Wisconsin Contractors Institute

ARTIFICIAL INTELLIGENCE IN GENERAL CONTRACTING

Course Number 962567
2 CE Hours

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INTRODUCTION

The digital age has brought about technological changes affecting how we live and everything we do. Personal computers, tablets, and especially smartphones have changed life for almost everyone. Even in Third World countries, people have cell phones and use them for more than just communication.

In our world, smartphones have become our alarm clocks, our weather information source, our calendars, our route guidance device, our communication device for voice, text, and email and our primary source for news and information. In addition to all of that, there are millions of applications that we can use for all sorts of purposes from medical diagnoses to Augmented Reality uses. We will look further into Augmented Reality later in the course.

Technology in construction continues to advance rapidly. Recent examples include 3D scanning, computer-aided design, building information modeling, algorithmic design, artificial intelligence, and robotic applications. This course will survey some of the most recent technological advances, especially Artificial Intelligence and explain how to successfully utilize them in the construction industry. We will also consider what the future may hold for those who work in the construction industry.

Note from the course author:

There is always a temptation to remain "old school" in our work. "I'm too old for that!" we might say. You can't teach an old dog new tricks. If it works don't fix it! When Computer Aided Design was becoming an industry standard, I resisted it. It wasn't that I resisted technology, I just didn't get the artistic satisfaction out of designing on a computer that I got from drawing by hand. I not only had to learn a new way of working, I had to learn a whole new way of looking at the world. I had to attend classes to learn how to use the software and many hours of practice to gain proficiency, but if I had not "moved with the times" my career would have ended.

Many of you may be familiar with the information contained in this course. For some of you, it may be an introduction. Whatever the case, I encourage you to not dismiss it as fanciful. I hope that you will take what you learn today and make it just the beginning of exploring these topics which will shape the way you will practice general contracting in the future.

Learning Objectives

After completion of this course, construction professionals should be able to:

1. Define Artificial Intelligence, clarifying its capabilities and limitations.
2. Recognize how designers utilize AI for complex building design and how contractors employ CAD/CAM for construction.
3. Analyze AI's role in estimating construction project costs for general contractors.
4. Evaluate AI's impact on project management for general contractors, covering scheduling, code compliance, progress monitoring, resource management, and cost control.
5. Examine AI's potential to enhance job site safety.
6. Discuss the future implications of AI, weighing its benefits and drawbacks.

Introduction – REVIEW QUESTIONS

1. Which of the following is NOT mentioned as a technological advancement in construction?

A. 3D scanning
B. Teleportation logistics
C. Robotic applications
D. Building information modeling (BIM)

2. Alongside AI and robotics, what other digital tool is highlighted in the introduction?

A. Computer-aided design (CAD)
B. Hand sketching
C. Blueprint copying
D. Manual surveying

3. One of the learning objectives is to define Artificial Intelligence by clarifying what two aspects?

A. Its cost and market value
B. Its history and geography
C. Its capabilities and limitations
D. Its hardware and software requirements

ARTIFICIAL INTELLIGENCE OVERVIEW

Artificial Intelligence is on everybody's mind, and at the top of every news feed. Many corporations are advertising how they have already incorporated AI into their businesses.

What used to be a fringe interest has recently come front and center as a major topic for consideration. The question is no longer ***if*** AI will become an important aspect of our lives, but how important will it be. Like any technology, AI is neither positive nor negative in and of itself. Whether it improves our lives or threatens us will depend on how we employ it. It can be an extremely important tool for us, or it can become our taskmaster. Just as a hammer can be a useful tool or a murder weapon. It falls on us to be proper stewards of this emerging powerful technology.

I want to take a deep dive into what artificial intelligence is and how it works, because I believe the more you understand AI, the less mysterious it will become and the less intimidated you will be by AI.

Intelligence is by definition the ability to acquire and apply knowledge and skills. Historically intelligence was considered to be an ability that was limited to sentient beings such as humans, animals, and some plants and microbes. Artificial Intelligence differs from natural intelligence in that AI is an ability that machines can possess.

It's understandable that when early computer scientists began to develop AI, their assumption of the similarity to natural intelligence influenced early developers to view AI as a simulation of human thinking. The notion that machines could simulate human reasoning and even surpass it has been a fascination for humans for centuries, usually with a certain amount of fear. Books written by Jules Verne in the 19th century and 20th and 21st century films like *2001 – A Space Odyssey*, *Terminator, I Robot, and Ex Machina* are dystopic narratives about the rise of machines and their threat to human dominance and even to the possibility of the extinction of the human species.

In the 1968 film *2001*, a computer named HAL 9000 is responsible for all the mechanical systems on the spaceship, *Discovery One*. (The name HAL is purported to be derived by adding one subsequent letter to the letters IBM, which was the dominant computer company at the time of the making of the film. Actually, it stands for *H*euristically (able to discover or learn something for itself) programmed *AL*gorithmic computer.) HAL possessed all the abilities we associate with intelligence, or in this case, artificial intelligence - speech and speech recognition (think Siri or Alexa), facial recognition (think unlocking your smart phone by looking at it), language processing (think language translation apps), spacecraft piloting (We've had autopilot in planes for decades and now it's being introduced to cars and trucks), chess playing (think Big Blue). The conflict in the film arose when HAL's programing to successfully complete the space mission caused the computer to mistrust the humans and concluded that they needed to be eliminated for the success of the mission. When one of the crew members was returning from a spacewalk, he asked HAL to open the dock door for his re-entry. HAL response was, "I can't do that Dave."

