



Experiential Learning:

HOW CAN AI AND BIG DATA BE USED FOR DIGITISING CONSTRUCTION?

HERE YOU WILL FIND

1. Overview **3**
2. Introduction to Big Data and Artificial Intelligence **4**
3. Artificial Intelligence and Big Data Today **9**
4. The Construction Industry & AI **16**
5. Summary **25**

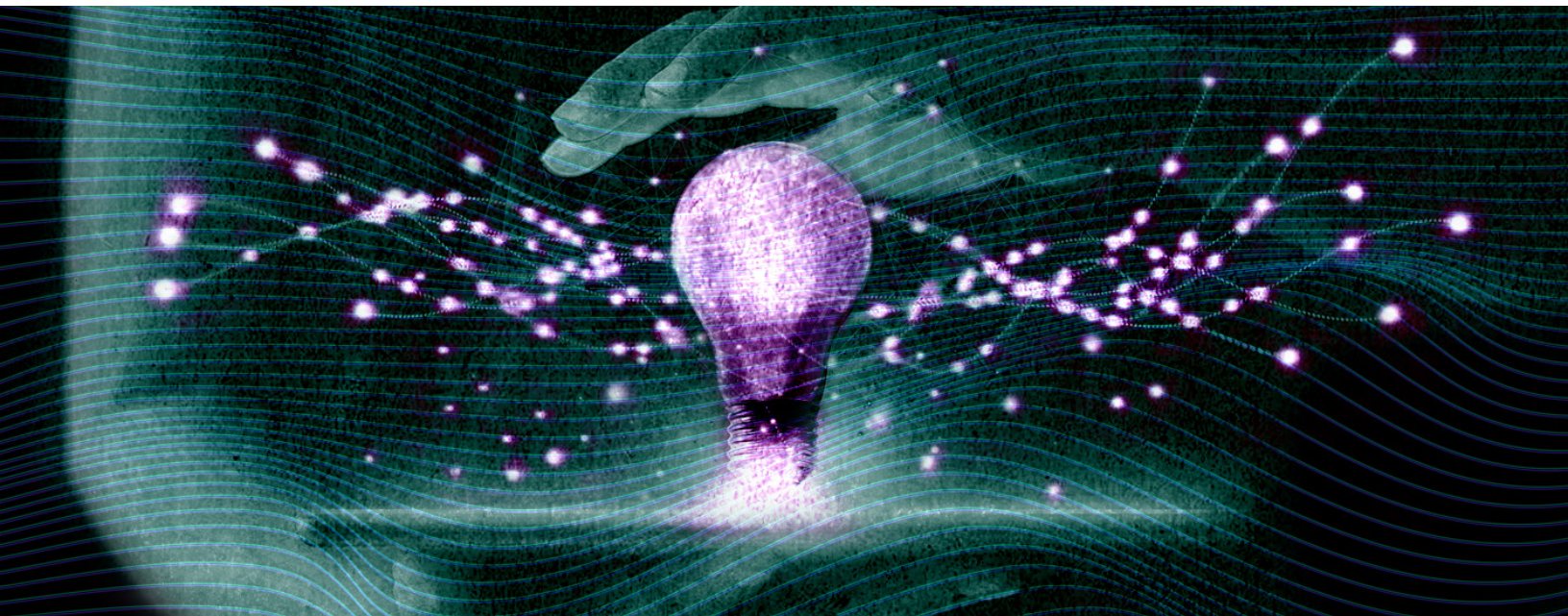
01. Overview

We're surrounded by non-stop tech slogans trying to validate products or ideas in today's fast-paced world. Everything we buy or use increasingly claims to be smart, automated, mobile or quantum in nature. These have become some of the most popular buzzwords used, and oftentimes abused, by marketing companies everywhere. While some are self-explanatory, like how mobile devices should be small and smart devices should make our lives easier, other words like Artificial Intelligence or Big Data can seem almost magical. So how big is Big Data? How intelligent is AI? How can I use it? Will machines ever rise up and try to terminate us? To answer these and many more questions, some context is needed. Let's examine the past to better understand the future.

02. Introduction to Big Data and Artificial Intelligence

BIG DATA

There is no one dictionary definition of what Big Data is. Some define it as internet-sourced multidimensional data, others speak to the unimaginable amount of information gathered. The first mention of these large scale data phenomena can be found as early as 1944, but the term in its most current understanding dates back to an article from 2005 by Tim O'Reilly called "What is Web 2.0?". It defines Big Data as "an accumulation of data that is too large and complex for



processing by traditional database management tools". Essentially, it's an amount of data that has outgrown the traditional means of analysis and management. To understand how we got to the point where we are overrun by so much information that we have started drowning in its sheer amount, let's take a quick dive into the history books.

