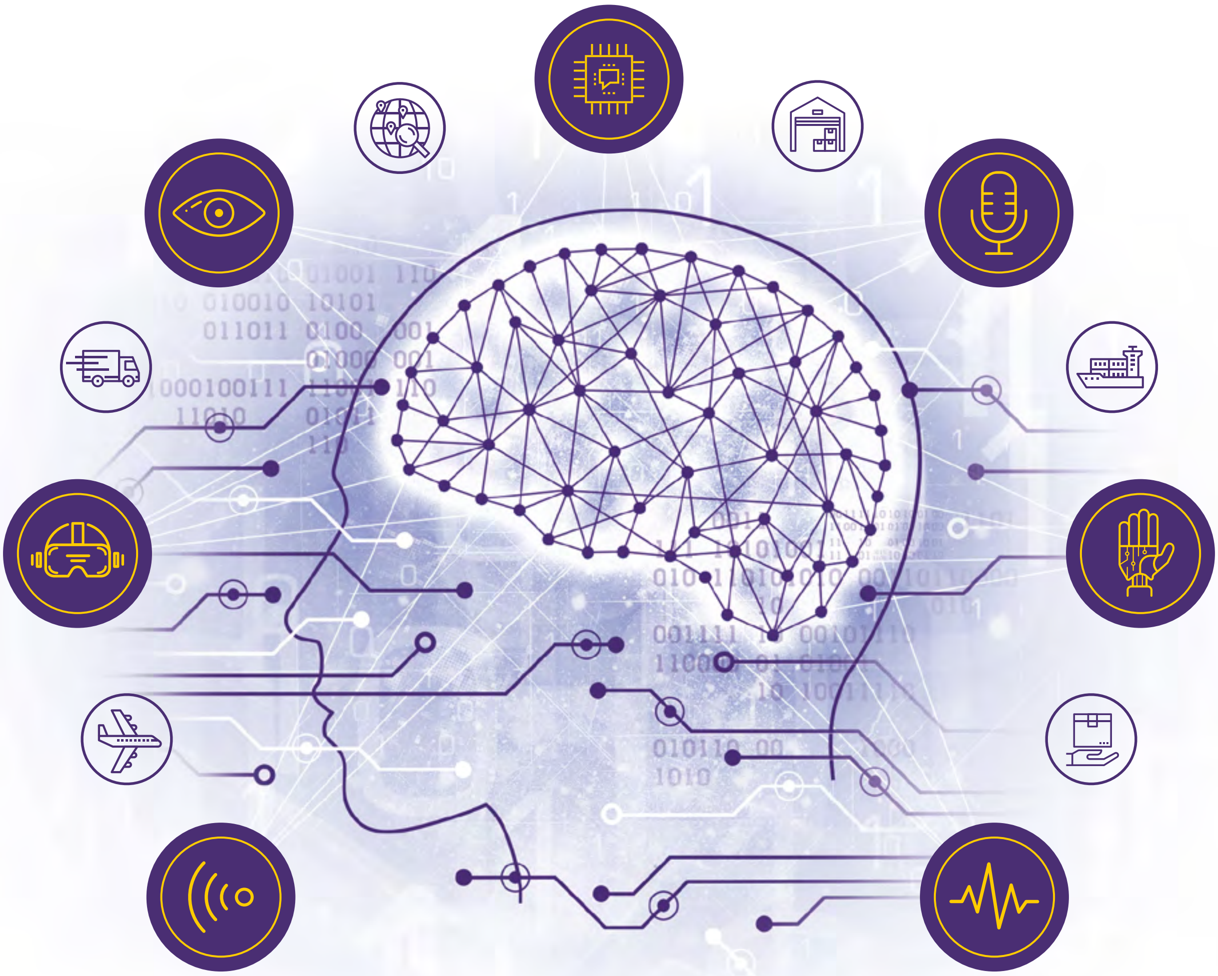

# ARTIFICIAL INTELLIGENCE IN LOGISTICS

A collaborative report by DHL and IBM on implications and use cases for the logistics industry

2018

Powered by DHL Trend Research

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# PREFACE

Today we find ourselves in another transformational era in human history. Much like the agricultural and industrial revolutions before it, the digital revolution is redefining many aspects of modern life around the world. Artificial intelligence (AI) plays an increasingly central role in this transformation. In recent years, AI has come roaring out of research laboratories to become ubiquitous and ambient in our personal lives, so much so that many consumers do not realize they use products and applications that contain AI on a daily basis.

AI stands to greatly benefit all industries, achieving adoption leaps from consumer segments to enterprises and onward to the industrial sector. Technological progress in the fields of big data, algorithmic development, connectivity, cloud computing and processing power have made the performance, accessibility, and costs of AI more favorable than ever before. Just as the relational database found its way into core business operations around the world – providing better ways to store, retrieve, and organize information – AI is now following a similar path. It is becoming an integral part of every future software system and soon we will no longer need to call it out as AI.

Already today, AI is prevalent in consumer-facing applications, clerical enterprise functions, online and offline retail, autonomous mobility, and intelligent manufacturing. Logistics is beginning its journey to become an AI-driven industry, but the future is still rife with challenges to overcome and opportunities to exploit.

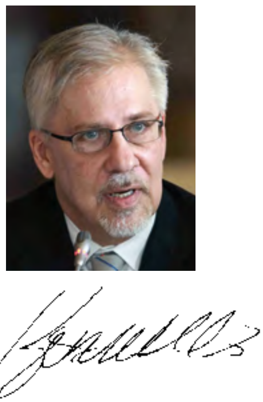
With this in mind, experts from IBM and DHL have jointly written this report to help you answer the following key questions:

- **What is AI, and what does it mean for my organization?**
- **What best practice examples from other industries can be applied to logistics?**
- **How can AI be used in logistics to reinvent back office, operational, and customer-facing activities?**

Looking ahead, we believe AI has the potential to significantly augment current logistics activities from end to end. As in other industries, AI will fundamentally extend human efficiency in terms of reach, quality, and speed by eliminating mundane and routine work. This will allow logistics workforces to focus on more meaningful and impactful work.

We think there has never been a more exciting time for collaboration between logistics and technology professionals as they enable AI in logistics. We hope you will find this an insightful read, and we look forward to working together to bring AI into your organization.

Yours sincerely,



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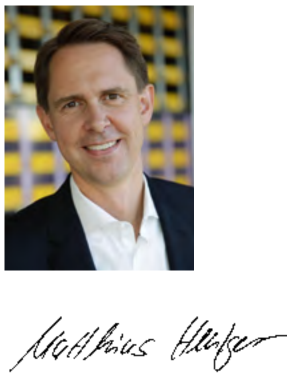

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# 1 UNDERSTANDING ARTIFICIAL INTELLIGENCE

## 1.1 Origin & Definition of AI

Artificial intelligence (AI) is not new. The term was coined in 1956 by John McCarthy, a Stanford computer science professor who organized an academic conference on the topic at Dartmouth College in the summer of that year. The field of AI has gone through a series of boom-bust cycles since then, characterized by technological breakthroughs that stirred activity and excitement about the topic, followed by subsequent periods of disillusionment and disinterest known as 'AI Winters' as technical limitations were discovered. As you can see in figure 1, today we are once again in an 'AI Spring'.

Artificial intelligence can be defined as human intelligence exhibited by machines; systems that approximate, mimic, replicate, automate, and eventually improve on human thinking. Throughout the past half-century a few key components of AI were established as essential: the ability to perceive, understand, learn, problem solve, and reason.

Countless working definitions of AI have been proposed over the years but the unifying thread in all of them is that computers with the right software can be used to solve the kind of problems that humans solve, interact with humans and the world as humans do, and create ideas like humans. In other words, while the mechanisms that give rise to AI are 'artificial', the intelligence to which AI is intended to approximate is indistinguishable from human intelligence. In the early days of the science, processing inputs from the outside world required extensive programming, which limited early AI systems to a very narrow set of inputs and conditions. However since then, computer science has worked to advance the capability of AI-enabled computing systems.

Board games have long been a proving ground for AI research, as they typically involve a finite number of players, rules, objectives, and possible moves. This essentially means that games – one by one, including checkers, backgammon, and even Jeopardy! to name a few – have been taken over by AI. Most famously, in 1997 **IBM**'s Deep Blue defeated Garry Kasparov, the then reigning world champion of chess. This trajectory persists with the ancient Chinese game of Go, and the defeat of reigning world champion Lee Sedol by **DeepMind**'s AlphaGo in March 2016.

### THE RISE OF AI

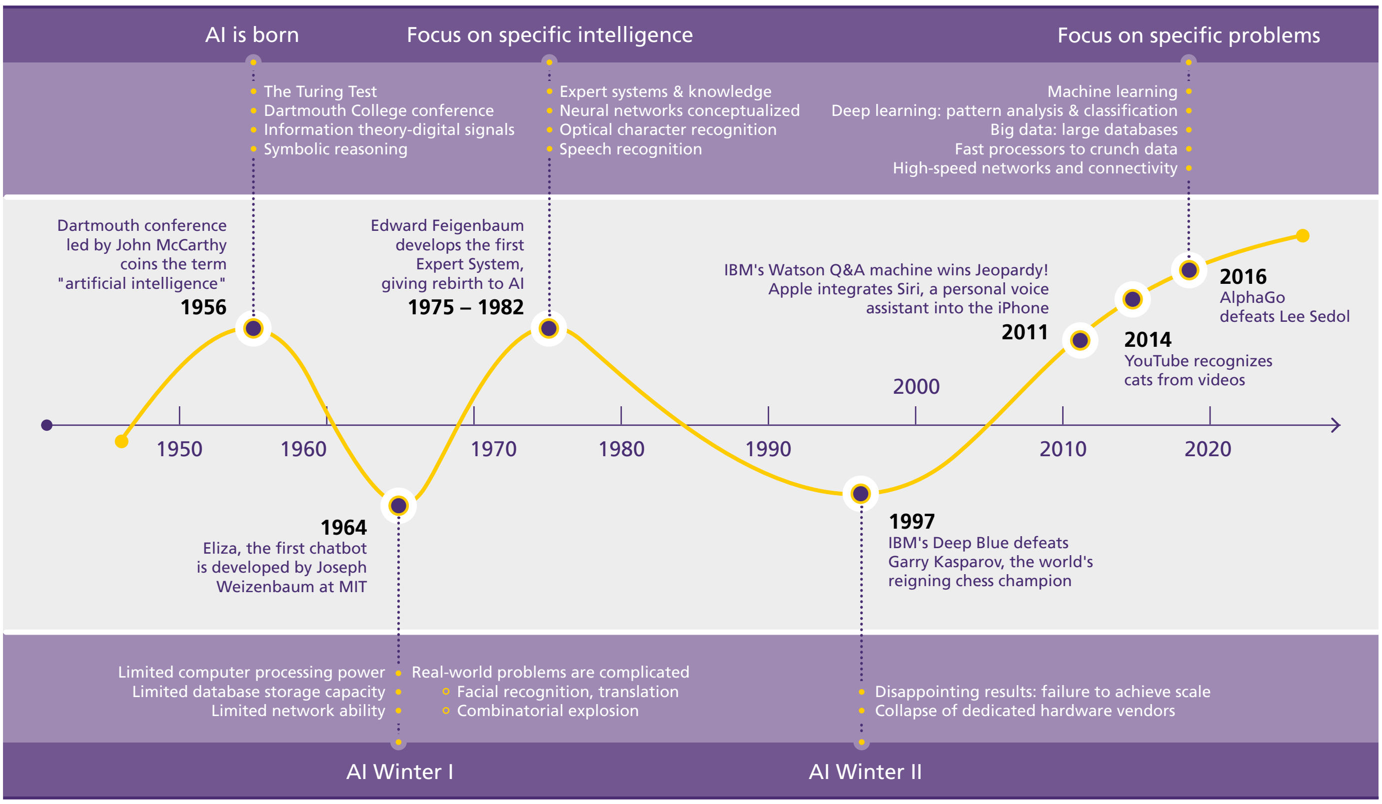



**Figure 1:** An AI timeline; **Source:** Lavenda, D./Marsden, P.

Sedol's defeat was a watershed moment for the prowess of AI technology. Previous successes had depended on what could be called a brute force approach; systems learned well-structured rules of the game, mastered all possible moves, and then programmatically decided the best move at machine speed, which is considerably faster than human decision making. In a traditional Go board of 19 by 19 lines, there are more possible combinations than the number of atoms on planet earth, meaning it is impossible for any computing system available today to master each move. DeepMind's AlphaGo effectively had to develop a sense of reasoning, strategy, and intuition to defeat Sedol; something that Go players have tirelessly tried to perfect for over 2,500 years yet DeepMind trained AlphaGo to do in a matter of months. The important outcome from Sedol's defeat is not that DeepMind's AI can learn to conquer Go, but that by extension it can learn to conquer anything easier than Go – which amounts to a vast number of things.[1]


**Figure 2:** Lee Sedol is defeated by DeepMind's AlphaGo in the ancient Chinese game of Go; **Source:** Getty Images

Current understanding of AI can quickly become convoluted with a dizzying array of complex technical terms and buzz-words common to mainstream media and publications on the topic today. Two terms in particular are important in understanding AI – machine learning which is a subset of AI and deep learning which is a subset of machine learning, as depicted in figure 3.

Whereas AI is a system or device intended to act with intelligence, **machine learning** is a more specific term that refers to systems that are designed to take in information, usually within a specific domain, and learn from what they have been given. These systems draw on the ability to evaluate and categorize received data, and then draw inferences from this. The output of this process is an insight, decision, or conclusion.

Figure 4 shows three applications based on machine learning. For example, when the input is an image of you uploaded to a social media platform, image recognition software analyzes the content of the image pixels for known patterns using machine learning algorithms in the hidden layers, and produces an output in the form of an automatic tag of your name in the uploaded photo. It is able to do this based on statistical probability that characteristics of the image resemble existing images you have uploaded previously.

## AI, MACHINE LEARNING & DEEP LEARNING

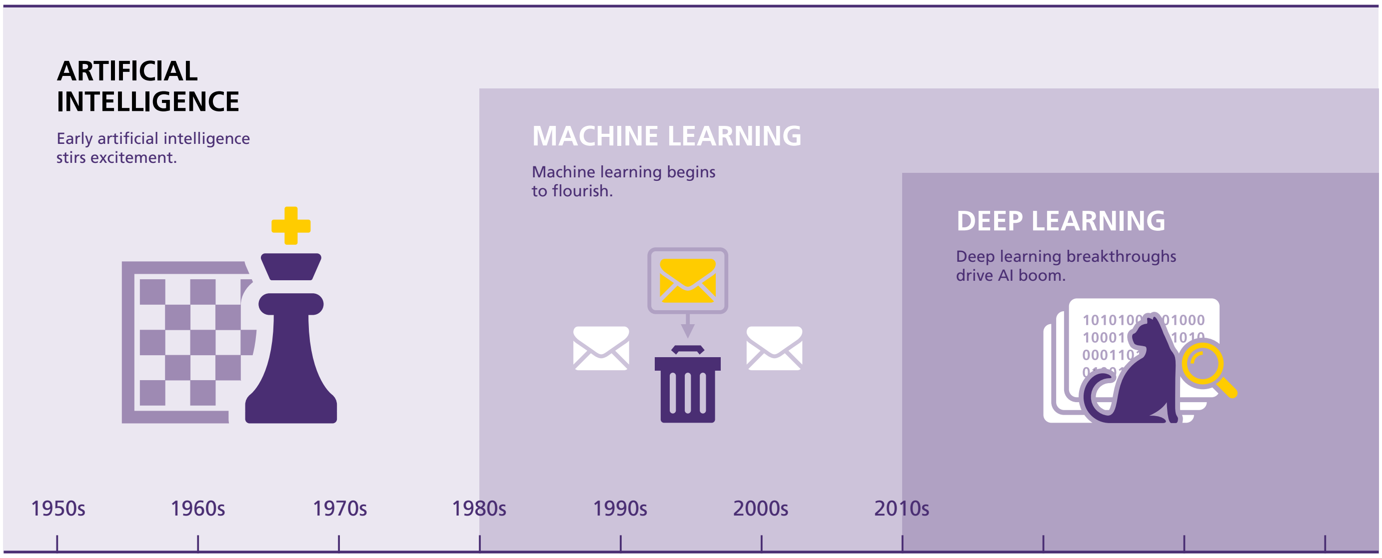
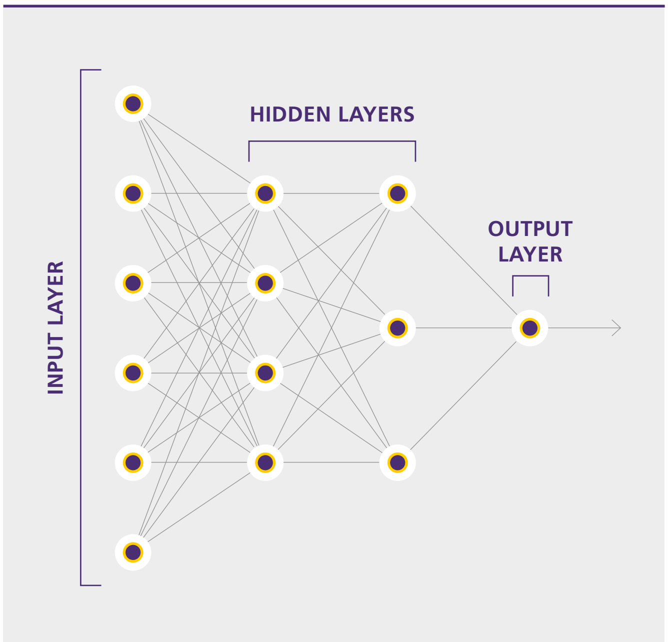



**Figure 3:** A visual representation of AI, machine learning, and deep learning; **Source:** Nvidia

[1] Moyer, C. (2016).