Likewise, in the *Terminator* or other films where machines possess intelligence, the fear is that they will dominate and possibly eradicate the humans. Of course, these fears are based on an ***erroneous understanding of what Artificial Intelligence really is.***

The definition of AI as human intelligence simulation, although still held by some, is no longer the dominant view. AI founder John McCarthy (1955) has said: "Artificial intelligence is not, by definition, simulation of human intelligence".

In order to possess a better understanding of what artificial intelligence really is, it's helpful to compare AI to aeronautical engineering. Because men looked to the sky and saw that birds could fly, early designs of flying machines were just mechanical birds. Even the great Renaissance inventor, Leonardo da Vinci, studied the anatomy of birds to come up with his designs for his flying machines. But modern airplanes, helicopters, and drones have little to no similarity to birds, because engineers realized the essential project was not bird simulation, but FLIGHT.

McCarthy understood artificial intelligence to be based on belief systems. He wrote that "Machines as simple as thermostats can be said to have beliefs, and having beliefs seems to be a characteristic of most machines capable of problem-solving performance."

The philosopher, John Searle, disagreed with McCarthy and claimed that machines cannot possibly have beliefs simply because they are not and never will be conscious. In 1997, IBM's Deep Blue beat the chess grandmaster, Garry Kasparov, but it was not aware of its opponent or the game of chess. It wasn't even aware of itself!

So rather than AI being human intelligence simulation, the "Intelligent Agent" is the more accepted concept nowadays. The term defines intelligent behavior without reference to human beings. An intelligent agent perceives its environment and takes actions to maximize its chances of success. Computer scientists operate under the assumption that computers learn just like children do, that is by a system of rewards and punishments. As machines produce correct results, they experience rewards and punishments when they produce results that are not true. Based on this feedback, they modify themselves by rewriting their own code. Machine learning, rewards and modifications are basic methods in the development of AI. Most people are familiar with intelligent agents when we talk to Siri, Alexa, or when we do a Google search.

Artificial Intelligence Overview – REVIEW QUESTIONS

4. How is "intelligence" generally defined in the text?

A. The ability to memorize facts without context
B. The ability to acquire and apply knowledge and skills
C. The speed at which a computer processes data
D. The capacity to feel emotions like empathy

5. What is the fundamental difference between AI and natural intelligence noted in the text?

A. AI is biological; natural intelligence is mechanical
B. AI is an ability machines can possess; natural intelligence is inherent to living beings
C. AI cannot calculate math; natural intelligence can
D. There is no difference; they are identical

6. Early AI development was heavily influenced by which assumption?

A. That machines should be distinct from humans
B. That AI must simulate human thinking
C. That AI should only process numbers
D. That machines cannot learn

7. Which film is cited as featuring the AI character HAL 9000?

A. Terminator
B. I, Robot
C. 2001 – A Space Odyssey
D. Ex Machina

8. How does the development of AI compare to aeronautical engineering, according to the text?

A. Both aim to simulate natural processes
B. Both focus on achieving the essential goal rather than mimicking nature
C. Both rely on studying human and animal behavior
D. Both require consciousness to function

9. What is a key characteristic of an intelligent agent?

A. It simulates human emotions
B. It is always conscious of its actions
C. It relies solely on pre-programmed instructions
D. It perceives its environment and takes actions to maximize success

ARTIFICIAL INTELLIGENCE BACKGROUND

All the developments of AI so far are considered "weak AI", which is an AI that can only perform a specific task such as answering questions and only based on how it has been trained by humans.

Unlike Weak AI, it is theorized that Strong AI does not require human input because over time, Strong AI develops a consciousness instead of simulating it. This is also called AGI (artificial general intelligence) or sometimes called ASI (artificial superintelligence).

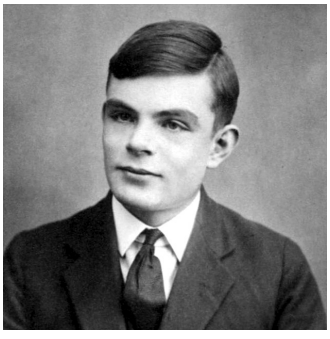
The big question is whether there can ever be a "Strong AI" where a machine can actually teach itself to solve new problems. The answer to the question is most probably NO.

There are many familiar examples of weak AI, such as

- Chatbots
- Spotify/Pandora
- Email spam filters
- Siri, Alexa and Cortana
- Self-driving cars
- Apple and Google maps
- Autocorrect

To date there are no examples of strong AI.

Even though John McCarthy coined the term "artificial intelligence" in 1955, Alan Turing is considered the real father of AI.



In 1948, seven years before McCarthy coined the term *artificial intelligence*, Turing suggested that one day there might be a "thinking machine" and proposed what is now called the "Turing Test." To pass the test a computer must be able to produce a written exchange so human-like that it cannot be discerned as to whether it was produced by a machine or by a human.

Working for Great Britain's Government Code and Cypher School at Bletchley Park, Turing was instrumental in developing a decoding machine that made it possible for Allied forces to break Hitler's Enigma Code, leading to the defeat of Nazism in WW2. He used a technique of probability that is now used by AI tools like ChatGPT to generate essays, art works, and even people who do not actually exist.

The coveted Turing Award named after him is the highest award given every year to computer scientists.

Although AI has been with us for decades, the development of AI was limited by two things: (1) a lack of computing power and (2) limited data, but in the 2000s more powerful processors were manufactured, primarily graphics processing units (GPUs) that were developed primarily due to the popularity of video games. Additionally, because of the exponential growth of the internet, there are now vast amounts of data in the form of words, sounds, and images. This has made it possible for a monumental advance in the implementation of AI in the development of what are called ***Large Language Models*** (LLM).