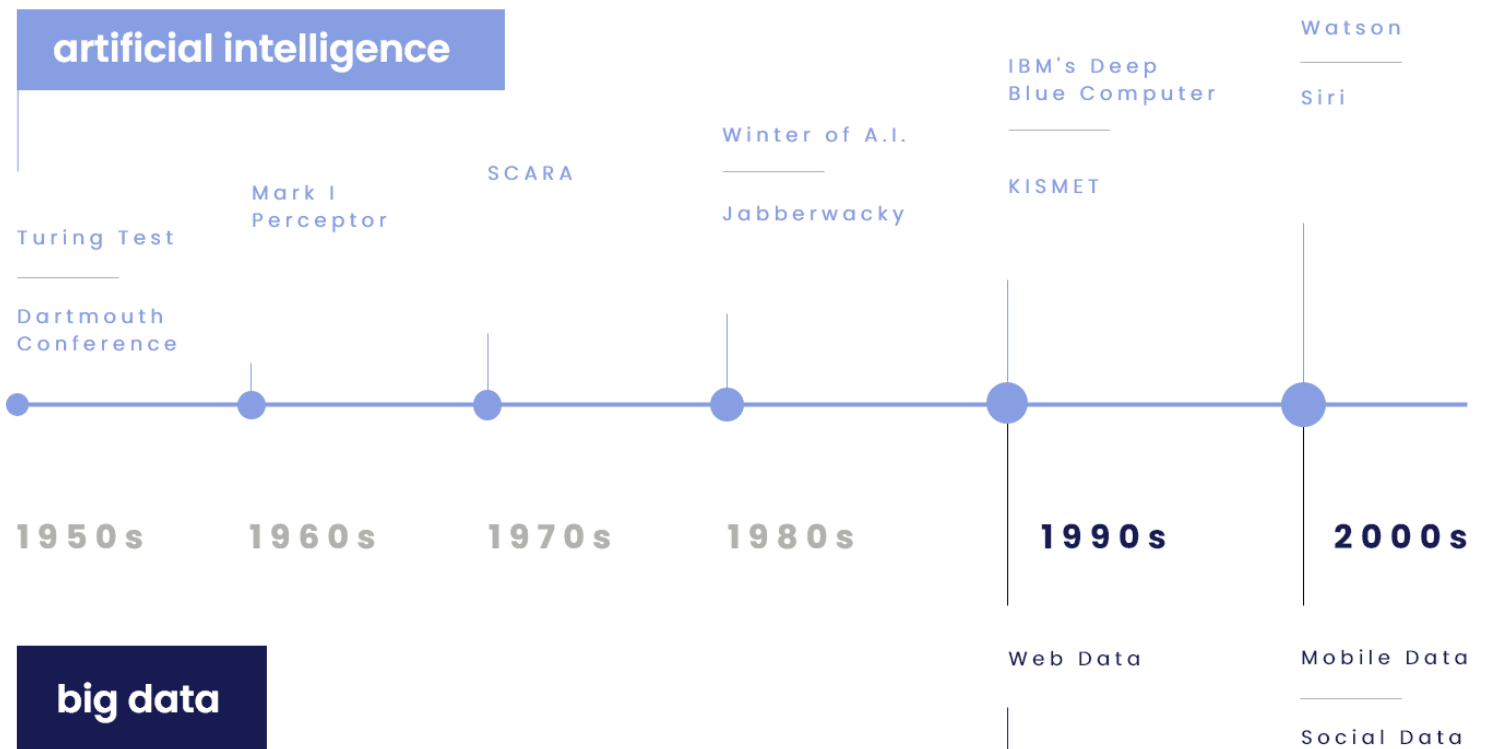
The application of big data and the quest to understand the information available to us is something that has been around for as long as business itself. From ancient Mesopotamia through John Graunt in the 17th century to the Social Security Act in the 1930s, the need to gather and analyze data has always been present in human history. However, it wasn't until the development of 'Colossus' - the very first data-processing machine - by the British to decipher Nazi codes in World War II, that we started using computers to aid us in the process of data analysis. Colossus could analyze coded messages for patterns at the same rate it would take 200 people to just read the messages alone.

This kick-started a series of events that in turn led to the invention of the World Wide Web in 1989. Its purpose was to share information through a hypertext system. This began the explosion of data at an extremely high rate as more devices gained the capacity to access the internet. This was the beginning of Big Data. To be able to deal with all this information, humans started building supercomputers which had the capacity to handle thousands of years of a single person's work in a matter of seconds.

The next revolution came with the emergence of social networks. The amount of data being created on a daily basis grew exponentially. Businesses and governments alike began to establish big data projects. In 2010, it was estimated that there were 5 exabytes of data stored since the beginning of time up to the

year 2003. That's **5,000,000,000,000,000** bytes of data, and by today, we are now creating that on a daily basis. This means over 90% of the data we have today was created over the last 5 years. Moreover, the rate at which big data has been growing isn't slowing down either. With more and more tech-savvy equipment we're collecting more and more data. So how can we handle this unimaginable amount of information being stored in the internet?

This is where Artificial Intelligence jumps in.