## DIAGRAM OF A NEURAL NETWORK




| Problem Type | Inputs | Hidden Layers | Output |
|---|---|---|---|
| Image Recognition | Picture(s) | Person? Face? Gender? Age? Hair & eye color? | Is it you? (%) |
| Loan Approval | Loan application | Income? Credit history? Employment? Marital status? | Will you repay? (%) |
| Online Ad Placement | Social media profile, browsing history | Demographics? Browsing history metadata | Will you click? (%) |

**Figure 4:** A diagram of a neural network with six inputs, seven tuning parameters, and a single output; **Source:** Nielsen, M.

**Deep learning** takes the concept of machine learning a bit further. Deep learning is about learning continually; the intention of the system is to learn from the real world and adjust the learning model as it takes in new information and forms new insights.

In simplified form, figure 5 depicts how deep learning algorithms can distinguish the content of an image, as well as where the elements of the image are in relation to one another, by analyzing pixel data alone. The human visual cortex is constantly doing this without our conscious awareness; however this perceptive ability in computers is truly novel. This is the type of system that is more useful in addressing real-world data challenges, which is why deep learning systems are the ones that have been directed at extremely large and fast-moving datasets typically found on social media platforms and in autonomous vehicles.

Deep learning is typically done with **neural networks**. Neural networks are humanity's best attempt to mimic both the structure and function of the human brain. As new data is fed into a neural network, connections between nodes are established, strengthened, or diminished, in a similar fashion to how connections between neurons in the human brain grow stronger through recurring experiences. Furthermore, each connection in a neural network can be tuned, assigning greater or lesser importance to an attribute, to achieve the quality of the output.

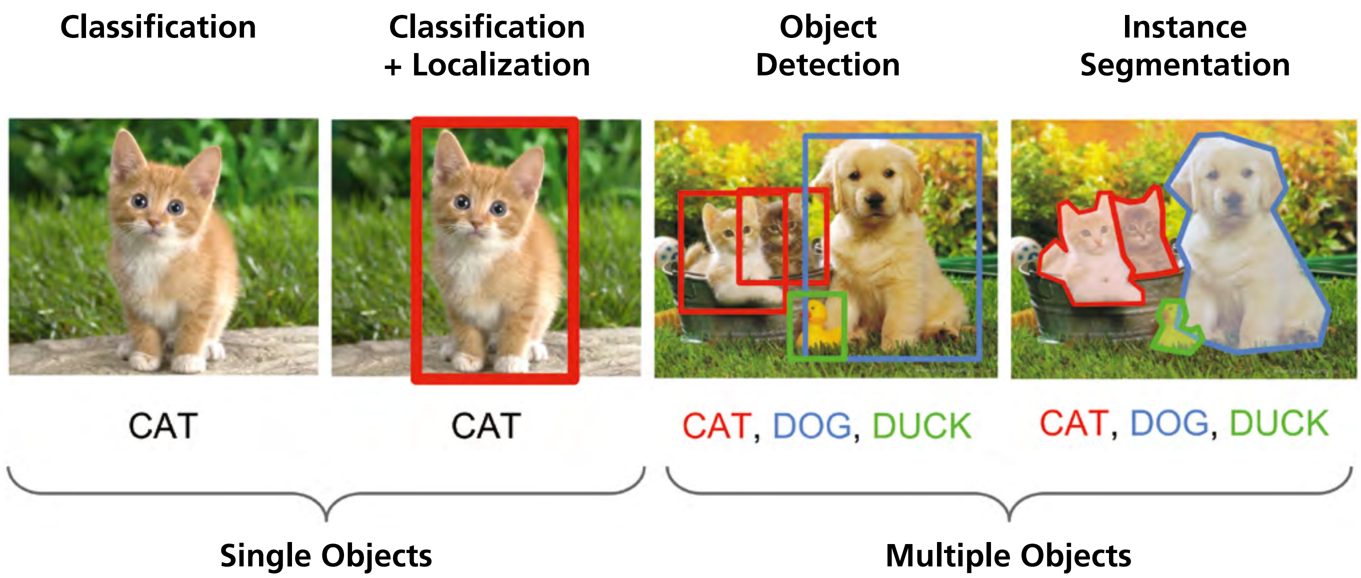



**Figure 5:** Deep learning goes beyond classifying an image to identify the content of images in relation to one another; **Source**: Stanford

## 1.2 How Machines Learn: Three Components of AI

Despite the oversimplification that tends to define AI in the popular press, AI is not one single, unified technology. AI is actually a set of interrelated technology components that can be used in a wide variety of combinations depending on the problem it addresses. Generally, AI technology consists of sensing components, processing components, and learning components (see figure 6).

### Sensing: The Fuel of AI

To be able to understand or "sense" the real world, AI must take in information. As real-world information comes in many forms, AI must be able to digest text, capture images and video, take in sound, and eventually gather information about environmental conditions such as temperature, wind, humidity, etc. – everything that is typically understood by humans through our sense of touch.

One of the most mature AI sensing capabilities is text-based processing. While AI systems have been processing structured data from databases, spreadsheets, and the internet for many years, recent advances in deep learning have improved AI's ability to process and understand unstructured data. Comments online, in social media, and even within apps are unstructured, so this critical capability dramatically increases the amount and diversity of inputs that AI can leverage to understand the world.

Much of our spoken interaction can now be captured by microphones and made sense of by AI systems. AI systems can consider the context in which spoken words were captured and, with access to large enough datasets containing similar and related phrases, can transform this once unusable data into valuable insight.

**Figure 7:** Smart speakers with AI-driven voice assistants; **Source:** Heavy

Advances in speech-to-text technology are significantly enabling voice-driven AI. Today the comprehension ability of AI-driven voice assistants is surpassing that of humans. The key metric for measuring speech-to-text performance is word error rate; effectively, how accurately does a person or system translate and interpret the words contained in a given voice sample. In a typical interaction between two people, the average percentage of words misunderstood by each person is 6%. Today the best AI-driven voice assistants are able to achieve a word error rate of 5%.

### A FULL AI LEARNING CYCLE

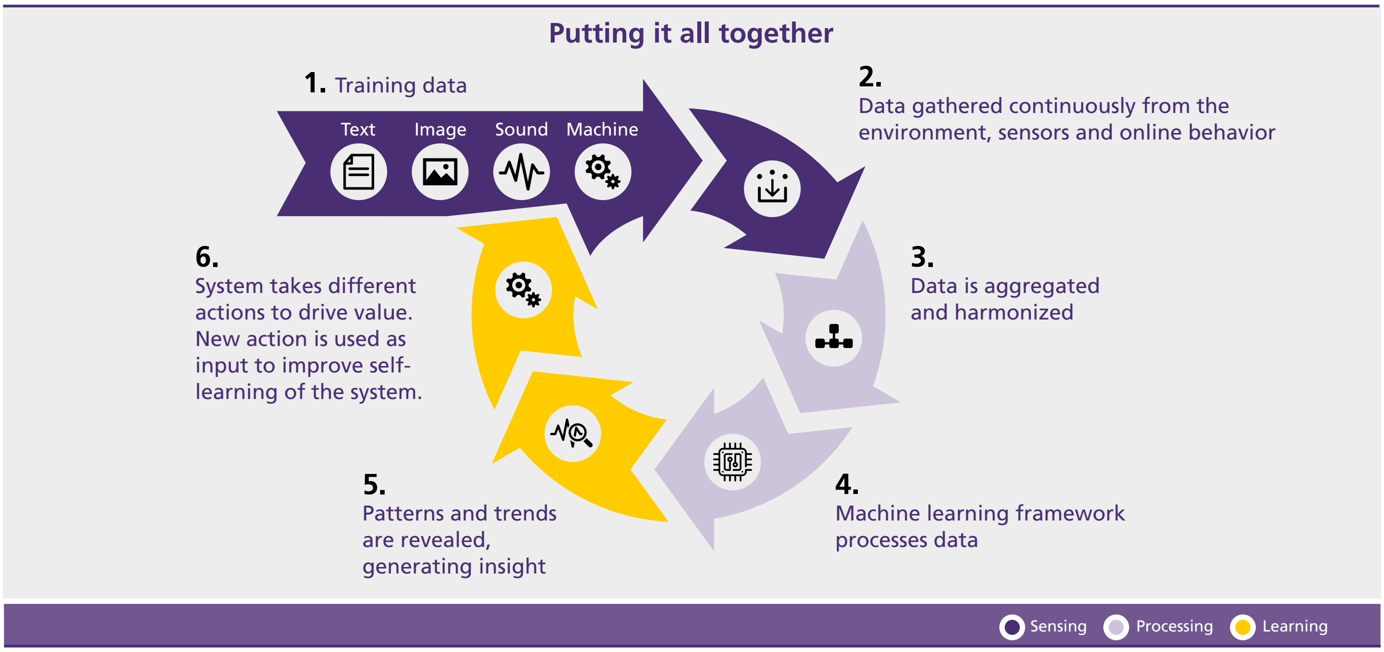



**Figure 6:** A full AI learning cycle; **Source:** IBM/DHL

And as AI-driven voice assistants improve their models and comprehension with each new query (in other words, as they are given new data to learn from) their word error rate continues to fall.[2]

Images are another rich source of insight from unstructured data. It was estimated that even four years ago 1.8 billion images were uploaded to the internet daily, and this number continues to grow.[3] Fortunately, many AI capabilities have been developed to process information from images. Companies like Google have leveraged this type of AI for years in consumer settings, and an increasing number of companies are deploying static and video-capable systems in their daily operations. As AI continues to get better at turning the vast sea of visual information into system-usable content, the accuracy with which these systems understand our world is also increasing.

The Internet of Things (IoT) is already making machine data available for consumption by AI-based systems, often for the first time. IoT involves collecting large heterogeneous datasets from vast fleets of heterogeneous devices, but making sense of this information and learning from it can be a challenging task even for the advanced data analytics tools of today.

## DEEP LEARNING IN ACTION

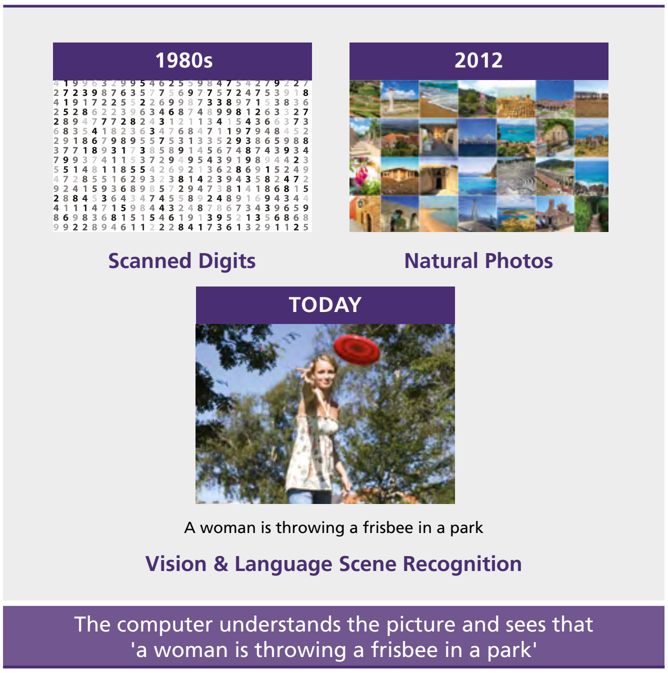



**Figure 8:** The evolution of picture understanding with deep learning; **Source:** IBM

The essence of IoT can be summarized in five parts: the connected "things" themselves, how they are connected, how data is collected, what you can learn from the data, and what you can do differently.[4] At the risk of oversimplification, AI steps in to support IoT in the fourth and fifth parts of this model, as shown in figure 9.

## AI IN THE INTERNET OF THINGS

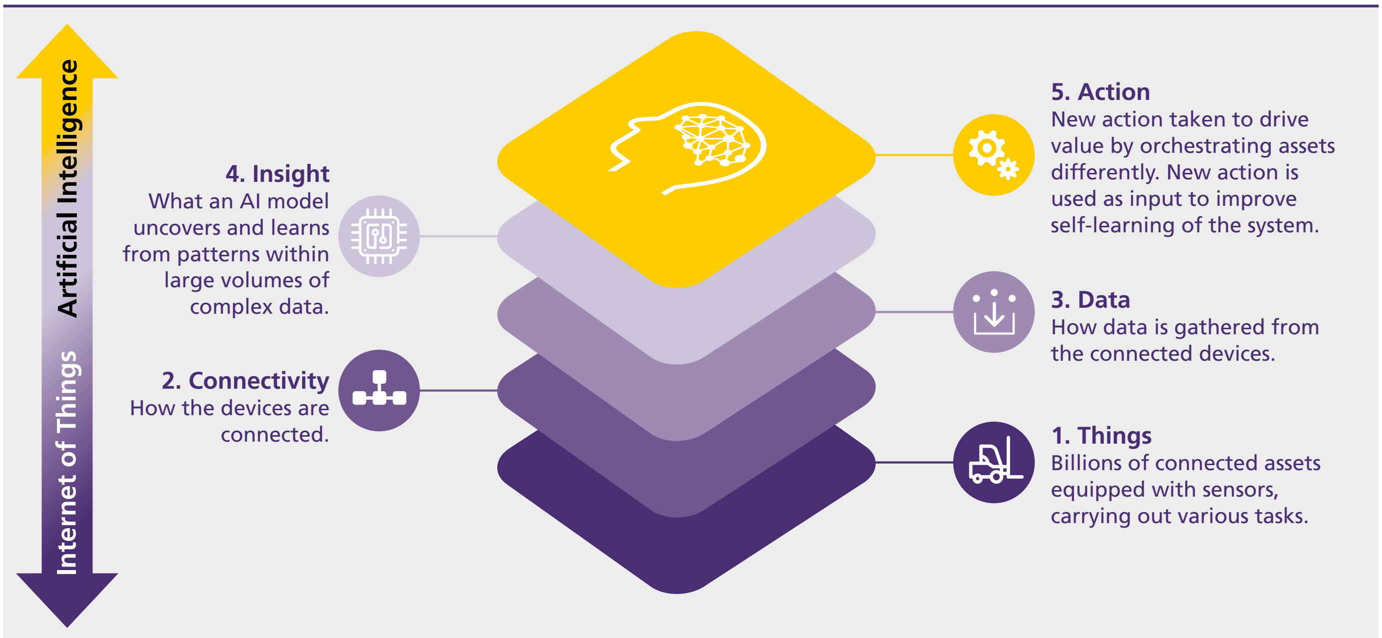



**Figure 9:** AI and IoT broken into five key components; **Source:** DHL

[2] Chen, F. (2017).
[3] Meeker, M. (2014).
[4] Chou, T. (2016).

## TAXONOMY OF MACHINE LEARNING METHODOLOGIES

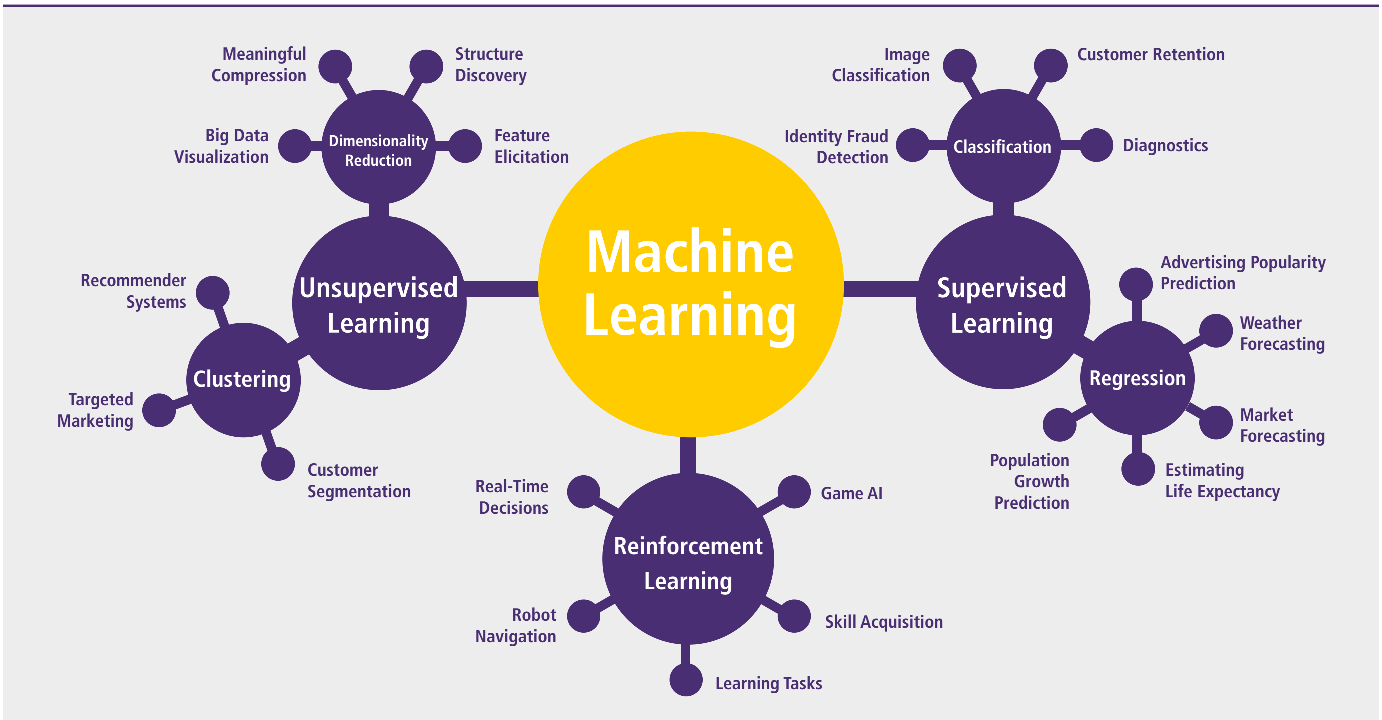



**Figure 10:** An overview of machine learning techniques; **Source:** Jha, V.

### Processing & Learning Components: Frameworks & Training Techniques

Once an AI system has collected data from sensing, it processes this information by applying a learning framework to generate insight from the data. In addition to the similarities that exist between human intelligence and AI, strong parallels have also been observed between how humans and AI systems learn. Youngsters tend to learn from their parents and teachers in highly structured settings with lots of reinforcement, whereas older, more experienced adult learners are well adapted to seeking their own inputs and learning from the world around them. Similarly, AI systems use supervised, unsupervised, and reinforcement learning to take in and process information about the world.

