ARTIFICIAL INTELLIGENCE AND THE CONSTRUCTION INDUSTRY

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Just as no one predicted in the 1990s that we would soon use phones for all the different applications we do today, it is impossible to fully predict how AI will be used in various industry sectors 20 years from now. We can be certain, however, that it will perform many of the functions currently performed by humans.

This white paper examines the use of Artificial Intelligence (AI) in the Architectural, Engineering, and Construction (AEC) industry. Over the last few decades, contractors have employed numerous new computer technologies to estimate, manage, and execute AEC work. These computers have generally performed basic math functions, such as calculating the impact of a new scheduled activity. But they have not been used to think — for example, by suggesting new ways to sequence work within the schedule. AI attempts to make computers think by analyzing data, running simulations, predicting future results, and suggesting new approaches.

In this paper, we explore:

- The history and background of AI
- Why the large construction world is poised for an AI revolution
- Types of AI and their uses for contractors and designers
- Concerns around AI and its use in construction

The history and background of AI

Artificial Intelligence can be defined as "the ability of a digital computer or computer-controlled robot to perform tasks commonly associated with intelligent beings."[1] We have been using AI in our everyday lives for some time; for example, CAPTCHA tests on websites ask you to identify photos showing bicycles or traffic lights in order to determine whether or not you are a human. Siri, too, is powered by AI and so is predictive text messaging.

However, the true power of AI was unleashed on the world in November 2022, when AI research organization Open AI released ChatGPT for testing to the general public. The chatbot is "generative," meaning it can generate new content — theoretically being able to write new essays, books, plays, movies, etc. Lawyers have even tried to use it to write legal briefs, although that has not worked out so well for those lawyers who inadvertently used fictitious case citations generated by ChatGPT.[2]

AI works by "training" the computer to make classifications and spot patterns by reviewing existing data. Indeed, the "GPT" in ChatGPT stands for "Generative Pre-trained Transformer." Trained to recognize word patterns from a large amount of text, ChatGPT can predict the next word in a sequence. It is possible for this type of training to be used for many applications outside of text, and that's where the future is heading.

Why the large construction world is poised for an AI revolution

Because generative AI "learns" from existing data, early adoption is most likely to occur in environments where large amounts of data already exist in a digital format. Within the context of mid-sized or larger projects, the AEC field is such an environment. Over the decades, an immense amount of digitalized data has been accumulated through Building Information Modeling (BIM), Primavera Schedules, and cost tracking data in any number of accounting systems.

Early adoption is also driven by financial necessity. Developers always try to bring projects in faster, cheaper, and better. Contractors often work in a competitive bidding environment, where they need to find a way to be a low bidder while still making a profit. Labor shortages, too, are compounding cost constraints. AI is set to tackle some of these challenges, as it can be used to cut costs, improve quality, and shorten delivery times.

As with any technology, scale is important. Nevertheless, large swathes of the construction industry remain barely digitalized at all, with whiteboards and low-powered scheduling software still commonly used, along with Computer-Aided Design (CAD) entirely updated with hand-drawn sketches. Cultural barriers, a lack of appropriate talent and computing power, and the costs of implementing computer-based technology have prevented many smaller contractors from developing the data needed to implement AI-based solutions.

Other challenges exist in international applications. AI generally requires internet connectivity, and some of AI's promise comes through self-operating machinery. Satellite technology (albeit with questionable speeds and reliability in some locations) means that connectivity is now almost universally accessible. However, there are places where it makes little sense to use basic machinery in developed countries — either because it cannot be practically serviced or because local labor is cheaper to use.

As a result, we can expect to see rapid AI adoption by larger members of the AEC community in the developed world and then to see AI use spread to smaller builders and penetrate more remote parts of the world, just as smartphone use has penetrated many less developed markets.

Types of AI and their uses for contractors and designers

Prominent subfields of AI and their uses in construction include:

Machine learning

Machine learning is one of the most significant AI applications in the construction industry. It involves using computer programs designed to "learn" from past experience in order to distinguish between items and make predictions. Potential uses include:

1. **Health and safety**
   - Wearables and trackers to alert employees of dangers such as fall hazards, close proximity to machinery, or excessive fumes/CO_2. The technology can also monitor unsafe employee behavior.
   - Improve risk management by analyzing past incidents and patterns and applying the learning to predict future risks.
   - Improve jobsite safety by using safety observation data to reduce incident rates.
2. **Project planning and scheduling**
   - Analyze schedules on earlier projects to develop sequences and durations and then apply those to quantities derived from BIM models of the new projects.
   - "Play" with the baseline schedule to optimize variables based on project needs.
   - Search for ways to overcome various jobsite impacts and model different sequences to see how that will affect the schedule.
3. **Cost estimating**
   - Identify productivity patterns and then apply those to refine cost estimation, e.g., to help contractors quantify the impact of weather based on previous projects.
   - Predict changes in material costs based on historical patterns, potentially allowing contractors to predict the costs of lumber, concrete, steel, and other materials.
   - Helpful in claims analysis, to use a statistical approach based on past performance instead of trying to create a "measured mile" or using Mechanical Contractors Association of America (MCAA) factors.
4. **Site logistics**
   - Analyze worker movements (e.g., getting materials/tools, toilet trips, etc.) through wearables to identify efficiencies.
   - Analyze location and movement data to determine if materials have been efficiently distributed on the project for installation.
5. **Quality control**
   - Analyze historical data to identify patterns associated with poor quality work, helping managers address the root causes (e.g., excessive overtime affecting the quality of work).
   - Detect non-conforming work or poor craftsmanship by feeding progress photos into appropriate software and generating reports.
   - Detect materials used that do not match specifications prior to use in a project.
6. **Resource optimization**
   - Analyze waste streams to find better ways to reduce and manage waste, thereby lowering materials and disposal costs, and improving sustainability. (Construction and demolition debris is estimated to make up nearly one-quarter of America's waste stream).[3]
7. **Loss prevention**
   - Track materials "walking" off the site and develop analytics to catch thieves.
   - Detect losses from water damage. (Plumbing failures cause about half of all Builder's Risk claims).[4]
8. **Equipment management**
   - Identify patterns to help better manage equipment and equipment maintenance to reduce downtime.
   - Learn how to perform many tasks presently controlled by humans, e.g., for machines that use detectors like Light Detection and Ranging (LiDAR) and GPS to steer the equipment.
   - Identify machinery problems/mistakes and improve future performance.

Computer vision

Computer vision enables computers to pull information from digital images, including videos, and to take actions or make recommendations based on that information. It is used for image classification, object detection, object tracking, and image retrieval based on the content of the image, which is useful for digital asset management systems.[5] Computer vision may help significantly with quality control as it can inspect work and identify improper practices. It can also be used to monitor progress, analyze productivity, and enhance safety management.

Robotics

Robotics uses machinery to mimic human actions, but robots lack "the human touch." AI can pull data from sensors and replicate some of that human touch. In an era of large labor shortages, contractors turn to robots to perform repetitive functions. For example, one manufacturer advertises that its rebar laying robots can place 5,000 lbs of rebar per hour in all weather conditions,[6] and a related company uses a bot to tie the rebar.[7] Another firm developed a painting robot to address the shortage of skilled labor.[8] Digital fabrication by way of 3D Concrete Printing (3DCP), while still in its infancy, uses robotics to print buildings with extruded cementitious materials.

AI-assisted design

The AEC industry has long been using BIM, which uses AI to analyze data fed into the model and to create models. Its main purpose is to reduce the risk of human error through tools like clash detection that identify conflicts in the drawings — for example, a heating, ventilation, and air conditioning (HVAC) duct running through a beam. As AI tools become stronger, so will BIM by helping users develop contingency plans and identify risks.

Generative AI can use algorithms to create and test hundreds or thousands of alternative designs against metrics identified by the architect. The architect or engineer feeds design parameters into the machine, which can then generate a series of design options for consideration and review. For example, by using a database of Frank Lloyd Wright designs, architects could use generative AI to design a house in Wright's style.

AI can be particularly helpful with design quality checks, such as clash detection within a design and identifying and accounting for different tolerances. For example, steel and concrete tolerances between the American Institute of Steel Construction (AISC) and the Architectural Control Authority (ACA) standards can create conflicts if architects do not build mechanisms into the design to account for them. Another potential benefit of AI design is that it can reduce risks by identifying incompatible materials or systems.[9]

There is currently a shortage of experienced design professionals, and while AI may not turn a freshly minted architect into a seasoned professional, it can help them avoid mistakes. By analyzing data sets to identify errors and omissions in prior projects, AI can create insights that traditionally come from human experience.

Perhaps most significantly, AI can be used to compare the performance of various options to create more efficient structures, enhance structural integrity, and perform lifecycle analysis for the long-term benefit of the owner. It can also help to enhance sustainability by designing for energy efficiency, greater accessibility and safety, and better traffic flow.[10]

Concerns around AI and its use in construction

Generative AI "learns" patterns from existing data sets and then employs those patterns to generate new content. The product can be remarkable, but it can also "learn" the wrong things. For example, one AI program was shown pictures of dogs and wolves to distinguish between the two animals. Because many of the wolf pictures had snow in the background, it determined that the difference was not in the animal but in whether the picture had a white background.

While AI is a powerful analytical tool, professionals must always keep in mind that it is a tool. Humans will need to vet the answers and content it gives to make sure that AI is focusing on the right things and presenting the right results.

Within construction, there is a danger that existing prejudices could infect AI. For example, Frank Lloyd Wright designed his buildings for people of his modest height, so an AI-generated design using his designs may incorporate this prejudice.

One of the most significant issues with AI is that it sometimes "hallucinates" — the term used when AI presents false information as being true. This may be due to guesswork to fill in data voids or wrongly applying its training.

Conclusion

The AEC industry is poised for an AI revolution that can provide better design, improved safety, and more efficient construction. However, there will be growing pains. Industry participants will need to make upfront investments in AI and partner with IT providers to maximize the potential of AI's benefits. Some workers will be displaced by robots or because their services are no longer needed. However, this can provide a benefit as those workers are already familiar with the industry and can potentially be re-trained to fill existing labor force gaps.

While AI is evolving at pace, design and construction professionals cannot accept AI output as "Gospel." They will need to carefully review it to ensure that it is not the product of hallucinations or poor training. Human vetting and consideration will always have their place.

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