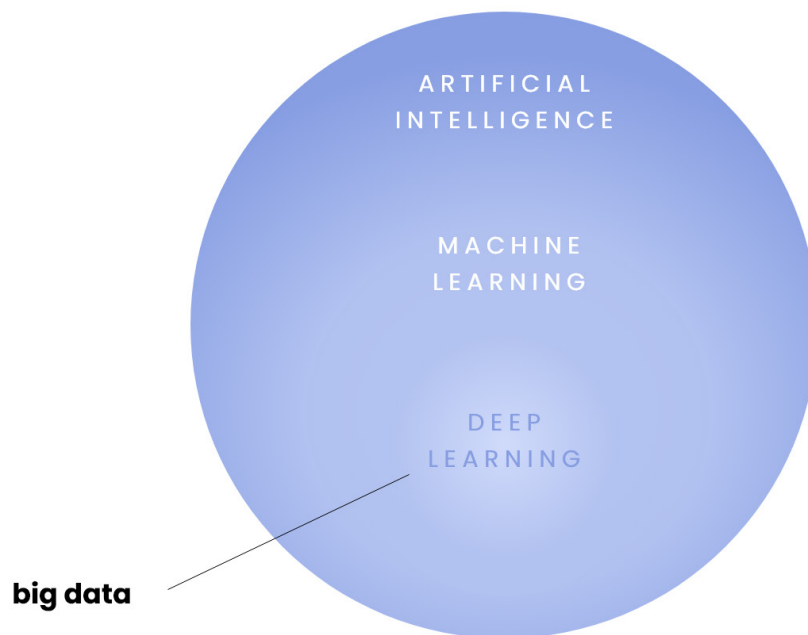
ARTIFICIAL INTELLIGENCE

The beginnings of modern AI can be traced back to the 1950s. First, Alan Turing devised a test allowing one to assess whether a machine was intelligent. Then, six years later at a conference at Dartmouth College, the term „artificial intelligence“ was coined. Scientists present at the conference speculated that the challenge of creating a machine capable of imitating intelligent human behavior would be solved within a generation. However, that turned out to not be the case. Time passed, advances were made, but the feat seemed always out of reach. A breakthrough finally came in the late 1990s, when IBM’s Deep Blue became the first computer to beat a human champion in their discipline, as it defeated the Russian grandmaster Garry Kasparov in a game of chess. This proved the possibility that manmade intelligence can outperform the best of humans. While progress was being made, there were still fundamental problems impeding the development of AI. As excited as people were about its possibilities, the development of the technology wasn’t going as fast as many had hoped.

The breakthrough finally came in 2006 when researchers developed machine learning algorithms capable of learning from exposure to large amounts of data alongside the development of computers that could handle the workload. This was the beginning of the most dynamically growing branch of AI. By applying the machine learning algorithms to enormous amounts of data we advanced to the next stage - deep learning. Exponential gains in computer processing power and storage ability allowed deep learning and machine learning to develop at a faster pace than before. Companies were able to store and crunch vast quantities of data for the first time. This also opened the doors to the creation of networks of intertwined AI algorithms that could form

self-teaching structures called neural networks.

This brings us to today. Some form of AI is embedded in most of the digital services we use now. Companies like Amazon, Facebook, Google, and others are leveraging AI to make ever-growing profits. Most industries are already making use of the benefits of both AI and Big Data. Of course, in some areas, machines still have a long way to go (e.g. translation, self driving cars, construction, etc.). However, in other fields computers are already helping us do our jobs better or even doing it for us. As a result of the advances in AI, we can see it almost everywhere nowadays, from Apple's Siri, to automatic car wipers, and with finishing on personalized playlists on in Spotify.



03. Artificial Intelligence and Big Data Today

Today, it's hard to talk about Big Data without mentioning some form of Artificial Intelligence. The fact is, that in order to be able to analyze and process large quantities of data fast enough, the human mind doesn't cut it anymore. This is where modern computing and AI come in. Computers don't tire, don't need sleep, and don't make mistakes, thereby making our lives a lot easier. Here are some day-to-day examples of how we currently make use of the gathered Big Data, along with deep learning, machine learning, and other forms of artificial intelligence in our world today.



CONSUMER GOODS & DURABLES

In modern society, it is hard to imagine a person without a cellphone. Since Apple launched its first iPhone, streamlining the smartphone, everything changed. Current age cell phones have more computing power than all of the combined computing power of the NASA Apollo missions' onboard computers. What many people don't know is that they are packed with hardware that hosts and enables AI's to do amazing behind-the-scenes work. Here is are how AI uses your smartphone to make your life easier:

- **Voice recognition**

The microphone in your smartphone enables your applications, like Siri or Alexa, to use voice recognition to identify the phone's owner. As you may have realized, voice recognition is nothing but an AI at work.

- **Preference recognition**

It's not only what we say but what we hear as well. Did you ever wonder how Spotify picks and recommends songs that just happen to be exactly what you wanted? It learns by what we listen to and uses AI to predict what we might like, paying attention to details that even we weren't aware of.

- **Image processing**

Have you ever taken a selfie? Or a photo in poor light conditions? You guessed it. It's not that the camera in your phone is that amazing (even though it kind of is). It's all the hard work of programmers that designed the algorithms processing it. For instance, Google has recently developed the machine learning-based feature 'Night Sight' which instantly restores brightness and color to dimly-lit photos. The contemporary camera is full of AI algorithms that work wonders in our palm-sized computer to give us face unlock, object detection, background blurring, AR filters, or panoramic photos, to name just a few.

- **Maps & traffic**

How is it that our maps know how long it will take us to get from point A to point B? How is it that for two different people the same routes can show different arrival times? You guessed it! AI once again.