**Supervised learning**, as the name suggests, is learning that takes place when an AI-enabled system is directly informed by humans. A doctor who evaluates x-ray images to detect cancer risk, for example, can annotate the images with his or her expert input, then feed them into an AI system to facilitate supervised learning. Another example of supervised learning is when the AI system sorts through x-ray images for a doctor to review and approve in an effort to help improve the learning of the AI system.

**Unsupervised learning** takes place, when an AI-enabled system is able to identify clusters or dimensions in the data itself without additional guidance from human data or computer scientists. This technique can lead to significantly novel and unexpected results based on the data the system is exposed to. As an example in 2014, unsupervised learning is how YouTube was able to recognize cat faces from uploaded videos, simply by "watching" 10 million of them with little guidance of the desired output.[5]

**Reinforcement learning** takes place when the AI system is tasked with not only processing the available inputs but also learning the 'rules of the game'. This is based not on direct human interaction but on the amassed data from environmental responses given to the AI system. An analogous example of reinforcement learning is how infants first learn to walk: they first observe others until they find the ability to try it themselves. They then try to walk on their own many times unsuccessfully, but they improve their abilities each time until they can successfully walk unaided. AlphaGo used reinforcement learning techniques in this way by ingesting a large number of completed and in-process Go games in order to simultaneously figure out how the game works and how to play and beat any competitor.

Many different types of machine learning framework exist today, each with its own core functionality of a deep learning capability based on neural networks. Data scientists and software developers need to access this core functionality in order to develop AI solutions, so they must select the framework that works best with their defined AI objectives and delivers the required deep learning capability.

[5] Oremus, W. (2012).

## 1.3 Trends Accelerating AI

Core technological advances are central to the continued development of AI. Significant progress has been made with all core AI technologies, and the levels of investment and demand for ongoing improvement give good reason to expect this growth will continue well into the future. Technological advances can be classified into three broad categories: improving computer processing speed and power, increasing AI system access to big data, and using algorithmic improvements to enable more complex AI applications.

**Computing Power & Speed:** AI is a computer processing-intensive technology – breakthroughs in computing power and efficiency have enabled the expansion and complexity of AI applications. In the technology industry, Moore's Law is used to show the relationship between the cost and speed of computer processing power over time, the trajectory of which results in an exponential curve as seen in figure 12. Until recently, a computing device's CPU, or central processing unit, typically provided the core function of processing. In recent years, GPUs, or graphical processing units, have begun to partially take over computer processing workloads, contributing significantly to the rise of AI.

Originally designed for the much larger and more complex computational workloads of rendering computer gaming graphics in real time, GPUs are designed to handle hundreds of tasks in parallel, and today are successfully being used to enable AI applications.

Advances in computer chip technology are an important part of the AI developmental story. Given the consistency of chip improvements and the likelihood that chip design will continue to improve, this is not the primary reason for the existence of AI but just one of the essential enablers.

### THE DIFFERENCE BETWEEN A CPU AND GPU

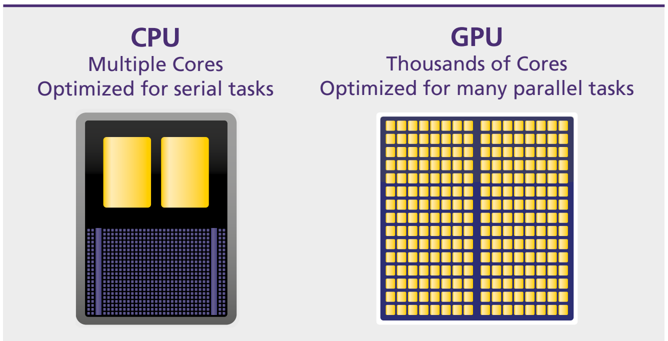



**Figure 11:** Comparison of CPUs and GPUs; **Source:** Nvidia

### LAW OF ACCELERATING RETURNS

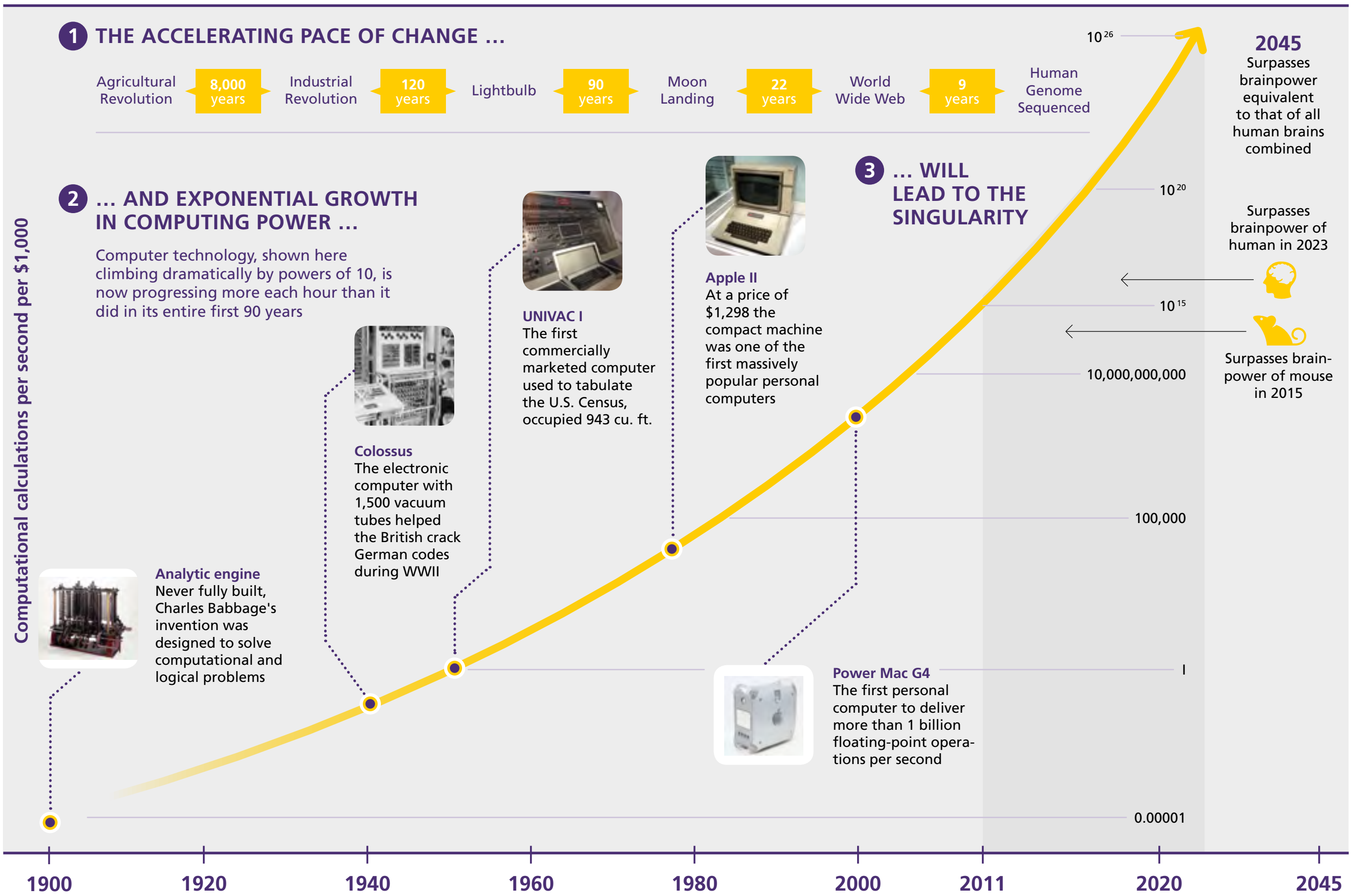



**Figure 12:** Ray Kurzweil's Law of Accelerating Returns depicts the exponential growth of computer processing power and technology innovations throughout history, and anticipates computers will exceed human intelligence in the future; **Source:** TIME / Wikipedia

**Big Data:** The existence of plentiful and easily accessible data is not a new phenomenon, however its ever-increasing volume, velocity, and variety is a key part of the AI story. Even though AI could exist on a smaller scale without these advances, AI requires data to demonstrate its full power. While new types of data have emerged in the past few years, and while there is a significant increase in the pace at which data is created and changes, AI systems are currently consuming only a tiny fraction of available data. This has been true for a long time. So even if data quantities were to stagnate, and the rates of data volume and velocity were to remain constant, AI would still have a lot of data to ingest, contextualize, and understand.

**Algorithmic Improvements:** The increasing abundance of data being created every day has invited researchers, data scientists, and software engineers to conceptualize sophisticated new algorithms capable of ingesting large volumes of complex data. Because of this, today AI is not merely-capable of handling the rapid assembly of large and quickly changing datasets but in fact thrives on this. These big datasets make the best contribution to AI's ability to learn when they are complex, so the more diversity in the data domain the better. This is an advantage AI systems have over other data processing methods: whereas standard systems get bogged down with large complex datasets, algorithmic improvements in recent years have improved significantly to be able to handle large volumes of heterogeneous data, enabling the detection of patterns and discovery of correlations that might not be obvious to humans or to standard rule-based systems. While these three technology advances are the main drivers of AI, considering the future of AI reveals not just a single trend, but the confluence of many underlying technology trends. This can be clearly seen in the Gartner Hype Cycle for Emerging Technologies (see figure 13).

Simultaneously, other important technology trends are developing along a path that complements AI, namely cloud computing and connectivity. As cloud computing advances to become a new industry standard, it allows centralized processing of large datasets. And as connectivity (through the internet and cellular networks) increases, it enables transmission and control of large datasets in real time. This means more and more datasets are being stored, processed, and accessed through the cloud, and connectivity to that information no longer limits overall system performance. As a result, the accelerating advancement of data storage, accessibility, and transmission speed is catalyzing the further development of AI. Technological factors provide essential support to the progress of AI, but their contribution pales in comparison to the way that social and commercial factors influence the viability of AI technology.

## GARTNER HYPE CYCLE FOR EMERGING TECHNOLOGIES SHOWN WITH AI INFLUENCES

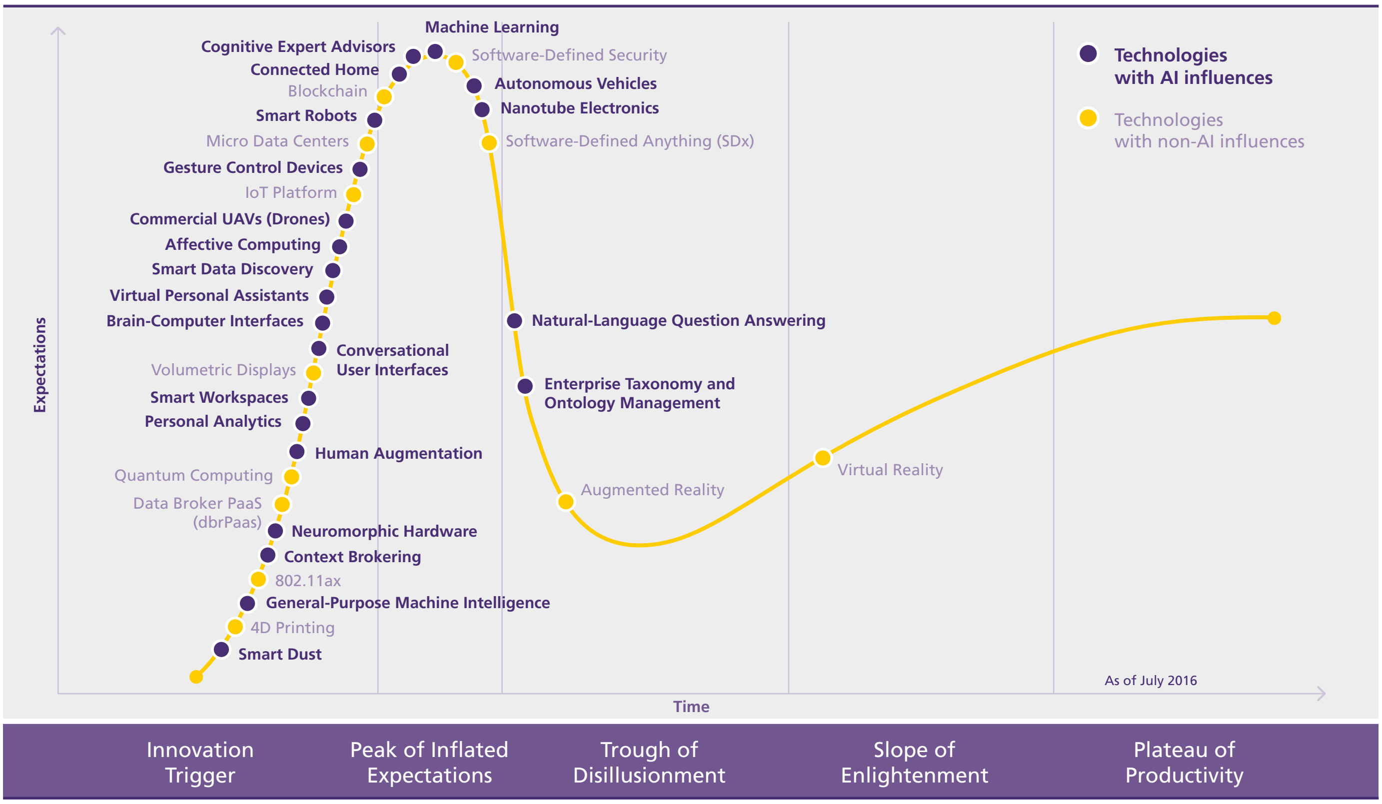



**Figure 13:** Gartner Hype Cycle shown with AI; **Source:** Gartner

**Talent & Skills:** Interest from younger generations studying AI, continued research output from academia, and strong demand for AI talent from corporations are driving progress in AI. Since 1996, the annual number of publications on AI has increased ninefold to just under 20,000 per year.[6] At the 2017 Neural Information Processing Systems (NIPS) academic conference, the world's most renowned and exclusive gathering of AI scientists and researchers, registration doubled in the past two years to accommodate nearly 8,000 attendees, with a double-digit growth rate in the number of papers submitted for the past three years.[7]

Figure 14: Stanford Professor and Google Cloud Chief Scientist Fei-Fei Li developed ImageNet in 2009 to accelerate progress in image recognition AI; **Source:** TED

Academic contributions such as Stanford's **ImageNet**, developed by Fei-Fei Li, have created an open-source repository of images used by private and commercial developers to train image recognition-based machine learning models, that today have reached over 97.3% accuracy in classifying objects, surpassing human perception abilities. Academic progress in AI today is characterized by two complementary shifts: enrollment in machine learning courses at leading universities has increased by a factor of four since 2000, and a growing number of academic leaders in AI are moving to the private sector. As one example, Fei-Fei Li pictured in figure 14, today holds the position of Chief Scientist on the Google Cloud team as well as her professorship at Stanford University.


**Figure 15:** Technology giants around the world are moving to AI first product strategies; **Source:** Johns, K.

**Heightened Technology Acceptance & Expectations:** Although many interesting innovations are created in research labs and academic institutions, it is commercial interests that tend to accelerate the changes shaping the world we experience day to day. In 2017, global smartphone adoption reached 2.5 billion users,[8] and global internet penetration reached 3.58 billion users or just over half the world's population.[9] At the same time, technology giants Amazon, Apple, Facebook, Google, IBM, and Microsoft in the US as well as technology companies Alibaba, Baidu, and Tencent in China have all adopted AI-first strategies in the products and applications they build.[10] Figure 15 depects Google's recent AI-first product strategy announcement.

As a result of this, society is increasingly accepting of technology and, by extension, of the AI elements within technology products. In developed markets around the world today, AI has become so ubiquitous and ambient that many people do not recognize they are using AI-enabled apps and services on a daily basis. Every search on Google, browse through Facebook, and website visit you make now triggers classifiers and learning models specially tailored for you.