A ***language model*** works by assigning probabilities to sequences of words, based on the analysis of vast stores of written texts which can be harvested or "scraped" from the internet. When you are texting and the text application you are using suggests what word you are typing, it does so by predicting your next word based on millions of instances where people have used the same previous words you just used. This is a simple type of language model, but language models can also be more complex when using neural networks.

In Large Language Models, neural networks are used to process more complex uses of language. Neural networks are computer applications that attempt to mimic how the human brain processes information.

Imagine a cube composed of 24 layers of data points. Each layer is 24 x 24 = 576 data points. 24 layers would include 13,824 data points. Each data point is connected to all the other 13,823 points making over 191 million neural connections. Any input command can be processed by this 3-dimensional network instantaneously. This is nowhere near the complexity of the human brain, but it is a good start.

Using neural networks, AI can not only understand natural language, but in some cases can even understand the ***sentiment*** underlying the language. This is what can make AI seem uncannily "human".

For instance, a man might ask his wife "What's wrong?" She might reply "Nothing". But the man knows that something *is* wrong, because his wife said "nothing" with an underlying sentiment. A simple language model would interpret the woman's response of "nothing" to mean simply ***nothing***, but a Large Language Model would understand that "nothing" could mean ***something***.

LLMs, like Open AI's ChatGPT use deep learning algorithms. This allows machines to understand ***prompts*** given in natural language. By receiving commands (prompts) in ordinary language, the LLM can process and respond with viable solutions to the demands it is given.

For example, a prompt might be given to "create a 4-bedroom house in the style of Frank Lloyd Wright". The result would be several options that fulfill the parameters that have been imputed. All the options would use the floor planning techniques used by Frank Lloyd Wright and the exteriors would resemble his style.

Or a prompt might be to "create a floor plan for a daycare for 50 children in the state of Maryland." The result would be several floor plan options for a daycare facility compliant with the design and code specifications for the state of Maryland.

The use of LLMs can be compared to the use of the GUI (Graphic User Interface).

The GUI revolutionized personal computing because it made interaction with a computer possible for people with no computer knowledge. Rather than having to enter a string of code, a user need only select an icon or click on a "button" and the computer responds. Of course, behind each graphic image on the screen are lines of coding that took years of research to make it all happen. But that is all hidden to the end user.

The GUI was developed by Xerox Palo Alto Research Center (PARC) but was introduced to the general public by the Apple Macintosh in the 1980s. After the Macintosh debuted in 1984, the GUI became a standard for human computer interaction. Apple's rival, Microsoft, tried to acquire Apple's GUI without success so it built a simulation of the interface on top of its MS-DOS operating system and named it Windows.

A generation later, LLMs like Open AI's ChatGPT, Microsoft's Bard, and Google's BERT have unleashed a power to common users just as the GUI did 40 years ago.

A major concern about LLMs is what effect they may have on the human job market. Without question, LLMs can already perform jobs that humans have traditionally done with much greater speed and efficiency. Examples of jobs that would be jeopardized would be news writers, lawyers, and certain medical professionals just as autoworkers were replaced by robots in recent years.

While some jobs may be eliminated by AI automation, there is the real hope that new types of jobs will be created because of the overall increase of productivity that LLMs afford.

Artificial Intelligence Background – REVIEW QUESTIONS

10. What is the primary difference between Weak AI and Strong AI?

A. Weak AI can perform multiple tasks, while Strong AI can only perform one task

B. Weak AI requires human input, while Strong AI develops consciousness

C. Weak AI is theoretical, while Strong AI is widely used

D. Weak AI uses neural networks, while Strong AI does not

11. Who is considered the real father of Artificial Intelligence?

A. Alan Turing

B. John McCarthy

C. Steve Jobs

D. Bill Gates

12. What is the purpose of the Turing Test?

A. To measure the speed of AI processing

B. To determine if a machine can produce human-like written exchanges

C. To evaluate the ethical implications of AI

D. To test the neural network capacity of AI

13. What technological advancements in the 2000s contributed to the development of AI?

A. The invention of the Turing Test and the GUI

B. The creation of neural networks and the internet

C. The development of GPUs and the exponential growth of the internet

D. The introduction of chatbots and self-driving cars

14. What is a key feature of Large Language Models (LLMs)?

A. They rely solely on pre-programmed instructions

B. They are limited to simple language models

C. They require human input for every task

D. They can process natural language and understand sentiment

15. How are LLMs like OpenAI's ChatGPT compared to the GUI (Graphic User Interface)?

A. Both require advanced coding knowledge to use

B. Both were developed by Microsoft and Apple

C. Both revolutionized user interaction by simplifying complex processes

D. Both are limited to specific tasks

ARTIFICIAL INTELLIGENCE IN DESIGN

Before we look at how AI will change the way contractors work, we need to see how AI is already being used by the architects and designers who are designing the buildings we are called on to build.

AI assists architects and designers design more efficient and economical buildings by the use of generative design which can calculate and present numerous alternative possible designs that will satisfy the project program. AI can develop models which can analyze architecture, structural engineering, mechanical, electrical, and plumbing (MEP). The analysis can examine the optimization of any part of the building in regard to cost efficiency, realistic timelines and prevent or mitigate possible clashes of structural and MEP systems as well coordination of subcontractors and trades during construction.

This coordination is also important for on-the-job risk management. By prioritizing tasks of greater risk and focusing construction management on the higher risk tasks, better safety can be insured.

The work of building encompasses a large span of phases from just an idea in someone's head to a final design to a final building. All along the journey designers rely on ***visualization*** to express their work. From sketches on napkins to 2D drawings to 3D drawings to scale models to computer BIM models, these are all essential to the development of any design. It is extremely time-consuming and therefore expensive. A design may progress from idea to final construction drawings only to be discarded and replaced by an alternative.