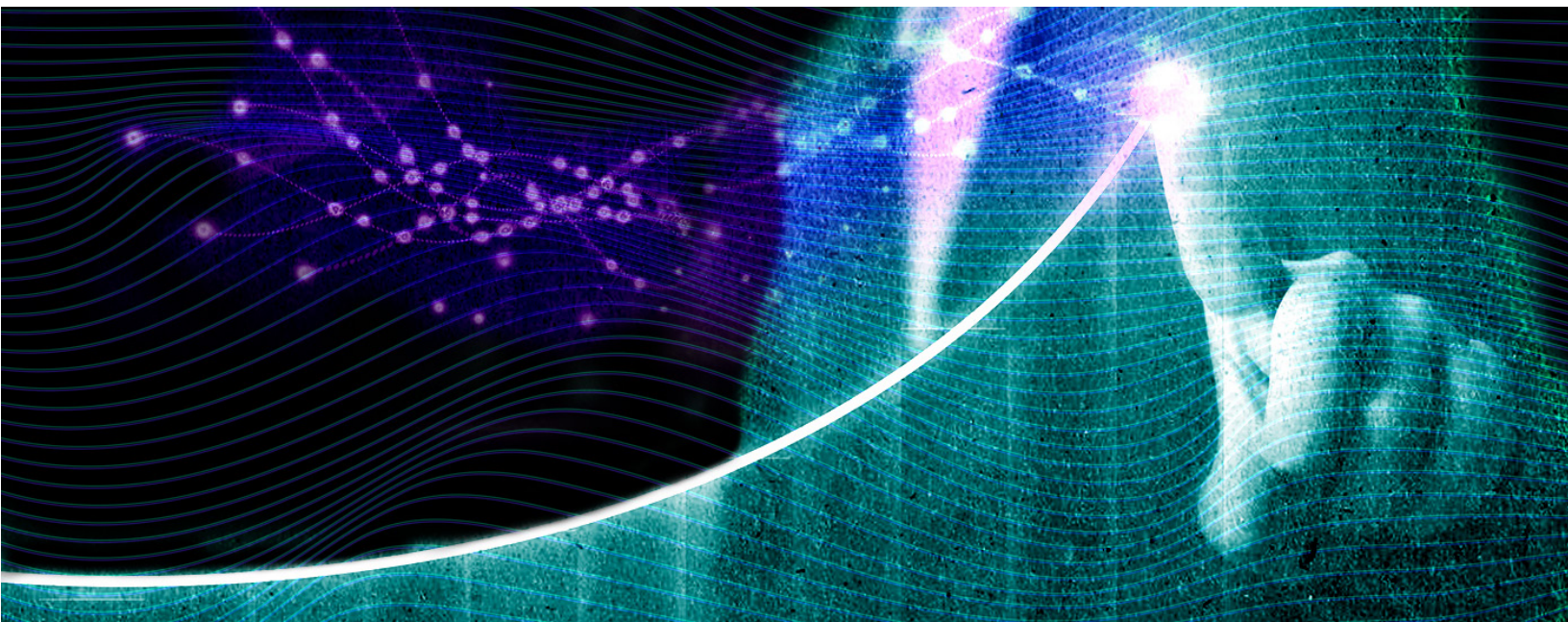


HEALTHCARE

Consumer goods aren't the only place where we can observe AI at its best. One of the first fields to benefit from early machine-learning algorithms was medicine. To this day, it is one of the top fields with the most potential for vast AI usage. It is not likely that human doctors will become obsolete, but it's paving ways for better, more efficient healthcare as we speak. For now, healthcare benefits from the use of AI are found in many areas, such as:

- **Disease diagnosis**

Detecting lung cancer or strokes based on CT scans can be done by most experienced doctors. The further along the disease, the easier it is to catch. Using AI can help radiologists spot diseases that are almost invisible to the human eye, and prevent the spread as early as possible. Moreover AI can use historical data in assessing the risk of sudden cardiac death or other heart diseases based on electrocardiograms and cardiac MRI images, decreasing fatalities and enabling



early preventive treatment. Moreover, what might look like a normal and benign image to a person, can be a cluster of exposing data with the smallest tell caught by the AI. Classifying skin lesions in images to catch melanoma before it spreads or finding indicators of diabetic retinopathy in eye images, makes 90% of patients treatable before they start showing symptoms.

- **Drug development**

Another area where AI can shine is in the shortening of the process of drug development and testing. Each of the four stages of the process is becoming more efficient thanks to machine learning and Big Data. ML algorithms can easily analyse all the available data and learn to automatically identify preferable target proteins. They can predict the suitability of a molecule based on structural fingerprints and molecular descriptors, enabling for faster drug candidate selection, and minimizing the risk of serious side effects. In the next stage, they can speed up the design of clinical trials by automatically identifying suitable candidates, shortening the process and improving its efficiency. Lastly, once the drug is available, AI can help find biomarkers making sure that the correct patients get treated with the right drug.

- **Medical equipment**

One of the most evident areas in how AI has taken medicine to the next level is in robotics. For example, the robotic surgical systems used nowadays help surgeons do their job even better. The robotic arms mimics the surgeon's hand movements with even better precision. The 3D view or high level, enhanced magnification of the operating field allows the surgeon to perform minute incisions with maximum precision and the best possible outcomes.



FINANCES

With modern banking increasingly moving online, fraudulent behaviour is harder and harder to track. Fortunately, machine learning is proving itself as a valid solution for making cyberspace a secure place. Tracking monetary fraud online is one of its examples. Widely-used services, like Paypal or Revolut, are using ML for protection against money laundering. AI is helping them track and compare millions of transactions taking place, distinguishing between legitimate or illegitimate transactions. Another good example is in algorithms used by banks to look at the spending patterns of their consumers. If a transaction does not fit the pattern (e.g. the amount is too high, or from a different timezone, etc.), then the AI will put the transaction on hold and alert a bank employee who in turn will reach out to the client.



