# Demystifying AI
for Construction

7 BIG IDEAS

Introduction

The goal of this report is to guide construction executives in understanding the business implications of artificial intelligence (AI) for the construction industry. The transformation sparked by industrialization has far reaching implications for the people, processes, and technology of industry, and AI technology is a major contributor to this shift. The companies that leverage it effectively stand to achieve sustained competitive advantage and market dominance in a rapidly changing and uncertain environment. This report is a starting point for developing a data centric AI business strategy that will help secure industry leadership.

Artificial intelligence is a broad term that has evolved over the years, but effectively just means machines or systems that do things normally associated with human intelligence, like transcribing voice audio, recognizing objects in images, or determining if an email is spam. Most of our interactions today with so called narrow AI, or AI designed to perform a specific task, are interactions with a set of algorithms. The subset of AI referred to as machine learning is a specific statistical approach that involves learning by identifying patterns in data sets (without explicit instructions like traditional logical systems) and modifying the algorithms to achieve better results over time. Google's translation service and predictive email suggestions are well known examples of AI systems that leverage machine learning (ML). Deep learning is a subset of ML that uses layers of processing in advanced artificial neural networks, similar to those in the human brain, to achieve goals iteratively. Finally, data science refers to the interdisciplinary field of computer science, statistics, and data analytics that uses these statistical techniques to understand systems. With these basics established, it is time to explore the business implications of AI for the construction industry with seven big ideas.

Artificial Intelligence

Machine Learning

Deep Learning

Data Science
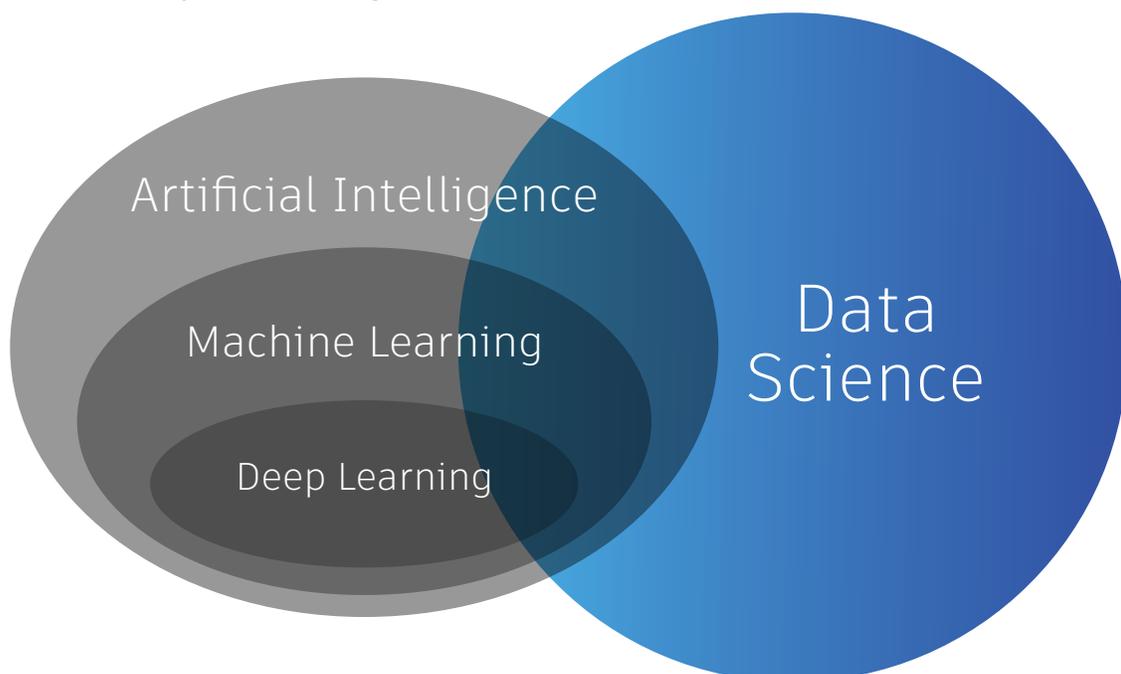
AI systems reduce errors and expose insights