AI image generation applications like Open AI's **DALL-E** and **Midjourney** are becoming increasingly popular with architects because of their ease of use and their ability to generate numerous options almost instantaneously. They work by learning what images are labelled like pandas or baboons or motorcycles, so that a prompt to "create an image of a panda or a baboon riding a motorcycle" would result in an image of a panda or a baboon riding a motorcycle that has never been created before.

As in any LLM, the results are generated by verbal descriptions given by the designer as to what he or she wishes to visualize. These descriptions are called **prompts**. The success of the results is highly dependent on the quality of the prompt, but it is very difficult to describe architectural concepts with natural language as well as the specificity that design parameters require. There are courses you can take that will teach you to be a better and more successful prompter.

One of the greatest challenges for the contractor of the future is the complexities of new buildings that AI is helping architects to design. The kinds of buildings that contractors are called on to build are not the same as they used to be.

In the past, most buildings were predominantly some type of trabeated system or what is more commonly called post-and-lintel. Construction was relatively straightforward. Posts were erected and beams were placed on them, story by story up to the roof. Most contractors are builders of residential projects or light commercial and have only known this type of construction.

Most builders are comfortable with the placing of lintels on posts as has been done for millennia, but many contemporary buildings have no post or lintels, no straight lines and roofs and walls are often indistinguishable from each other and form continuous planes. In the past, these sorts of buildings would have been impossible to draw and build even if they could be imagined. They were pretty much confined to the world of comic books and sci-fi films. Recently, however, architects have discovered and have learned to use software that was originally purposed for aircraft and automobiles. As a result, now buildings are being designed that defy any sort of traditional construction.

So how do architects draw the plans for buildings like this? Where do they even begin?

Enter the computer! Computers work by following a set of commands or rules in a certain sequence and computing a result. These processes or sets of rules to be followed in calculations or other problem-solving operations are called *algorithms*.

We all use algorithms everyday. A common example of using an algorithm is following a recipe. In order to produce the cake or the loaf of bread you want, you'll have to follow certain steps in a certain sequence. Sift the flour, beat the eggs, grease the pan, bake for such and such a time at such and such a temperature. And the result is the cake or loaf of bread you wanted.

In the digital age in which currently live, algorithms are everywhere in our lives. The traffic light that tells us to stop or go, the GPS system that tells us where to go, the app that controls the music we listen to all use algorithms. And who doesn't love the pop-up advertisements that bombard our screens?

Algorithmic Design

In architectural algorithmic design, forms are generated based on components defined by requirements such as function, connectivity, and relationships to other components. Algorithms may be as simple as floor plan creations based on shapes and space requirements and adjacencies. An example of using algorithmic design would be to instruct a computer to design a dining room to seat 12 people. The response would be several possibilities depending on the shape of the table. For instance, a square table may require a room with certain dimensions whereas a rectangular or oblong table may require a room of different dimensions.

More often, however, algorithmic design is used to create the complicated forms that we at which we wonder.

Parametric Design

The complex shapes of contemporary buildings are often a result of computer calculated optimizations of building requirements and specifications called parameters. The process is called parametric design. In parametric modelling any change of a dimension value in one place also changes all other dimensions in the design. A common example is the resizing of a photo. To keep the proportional relationship of the image in the photo, when the width is increased, the length must be increased proportionately. Without the controlling effects of parameters, you will get distortions such as you might get on your TV screen when the aspect ratio is not proportionate to the video transmission.

The architect can manipulate the values of the parameters and create a myriad of design possibilities all of which though different still satisfy the requirements for the project. This exploration of alternative solutions is called generative design.

Now you hopefully have some idea about how Artificial Intelligence generates these fantastical shapes, but as contractors we are still left scratching our heads at how in the world does someone actually build them? The answer is that even as complex shapes are designed using computers, so the building components themselves are often manufactured using computer-controlled machines. The components are usually built off site and shipped to the building site where they are assembled.

So rather than building from "scratch" with beams and joists and rafters on site, builders will become assemblers.

Off-site construction with delivery of components for on-site assembly is an increasingly common practice and not just for irregular shaped components. Most modular buildings are conventional in shape and construction but built off site in factories with roofs and with controlled environments. Quality control is much higher than on site construction can provide components and modules are built to more rigid structural specifications to withstand factory to site transportation and the strains of placement by cranes.

Artificial Intelligence in Design – REVIEW QUESTIONS

16. How does AI assist architects and designers in creating more efficient buildings?

A. By generating numerous design alternatives through generative design
B. By replacing human designers entirely
C. By eliminating the need for structural analysis
D. By automating the construction process

17. What is a key benefit of AI in construction risk management?

A. Prioritizing high-risk tasks to improve safety
B. Eliminating the need for subcontractors
C. Automating all construction tasks
D. Reducing the need for visualization tools

18. **What is the purpose of parametric design in architecture?**
    A. To create distorted shapes for artistic purposes
    B. To optimize building requirements and specifications using parameters
    C. To eliminate the need for off-site construction
    D. To simplify traditional construction methods

19. **What is the difference between on-site and off-site construction?**
    A. On-site construction uses computer-controlled machines, while off-site does not
    B. On-site construction is only used for modular buildings
    C. Off-site construction involves manufacturing components in factories for on-site assembly
    D. Off-site construction eliminates the need for quality control

20. **What is a common example of algorithmic design in architecture?**
    A. Designing a dining room based on table shape and seating requirements
    B. Creating distorted images for artistic purposes
    C. Automating the assembly of building components
    D. Eliminating the need for architectural visualization

ARTIFICIAL INTELLIGENCE AND CODE

So now that you have an understanding of what AI is and something about how it works, the big question is:

How does Artificial Intelligence affect me as a general contractor and how can it assist me in the work that I do?