TRANSPORTATION

- **Aviation**

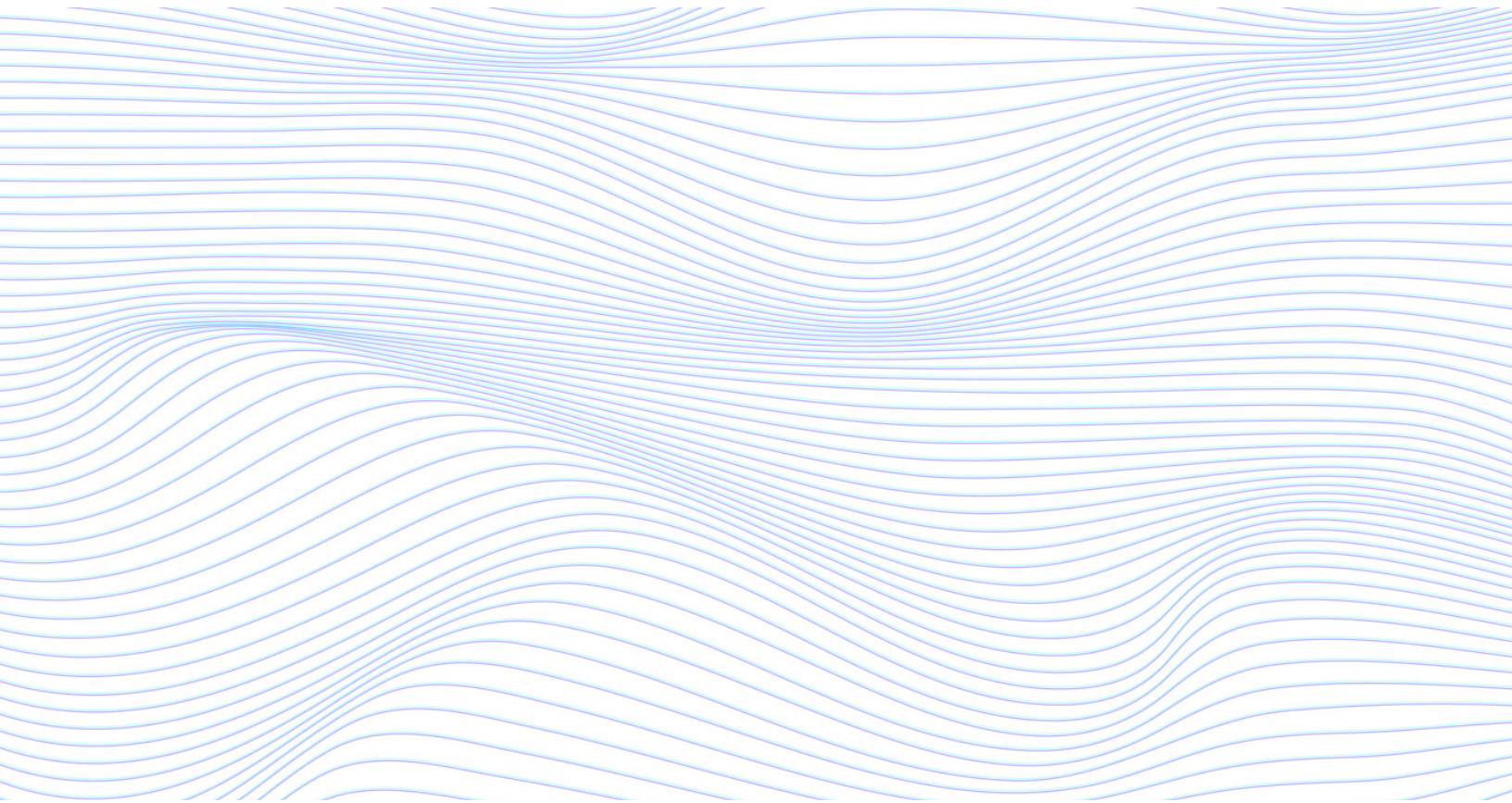
The last but certainly not least interesting example of how AI is being currently used is with the advent of self-driving vehicles. We all hear about self-driving cars on the news from time to time. However not many of us realize that we've already been using AI in a different branch of transportation. In aviation, we have been trusting AI to autopilot airplanes for years. Of course, the first autopilots were primitive and nowhere near sophisticated enough to be called intelligent, but that has changed. Now the newest systems can help pilots from take-off to landing.

Machine learning assists pilots with systems like the Automatic Dependent Surveillance Broadcast (ADS-B), which helps to prevent mid-air collisions, and advanced autopilot systems that are able to autonomously land aircraft in case of emergency. The Maneuvering Characteristics Augmentation System (MCAS) increases the safety at times when there's a need to compensate for aircraft handling characteristics, among other further systems. As much as we get excited about the hot new thing, we tend to forget about the marvels of technology that have been in use for a while and that we tend to take for granted.

- **Automotive**

It is a crowning achievement of what we have been able to accomplish using hardware and machine learning. Google is one of the pioneers of deep learning. It first used deep learning for image recognition and now is able to use it for image enhancement. Google's self-driving car division uses these previously developed algorithms in their early self-driving car prototypes. While it's not clear when we'll see unmanned vehicles being admitted for public use, the breakthroughs originating from these experiments are already being used in the industry today. More and more cars nowadays already have smart systems that are based on machine learning that allows them to perform tasks and or improve safety. Lane assist helps drivers stay in their lane, parking aids assist or even perform the parking maneuver for the driver, automated braking systems prevent cars from crashing into suddenly appearing objects in front or behind them, and automatic wipers sense the gathered water on the windshield and turn on, to name just a few.

These are just a few examples of how AI is revolutionizing modern industries. There are many more areas where AI and Big Data are being put to use to improve processes, deliver personalized experiences, or even save lives on a daily basis, all around the world, and we've only begun to scratch the surface of its applications.