AI is helping to decide which posts, pages, and advertisements to show you – this is something beyond the capabilities of any human or group of humans, given the four billion scale of the internet user base. People in many geographies and walks of life are increasingly dependent on technology for core aspects of their existence. This cycle of dependence on and appreciation of technology is central to the future trajectory of AI.

[6] Scopus. (2017).
[7] Wu, Q./Zhang, C. (2017).
[8] Evans, B. (2017).
[9] Statista (2016).
[10] Chen, F. (2017).

**Investment & Funding for AI:** Other contributing factors to the recent surge in progress and interest in AI are the precipitous spikes in venture capital investment in AI startups and corporate funding for AI R&D and acquisitions. In 2017 alone, a group of 100 AI startups raised $11.7 billion in aggregated funding across 367 deals, contributing to a sixfold increase in investment since 2000[11] as depicted in figure 16. Among technology corporations, Baidu and Google specifically spent between $20-$30 billion on AI in 2016, where 90% was allocated for R&D and deployment, and 10% for acquisitions.[12] Finally, 9,043 U.S. patents were issued to IBM in 2017, more than 3,300 of which were related to AI or cloud technologies.[13]

These unprecedented levels of investment are indicative of the hype surrounding AI, and underscore the value that investors and technology leaders believe AI can bring to the world. While current development of AI-based systems is centered primarily in the US and secondarily China, the growth of AI is a truly global phenomenon. Figure 17 shows the global distribution of AI startups, with representation on six continents.

**Emergence of Cognitive Enterprises:** Non-technology enterprises are also beginning their journey towards AI; in 2017 the term "artificial intelligence" was cited by CEOs in 300 quarterly earnings calls.[14] Companies in every industry are embracing digital transformation and, as this progresses, they will increasingly use AI in more and more business workflows, processes, and productivity tools.

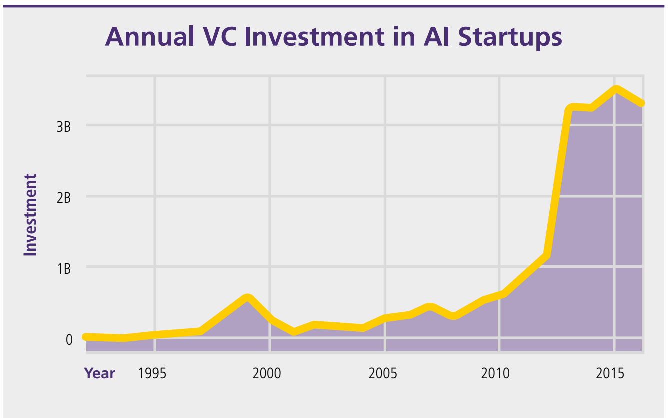



**Figure 16:** Since 2000, there has been a sixfold increase in annual venture capital investment in US startups developing AI systems; **Source:** Alindex.org

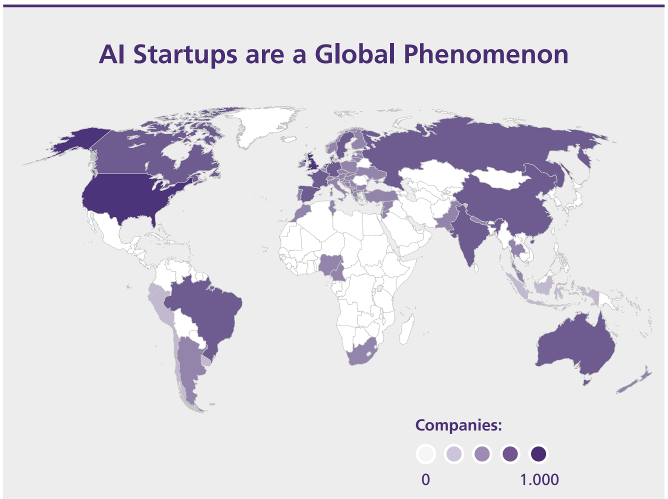



**Figure 17:** Thousands of AI startups are emerging globally; **Source:** VentureScanner

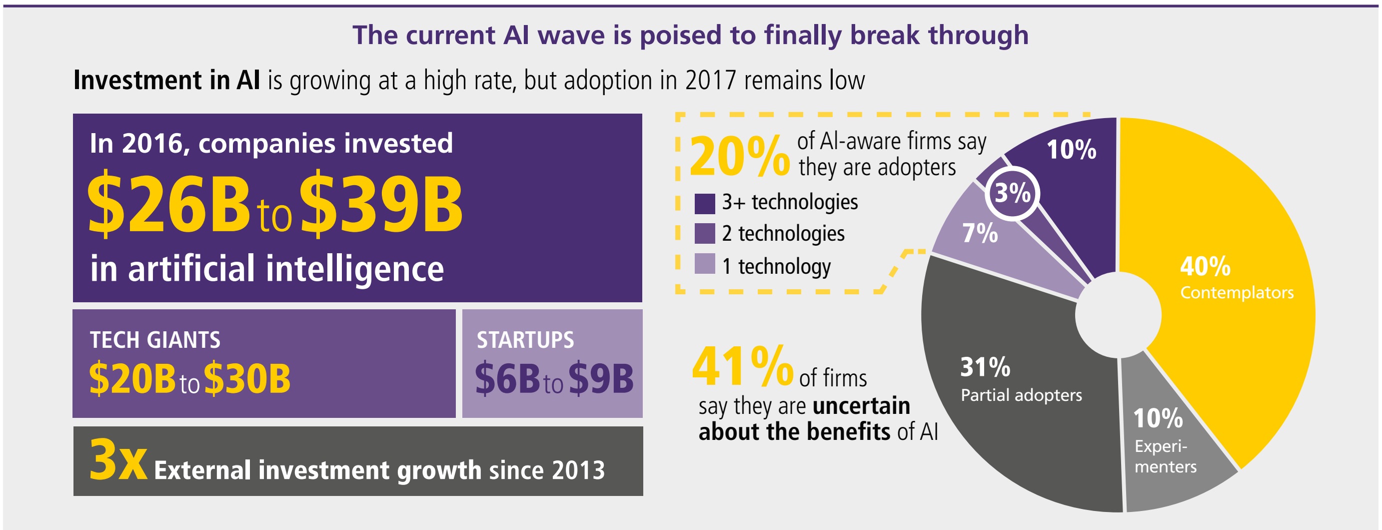



**Figure 18:** Investment in AI superseded enterprise adoption and deployment in 2016; **Source:** McKinsey

[11] CB Insights (2017).
[12] McKinsey Global Institute (2017).
[13] Quinn, G. (2018).
[14] Chen, F. (2017).

Today, about 60% of corporations in the Forbes Global 2000 are either carefully assessing AI or making productive use of it by adapting solutions to fit their specific business context, and improving and extending proven solutions. As seen in figure 18, in a McKinsey survey of 1,300 CEOs in 2016, only 20% of enterprises are already making productive use of AI technologies at scale or in their core business.

The industry sectors leading the adoption of AI are those with core products or services centered on technology. Highest AI users include technology, telecommunications, banking, and to a lesser extent automotive companies. The slowest adopters are companies uncertain about the benefits of AI. As more companies in non-technology industries start to implement AI successfully, this will convince business leaders and strategists that AI solutions are viable, offer significant benefits to many parts of the organization, and represent a worthwhile investment.

## 1.4 Challenges & Risks

Relative to its true potential, AI is still in its infancy, even if its marketing has reached maturity. A key challenge facing the progress of AI is that individuals do not trust it, largely thanks to the hype generated by the media and marketing messages from vendors of AI solutions. Much of the coverage and portrayal of AI in the popular press has focused on the concept of super-human machine intelligence also termed “super intelligence” (SI) depicted in figure 19. “General intelligence” (GI) is an AI variant that represents systems with capabilities that equate to human intelligence.

“Narrow intelligence” (NI), which describes the status of AI today, is the same idea with a more restricted scope, often focusing on just one small aspect of a larger topic. All AI in existence today and mentioned in this report falls under this category of narrow intelligence.

SI imagines a world in which AI is able to radically overtake human intelligence. Elon Musk of Tesla and the prominent Swedish philosopher Nick Bostrom have argued that AI, or more specifically SI, could have catastrophic consequences for humanity if left without an oversight. Many similar and impossibly distant theoretical fears have been associated with AI and, while these ideas are worth exploring, they are a long way away from being close enough to worry about. AI researcher and thought leader Andrew Ng summarized this well with his statement “I worry about super intelligence the same way I worry about overpopulation on Mars”[15] effectively meaning that SI could occur in a distant future, but there are still significant technical, societal, and commercial obstacles to overcome long before it becomes relevant. GI and SI are currently non-existent in corporate and industrial applications so, while these fears get lots of attention, they should not divert the focus of corporate leaders who hope to improve business performance with the use of AI.

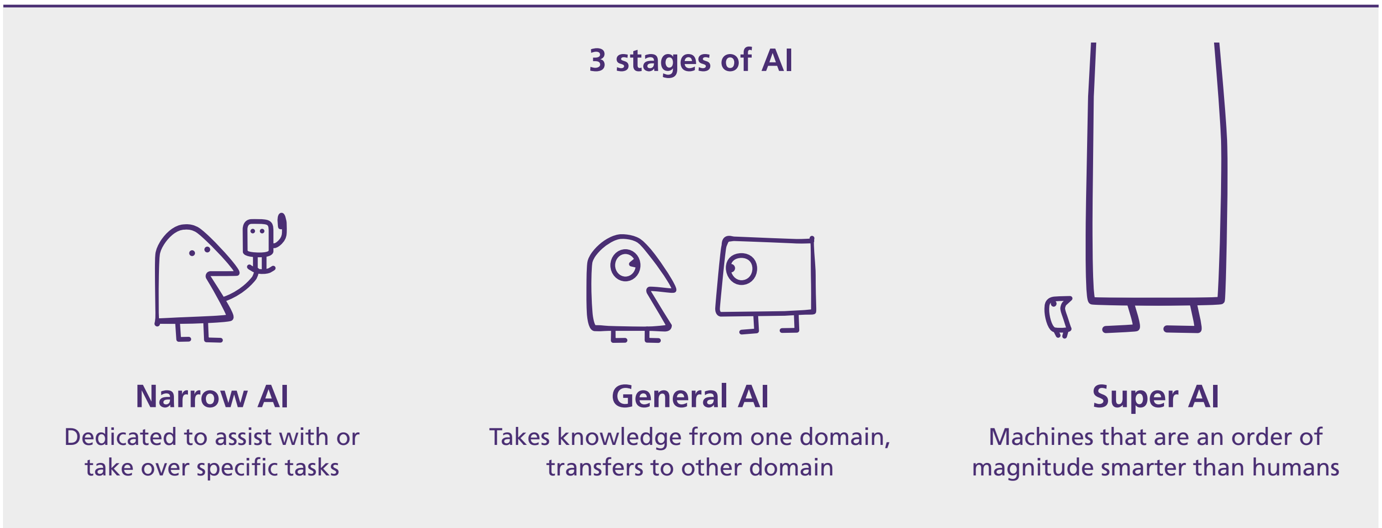



**Figure 19:** A comical but representative theoretical depiction of the three stages of AI; **Source:** van der Linde, N.

[15] Ng, A. (2017).


**Figure 20:** Collaborative robots automate repetitive tasks and can work alongside human operators; **Source:** Universal Robots

More practical fears about AI relate to its potential to improve and thus deepen the impact of automation. As AI develops, it will begin to take over functions that today require human intelligence. It is estimated in a McKinsey study that 49% of all activities that people are paid to do today could be automated by adapting currently demonstrated technology.[16] Highly repetitive, highly predictable work with a high frequency has the potential to be replaced by automation.[17] At this point in time, AI is good at automating the simple, often repetitive tasks that define many aspects of modern working life.

What's more, as the price-performance ratio of automation becomes increasingly favorable, AI-driven automation will likely replace large amounts of low- to medium-skilled human labor. Here it will become essential for individuals, societies, and governments to jointly develop mechanisms to adapt to these changes.

There is however a twist. AI will also greatly amplify the performance of individuals in their workplace. Human capital experts believe only 9% of jobs will be fully replaced by AI; the remaining majority of jobs will achieve a leap in productivity and output as AI becomes prevalent in the workplace.[18] When job displacement due to AI occurs, it is important to recall that AI follows a path of any other creative destruction scenario. Although some jobs may be lost, many more will be created in sectors and industries that are nearly impossible for us to imagine today. Once such example is the growth of medium-skilled labor to manage and operate fleets of flexible, collaborative non-industrial robots seen in figure 20.

Another knock-on effect of increased automation will be an increase in the value of human touch and connection. As AI begins to relieve humans of much routine and lower-order work, higher-order work that requires caring and empathy will become more important.

## 1.5 Why Logistics? Why Now?

There are many reasons to believe that now is the best time for the logistics industry to embrace AI. Never before has this maturing technology been so accessible and affordable. This has already made narrow forms of AI ubiquitous in the consumer realm; the enterprise and industrial sectors are soon to follow.

In logistics, the network-based nature of the industry provides a natural framework for implementing and scaling AI, amplifying the human components of highly organized global supply chains. Furthermore, companies deciding not to adopt AI run the risk of obsolescence in the long term, as competitors seize and effectively use AI in their business today.

[16] McKinsey Global Institute (2016).
[17] Sawyerr, M. (2017).
[18] Sawyerr, M. (2017).

Researchers at IBM estimate only 10% of current systems, data, and interactions include elements of AI analysis and results. However the returns on AI investments are already improving; relatively moderate outlay is generating a much larger return than ever before. But as complexity grows – with more unstructured data, more sophisticated learning algorithms and techniques, and more high-level decision-making tasks – the cumulative nature of AI means that AI analysis and results will improve even further.

There is another indicator that now is a good time for AI to flourish – this is the state of its adoption in the world today. Innovations occur first and become mainstream in the consumer world. Once a tipping point is reached, these innovations work their way into commercial enterprises and ultimately into industrial companies. AI is stretching beyond consumer ubiquity and into customer-focused commercial ventures. Eventually, once the value of AI is proven in the commercial context it will arrive in the industrial setting. The specific timing of these transitions is impossible to predict, but the fact that AI is now deeply embedded in consumer markets and is experiencing explosive growth in customer-facing commercial areas clearly indicates the use of AI in industrial sectors such as logistics is quickly approaching.

Logistics companies are uniquely positioned to benefit by applying AI in almost all aspects of the supply chain. One of the most underutilized assets in the industry is the high volume of data that supply chains generate on a daily basis. This data is both structured and unstructured, and AI will enable logistics companies to exploit it. In addition, as many logistics companies around the world embrace digital transformation, transitioning away from legacy enterprise resource planning systems to advanced analytics, increased automation, and hardware and software robotics, and mobile computing, as seen in figure 21, the next obvious step in the increasingly digital supply chain is to apply AI.

Furthermore, logistics companies depend on networks – both physical and increasingly digital – which must function harmoniously amid high volumes, low margins, lean asset allocation, and time-sensitive deadlines. AI offers logistics companies the ability to optimize network orchestration to degrees of efficiency that cannot be achieved with human thinking alone. AI can help the logistics industry to redefine today's behaviors and practices, taking operations from reactive to proactive, planning from forecast to prediction, processes from manual to autonomous, and services from standardized to personalized.

**Figure 21:** Increasingly digital supply chains are capable of much more using AI; **Source:** DHL

# 2 AI BEST PRACTICES FROM OTHER INDUSTRIES

In order to apply artificial intelligence (AI) effectively, it is helpful to examine best practice from other industries. This can inform the approach to using AI in logistics. This chapter highlights exemplary use cases from the consumer, enterprise, retail, transportation, and manufacturing industries that have comparable application potential in logistics.

## 2.1 Consumer AI: Ambient Assistance in Everyday Life

AI has been expanding into our personal lives over the past several years. In fact, this has happened so gradually yet stealthily that some 63% of global consumers do not realize they are now using AI on a daily basis.[19] In developed economies this technology has become almost ambient in our lives.

In the future, this trend will continue to accelerate, enabling us to see and understand the world in new ways, interact with computers in a natural way, and experience personalized services at global scale.

Advances in AI and computer vision are bringing a true sense of sight to our computing devices. In February 2017, the photo-based social media platform **Pinterest** introduced visual search, a technology that identifies objects in pictures or a live camera feed and then uses ID tags to present photos of related items. The idea is to show items to the user that they might find interesting or want to purchase. Now when you see something out in the real world, you can find out more about it (such as the price or where you can buy it), simply through a live photo stream of the item using the Pinterest app.

AI is also enabling us to interact with computers in natural and meaningful ways. In addition to the advances in natural language processing (NLP) that enabled the smart home speaker boom (mentioned in Chapter 1), AI can help us understand language in new ways.