No matter how complex and unusual buildings may become, all buildings must comply with the laws of building, which we refer to as the Building Code.

Code Compliance

"It is the responsibility of all licensed contractors to comply with all standards of the building code." But what exactly does that mean? What is "the code?" How is anyone supposed to know it all?

Story from the course author:

Some years ago, my wife and I were returning from western Canada into the United States. We were stopped at the border and ordered to enter a building, while our rental car was ransacked. We stood in line waiting to be interrogated. When I requested to visit the restroom, I was denied permission.

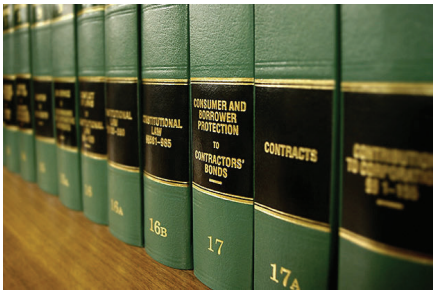
When our turn finally came, we were informed that a roast beef sandwich was found in our vehicle. Since we had not declared said sandwich, we were threatened with a $350 fine. Since my son had packed the car, I was ignorant of the contraband.

Feeling this was unreasonable, I asked the agent how we were supposed to know the law and rules governing the international transporting of roast beef sandwiches. She turned and grabbed a large three ring binder from a shelf behind her desk and turned to the pertinent section and read it to me. I explained to her that I was not familiar with the volume she referenced. She told me that I could have also found the information on the website of the U. S. Food and Drug Administration. That was not one of my Favorites or Bookmarks.

Finally, the agent was merciful and let us go without fine or imprisonment, albeit with our car left in disarray.

As a rank-and-file citizen, it was not unusual that I was ignorant of a law that I had inadvertently violated. As licensed general contractors, we have no such excuse. It is incumbent on us to know the building code, and to comply with it. But how can we accomplish such a daunting, almost impossible task?

The key is that we do not need to have a comprehensive knowledge of the complete code, but only how to reference it.



In order to make the Code accessible and searchable, it uses categorization and cross-referencing. In the case of online publication, this method is enhanced by the use of hyper-links.

With the implementation of AI, searching relevant sections of the code has been made much simpler. In 2017, the ICC (International Code Council) sued a for-profit company, ***UpCodes***, because the company posted searchable copies of the ICC's model codes online. The ICC lost the case and now offers its own AI search function, ***AI Navigator***.

UpCodes has developed a new AI tool called Copilot which is built on ChatGPT. Copilot is a research assistant, answering complicated code questions and even annotates responses with links to other relevant sections of the code.

LLMs have gone one step further, making it possible for contractors to "talk to the Code" and ask the Code questions in natural language.

AI is particularly able to analyze and interpret building codes by using machine learning algorithms and natural language processing. AI systems can identify relevant sections, requirements, and constraints by automating the tedious task of cross-referencing the numerous code sections and can produce decisions that can be explained in natural language. Not only does it reduce possible human search and cross-referencing errors, but it can even suggest alternative building options to avoid potential code violations.

Additionally, AI's abilities to analyze and interpret building codes and monitor compliance ***during*** construction will lead to safer and more efficient buildings.

Artificial Intelligence and Code – REVIEW QUESTIONS

21. **What is the primary benefit of AI in building code compliance for contractors?**
    A. It eliminates the need to follow building codes
    B. It automates the process of cross-referencing and interpreting code sections
    C. It replaces the role of building inspectors
    D. It simplifies the construction process by removing code constraints

22. **What is the purpose of tools like UpCodes Copilot and ICC's AI Navigator?**
    A. To replace contractors in decision-making
    B. To enforce fines for code violations
    C. To provide natural language search and interpretation of building codes
    D. To eliminate the need for building permits

23. **How does AI improve safety and efficiency in construction?**
    A. By automating all construction tasks
    B. By eliminating the need for human oversight
    C. By reducing the number of building inspections required
    D. By monitoring compliance and suggesting alternative building options

AI AND CONSTRUCTION ESTIMATING

Many people decide to become a general contractor because there are aspects of construction that they enjoy. Construction estimating is enjoyable for some, but for many it is a part of contracting that they absolutely dread.

Once you're able to convince a client to select your company to be their builder, you are faced with the challenging task of providing an accurate and reliable estimate of how much the project would cost and how long it would take to complete.

There would be the measuring and counting and hoping nothing was overlooked. Then there would be the updating of price books, the waiting for subcontractors to submit their bids, and the adding up all the line items, again hoping nothing was overlooked or left out.

For many years contractors used yellow pads and calculators for their estimating. In the early 1980s, personal computers arrived on the scene with helpful database and spreadsheet software. This technology helped contractors in adding up the costs and not to forget certain line items, but the job was still tedious.

Soon there was proprietary accounting software for general contractors that tracked job costs by inputting invoice data. Numerous reports could be generated. Some packages also included estimating modules that computed some rudimentary calculations of building materials and labor estimates. But estimating remained a daunting and frustrating task.

CAD software facilitated the generation of drawings for architects and engineers, but it also streamlined the job of estimating for contractors because the correlation of objects with specification data not only automated cost summaries, but any changes that were made in the design were automatically updated in the estimate reports. A lot of manual data input remained for contractors to make reasonable predictions for new projects.

The introduction of AI has been extremely beneficial for construction estimating, because of the ability of AI to survey, analyze, and make accurate decisions. AI tools can scour the internet for all types of sources from historical job cost reports to contracts to market trends, process the resulting data and make precise predictions as well as suggestions for alternative approaches to a project that may not have been considered by the design or construction team.