The power of a data centric approach is twofold: reducing errors improves performance incrementally, while exposing insights affords disruptive change that leads to competitive advantage. The vast majority of performance improvement in organizations is focused on reducing errors, because these are obvious examples of deficiencies in the effectiveness of the organizational machine with a clear path for correction. It is much more difficult to expose insights, and there is no clear formula for finding them or scaling them purposefully. But it is precisely this method by which AI systems provide value by identifying patterns and exposing relationships that are nonintuitive, or even counter intuitive, based on data. Many firms track key performance indicators (on projects), but AI supercharges a company's ability to track progress and get actionable intelligence in real time.

Furthermore, AI has the potential to manage the interface between the digital and the physical world by digitizing physical activity and exposing contextual digital information in the real world. Combined with the trillion fold increase in computing power since artificial intelligence was invented in the 1950s, businesses now have unprecedented access to business intelligence and strategic insights in both internal and external data sources. The first stop on the road to analytical excellence (and the key to exposing insights) is to build business systems that effectively capture data that is critical to understanding and improving business performance. The main conclusion to draw here is that these general purpose approaches are (or will be) applicable to nearly every industry, and construction is no exception.

Examples of AI at Work:

- Translating languages in text or speech >
- Analyzing financial for mortgage lending >
- Matching workers to job openings and interviews >
- Handling customer service inquiries >
- Providing diagnostics of radiology images >
- Identifying security vulnerabilities & threats >
- Optimizing data center energy performance >
- Improving sales and customer service >
- Using virtual agents to interact with customers >

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"The Key Definitions of AI That Explain Its Importance"–Forbes

"A Strategist's Guide to Artificial Intelligence"–PwC

"The Great AI Awakening"–New York Times

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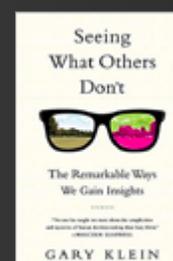
SEEING WHAT OTHERS DON'T by Gary Klein

Learning happens most effectively in structured data platforms

2

The primary mechanism for any algorithm to find patterns, identify relationships, and expose insights is to analyze large amounts of data. The lower quantity and quality of the data, the less robust the findings. Construction as an industry is unique in that it generates large amounts of unstructured data markups, annotations, changes, issues, and relevant experiences all documented on the note pads, PDFs, non standard databases, and human brains that make up the construction machine. Unstructured data makes it difficult for AI systems to analyze data and expose insights, so standardizing how data is captured and tracked across an organization is effectively step one of the journey towards data analytics excellence. This involves the interaction of internal enterprise platforms, external third party platforms, and project based systems.

Common Data Environments will be the mechanism for how these platforms are structured, and how they interact with one another using international standards (ISO). The construction industry maintains data in these domains independently today, so moving towards an integrated platform approach is critical to take advantage of the benefits of AI systems. Finally, many if not most business processes today are centered around human capabilities, and human brains. With AI capabilities available to augment human capabilities, business leaders need to think about how business processes can be reinvented to support new technologies through approaches such as business process reengineering. Improving data capture and tracking in a structured environment helps businesses create a strong foundation that will allow them to quickly derive business value from new technologies.

Current State:

Only 30% of construction companies are looking at historical information from past projects and comparing those findings to current projects to identify trends and patterns.