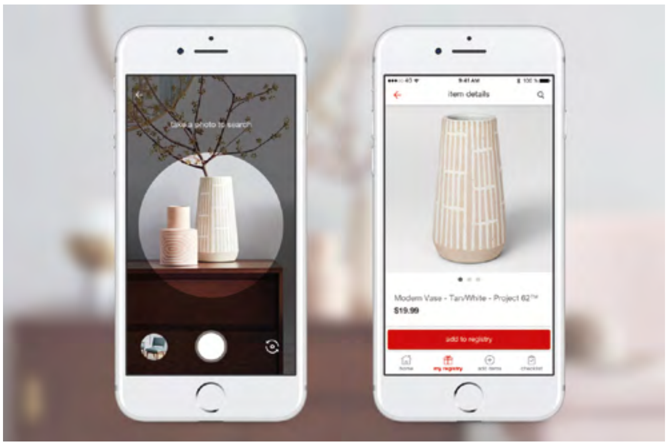


**Figure 22:** Pinterest visual search is able to make purchase recommendations based on image content; **Source:** TechCrunch

Intelligent tutoring apps like **Duolingo** use automatic speech recognition (ASR) and natural language processing (NLP) technologies to recognize errors in foreign language pronunciation and help users correct them. Taking this one step further, in November 2017 **Google** launched a pair of wireless earbuds featuring real-time translation. This solution allows users to both listen and speak in up to 40 foreign languages using the earbuds with their smartphone.

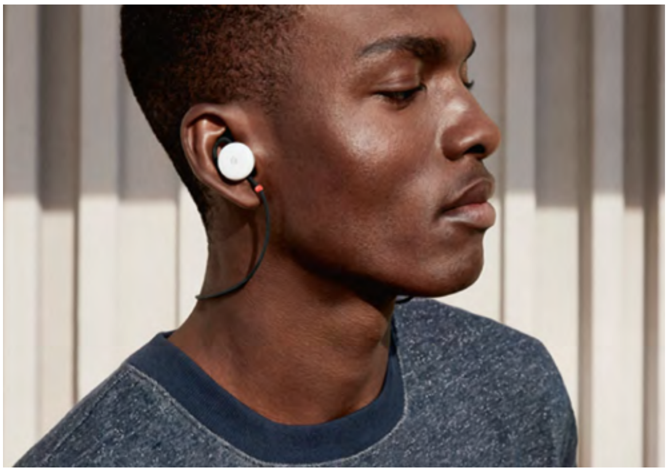


**Figure 23:** Google Pixel Buds allow real-time translation of up to 40 languages; **Source:** Google

[19] An, M. (2017).

The earbuds and translation technology depicted in figure 23 make foreign language acquisition and understanding more fun and interactive and, in addition, they break down linguistic barriers that have long been regarded as insurmountable.

AI presents the opportunity to develop highly personalized products and services to customers at scale. Today, 3.2 billion out of 4 billion internet users or 79% of the global internet population are active on social media.[20] The unstructured content within social platforms, blogs, and other user-generated content represents a gold mine for organizations to develop a significantly deeper understanding of their customers using AI-based sentiment analysis tools. These can reveal the tone and meaning held within product reviews, social media chatter, and online articles, and companies can use this information to adapt ad messages and delivery to trigger the desired consumer reactions.

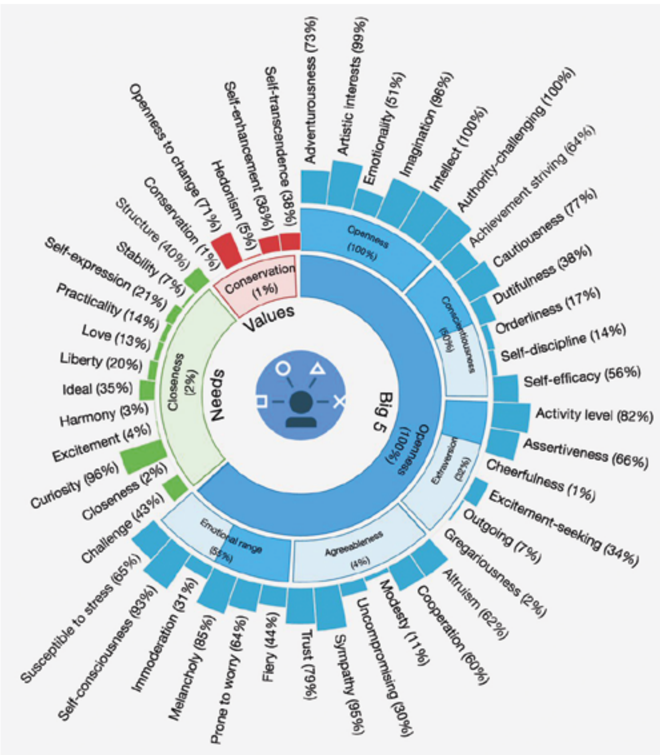



**Figure 24:** IBM Watson uses NLP to develop personality insights; **Source:** IBM

**IBM Watson's** Personality Insights tool is a good example of this. Using NLP techniques to analyze online content from any given person, this tool can develop a highly specific understanding of that person's character, as seen in figure 24.

This tool can be used for the creation of novel and personalized services. For example in the wealth management industry, IBM Watson Investment Advisor can draw correlations between a customer's personality, life situation, and the vast ocean of financial market data. These inputs can be matched with various investment alternatives to recommend an optimal personalized wealth management strategy. In addition to this, this system uses deep learning to provide financial advisors with a highly efficient and personalized way to serve clients, while indicating how to deepen relationships through other channels in their firms, such as lending solutions.

## 2.2 Enterprise AI: Working Smarter & Harder on Behalf of Professionals

As it turns out, enterprises across industries share similar needs where AI can augment the productivity and effectiveness of individual knowledge workers. As more companies in more industries embrace AI, they will begin to use it to augment core business activities. Four key use cases shared across industries are customer support, expert assist, input management, and content discovery.

**Customer Support:** This refers to the automation of customer interactions by voice or chatbots. In the enterprise, these virtual assistants are being developed to allow more complex dialogs with customers. Industry research firm Gartner predicts that by 2020, the majority of commercial interactions will take place between customers and virtual agents.[21] Though typically met with skepticism from customers, the use of chatbots and other virtual agents can be highly effective for automating low-level customer service inquiries. **Autodesk**, a global leader in computer-aided design and engineering software, has been immensely successful in this endeavor. Using the IBM Watson Conversation service, the company built the Autodesk Virtual Agent (AVA) which is able to answer 40 unique low-level queries at a rate of 30,000 interactions per month and cuts response time to customer inquiries from 1.5 days to 5 minutes, or just about a 99% reduction.

[20] Williams, B. (2017).
[21] Gartner (2011).


**Figure 25:** KLM's BlueBot enables customer interaction via popular messaging platforms; **Source:** KLM

The continual use of chatbots enables them to improve over time, and evolve to handle more complex queries. One such example is **KLM Royal Dutch Airline's** BlueBot, which started at launch by answering basic inquiries but now enables customers to book flights and even provides assistance with what to pack for a trip. Businesses around the world are capitalizing on the value of delivering higher quality customer service at lower cost through conversational interfaces.

**Expert Assist:** This refers to AI-based systems that enable knowledge workers to retrieve and produce information in a highly efficient manner. Typically, knowledge workers spend somewhere between 15 minutes and more than an hour per day searching for business information in outdated database systems and corporate intranets powered by keyword search search technology. These return low-quality results in terms of the content or responsible domain expert they are seeking. AI can reduce this search time dramatically by using automatic clustering, ontologies, and visual recognition technologies to identify for the knowledge worker the right information, content, and person. This reduces the search time by 50% or more.[22]

Expert assist can also aid in the creation of content. In 2016, US-based newspaper **The Washington Post** deployed Heliograf, a home-grown AI-based solution that could generate short reports from narratives, facts, and data provided by human reporters. Heliograf produced around 300 short reports covering the Rio Olympics and today has written over 850 articles. Media outlets using AI reporting tools say they are enabling journalists to do more high-value work, rather than taking their jobs. The US-based Associated Press estimates that these tools have freed up 20% of reporters' time spent covering corporate earnings, and even increased the accuracy of reporting by eliminating human error from the quantitative nature of financial reporting.[23]

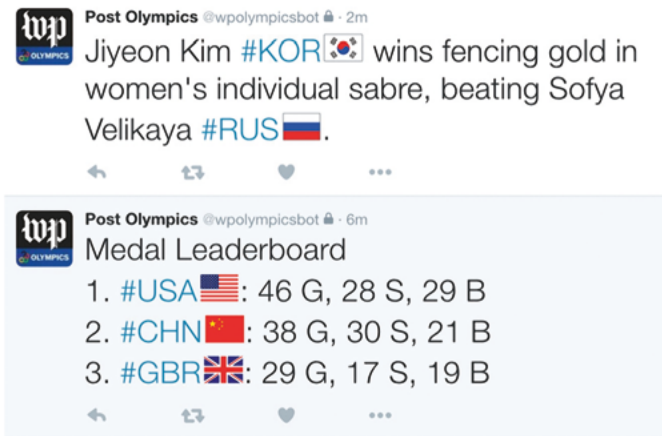



**Figure 26:** Tweets generated by the AI-powered Heliograf covering the 2016 Rio Olympics; **Source:** Kafka, P.

**Input Management:** This refers to the automatic (pre) processing of incoming mail, emails, invoices, spreadsheets, presentations, PDFs, and other documents with the help of AI. Most companies need to process large volumes of information on a daily basis. For example, the average knowledge worker sends and receives more than 120 email messages per day.

Digitization helps to reduce some of the burden: letters get scanned, invoices are entered into accounting software, presentations and spreadsheets are uploaded or accessed in shared drives in the cloud. But before this can happen, humans are typically involved – someone has to decide which department should receive the letter, which text block should be used, or who else needs to be involved.


**Figure 27:** IBM Watson's semantic analysis and processing of emails helps companies understand meaning and prioritize business activities accordingly; **Source:** Ben Hilder/Getty Images

[22] IBM (2018).
[23] Moses, L. (2017).

AI-based solutions can do some of this (pre)processing. **VKB**, an insurance company in southern Germany, has implemented an AI-powered input management tool using IBM Watson to identify the topics and sentiment from unstructured text in incoming emails and letters. This information is used to prioritize and route these items to the correct departments.

**Content Discovery:** This refers to the automatic analysis of unstructured data from emails, PDFs, pictures, audio and video, made possible by the evolution of big data analytics tools and with the help of AI.

Most companies have lots of this unstructured data – it typically represents 80% of all company data and usually does not get analyzed. IBM Watson researchers estimated that in September 2017, 17 trillion PDFs existed across all enterprises.[24] AI helps to understand different data formats and allows companies to analyze relevant data. The **Frauenhofer Society**, a leading technical research institution in Germany, is using this approach to identify emerging scientific trends and allocate researchers accordingly. This is helping to advance the progress of science through faster discovery of new insights and more effective project resourcing.[25]

## 2.3 AI in Retail: Personalized Online Experiences & Self-Learning, Replenishing Spaces

Online shopping experiences have much AI in the background. Today only 2% of online shoppers make a purchase on their first visit to an e-commerce site. Ad retargeting has therefore become commonplace, a technique to recoup the 98% of potential customers who do not purchase first time. While lucrative in some aspects, this can be incredibly annoying for many; nearly 40% of consumers do not respond to retargeted ads on principle because they immediately identify the advertiser's strategy.[26] Part of this dissatisfaction is because, like many forms of automation today, ad retargeting is largely scripted and impersonal. With access to billions of data points on user behavior and real-time advertisement availability, retailers can use AI to dynamically identify specific customer segments in higher quantities to recommend more relevant products and services.

For retailers and e-tailers that succeed in this endeavor, AI-driven recommendations can be a powerful business driver. Today, the AI-enabled content ranking and recommendation systems that are used by the video streaming service **Netflix** account for 80% of all movies watched.[27] Similarly, online retailer **Amazon**'s AI-driven product recommendations account for up to 30% of the company's revenue.


**Figure 28:** Netflix's recommendation engine uses machine learning to understand the best way to present titles, images, ordering, and rows to its users; **Source:** Business Insider

AI is not only innovating online retail; brick-and-mortar continues to be in a state of transformation as retailers seek enticing new ways to improve in-store experiences, and maximize revenue per unit of floor and shelf space. AI is coming to the aid of both these objectives.


**Figure 29:** OSHbot helps customers find what they are looking for and makes employees more productive; **Source:** Lowe's Innovation Labs

[24] Hunter, B. (2017).
[25] IBM Watson/IBM Institute for Business Value (2018).
[26] Abhishek, A. (2017).
[27] McAlone, N. (2016).

American home improvement retailer **Lowe's** is using a customer service robot called OSHbot, developed in conjunction with **Fellow Robots**, to help customers find information about a specific product, then accompany the customer to the location where they can find that product. Here, deep learning algorithms, natural language processing, and computer vision handle both the recognition of the item, down to perhaps a single nail or bolt, and comprehension of the customer request. If the robot is unable to do this on its own, it has the ability to call a human expert to assist. OSHbot is able to do real-time inventory level checks and, as a mobile telepresence unit, can connect employees between stores. This allows employees to devote more time to helping customers with complex projects, while simultaneously boosting store efficiency through enhanced inventory management and collaboration.[28]

## 2.4 Autonomous Transportation: AI Under the Hood

While there are myriad factors influencing the development, acceptance, and distribution of fully autonomous transportation, this section examines how AI is contributing to the progress of autonomous vehicles. For fully autonomous vehicles to become widely accepted, they need to significantly outperform human driving capabilities. This begins by enabling the vehicle to perceive and predict changes in its environment – something that is simply impossible without AI. Autonomy today relies on a suite of sensing technologies presented in figure 30 that work together to produce a high-definition three-dimensional map of the vehicle's environment.

Deep learning algorithms on board the vehicle process this live stream of environmental data to identify obstacles and other cars, interpret road signs, street markings, and traffic signals, and comply with speed limits and traffic laws. Since there is no possible way to hard-program an autonomous vehicle to react to every possible driving scenario in the real world, developers must turn to the continuous knowledge acquisition of deep learning. This way they can develop autonomous vehicles that constantly improve their capabilities as they are introduced to new surroundings. Traditional auto industry players such as **BMW**, **Daimler**, **Ford**, **Toyota**, and **VW** have embraced AI as a critical component in their autonomous vehicle development journeys. More famously, newer entrants like **Google**, **Tesla**, and **Waymo** have developed their own autonomous vehicles using proprietary AI and manufacturing techniques. On the other hand, automotive suppliers such as **Bosch**, **Mobileye**, **Nvidia**, **Quanergy**, and **ZF** are making components including sensors, algorithms, and data available to support further development of autonomous vehicles. In addition, mobility platform companies **Lyft** and **Uber** are partnering with established automotive companies to offer on-demand rides autonomously.

### SENSING TECHNOLOGIES IN AUTONOMOUS VEHICLES

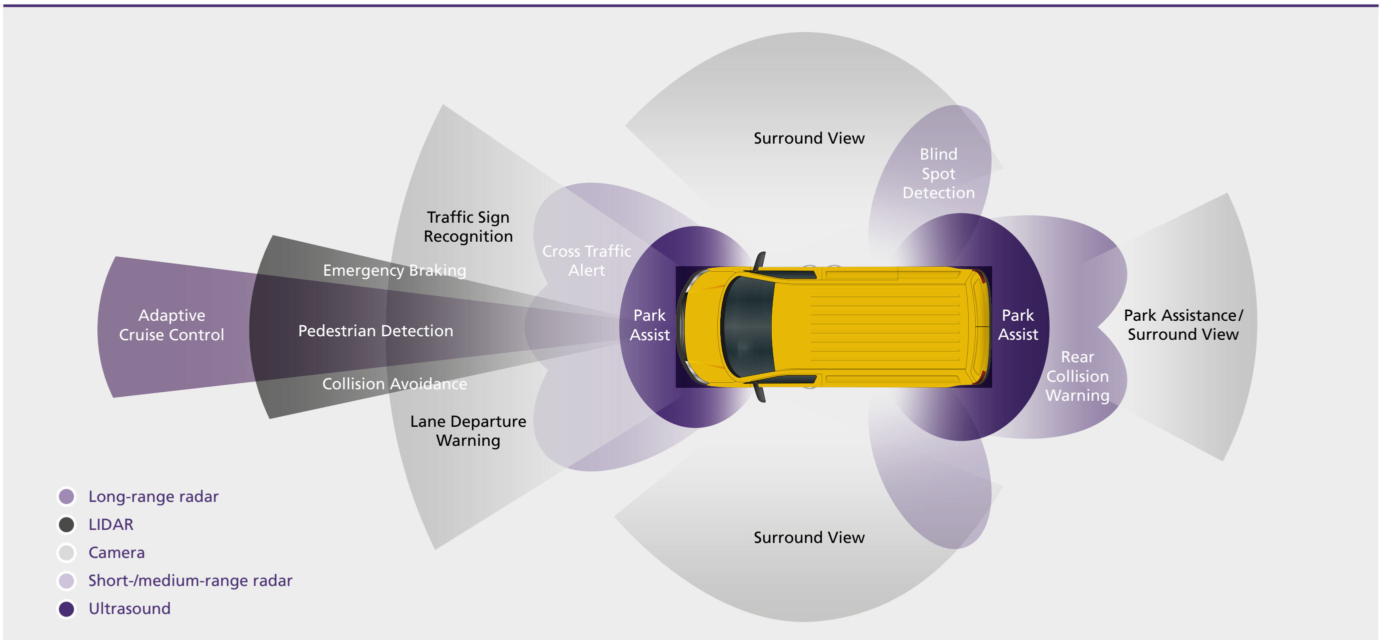



**Figure 30:** An overview of sensing technologies present in today's autonomous vehicles; **Source:** AGA

[28] Singularity University (2017).