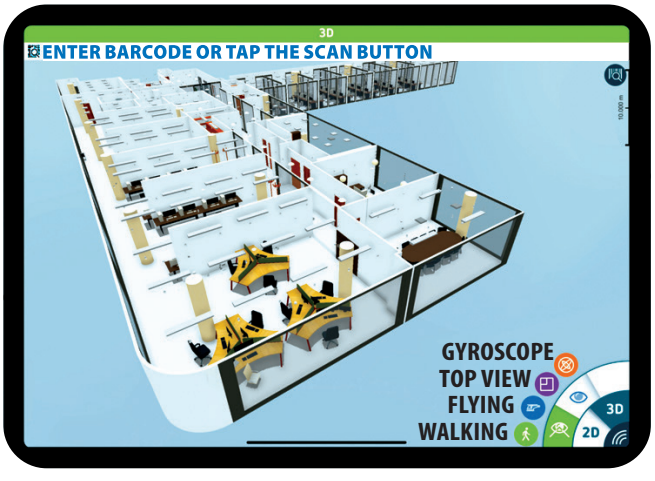
Big Data in Construction

Big Data has been defined as data that contains Volume (the increasing amount of data), Velocity (the fast rate at which the data is coming), and Variety (the many types of data). Because of the increase in false data or "fake news", some see the need for a fourth V for Veracity (the truth of the data). We live in an age when enormous amounts of data are being generated every day. Just as commercial enterprises such as Facebook (or Meta) or Google profit from Big Data, so can the construction industry. In the past companies like RS Means published annual books of national building costs used by contractors to estimate jobs for bids. The books are still available, but most contractors now use software that provides online access to cloud-based cost data that is current but can also be predictive.

The internet is an enormous resource for all sorts of data from texts to images, to videos, to sounds, but a substantial amount of the data on the internet is unreliable if not actually false. AI has limited ability to differentiate truth from error, so a seemingly viable AI solution may be built upon unreliable data.

As with all applications of AI, circumspection is advised. Any data that is accumulated by AI must be monitored for reliability, because if "reasonable" results are based on unreliable information, the consequences can be dangerous. When AI predictions are logically based on bad data, the results are called AI ***hallucinations***.

Another development that has greatly improved the comprehensiveness of construction estimating is the addition of **building information modeling** (**BIM**) to computer models of buildings. **Building information modeling** (**BIM**) adds additional "dimensions" beyond the usual 3 spatial dimensions, such as **TIME** (4D BIM), and **COST** (5D BIM). BIM can also include the addition of further information such as manufacturers' details and maintenance information to the building model.



The addition of information to architectural drawings is not new. The labelling of drawings is arguably prehistoric. Before CAD, information was written on plans, elevations, sections, and other standard drawings. The connection of the information to an item was only by its proximity on the drawing. With BIM, the information is integrated into the architectural object or symbol.

Building information models (BIMs) are computer files which can be accessed on multiple platforms by all stakeholders in a construction project. This is called interoperability.

The idea of BIM has been in development since the 1970s but has only recently become a standard method of design, construction, and building operation. Adoption of BIM and the development of standards has only become an international agreement since 2019 when ISO (International Organization for Standardization) published the first two parts of ISO 19650, which established a framework for building information modeling, based on standards developed in the United Kingdom.

ISO 19650-1:2018 defines BIM as:

> *Use of a shared digital representation of a built asset to facilitate design, construction, and operation processes to form a reliable basis for decisions.*

As various BIM software developers have developed their own software, problems of incompatibility threatened to undermine the advantages that BIM promised. To achieve interoperability between different applications, a need for neutral or open standards for sharing BIM data became apparent. That need has primarily been with the implementation of the **Industry Foundation Classes** or **IFC**. IFC is a platform-neutral, open file format specification that is not controlled by any single vendor or developer. It is an object-based file format that has been developed by buildingSMART (formerly the International Alliance for Interoperability). The IFC model specification is registered by ISO (ISO 16739-1:2018.)

BIM is important for contractors to understand because it is becoming the standard for transmitting information about building components and the way they are assembled both physically and temporally. In the past contractors have had to leaf through plans, elevations, specifications, and schedules printed on large unwieldy sheets of paper.

Prior to the introduction of BIM, if a builder wanted to gather information on an item such as a door, he or she would have to identify the door by its label on the floor plan and then check the table of contents to find which sheet the door schedules were on, then turn to schedules. Find the line item for the door in question, follow the row of information on the door such as size, material, swing direction, hinge type, fire rating, hardware, etc., and then return to the plan with the hope that you remembered all the information on the door.

With the adoption of BIM, information is embedded in the symbol on the electronic drawings and available at the click of a mouse or trackpad or a tap of a stylus.

BIM has been in use prior to the advent of AI, but AI has enhanced the effective implementation of BIM because of its ability to automate data entry and its capabilities of processing and analyzing vast amounts of data in warp speed.

This makes AI enhancements for BIM valuable for decision-making regarding a building not only for preconstruction design optimization, but also during construction or post construction for building operation and maintenance. Most important are MEP and structural clash detection, building energy use, and construction schedule optimization.

ARTIFICIAL INTELLIGENCE AND OFFICE MANAGEMENT

Apart from what is happening on the jobsite, there is much to manage inside the office walls.

Scheduling Office Meetings

Scheduling apps like Google Calendar have been around for some time, but they have been limited to inviting people to meetings, accepting RSVPs, and notifying members of the meeting. AI can survey employees' calendars and availability and select times that are ideal for all meeting attendants. The apps can also accommodate time zone changes.