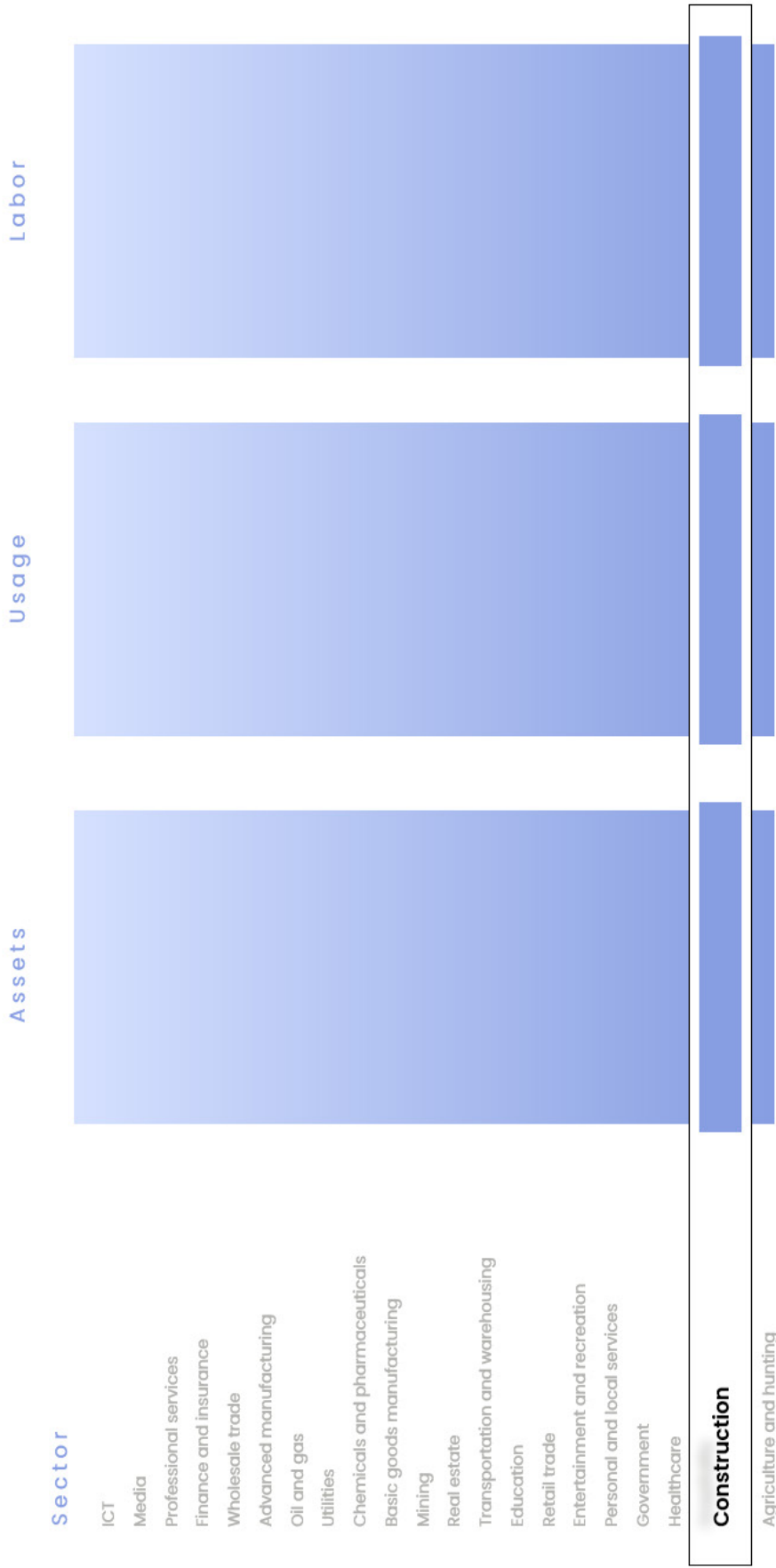
04. The Construction Industry & AI

Like any other industry, construction is a wonderland for possible AI applications. The ways that, with proper information and analysis, the industry could become safer, more sustainable, and more efficient are endless. Unfortunately, before that can happen, baby steps need to be taken and the mentality around its use has to change.

CONSTRUCTION NOW

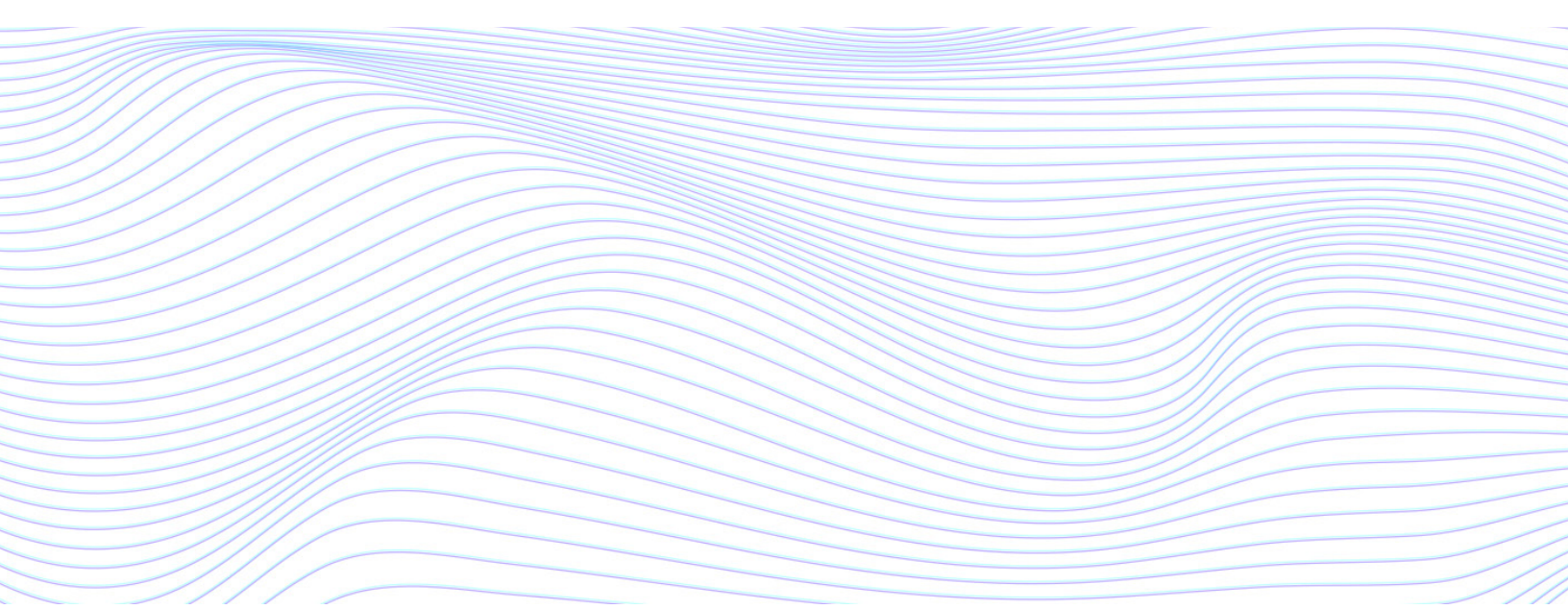
When it comes to technological innovation, construction is no different than any other industry. It has its R&D players and scientists that work around the clock to come up with new useful technology or materials to be applied to the site. This is the case when it comes to heavy equipment, new materials, and even health and safety equipment, but digitisation lags behind. Even though the sector as a whole is worth more than \$10 trillion annually, it remains severely under digitised. This doesn't only concern futuristic AI or deep learning, where again construction is way behind the curve, but the basic digitisation of processes and day-to-day paperwork has not become an industry standard as seen in other areas. Fortunately, things seem to be slowly shifting with solutions that digitize the industry, enabling the eventual use of deep learning, and are slowly beginning to be implemented across the industry. While not everyone understands that all of the tools already available to other industries are within arm's reach of construction, we just need to put our best foot forward and concentrate on catching up.