A primary reason is that data is not being captured in a structured way that can be easily analyzed across project portfolios. (Source: **Dodge Analytics**)

ISO 19650: Organization and digitization of information about buildings and civil engineering works

International standards like this one will help standardize how data is captured, exchanged, and managed in Common Data Environments

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KEEP READING ───────────

"The Building Data Analytics Revolution in Three Acts"–Building D+C

"Key Performance Indicators (KPIs) of Construction Report"–Dodge/Autodesk

"ISO 19650 Building Information Modeling"–BSI

DEEP READD ───────────
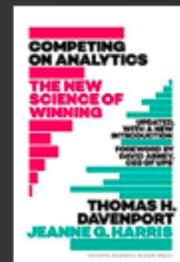
COMPETING ON ANALYTICS
by Thomas H. Davenport & Jeanne G. Harris

Human/machine collaboration is the best of both worlds

3

Countless examples exist of humans and machines working better together than individually. This is true in both the physical and digital domains. Machines are better at data processing, humans are better at generalization. Machines are better at brute strength and rapid motion, while humans excel in adapting to unstructured physical environments. Machines are better at identifying patterns, while humans are better at understanding business implications and executing a strategic plan. It is helpful to think of AI systems as a digital advisor, providing a sort of "augmented intelligence" to a field engineer, a superintendent, or a business line executive. This approach has the potential to unlock predictive capabilities by identifying leading indicators that can identify and correct problems before they arise.

These digital collaborations will dramatically increase an individual's capacity to generate value in the trailer or on the jobsite, and will support more proactive decision-making. Many professionals are concerned about offloading tasks to digital systems, but many AI applications can function more like decision support systems, where humans make the final decisions. Similarly, in the physical space, collaborative robots ("cobots") can augment human strength or dexterity to improve performance. Overall, this collaborative approach drives evidence-based decision-making by reducing errors in existing processes (incremental value) and exposing opportunities to generate competitive advantage (disruptive value).

> "The problem right now isn't so much that robots are replacing jobs; it's that workers aren't prepared with the right skills necessary for jobs that are evolving fast due to new technologies, such as AI.
>
> *–Human + Machine*

Image courtesy of KUKA

The manufacturing industry has shown that "cobots" perform better than robots or humans alone

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KEEP READING

"The Key Definitions of AI That Explain Its Importance"–Forbes

"A Strategist's Guide to Artificial Intelligence"–PwC

"The Great AI Awakening"–New York Times

DEEP READ

HUMAN + MACHINE
by Paul R. Daugherty and H. James Wilson

The future of work will be task automation, not job replacement

4

AI does not care about our existing job structures. There will not be AI project engineers, AI principals, or AI construction managers. The idea of "replacement" is not a relevant framework for understanding AI and the future of work. This is because our current job structures are based on human capabilities, not AI capabilities—in fact most jobs in construction involve many disparate, separate tasks, each one requiring a different but related skillset. It is these specific tasks that will be streamlined, optimized, or even fully automated by AI systems. Counterintuitively, these advancements are not necessarily based on "menial" or low-wage tasks. For example it has been widely published that the imaging analyses performed by radiologists, one of the highest paid professions, are already performed more accurately with an AI system than even the most experienced radiologist. Meanwhile, plumbers and nurses can sleep well at night knowing that their profession will be one of the last to be automated due to the broad range of physical tasks and human interaction required.

Complex physical and digital interactions with poor data inputs are hard for computers to solve, so instead, AI developers focus on creating discrete capabilities that can solve general-purpose problems that affect many industries, or technology that will afford strategic competitive advantage if solved. This is not to say that massive labor market disruptions are impossible – because automation will increase a human's capacity, fewer workers will be needed to provide the same value. However, the reality is that many skilled jobs remain unfilled across developed economies. Depending on what new, currently unknown jobs will be created because of increased automation, and what skillsets they require, many labor markets may face an uncertain future.