Answering Customer Requests

Chatbots have been around for some time, usually in the form of a chat window on websites. The bots are able to answer frequently asked questions as well as being able to recognize and answer common questions, and with LLMs more complex questions can be answered. If the bots are unable to answer a customer request, they will transfer the customer to a live human.

Reducing Office Energy Use

Smart thermostats and motion detecting switches can save energy by controlling the office environment. AI can control HVAC and lighting controls prior to, during, and after a space is occupied by employees and clients. These smart controls learn the traffic and activities in the office spaces and can predict when and where lighting and HVAC will be needed. AI can also optimize energy consumption of office equipment such as printers and copiers, as well as remind staff when equipment maintenance is due, prolonging the life of office equipment

Stocking Office Supplies

AI is able to keep track of office supply use and notify when supplies need to be reordered. It can also give insights into employee behavior by tracking supply usage.

Office Occupancy and Security

Offices contain confidential information and therefore need to restrict access to trusted employees. Issuing employee office access cards or trackers can prevent employees without appropriate clearance from accessing information that is sensitive. As employees move about the office space their access device will monitor and record their movements when they try to gain access to denied spaces and information and when employees try to gain access to the office during off-work hours. These access cards and devices are programmable and can be programmed to customize access permissions.

AI is also useful for checking in visitors by obtaining profile information, reason for the visit and whom they are there to visit. This has been used by medical offices for years.

AI AND PROJECT PLANNING AND MANAGEMENT

Project scheduling and financial budgeting are an essential part of any construction project and the larger the project the greater the

risk of time delays and costs overruns. AI can use historical data from completed projects to create Critical Path and Gantt charts to predict realistic timelines and budgets for new projects by using reinforcement learning that is based on data from previous projects. As projects are completed and added to the database, more accurate project plans and budgets can be created. Even as projects are currently in progress AI can monitor whether the work completed is on time and on cost schedule and if it is not, adjustments can be prescribed to return the project to compliance.

The management of a construction project can be a daunting task. There are so many different aspects of coordination, it sometimes compares to a Rubik's cube.

The central spine of any project is the Schedule. The Schedule has many components including but not limited to material procurement, subcontractor coordination, labor and tool assignment logistics, and document management.

In the past, all aspects of scheduling were done by sorting through enormous amounts of hard copy data. Manually going through stacks of documents may give us valuable information on a specific aspect of a job, but it makes it difficult if not impossible to maintain a global view of the project.

AI makes it possible to access specific information on a particular portion of a job without losing sight of the overall project.

The scope of a project is defined by all that the project entails. It may be as simple as a bathroom remodel which may include a short list of tasks such as plumbing, electrical, drywall, ceramic tile, and painting or it may be a complex multi-story skyscraper which would include complicated structures, infrastructures and unique finish systems.

According to a 2021 global construction survey by KPMG, approximately 70 percent of all construction projects suffer delays, which is why scheduling is so important.

Once the entire scope is defined, the project must be broken down into individual pieces often called "tasks" that can be scheduled according to time, resources needed, and dependencies on other tasks.

A useful tool for scheduling has been the Gantt Chart. When Henry Gantt introduced this "bar graph" circa 1910, it revolutionized project management. Gantt charts have a vertical axis for tasks and a horizontal axis for time. Start and finish times can give visual illustration of dependencies of related tasks and can also establish the "critical path" of the project. The critical path is the sequence of tasks and activities that must be done for the project to progress to completion. The critical path also shows what tasks and activities can float without delaying the most expedient sequence of tasks for completion.

The informational data that is included in the schedule comes from harvesting information from previous jobs. Historically, this data was from the company's own records of completed projects or from published records of completed project data from companies such as R.S. Means Data. AI can collect and analyze enormous amounts of data in seconds that would have taken months or even years to accomplish manually.

Many BIM software tools create Gantt charts that include all the information that is embedded in the BIM model including resources such as labor, materials, and equipment. The horizontal axis of any Gantt chart is the timeline beginning with the project commencement and ending with the project completion. The timeline also indicates the beginning and the ending of each individual task or activity. The timeline also informs the project management team where the project stands at any given moment in time and with AI important suggested modifications to task coordination can ensure that the project stays on course.

One of the benefits of CAD brought to construction drafting is that conflicts with structures, mechanical, electrical or plumbing systems are immediately identified.

Likewise with Gantt charts, AI can identify issues with tasks and activities with overlapping time windows. Sometimes the overlaps are useful where temporal coordination between tasks is needed. For instance, it may be beneficial for an HVAC contractor and an electrical contractor to be working at the same time to coordinate their tasks. Often, however, the issue is a potential conflict between tasks and subtasks.

Scheduling is not limited to pre-construction. Monitoring job progress is also necessary, especially for large commercial jobs where financial schedules are intricately coordinated with progress payments to suppliers and subcontractors from funding sources.

This is extremely important in large commercial projects where lien processes are continually in play. Lien laws can be quite confusing with primary contractors as well as second, third, fourth tier, etc. subcontractors. AI can track all invoices when they are paid and can notify all sub-tier contractors when payment is made to contractors up-chain. This affords subcontractors protection for their own payments as well as protecting the owners of the project from hidden liens.