Convenience, cost reduction, and increased efficiency in the form of lower emissions and fewer accidents are the primary drivers for autonomous vehicle use. Thanks to the falling cost of components, increasing performance of deep learning algorithms, and the growing collective body of transportation industry knowledge on the topic of autonomous driving, the supporting technology is developing rapidly. However full implementation – in other words, a vehicle without a driver in the legal sense – will necessitate significant regulatory changes in any country and this will take some time.

## 2.5 Engineering & Manufacturing: AI Shapes the Physical World

The use of AI in engineering and manufacturing signals a departure from the purely digital world. It can now shape the physical world around us. The manufacturing conglomerate **General Electric** is grappling with ways to deliver power, energy, and air travel to the world without a single interruption. Part of the answer may be to use AI to inform the production requirements and manage the continuous operation of GE's heavy machinery.

**Figure 31:** Parts for GE's commercial aircraft engines are produced and supplied by one of 20 worldwide GE Brilliant Factories; **Source:** GE

GE's Brilliant Factory program is at the forefront of AI initiatives in manufacturing. There are 20 Brilliant Factories worldwide, spanning 9 industry sectors and linking real-time data from design, engineering, manufacturing, supply chain, distribution, and service activities into one intelligent system. Data from many of these functions is processed on GE's Predix cloud-based software platform.

Being able to predict defects and failures using AI has enabled GE to reduce unplanned downtime on the shop floor by 20%, and significantly improved product quality, throughput, and yield.[29]

**Figure 32:** The John Deere production line in Mannheim uses NLP and image recognition AI to streamline production and maintenance; **Source:** John Deere

In the agricultural sector, **John Deere** is seeking ways to feed a world populated by 10 billion people with access to only a finite amount of arable land. The agricultural machinery company uses IBM Watson and a smart manufacturing platform to deliver AI-powered assembly and maintenance at its largest manufacturing plant in Mannheim, Germany.

With a deep learning-enabled camera application on their mobile device, a plant worker can photograph machinery at the workstation and Watson uses an AI image recognition algorithm to determine the cause of any fault. The worker receives an explanation from Watson about how to fix the fault. They can even interact with Watson via voice command, leveraging the system's natural language processing capabilities, to remain handsfree while working on the shop floor.

The system is connected to an intelligent order management system so, once the problem is understood and the required parts are identified from the image, the correct parts order can be placed automatically. Finally, if specialist intervention is needed, the smart manufacturing platform can check the technician's schedule and suggest the best times for maintenance.[30]

[29] GE Aviation (2017).
[30] Lee, D. (2016)

# 3 ARTIFICIAL INTELLIGENCE USE CASES IN LOGISTICS

As outlined in the previous chapters, artificial intelligence (AI) has a growing presence in our personal lives and is rapidly being applied by businesses to increase efficiency and create new value. Drawing inspiration from best-practice examples of AI in several different industries, there are numerous opportunities for AI to be applied in logistics.

## 3.1 Back Office AI

In an increasingly complex and competitive business world, companies that operate global supply chains are under unprecedented pressure to deliver higher service levels at flat or even lower costs. At the same time internal functions of global corporations such as accounting, finance, human resources, legal, and information technology are plagued by large amounts of detail-oriented, repetitive tasks. Here, AI presents a significant opportunity to save time, reduce costs and increase productivity and accuracy with cognitive automation.

**Cognitive Automation** refers to intelligent business process automation using a combination of AI and robotic process automation (RPA). This is the replacement of clerical labor using software robots that can be integrated into existing business applications and IT systems.[31] As seen in figure 33, RPA is not equivalent to AI; where AI is able to learn and extract insights from unstructured data, RPA is able to execute rule-based workstreams given well-structured inputs on behalf of human workers, and cannot learn beyond its initial programming.

**RPA AND AI: THE BRAWN AND BRAINS OF PROCESS AUTOMATION**

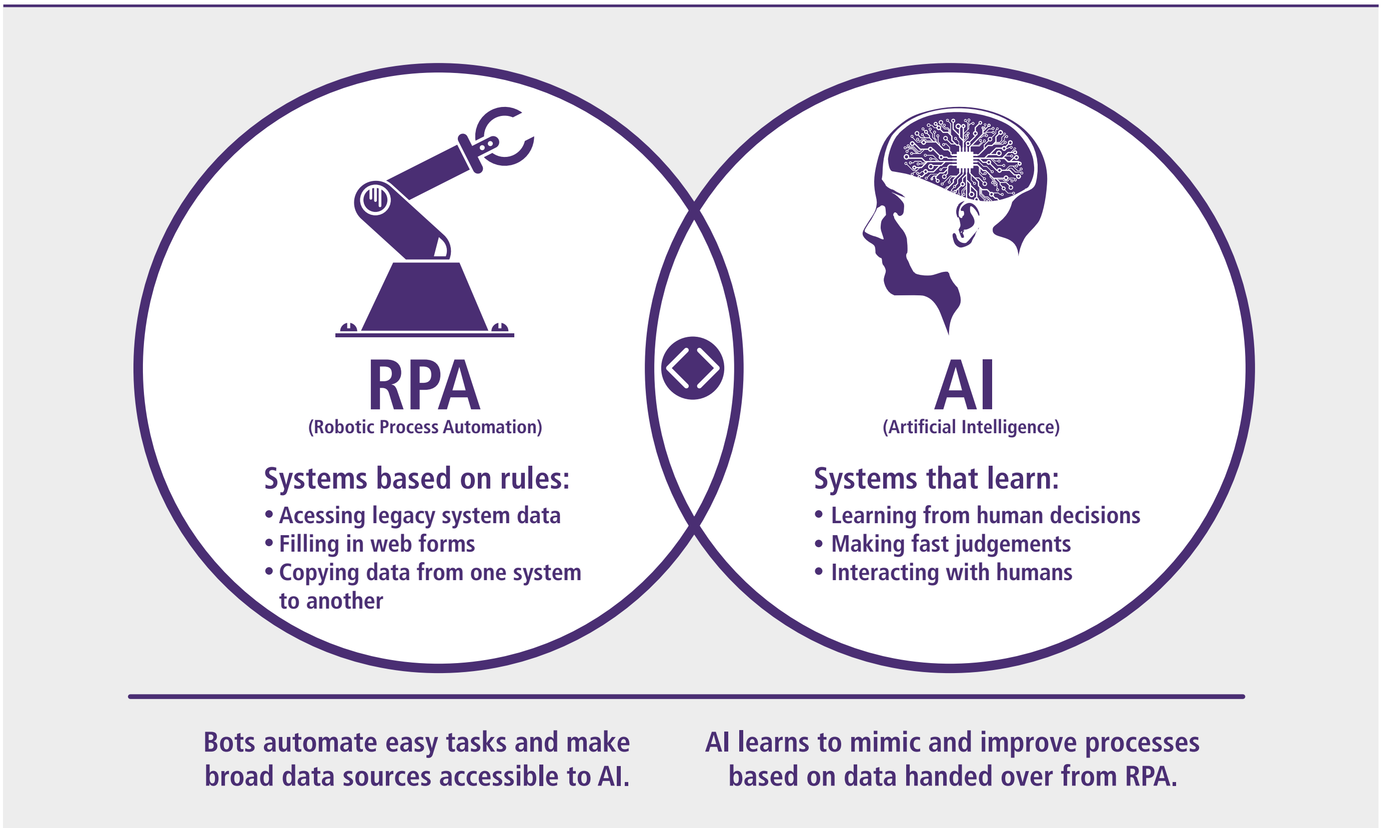



**Figure 33:** A comparison of RPA and AI; **Source:** Boston Consulting Group

[31] Kalakota, R. (2016).

## HOW RPA CAN SUPPORT BACK OFFICE PROCESSES

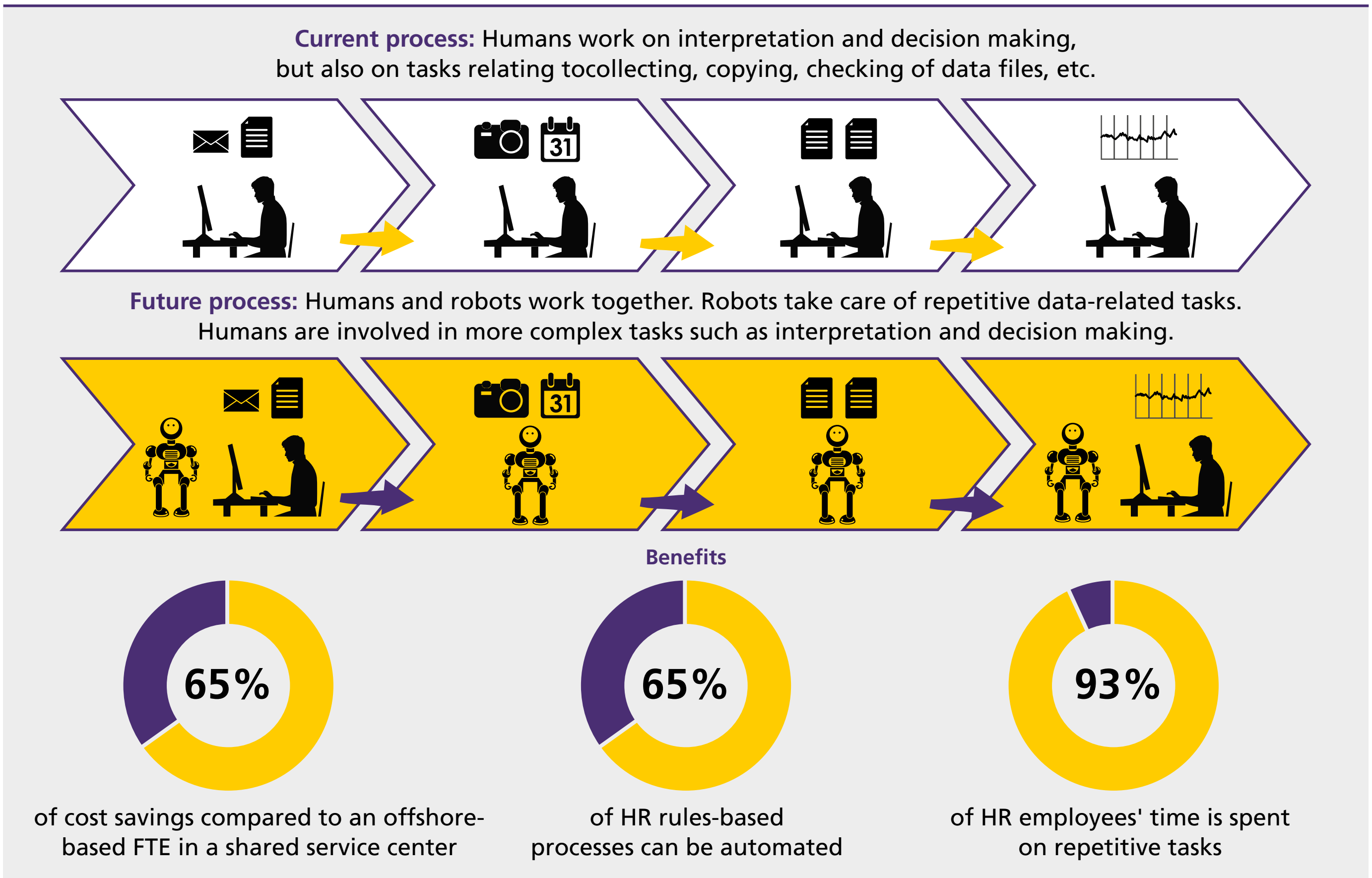



**Figure 34:** A comparison of current back office processes and future processes assisted with RPA; **Source:** Ernst & Young

**Financial Anomaly Detection:** Logistics service providers often rely on vast numbers of third parties including common carriers, subcontracted staff, charter airlines, and other third-party vendors to operate core functions of their business. This puts an increased burden on logistics accounting teams to process millions of invoices annually from thousands of vendors, partners, or providers. Here, AI technologies like natural language processing can extract critical information such as billing amounts, account information, dates, addresses, and parties involved from the sea of unstructured invoice forms received by the company.

Once the data is well-classified, an RPA bot can take it and input it into existing accounting software to generate an order, execute payment, and send the customer a confirmation email, all without human intervention. Consultancy firm **Ernst & Young** (EY) is applying a similar approach for detection of fraudulent invoices. Using machine learning to thoroughly classify invoices from international parties and identify anomalies for expert review helps EY comply with sanctions, anti-bribery regulations, and other aspects of the US Foreign Corrupt Practices Act. EY's fraud detection system achieves 97% accuracy and has been rolled out to over 50 companies.[32] Similar logic can be applied to any business process with high-frequency repetitive tasks.

**Figure 35:** AI and RPA can process critical business information to help empower teams; **Source:** DHL

[32] Zhou, A. (2017).

**Cognitive Contracts:** Global logistics and supply chain operators typically manage large fleets of vehicles and networks of facilities worldwide. **Leverton** uses AI on its platform of the same name to simplify the processing and management of real estate contracts for businesses. The system uses natural language processing to classify any contractual clauses, policy-relevant sections, and signature portions. Paired with a human-in-the-loop to review these findings, contracts written in complex legal language often several hundred pages in length can be processed in a fraction of the time it would take a team of human experts.

Keeping customer information up to date is a challenge for large enterprises; up to 25% of all phone numbers and email addresses stored in digital contact applications are no longer in use.[33] In the logistics industry, keeping address information complete and current is critical for successful delivery of shipments. Often, large teams of data analysts are tasked with CRM cleanup activities, eliminating duplicate entries, standardizing data formats, and removing outdated contacts. American startup **CircleBack** has developed an AI engine to help manage contact information, continually processing billions of data points to determine whether contact information is accurate and up to date.[34] Furthermore as mentioned in Chapter 2, AI tools trained in input management can use natural language processing to do some pre-processing of customer address information to ensure completeness, correctness, and consistency with global and regional address formats.

**Cognitive Customs** refers to customs brokerage processes augmented and automated using AI. At the risk of oversimplification, customs brokerage services generally involve the following four major steps:

1. Shipment data and documents (bills of lading, commercial invoices) are received from customer shipments. Heterogeneous document formats and various degrees of completeness must be harmonized before declaration.
2. Once all necessary data and documents are thoroughly completed and successfully harmonized, the goods are declared, and must be translated into valid customs codes to be accepted by customs.
3. Customs officers validate the given information, provide tax statements, and release goods.
4. Brokerage costs are invoiced to the customer according to commercial agreements.


**Figure 36:** AI can assist address management for logistics providers, ensuring successful delivery; **Source:** DHL

The major issue with customs declarations today is that they rely on highly complex manual processes that require skillful knowledge of regulations, industries, and customers. It is also an effort-intensive process; information must be cross-referenced and validated from customer and carrier documents, regulatory bodies, and government-specific forms. All of this necessitates close attention to detail yet, of course, it is difficult for human workers to maintain consistent levels of concentration throughout the workday. This can result in costly mistakes; companies may incur non-compliance fees and demurrage charges for goods held in customs too long.

The solution is AI for customs brokerage; an enterprise AI platform like IBM Watson can be trained with legislative materials, regulatory documents, customs brokerage SME knowledge, and customer and industry handbooks to learn how to automate customs declarations. Using natural language processing and the self-learning capabilities of deep learning, a customs brokerage AI could ingest customs documents in myriad formats, extract relevant information using its collected body of knowledge, and present an automatic declaration. When the AI-based system runs into an exception case, a human customs brokerage expert could review the declaration. Their input as well as each automated declaration provides new data with which the AI-based system can continue to improve its performance.

[33] Deloitte (2016).
[34] Deloitte (2016).

## 3.2 Predictive Logistics: The Next Operational Paradigm

In a world characterized by uncertainty and volatility, AI can help the logistics industry fundamentally shift its operating model from reactive actions and forecasting to proactive operations with predictive intelligence. This section will identify both global, network-level prediction opportunities as well as process-specific prediction opportunities.

**Predictive Network Management** using AI can significantly advance the performance of logistics operations. For air freight, on-time and in-full shipment is critical as it represents only 1% of global trade in terms of tonnage but 35% in terms of value.[35] Most air freight lanes and networks are planned using historical data and expertise from professionals with decades of industry experience. **DHL** has developed a machine learning-based tool to predict air freight transit time delays in order to enable proactive mitigation. By analyzing 58 different parameters of internal data, the machine learning model is able to predict if the average daily transit time for a given lane is expected to rise or fall up to a week in advance. Furthermore, this solution is able to identify the top factors influencing shipment delays, including temporal factors like departure day or operational factors such as airline on-time performance. This can help air freight forwarders plan ahead by removing subjective guesswork around when or with which airline their shipments should fly as shown in figure 37.


**Figure 37:** Different air freight carriers lined up in Hong Kong; **Source:** Air Cargo News

**Figure 38:** The fidget spinner flash craze created a large unanticipated spike in supply chain demand; **Source:** Wasp Buzz

The need for **Predictive Demand and Capacity Planning** is self-evident in the fidget spinner boom of 2017. The three-paddle shaped spinning toy suddenly and unexpectedly sold an estimated 50 million units in a period of several months. In the US, fidget spinners quickly shot up to 20% of all retail toy sales in this period.[36] This inundated air freight and express networks with shipment volumes, shown in figure 39, as toy merchants rejected the normal lead times associated with ocean shipment of manufactured goods.

The first videos of teenagers doing tricks with fidget spinners began trending on YouTube in February 2017. Hidden deep within online browsing data, YouTube video views, and conversations on social media, AI in its current state is able to identify both the quantitative rise in interest in a topic, as well as the context of that interest from semantic understanding of unstructured text. This enables predictions to be made about which fads could boom in a similar fashion to fidget spinners. Thanks to the speed and efficiency of global supply chains and express networks, even a few weeks' lead time provides significant advantage to merchants facing unexpected spikes in demand.