Skills Declining in Value:

- Manual dexterity, endurance, and precision
- Memory, verbal, auditory, and spatial abilities
- Management of financial, material resources
- Technology installation and maintenance
- Reading, writing, math, and active listening
- Management of personnel
- Quality control and safety awareness
- Coordination and time management
- Visual, auditory, and speech abilities
- Technology use, monitoring, and control

Source: **WEF Future of Jobs Report**
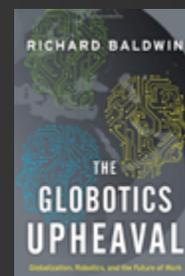
AI and robotics have different development trajectories

5

Mainstream media has not helped to clarify the difference between artificial intelligence and robotics. It seems virtually every article on AI has a header image of a terminator-esque cyborg with a metallic but distinctly humanoid form. To be clear—physical robots are not AI, automation of tasks is different than directly replacing human jobs, and the robotic construction jobsite is a long way off. Robotics has revolutionized many industries by mechanizing repetitive tasks and improving production control in highly structured environments like assembly lines. The two approaches for construction are to either use general purpose robots tuned to specific applications (the manufacturing approach) or to develop bespoke machines for specific tasks (such as laying bricks or installing pipe). Construction has a systemic challenge in that each unique jobsite is a highly unstructured physical space that is rapidly changing, which is a challenging environment for robotics applications.

The construction robotics market is certainly growing, but the primary near-term benefit will be in using robotics and 3D printing in prefabrication factories rather than on jobsites. On site, automation capabilities are being integrated into traditional construction equipment, such as for automated machine guidance (AMG). However, methods for process improvement such as prefabrication, modularization, and design-for-manufacturing-and-assembly (DFM+A) will have a much larger impact on efficiencies than on-site robots in the near future. It is in fact the move to more structured, controlled, trackable processes that will lead the way for robotics and jobsite automation technologies to thrive and advance.

Early Days:

3.27%

Share of US construction spend using modular construction

55%

Share of construction companies using prefabrication for more than 20% of project work

7,000

Number of global jobsite robots expected by 2025. NYC alone has over 7,000 construction sites

COVERS LIKE THIS OBFUSCATE THE RELATIONSHIP BETWEEN ROBOTICS AND AI

KEEP READING

"Ways to Think About Machine Learning"—Benedict Evans, Andreesen Horowitz

"Robotics in Construction: Resources"—Autodesk

"Parametric Building Information Generation for Design & Construction"—Front Inc.

DEEP READ

THE SECOND MACHINE AGE by Erik Brynjolfsson and Andrew McAfee

AI applications will be developed based on business value

6

When thinking about the implications of AI, construction executives should think in terms of business models—what problems yield a big payoff when solved. The payoff could be in terms of technical excellence, sustainable competitive advantage, stable and scalable profit, or many others. The construction industry clearly shares many characteristics with other industries – we have project schedules, CRM systems, financial management systems, and human resources obligations just like the rest. AI systems that optimize, improve, and even revolutionize these processes will be developed by Google, Microsoft, Salesforce, and others, because there is a clear business model to scaling these technologies across many industries. All these solutions can be simply adopted by construction companies to reap the productivity rewards.

Other capabilities are unique to the construction industry and will be generated internal to the construction industry by leading firms, construction software companies, and startups. It may be difficult to determine which capabilities should be developed by construction firms in-house, and which should be adopted from the outside. In the early stages of this transition, companies that establish a culture of innovation that can quickly adopt and implement new business solutions will have a substantial edge over competitors slowly implementing point solutions. Business leaders must understand that sustainable competitive advantage is up for grabs in this space for the firms that can figure out how to optimize their systems, upskill their staff, and scale technologies that will revolutionize how they work.

General Purpose AI Applicable to Construction:

- Natural language processing
- Speech-to-text
- Real-time language translation
- Image recognition
- 3D object classification
- Financial risk analysis
- Inventory optimization
- Labor optimization
- Job/bid matching
- Digital twins
- Virtual agents

Robotic Process Automation:

Robotic Process Automation (RPA) has become a popular (and confusing) term to broadly describe any automation of digital tasks and processes (and having nothing to do with physical robots). Some researchers use the term "robot" to refer to any form of automation of a typically human task, whether physical or digital.