digitalisation by



THE FUTURE

Once construction implements tools that will allow it to gather more data, the possibilities for AI applications are almost infinite: from design to pre-construction and throughout construction finishing in operations and asset management. There is already a growing focus on technological solutions that incorporate deep learning for the industry. In the future, these emerging solutions will help construction overcome some of their greatest challenges, from cost and schedule overruns, all the way to safety concerns. For the time being, most industry players lack the resources to implement innovative, often experimental, AI solutions without a proven high return of investment (ROI). Only the biggest, global companies can afford and have the capabilities (resources, people, and processes) to implement deep-learning solutions. Once the ball starts rolling and the technology becomes a proven need and more accessible for smaller companies, we will see a boom in the usage of AI in the industry, impacting all industry essential stages and players. Examining where AI solutions are beginning to emerge, and how they are widely used today, we can predict future applications and use cases that have already made an impact in other sectors and that can be applied in the construction industry.





QUALITY & EFFICIENCY

The quality and efficiency of construction sites can be the difference between a profitable project and a financial fiasco. Delays, costs, downtimes, or unfavorable environmental conditions can all bury a project. However, thanks to artificial intelligence even the most inimical events can become manageable in the future.

- **Quality**

In the future, when a massive amount of data is being created and collected on construction sites every day, AI systems will have the insight to help us apply improvements on a daily basis. Every historical project, job site, or process will become a potential source of knowledge. Data gathered from images captured by cameras, mobile devices, drones, sensors, building information modeling (BIM), designs, and others will become a pool of priceless information. By analyzing all of this information, AI will be able to change and optimize workflows, offer the best available solutions and resources, optimize the construction process while ensuring maximum profit and quality at the same time. This will significantly accelerate the decision-making process by implementing actionable insights in real-time. Self-driving construction machinery will be able to perform repetitive tasks more efficiently than their human counterparts, such as pouring concrete, bricklaying, welding, and demolition. Excavation and prep work will be performed by autonomous or semi-autonomous bulldozers, which will prepare job sites with the help of a human programmer to the exact specifications of the design, mitigating the chance for costly human errors.

- **Efficiency**

Construction is all about efficiency. Whether it's about getting the estimation right, ordering a precise amount of materials, or ensuring that everything on the site goes smoothly, AI can be of tremendous help. Enhanced analytic platforms can collect and analyze data from sensors to understand signals and patterns. This will allow AI-packed programs to deploy real-time solutions, cut costs, apply preventive maintenance, and minimize downtime. Image recognition of photographs collected by cameras and drones will be used to identify existing danger zones and compare them with existing blueprints to identify structural defects or hazardous areas. Autonomous machinery will allow people to do their work more precisely and efficiently. This will free up human workers for the construction work itself and reduce the overall time required to finish a project. Project managers will be able to track work on job sites in real time. They will use facial recognition, onsite cameras, and similar technologies to assess the work progress, worker productivity, conformance to procedures, and react to any unforeseen events in real time.



HEALTH & SAFETY

One of the key challenges facing construction since its earliest days has been the safety of workers and structures on construction sites. This is also one of the areas where artificial intelligence can shine and offer life-saving solutions.

- **Safety**

Of course, every construction project has some risk that comes in many shapes and sizes. The larger the project, the bigger the chance of something going

wrong. Knowing where everyone is at all times and making sure they behave accordingly to health and safety regulations is almost impossible. Or is it? Imagine all the data that is collected on sites even today. Cameras, cellphones, sensors, drones, microphones, and more all collect data that without a proper analysis is just gibberish. However, AI would be able to recognize patterns and assess the data collected on work sites to identify unsafe working environments, hazardous worker behavior, or predict catastrophic events before they have a chance to happen. This in turn could be used to aggregate data to change processes and improve future training and education priorities, therefore minimizing the risk of their recurrence. Construction site workers are five times more likely to be killed on the job than other laborers. Falling, getting struck by heavy objects, electrocution or getting caught are just a few ways a person can sustain grievous injuries or even die on the site. Thanks to AI the risk of any of these happening can be seriously decreased. It would allow us to act to prevent these accidents rather than having to deal with the consequences.