**Figure 39:** Predicting spikes in demand for specific goods is critical to keep networks moving efficiently; **Source:** DHL

[35] Boeing (2016).
[36] The Economist (2017).

**DHL**'s Global Trade Barometer is a unique early indication tool for the current state and future development of global trade. The tool uses large amounts of operational logistics data, advanced statistical modeling, and artificial intelligence to give a monthly outlook on prospects for the global economy. The model takes a bottom-up approach and uses import and export data of intermediate and early-cycle commodities from seven countries to serve as the basis input for the system, measured in air freight and containerized ocean freight levels. Overall, the system regularly evaluates 240 million variables from seven countries (China, Germany, Great Britain, India, Japan, South Korea, and the US) that represent 75% of global trade.[37] An AI engine, together with other non-cognitive analytical models, expresses a single value to represent the weighted average of current trade growth and the upcoming two months of global trade. Tests with historical data reveal a high correlation between the DHL Global Trade Barometer and real containerized trade, providing an effective three-month outlook for global trade.

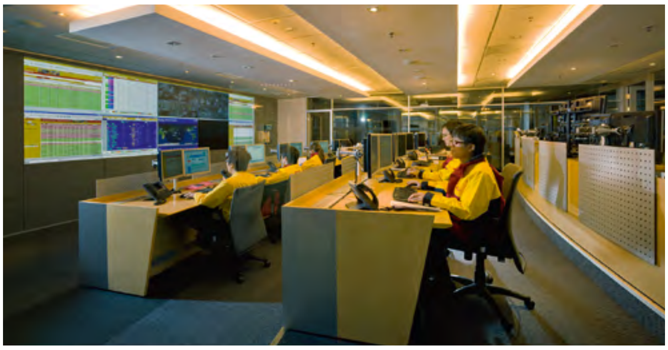


**Figure 40:** DHL's Resilience360 platform uses ML and NLP to identify supplier-side risks; **Source:** DHL

**Predictive Risk Management** is critical for ensuring supply chain continuity. The DHL Resilience360 platform is a cloud-based supply chain risk management solution that has been tailored to the needs of global logistics operators. For supply chain leaders in many industries, including the automotive, technology, and engineering and manufacturing sectors, managing the flow of components from thousands of worldwide suppliers is a regular part of daily business. Problems with suppliers, from material shortages to poor labor practices and even legal investigations, can cause critical disruptions in the supply chain.

The Resilience360 Supply Watch module demonstrates the power of AI to mitigate supplier risks. Using advanced machine learning and natural language processing techniques, Supply Watch monitors the content and context of 8 million posts from over 300,000 online and social media sources.[38] This allows the system to understand the sentiment of online conversations from unstructured text to identify indicators of risk ahead of time. This in turn allows supply chain managers pictured in figure 40 to take corrective action earlier, and avoid disruption.


**Figure 41:** DigitalGlobe enables satellites to recognize details of objects up to 30cm in size. **Source:** DigitalGlobe

**Intelligent Route Optimization** is critical for logistics operators to efficiently transport, pick up, and deliver shipments. Logistics providers and last-mile delivery experts typically have deep explicit and implicit knowledge of cities and their physical characteristics. However, new customer demands such as time-slot deliveries, ad-hoc pickups and instant delivery are creating new challenges with intelligent route optimization. **Deutsche Post DHL Group** pioneered the SmartTruck routing initiative in the early 2000s to develop proprietary real-time routing algorithms for its fleet operators and drivers. Recently new soft infrastructure of cities such as digital and satellite maps, traffic patterns, and social media check-in locations are creating a wealth of information that can augment systems like SmartTruck and improve the overall routing of truck drivers on delivery runs.

Satellite imagery company **DigitalGlobe** shown in figure 41 delivers high-resolution pictures of the planet's surface to ride-sharing giant **Uber**. These images provide rich input sources for the development of advanced mapping tools to increase the precision of pick up, navigation, and drop off between its drivers and riders. DigitalGlobe's satellites can decipher new road-surface markings, lane information, and street-scale changes to traffic patterns before a city adds themto its official vector map.[39] This level of detail from satellite imagery can provide valuable new insight to planning and navigating routes not only for the transport of people but for shipments as well.

[37] DHL (2018a).
[38] DHL (2018b).
[39] Meyer, R. (2016).

## 3.3 Seeing, Speaking & Thinking Logistics Assets

AI also stands to greatly benefit the physical demands of working in modern logistics. The use of AI-enabled robotics, computer vision systems, conversational interfaces, and autonomous vehicles is the physical embodiment of AI in logistics operations, welcoming in a new class of tools to augment the capabilities of today's workforce.

**Figure 42:** The sorting of unstructured parcels is a challenging, manual task today; **Source:** SCMP

**Intelligent Robotic Sorting** is the effective high-speed sorting of letters, parcels, and even palletized shipments – one of the most critical activities of modern parcel and express operators. Every day millions of shipments like those shown in figure 42 are sorted with a sophisticated array of conveyors, scanning infrastructure, manual handling equipment, and personnel. The logistics industry can draw on AI-driven robotics innovations from the recycling industry. The Finnish company **ZenRobotics** has been developing intelligent robotic waste sorting systems since 2011. The company's ZRR2 robotic system uses a combination of computer vision and machine learning algorithms embedded in off-the-shelf robotic arms in a synchronized way to sort and pick recyclables from moving conveyor belts. The AI engine ingests real-time data from three different cameras and sensor types, and is trained to identify a wide variety of food and beverage cartons by recognizing logos, labels, and 3D forms.[40] The result is a system consisting of two AI-powered robotic arms that can sort unstructured recyclables on a moving conveyor belt at a rate of 4,000 items per hour with high degrees of precision.[41] This suggests a useful AI application in logistics. Similar sorting capabilities could theoretically be applied to parcel and letter-sized shipments to reduce human effort and error rates.

**Figure 43:** Overview of the ZenRobotics recycling sorter; **Source:** Recycling Magazine

Autonomous guided vehicles (AGVs) are already starting to play a bigger role in logistics operations. Within any given logistics operation, it is typical to see multiple people operating material handling equipment such as forklifts, pallet jacks, wheeled totes, and even tugging cars to move goods between locations or vessels. To reduce this, companies today are beginning to use non-industrial, collaborative robotics, including AGVs. AI is a key part of this story.

**Figure 44:** GreyOrange AGVs use AI-based navigation and collaboration to learn and to improve their performance over time; **Source:** GreyOrange

[40] Kite-Powell, J. (2017).
[41] ZenRobotics. (2018).

**GreyOrange**, a Singapore-founded automation and robotics company that develops self-navigating AGVs like those shown in figure 44 recently also launched GreyMatter, its next generation software platform.[42] One of the company's launch partners for both innovations is Nitori, a Japanese furniture and home furnishings chain. As the name suggests, GreyMatter makes use of AI to allow real-time collaboration between AGVs, enabling optimized navigation path planning, zoning, and speeds, as well as self-learning to improve AGV capabilities over time. When given orders to fulfil, the AGVs and the platform are aware of each item that is being transported and the routes that are taken to retrieve and deliver these items. Nitori is using this valuable data to achieve the most efficient handling routes and predict product popularity and seasonal trends[43] – self-optimizing operations that ensure ever-shortening fulfilment times as well as real-time visibility of product demand.

**AI-Powered Visual Inspection** is another high-potential area for AI in the logistics operational environment. As noted in Chapter 2, advances in computer vision are allowing us to see and understand the world in new ways, and logistics operations are no exception. IBM Watson is using its cognitive visual recognition capabilities to do maintenance of physical assets with AI-driven visual inspection.

In industrial sectors like logistics, damage and wear to operational assets over time are simply inherent. Using a camera bridge to photograph cargo train wagons, IBM Watson was recently able to successfully identify damage, classify the damage type, and determine the appropriate corrective action to repair these assets. First, cameras were installed along train tracks to gather images of train wagons as they drove by. The images were then automatically uploaded to an IBM Watson

## HOW IBM WATSON LEARNS VISUAL INSPECTION OF LOGISTICS ASSETS

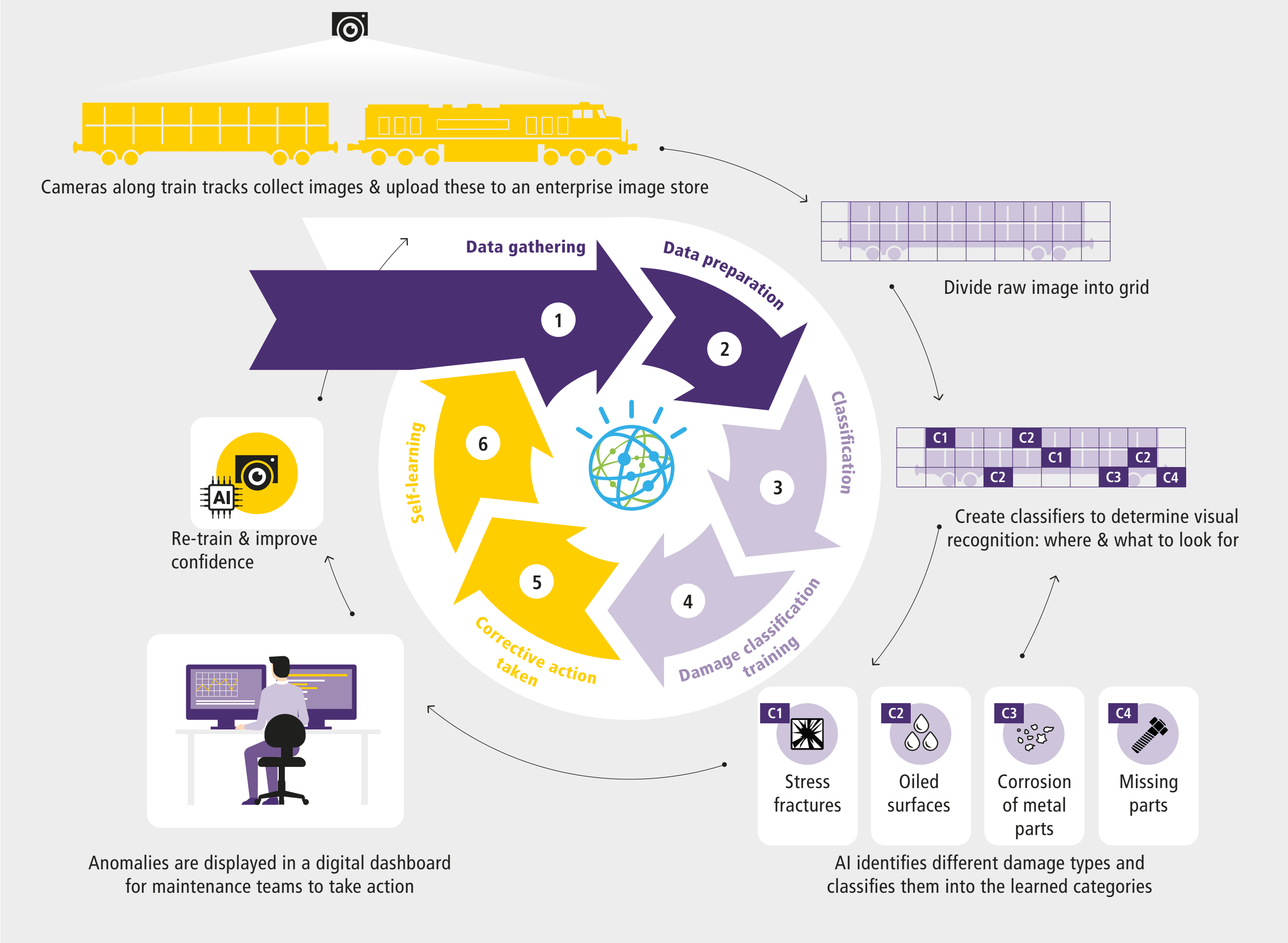



**Figure 45:** IBM Watson visual recognition enables maintenance with AI visual inspection; **Source:** IBM

[42] GreyOrange (2018).
[43] Francis, S. (2017).

image store where AI image classifiers identified damaged wagon components. The AI classifiers were trained on where to look for wagon components in a given image and how to successfully recognize wagon parts and then classify them into seven damage types. As more data was gathered and processed, Watson's visual recognition capabilities improved to an accuracy rate of over 90% in just a short period of time. The anomalies and damages discovered by Watson were sent to a workplace dashboard managed by maintenance teams.[44] This model and process can loosely be applied to other types of logistics asset including but not limited to aircraft, vehicles, and ocean vessels.

**Computer Vision Inventory Management & Execution** are becoming reality today in the retail industry. French startup **Qopius** is developing computer vision-based AI to measure shelf performance, track products, and improve retail store execution. Using deep learning and fine-grained image recognition, Qopius is able to extract characteristics of items such as brand, labels, logos, price tags, as well as shelf condition – for example, out of stock, share of shelf, and on-shelf availability as shown in figure 46. In warehouse inventory management, similar use of computer vision AI offers potential for real-time inventory management at the individual piece and SKU level.

Canadian startup **TwentyBN** is working on deep learning AI that is able to decipher complex human behavior in video streams. Previous applications of its technology include autonomous detection from video feeds alone of things like an elderly person falling, aggressive behavior on public transport, and shoplifting in stores. Considering that many warehouses today are equipped with surveillance cameras for safety purposes, this type of AI technology can be used to optimize performance (by detecting, for example, successful pick and pack tasks) and increase operational safety (for example, with instant alerting of accidents involving workers).

As mentioned previously, **Conversational Interfaces** are becoming increasingly common in the consumer world. Shown in figure 47, voice-based picking has been around in supply chain operations since the 1990s, but recent breakthroughs in natural language processing are bringing new conversational capabilities to the supply chain.

American startup **AVRL** is enabling traditional industrial IT platforms with conversational capabilities via proprietary, natural language AI. Before the parallel advancements of AI and speech recognition technologies, voice-enabled tools in the supply chain were static; they were limited to keywords and audible menus, and operated with fixed commands. Furthermore, these systems were limited in terms of interaction, supporting only a number of languages, accents and dialects. As a result, humans had to rely on relatively scripted responses to operate these rigid voice systems.

## INVENTORY MANAGEMENT USING COMPUTER VISION AI: QOPIUS


Normal 2D image of retail shelf taken with smartphone

Overlayed visualization of product and shelf insights using Qopius

**Figure 46:** Qopius computer vision AI can recognize insights about product and shelf attributes to optimize inventory management; **Source:** Qopius

[44] IBM (2018).

With the type of voice technology offered by AVRL, systems can interpret the semantic meaning and intent of a phrase and then connect the vocal mention of product names with product information contained within an ERP, WMS, or TMS system. This allows logistics operators to conversationally interact with their IT systems just as they would with another human being, even when using colloquial or informal phrasing. The ability to automate input, store, and retrieve information via conversational voice interaction removes time and complexity from many warehouse tasks that require manual input or lookup of information.

**Figure 47:** Supply chain voice applications will soon get a big boost from conversational AI; **Source:** PACCAR Parts

## SEEING, SPEAKING & THINKING LOGISTICS OPERATIONS


**Figure 48:** Seeing, speaking & thinking logistics operations; **Source:** DHL



**Autonomous Fleets** will eventually be used in all aspects of the supply chain from end to end. Early signs of this can be seen in intra-logistics, line-haul trucking, and last-mile delivery.

**Truck Platooning** refers to the intelligent caravanning of groups of semi-trucks. With machine-to-machine communications and collaborative assisted cruise control technology, between two to five semi-trucks can follow each other and autonomously synchronize acceleration, steering, braking and following distance. The platoon is controlled by a human driver operating the lead truck, with a backup driver in each following truck if needed.

**Figure 49:** DAF's platooning technology will be trialed on UK motorways in 2019; **Source:** DAF

The **British Transportation Research Library**, together with **DHL** and **DAF Trucks**, will pilot a platooning project on UK motorways in 2019. This is one of many recent and planned platooning trials across the trucking industry like the one shown in figure 49. Autonomous vehicles and trucks today actually handle freeway driving relatively well, and each platooning trial or autonomous freeway mile driven by semi-trucks adds new data for all trucks to improve their autonomous driving capability. Over time this capability will continue to get better until fully autonomous trucks become a reality. Experts estimate that freeway autonomy intelligence is largely complete; the main challenge is now the miles on smaller streets between freeways and destinations.[45]

In recent years, there has been extensive experimentation with **Last-Mile Delivery** with the aim of reducing cost and complexity. One method in particular has captured consumer imagination and media headlines – delivery via autonomous unmanned aerial vehicles – but regulatory frameworks and sufficiently dense road delivery networks limit the commercial viability of this to rural areas at best. A more practical application of autonomy in the last mile comes in the form of autonomous unmanned ground vehicles (UGVs) that operate fully autonomously or in collaboration with a delivery person.

[45] Chen, F. (2017).


**Figure 50:** Robby Technologies Robby 2 can navigate autonomously with 6-wheel drive and advanced AI to handle obstacles and interaction with humans; **Source:** Robby.io

American startup **Robby Technologies** is developing Robby 2, an autonomous unmanned ground vehicle shown in figure 50 with advanced AI for navigation and interaction capabilities. Given the dynamic complexity of navigating sidewalks, pedestrians, road and rail crossings, Robby's on-board AI is called upon to continuously sense and react to novel situations and become smarter with use. Embedded conversational AI helps improve interaction between humans and the robot; if a person blocks Robby's path, a soft voice politely asks "excuse me" and will even say "thank you" when a person makes room for the robot.[46] With growing delivery demand in dense areas, autonomous robots like Robby can help existing last-mile delivery fleets manage increased volumes at lower cost.