KEEP READING

"Machine Learning is a Moneyball Moment for Companies"– Forbes

"Why Companies That Wait to Adopt AI May Never Catch Up"– HBR

DEEP READ
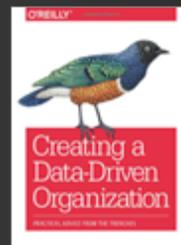
CREATING A DATA-DRIVEN ORGANIZATION by Carl Anderson

The opportunity is to increase capacity; the challenge is how to transition

7

The construction industry has a capacity problem. Governments are not investing enough in infrastructure, a skilled labor shortage threatens projects across the world, cost and schedule conformance is suboptimal, and labor productivity has stagnated. AI systems will reduce errors and expose insights that will allow the construction industry to increase its value per employee and its effectiveness in project delivery across the project lifecycle. In summary, AI systems will help increase the capacity of the construction industry to deliver projects sustainably and efficiently. However, the Building Information Modeling (BIM) transformation of the past decade or so has demonstrated that cultural challenges are often just as formidable as technological ones.

If we could build up the construction industry from scratch, we could rewrite history and develop a data-centric approach to delivering construction projects. But instead we must deal with the current state of affairs, transitioning our workers, our processes, and our technologies to take advantage of these revolutionary capabilities. Many companies have pockets of excellence where innovation thrives, but the challenge is to scale these practices to truly disrupt the industry at large. Navigating this rapidly changing environment will not be possible for everyone—but those who can harness the power of AI stand to reap the rewards of industry leadership, high profitability, and sustainable competitive advantage.

> Right now, everyone focuses on the technology of big data, but we need to refocus our attention on the people, the processes, the business partnerships, revenue generation, and business results. Most of the conversation has been about generating insights from big data. Instead we should be talking about how to translate those insights into tangible business results.
>
> *—The Culture of Big Data*

> The future is here, it's just not very evenly distributed.
>
> *—William Gibson*

KEEP READING

"Companies are Embracing Analytics, But Don't Have a Data-Driven Culture" – HBR

"Why Data Culture Matters" – McKinsey

"The Culture of Big Data" – OReilly

"Big Data and AI Executive Survey 2019" – NewVantagePartners

DEEP READ

THE AI ADVANTAGE by Thomas H. Devenport

Conclusion: A Lifecycle Vision

In the context of the construction project lifecycle, the application of AI can mean many different things. It is clear that virtually every aspect of the construction process from early stage master planning through to operations and maintenance will benefit from artificial intelligence. The graphic below is a vision of just some of the ways that AI will optimize, automate, and reinvent processes across the project lifecycle.

PLANNING

Generative design of spaces based on programming requirements

Visualization, simulation, and analysis of sustainability program objectives

DESIGN

Design automation using standard 3D parts families matched to project requirements

Design model checking to identify errors and omissions based on design quality

Generative design of parts, assemblies, and prefabricated components

Simulation of constructability of designs based on performance data

CONSTRUCTION

Demand prediction recommendation engines for managing backlog and project pursuits

Analyzing subcontractor default risk based on performance and financial health

Real-time voice and text language translation for collaborating with international teams

Intelligently matching bids to job pursuits based on job and company characteristics

Trade coordination of MEP systems based on automated routing and constructability

Schedule and cost optimization based on internal and external business factors

Automated comparison of BIM to reality capture models from scanners and drones

Predictive maintenance and inventory management of construction equipment and tools

Root cause analysis of RFIs, CCOs, and claims

Automated safety and quality risk assessment and prioritization of tasks

Automated digital production of reports, drawings, submittals

Automated tracking and billing of labor, equipment, and materials using sensors

3D feature recognition on jobsites to assess schedule conformance

Optical character recognition and digitization of text for project management

Supply chain optimization using prefabrication, consolidation centers, and automated delivery

OPERATIONS

Automated analysis of sensor networks for performance recommendations

Optimizing asset performance based on intelligent digital twins

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