● **Health**

It's easy to understand all the ways gathering data and using AI can help from a safety perspective, but can it affect the health of the workers? Of course it can. The amount of information about all external factors gathered by electronic equipment and sensors today can be a valuable resource in understanding the implications and risks of particular professions. We already are aware of how environmental factors like noise, radiation, vibration, heat, etc., can have on the human body and the deterioration of health. Deep-learning neural networks will be able to analyze medical and environmental data; pinpointing agents that have the biggest impact on health problems of different specialist jobs. This

in turn will allow for better allocation and management of human resources, minimizing their exposure to harmful factors, and providing them with a healthy post-retirement life.



OPERATIONS & PROJECT MANAGEMENT

We have established that AI can revolutionize all of the work done in and revolving around the construction site, but can it be as efficient as in the office? Of course! Most big scale projects, at some point, go over the estimated budget despite employing the best project teams. AI project schedule optimizers can take into consideration billions of alternatives for project delivery and continuously improve the overall project planning and scheduling. Neural networks will be able to predict and prevent cost overruns based on factors such as the project size, contract type, or the competence and experience level of the project manager. Historical data, such as planned start and end dates, combined with the known project outcomes will be used by predictive models to envision realistic timelines for future projects. AI will help staff remotely access real-life training materials which will help them enhance their skills and knowledge quickly in the needed topics. This will reduce the time it takes to onboard new resources onto projects and into companies. As a result, project delivery will become expedited. Deep learning will also help companies to improve and optimize their construction processes.

Through reinforcement learning, AI algorithms will use the experience to run trial and error scenarios, identifying the best practices to follow for future projects depending on their specifications. The implementation of these process changes

in project estimation, planning, scheduling and delivery, will allow construction companies to significantly improve the quality of their overall project workflow, minimize costs, and maximize the available resources. This in turn will benefit all the stakeholders by lowering construction costs and creating higher profit margins. Moreover, building managers will be able to use countless AI solutions long after the construction of a building has completed. Building information modeling, which stores information about the structure of the building, will be able to be used by AI to monitor or even prevent problems associated with the exploitation of the structure from occurring altogether.



DESIGN & ENGINEERING

When it comes to design and engineering, there are things that we already do that heavily rely on computers. Computer Aided Design (CAD) software is a standard nowadays, but what of AIAD (AI Aided Design)? How does AI already help and what can it bring to the table in the future? Just like in radiology, designers and engineers will be able to rely on AI to help them with most of the mundane tasks and heavy calculations. Some companies are already working on solutions that will help the industry professionals do their jobs more easily and efficiently. A great example of this is [**Nvidia's ArchiGAN: a Generative Stack for Apartment Building Design**](#). The technological powerhouse published research on how AI can get leveraged to design floor plans and entire buildings. This means that soon, instead of having to design each apartment separately, the engineer or architect will be able to focus on the grand scheme of things and leave the details to the machine.

Civil engineers and contractors are already using AI-powered recommendation systems to study design charts to indicate relevant improvements. These systems collect architectural and structural data, providing architects and engineers with solutions in the fields of design and construction. They can take into account various criteria like the implementation timeline, total costs, likelihood of implementation mistakes occurring, or the environmental site characteristics (seismic shocks, floods, strong winds, etc.), proposing solutions that fit all of the criteria. As a result, these specialists will have all of the information needed to design the most efficient and cost-effective solutions.

AI will also be able to help by improving Building Information Modeling (BIM). AI bots will be able to follow the lifecycle of a construction project making sure that every aspect goes according to the designs. Through gathered data from various sources, AI algorithms will be able to take care of quality management, thereby ensuring uninterrupted project flow, constructional safety, and efficient development. Moreover, machine learning based algorithms will be able to identify and mitigate clashes between the different models generated by different teams in various softwares during the planning and design phase to prevent or minimize rework. It will be able to analyze all the variations of used solutions and generate design alternatives. In the future, machine learning and deep learning will automate and optimize the work of designers and engineers, by refining the now available design tools, analyzing historical information, and helping to choose the most efficient solutions.

05. Summary

Big data, artificial intelligence, machine learning, and deep learning are being used in exponentially-increasing applications throughout the world. Even though the current use of technology has just begun to scratch the surface of its possibilities, it has already had a permanent impact on our lives. At some point, these technologies will become an integral part of most, if not all, industry standards. The same goes for the construction industry. Implementing these solutions in the future will reduce building costs, enable skilled employees to



perform their tasks without repeating historically-made mistakes, gather, track and analyze everything going on on sites, increasing the safety and efficient project management. AI will allow us to learn quicker, see details easily missed by the human eye and be used for optimizing and automating processes and designs. Working around the clock to forecast and predict problems before they even arise, will mitigate costs and always ensure project profitability.

When it comes to the implementation of these technologies in construction, it isn't if, but rather just a matter of when. Despite the fears across many industries, AI is unlikely to replace the human workforce. Instead, it will alter business models in the construction industry, reduce expensive errors, reduce worksite injuries, and make building operations more efficient. It will help humans make less mistakes and be more efficient doing what they do best. Industry leaders should prioritize investment based on the areas of greatest impact (where AI can do the most good for their company's unique needs). Early movers will set the direction and shape the development of the industry, benefitting in the short and long term alike.

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