## 3.4 AI-Powered Customer Experience

The dynamic between logistics providers and customers is changing. For most consumers, touch points with a logistics company begin at checkout with an online retailer and end with a successful delivery or sometimes a product return. For businesses, touch points with logistics providers are characterized by long-term service contracts, service level agreements, and the operation of complex global supply chains. AI can help personalize all of these customer touch points for logistics providers, increasing customer loyalty and retention.

**Voice Agents** can significantly improve and personalize the customer experience with logistics providers. In 2017, **DHL Parcel** was one of the first last-mile delivery companies to offer a voice-based service to track parcels and provide shipment information using **Amazon**'s Alexa, as shown in figure 51. Customers with an Amazon Echo speaker in their home can simply ask things like "Alexa, where is my parcel?" or "Ask DHL, where is my parcel." Customers can then speak their alphanumeric tracking number and receive shipment updates. If there is an issue with a shipment, customers can ask DHL for help and be routed to customer assistance.


**Figure 51:** Ask Alexa! Shipment tracking via voice; **Source:** DHL

Taking this one step further, Israeli startup **package.ai** has developed Jenny, a conversational agent to assist with last-mile delivery. Jenny can contact parcel recipients via Facebook Messenger or SMS to coordinate delivery times, locations, and other specialized instructions. The chat-based service can also send driver progress updates and last-minute changes, as well as close the loop with delivery confirmation and gathering feedback from customers. The conversational capabilities and context Jenny is able to process makes for a natural touch point for customers, as well as cutting down on up to 70% of operational costs through route optimization and successful first-time delivery.[47]

Content discovery AI can enable logistics companies to be proactive about managing their customer relationships. Already today, hedge fund organizations like **Aidyia** and **Sentient Technologies** are using AI to explore market data and make stock trades autonomously; each day, after analyzing everything from market prices and volumes to macroeconomic data and corporate accounting documents, their respective AI engines make market predictions and then "vote" on the best course of action. Initial trials showed a 2% return on an undisclosed sum which, while not statistically significant, represents a significant shift in how firms can conduct research and execute trades.[48]

[46] Orr, J. (2017).
[47] package.ai (2017).
[48] Wired (2018).

**Anticipatory Logistics** takes the AI-powered logistics customer experience to the next level, delivering goods to customers before they have even ordered them or realized they needed them. Anticipatory logistics seeks to leverage the capabilities of AI to analyze and draw predictions from vast amounts of data such as browsing behavior, purchase history, and demographic norms as well as seemingly unrelated data sources such as weather data, social media chatter, and news reports to predict what customers will purchase. Exposing these data sources to AI analysis, companies can effectively predict demand and shorten delivery times by moving inventory closer to customer locations and allocating resources and capacity to allow for previously unforeseen demand. In some cases, it would even require having non-purchased inventory constantly in transit to allow for instant delivery for an order placed while the goods are in motion.

## 3.5 Getting Started with AI in Your Supply Chain

The use cases outlined in this chapter cover a broad range of AI applications across the supply chain that can create new value in the form of operational efficiencies, cost savings, and increased customer loyalty. However, we recognize that it is not a simple task to shift current logistics operating models to the proactive, personalized, autonomous, and predictive examples exemplified in this report. The transition to cognitive logistics is a multi-year journey that will require effective leadership, sound understanding of business value drivers, AI skills and talent, and an organizational culture that supports the ongoing development of AI-driven business.

### Project Selection: Business Value Drivers & Data Analytics

All too often with new technologies, individuals, teams and organizations can get overhyped on shiny new things like AI and its promised capabilities. Instead, it is useful to ask: What are the business problems that can be solved using AI? Does this problem demand an AI solution?

A cautious stocktake of business value drivers such as cost reduction, improved customer experience, and efficiency gains through better insights is required before starting an AI project. Simpler forms of non-cognitive data analytics should be considered unless your organization requires complex classification of data on a regular, ongoing basis. Here it is important to ask: “What business metric does the proposed AI project address? Is there potential to make significant quantitative impact using AI?”

It is also critically important to evaluate the data needed for the AI project as it is impossible to create output from an AI framework without input. Consider the key question: Are there large amounts of accessible data, relevant to the problem to be solved? More specific but still important questions are: How clean is this data, how frequently is it collected, and by which routes can it be made accessible to team members?

### AI Teams & Skills

Next it is necessary to identify the location of natural AI competencies within the organization, such as analytics, data science, and digital innovation functions, for example. Are these people easy to access and engage in your AI initiative? This may depend on the project timespan – engaging teams might be simpler for a one-off AI project than for a long-term initiative to build sustainable AI competence deep within the fabric of the organization.

If sufficient AI skills and competencies cannot be found or accessed internally, it may be necessary to source these externally. Today there is an extreme shortage of relevant talent – experienced data scientists and software engineers with machine learning expertise – in non-technology industries but to bring these competencies in-house requires significant investment. Given these constraints, a partnering model is likely to provide a more cost-effective option for many organizations.

### Culture: Trust, Quality & Learning

Change management and the cultural shift associated with AI can perhaps outweigh the challenging technical complexity of implementing it. The first thing to address within the organization is trust. It is important to establish deep understanding of organizational attitudes towards AI, especially any fears of potential job loss through automation. Here, the support from vocal, empowered leaders in the company who are supportive of new technology and the change it can bring about can be an essential asset.

The second factor to address is cultural tolerance around quality and performance. AI systems are firstly probabilistic by design, and secondly improve over time with more data. AI systems trained with insufficient or improper data are almost certain to produce disappointing results at first, but over time can improve to achieve high degrees of output accuracy and performance. It is important not to dismiss an AI project in its infancy due to output performance alone, but remain agile and seek to improve system performance with new data or modifications to the core framework.

Here the organization must get comfortable with questions like how good is good enough? How accurate does a system need to be for commercial viability? Keep in mind that AI, when well designed and implemented, can make more complex and better decisions more frequently on our behalf, so it is important to incubate AI systems through early stages of development.

The third cultural factor to consider is the organization's commitment to ongoing sharing and learning. In the same way as AI systems improve over time with more data, organizations must be agile to learn and evolve with these new systems.

## Two types of AI Project: Cost Reduction & New Value Creation

To help you get started on an implementation, we have included a decision framework for two fundamental types of AI project: cognitive automation and improved insight generation.

AI projects mentioned in this report such as address management, invoice processing, and cognitive customs leverage **Cognitive Automation** to reduce cost through automation using three strategic value drivers:

- Reduction in the number of manual processes
- Reduction in human effort per process
- Reduction in error rate from human decision making

The framework below guides you through project selection and provides the best-match analytics project for your needs.

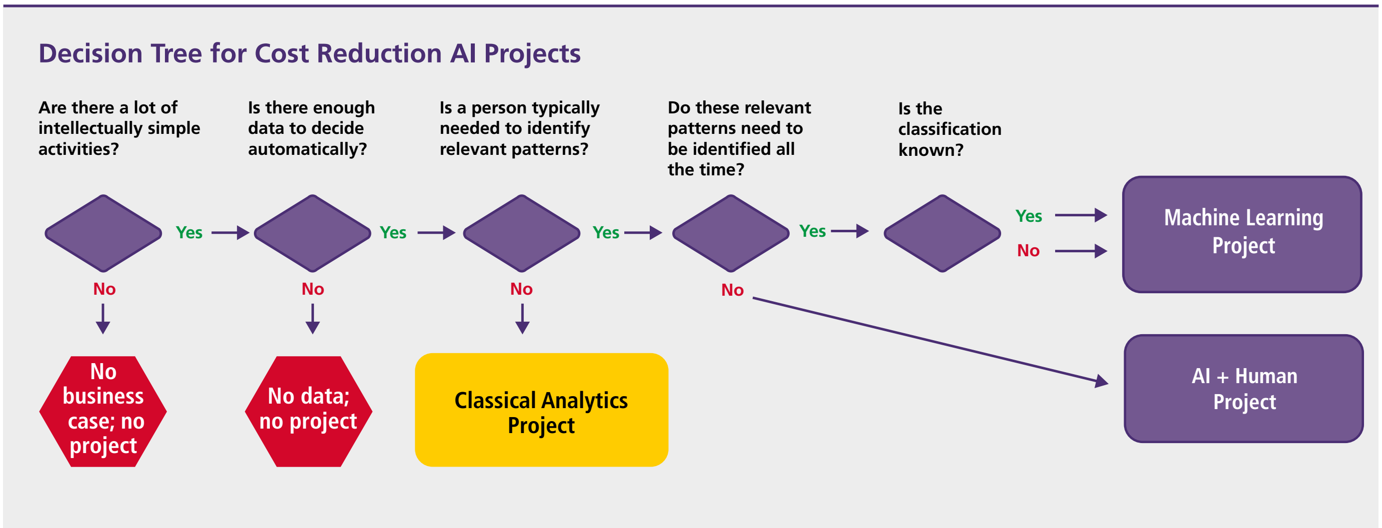



**Figure 52:** Decision tree for cost reduction AI projects; **Source:** IBM

AI projects mentioned in this report such as visual asset inspection, predictive network and risk management, and the DHL Global Trade Barometer leverage improved **Insight Generatio**n to enable better decisions within the organization. This increases operation efficiency, improves customer experience, and ultimately creates profitable revenue growth through four strategic value drivers:

- Increased number of positive decisions
- Increased impact of positive decisions
- Decreased number of negative decisions
- Decreased impact of negative decisions

The framework in figure 53 guides you through project selection and provides the best-match analytics project for your needs.

Once you've identified which of the two types of project you will undertake, the next step is actually planning the implementation. There are many different ways to manage the implementation of an AI project and experts at IBM and DHL recommend a mix of four techniques to successfully deploy AI: design thinking to reveal unmet needs of users, traditional IT project management to scope the systems and resources needed, AI-specific methodologies for knowledge curation and training, and agile methodologies for the continuous development and improvement of the system once trained.

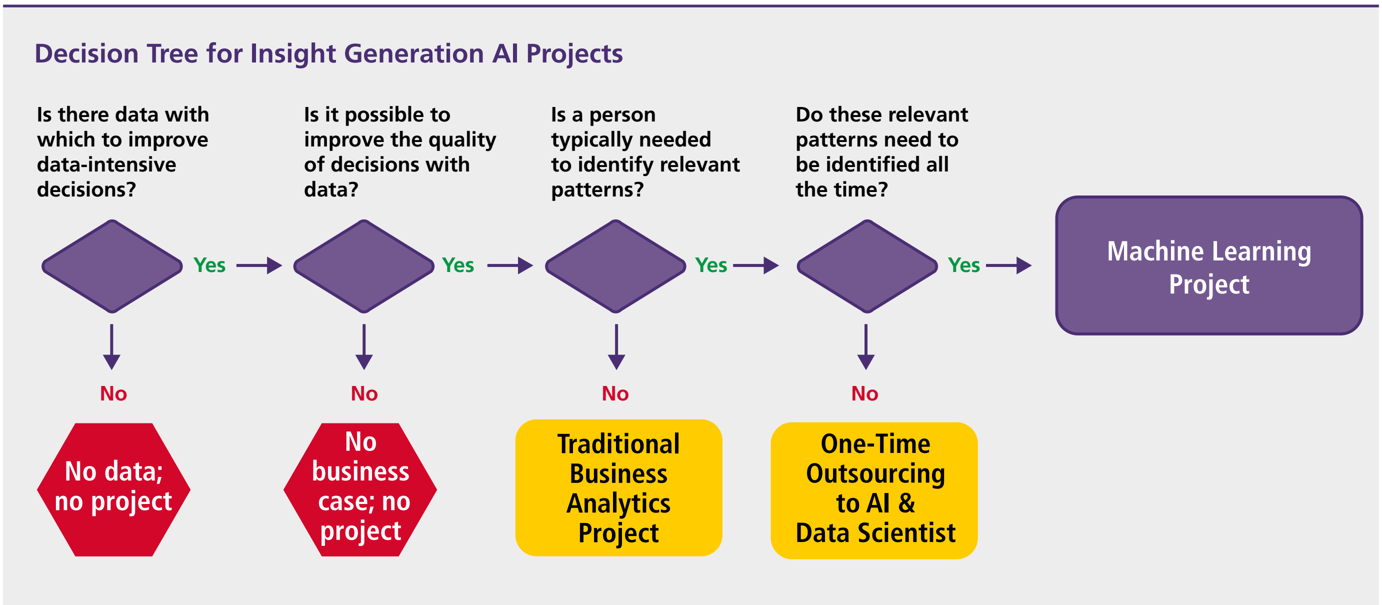



**Figure 53:** Decision tree for insight generation AI projects; **Source:** IBM

# CONCLUSION AND OUTLOOK

Artificial intelligence (AI) is once again set to thrive; unlike past waves of hype and disillusionment, today's current technology, business, and societal conditions have never been more favorable to widespread use and adoption of AI. In the consumer world, AI is already here to stay. Among businesses, leading industries such as tech, finance, and to a lesser extent mobility are well into their AI journey. Industrial enterprise sectors like logistics are beginning theirs in earnest now.

Drawing on learning from the consumer, enterprise, retail, mobility, and manufacturing sectors provides valuable foresight of how AI can be productively applied in logistics. Enterprise AI will alleviate burdensome tasks that define many aspects of modern working life.

As big data from operational, public, and private sources becomes exposed to and processed by AI, the logistics networks will shift to a proactive and predictive paradigm. Computer vision and language-focused AI will help logistics operators see, understand, and interact with the world in novel, more efficient ways than before. These same AI technologies will give rise to a new class of intelligent logistics assets that augment human capabilities. In addition, AI can help logistics providers enrich customer experiences through conversational engagement, and deliver items before customers have even ordered them.

AI however it is not without its challenges. The bias and intent of each AI developer can become intertwined in the system's decision-making functions, raising complex questions about the ethics of AI models. Here, business, society, and government bodies will need to develop standards and regulations to ensure the continued progress of AI for the benefit of humanity.

We believe the future of AI in logistics is filled with potential. As supply chain leaders continue their digital transformation journey, AI will become a bigger and inherent part of day-to-day business, accelerating the path towards a proactive, predictive, automated, and personalized future for logistics. Ultimately, AI will place a premium on human intuition, interaction, and connection allowing people to contribute to more meaningful work.

In a 2017 survey of CEOs, there was an almost even four-way split among leaders who said they were using AI, thinking of using AI, have heard of AI, or believe AI is not a priority.[49] This begs the question, who will teach our business leaders about AI?

At DHL and IBM, we believe the time for AI in logistics is now. We look forward to hearing from you and creating opportunities for collaboration and joint exploration using AI in your organization.

[49] Curran, C. (2017).

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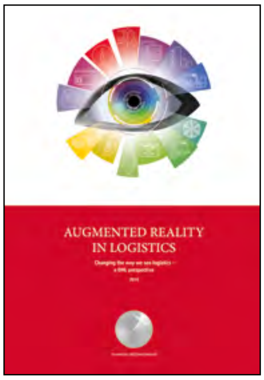


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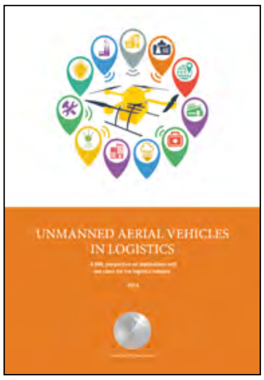


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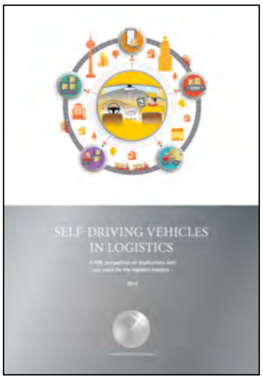


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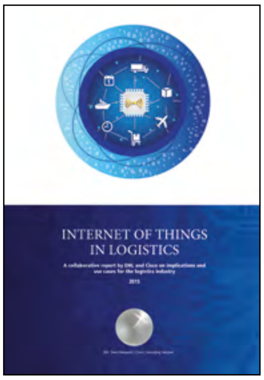


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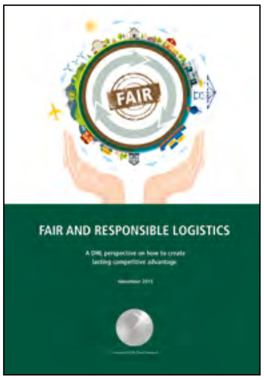


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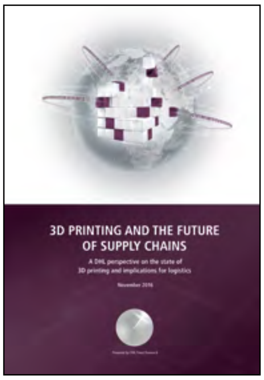


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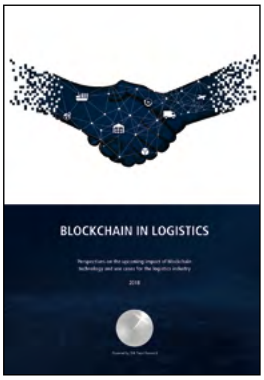


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