, called AlphaGo Master, AlphaGo Zero, and AlphaZero.

In October 2015, the original AlphaGo became the first computer Go program to beat a human professional Go player without handicaps on a full-sized 19 x 19 board. In March 2016, it beat Lee Sedol in a five-game match. This became the first time a Go program beat a 9-dan professional without handicaps. Although AlphaGo lost to Lee Sedol in the fourth game, Lee resigned in the final game, giving a final score of 4 games to 1.

At the 2017 Future of Go Summit, the successor to AlphaGo called AlphaGo Master beat the master Ke Jie in a three-game match. Ke Jie was ranked the world No.1 ranked player at the time. After this, AlphaGo was awarded professional 9-dan by the Chinese Weiqi Association.

AlphaGo and its successors use a Monte Carlo tree search algorithm to find their moves based on knowledge previously "learned" by machine learning, specifically using deep learning and training, both playing with humans and by itself. The model is trained to predict AlphaGo's own moves and the winner's games. This neural net improves the strength of tree search, resulting in better moves and stronger play in following games.

Movie making

It is all but a certainty that within the next few decades it will be possible to create movies that are 100% computer generated. It is not unfathomable to envision a system where the input is a written script and the output is a full-length feature film. In addition, some strides have been made in natural generators. So, eventually not even the script will be needed. Let's explore this further.

Deepfakes

A deepfake is a *portmanteau*, or blend, of "deep learning" and "fake." It is an AI technique to merge video images. A common application is to overlap someone's face onto another. A nefarious version of this was used to merge pornographic scenes with famous people or to create revenge porn. Deepfakes can also be used to create fake news or hoaxes. As you can imagine, there are severe societal implications if this technology is misused.

One recent version of similar software was developed by a Chinese company called Momo who developed an app called *Zao*. It allows you to overlap someone's face over short movie clips like Titanic and the results are impressive. This and other similar applications do not come without controversy. Privacy groups are complaining that the photos submitted to the site per the terms of the user agreement become property of Momo and then can later be used for other applications.

It will be interesting to see how technology continues to advance in this area.

Movie Script Generation

They are not going to win any Academy Awards any time soon, but there are a couple projects dedicated to producing movie scripts. One of the most famous examples is Sunspring.

Sunspring is an experimental science fiction short film released in 2016. It was entirely written by using deep learning techniques. The film's script was created using a long short-term memory (LSTM) model dubbed Benjamin. Its creators are BAFTA-nominated filmmaker Oscar Sharp and NYU AI researcher Ross Goodwin. The actors in the film are Thomas Middleditch, Elisabeth Grey, and Humphrey Ker. Their character names are H, H2, and C, living in the future. They eventually connect with each other and a love triangle forms.

Originally shown at the Sci-Fi-London film festival's 48hr Challenge, it was also released online by technology news website Ars Technica in June 2016.

Underwriting and deal analysis

What is underwriting? In short, underwriting is the process by which an institution determines if they want to take a financial risk in exchange for a premium. Examples of transactions that require underwriting are:

- Issuing an insurance policy
  - Health
  - Life
  - Home
  - Driving
- Loans
  - Installment loans
  - Credit cards
  - Mortgages
  - Commercial lines of credit
- Securities underwriting and Initial Public Offerings (IPOs)

As can be expected, determining whether an insurance policy or a loan should be issued and at what price can be very costly if the wrong decision is made. For example, if a bank issues a loan and the loan defaults, it would require dozens of other performing loans to make up for that loss. Inversely, if the bank passes up on a loan where the borrower was going to make all their payments is also detrimental to the bank finances. For this reason, the bank spends considerable time analyzing or "underwriting" the loan to determine the credit worthiness of the borrower as well as the value of the collateral securing the loan.

Even with all these checks, underwriters still get it wrong and issue loans that default or bypass deserving borrowers. The current underwriting process follows a set of criteria that must be met but specially for smaller banks there is still a degree of human subjectivity in the process. This is not necessarily a bad thing. Let's visit a scenario to explore this further:

A high net worth individual recently came back from a tour around the world. Three months ago, they got a job at a prestigious medical institution and their credit score is above 800.

Would you lend money to this individual? With the characteristics given, they seem to be a good credit risk. However, normal underwriting rules might disqualify them because they haven't been employed for the last two years. Manual underwriting would look at the whole picture and probably approve them.

Similarly, a machine learning model would probably be able to flag this as a worthy account and issue the loan. Machine learning models don't have hard and fast rules but rather "learn by example."

Many lenders are already using machine learning in their underwriting. An interesting example of a company that specializes in this space is Zest Finance. Zest Finance uses AI techniques to assist lenders with their underwriting. AI can help to increase revenue and reduce risk. Most importantly well applied AI in general and Zest Finance in particular can help companies to ensure that the AI models used are compliant with a country's regulations. Some AI models can be a "black box" where it is difficult to explain why one borrower was rejected and another one was accepted. Zest Finance can fully explain data modeling results, measure business impact, and comply with regulatory requirements. One of Zest Finance's secret weapons is the use of non-traditional data, including data that a lender might have in-house, such as:

- Customer support data
- Payment histories
- Purchase transactions

They might also consider nontraditional credit variables such as:

- The way a customer fills out a form
- The method a customer uses to arrive at the site or how they navigate the site
- The amount of time taken to fill out an application

Data cleansing and transformation

Just as gas powers a car, data is the lifeblood of AI. The age-old adage of "garbage in, garbage out" remains painfully true. For this reason, having clean and accurate data is paramount to producing consistent, reproducible, and accurate AI models. Some of this data cleansing has required painstaking human involvement. By some measures, it is said that a data scientist spends about 80% of their time cleaning, preparing, and transforming their input data and 20% of the time running and optimizing their models. Examples of this are the ImageNet and MS-COCO image datasets. Both contain over a million labeled images of various objects and categories. These datasets are used to train models that can distinguish between different categories and object types. Initially, these datasets were painstakingly and patiently labeled by humans. As these systems become more prevalent, we can use AI to perform the labeling. Furthermore, there is a plethora of AI-enabled tools that help with the cleansing and deduplication process.

One good example is Amazon Lake Formation. In August 2019, Amazon made its service Lake Formation generally available. Amazon Lake Formation automates some of the steps typically involved in the creation of a data lake including the collection, cleansing, deduplication, cataloging, and publication of data. The data then can be made available for analytics and to build machine models. To use Lake Formation, a user can bring data into the lake from a range of sources using predefined templates. They can then define policies that govern data access depending on the level of access that groups across the organization require.

Some automatic preparation, cleansing, and classification that the data undergoes uses machine learning to automatically perform these tasks.

Lake Formation also provides a centralized dashboard where administrators can manage and monitor data access policies, governance, and auditing across multiple analytics engines. Users can also search for datasets in the resulting catalog. As the tool evolves in the next few months and years, it will facilitate the analysis of data using their favorite analytics and machine learning services, including:

- Databricks
- Tableau
- Amazon Redshift
- Amazon Athena
- AWS Glue
- Amazon EMR
- Amazon QuickSight
- Amazon SageMaker