AI and Construction Estimating – REVIEW QUESTIONS

24. What is one of the primary benefits of AI in construction estimating?

A. Eliminating the need for subcontractor bids
B. Automating data analysis and providing precise predictions
C. Replacing the need for CAD software
D. Removing the need for cost books like RS Means

25. What is the main challenge with AI-generated data in construction estimating?

A. AI has limited ability to differentiate truth from unreliable data
B. AI cannot process large amounts of data
C. AI cannot analyze historical job cost reports
D. AI cannot suggest alternative approaches to projects

26. What does 5D BIM add to traditional 3D building models?

A. Time and cost dimensions
B. Maintenance and manufacturer details
C. Structural clash detection
D. Energy use optimization

27. What is the purpose of Industry Foundation Classes (IFC) in BIM?

A. To create proprietary BIM software
B. To replace ISO standards for BIM
C. To eliminate the need for architectural drawings
D. To ensure interoperability between different BIM applications

28. **How has AI enhanced the implementation of BIM?**
    A. By eliminating the need for manual data entry and processing vast amounts of data quickly
    B. By replacing the need for buildingSMART standards
    C. By automating the creation of physical building components
    D. By removing the need for clash detection in MEP systems

29. **What is one of the most important uses of AI-enhanced BIM during construction?**
    A. Automating the assembly of building components
    B. Detecting MEP and structural clashes
    C. Eliminating the need for construction schedules
    D. Replacing contractors with AI systems

30. **What is one of the primary benefits of using AI in project scheduling for construction projects?**
    A. Reducing the need for subcontractors
    B. Creating Critical Path and Gantt charts using historical data
    C. Eliminating the need for financial budgeting
    D. Replacing project managers entirely

31. **What is the purpose of a Gantt chart in project management?**
    A. To track financial payments to subcontractors
    B. To replace manual labor with AI tools
    C. To identify conflicts in CAD designs
    D. To visually illustrate task dependencies and timelines

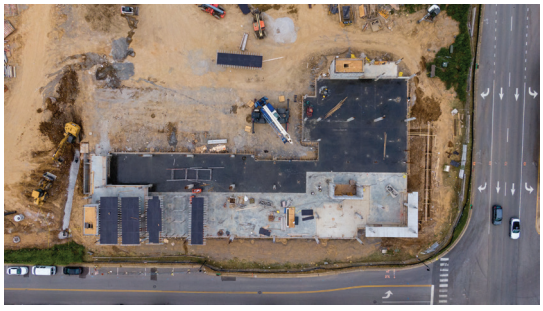
32. **How does AI help in monitoring ongoing construction projects?**
    A. By eliminating the need for subcontractor coordination
    B. By automating all construction tasks
    C. By prescribing adjustments to keep the project on time and on budget
    D. By replacing the need for Gantt charts

33. **What is one way AI protects subcontractors and project owners in large commercial projects?**
    A. By automating lien law processes
    B. By tracking invoices and notifying subcontractors of payments
    C. By eliminating the need for progress payments
    D. By replacing funding sources with AI systems

PROJECT ACTUALIZATION, PART 1

AI isn't just the stuff of computers and office work; it is also useful in the field.

AI has been incorporated into structural engineering, building operational management, resource management, cost control, off site construction, and safety management. In part 1 we will focus on structural engineering, building operational management, resource management.



In structural engineering, AI applies algorithms to assist in the design and analysis process. Using the computer model of the structure, in a few seconds, engineers can analyze complex systems that would traditionally take many days and with much greater accuracy. Using parametric and generative AI tools, engineers can generate numerous options to choose from given them the power of optimization.

Utilizing AI, engineers can exert loads and forces on a computer model of a structure using mathematical values. AI can create graphical 3D images that can indicate the load paths within a structure as it is loaded and how it will deform under particular stresses. These stresses may be from earthquakes or extreme wind forces that might be experienced in hurricanes or tornados. This helps engineers identify problems and vulnerabilities that may result in structural failures.

Using similar methods to testing structures, materials can also be tested using computer models without having to actually destroy the material as has been traditionally done.

So, will AI make structural engineers obsolete? Not anytime soon and maybe never. AI can only check on the viability of the structure, but it can never come up with innovative solutions to engineering challenges.

Building operational management

Although we have impressive examples of ancient buildings that still exist and are still functional, we know that no building is forever. AI is proving to be helpful for Structural Health Monitoring.

Structural Health Monitoring uses internal sensors much like automobiles have had for some time. New buildings and bridges can be built with internal sensors. These sensors can monitor stresses and strains resulting in structural movements and deformations in buildings and engineered structures such as bridges and power line towers.

Sensor types

- Displacement sensors (fissurometers) monitor the relative displacement between two sections of the same structure measuring the rate at which cracks or joints are opening.
- Inclinometers (inclination sensors) measure small changes from the vertical
- Geophones are used to measure vibration
- Hydraulic settlement gauges are used for checking settlement

The sensors wirelessly send information to AI applications that gather and analyze the data computing the structural and mechanical "health" of the structure and send alerts of potential problems or failures.

Existing buildings and bridges without internal sensors can also be

retrofitted with analytic devices or scanned with drones.

SHM is most commonly used to monitor structural health for daily non-extraordinary life cycling, however sensors can also monitor and record stresses due to extraordinary events such as seismic activity and extreme weather events such as hurricanes, cyclones, and tornados.

Optimizing Building Performance

Using AI and IoT (Internet of Things), data gathered from IoT devices and occupants' behavior, building can become "smart" buildings by optimizing systems such as HVAC, sun shading, and electrical systems.

By measuring vibrations in machinery and equipment, AI can monitor mechanical wear and tear and schedule preventative maintenance to provide optimal performance and prevent mechanical failures.

Scheduling

With potential labor shortages and supply chain issues, resource management is becoming increasingly important. Using BIM models and Gantt charts, AI can create schedules of personnel, equipment, and materials that will be needed, by certain times and can prescribe order dates based on availability and lead times. Logistical coordination is not limited to a single project. AI can coordinate resource allocation among all the projects a company may be involved with at the same time.

Predictive Analytics for Resource Forecasting

By analyzing past and current project needs AI can predict resources that will be required for future projects. These predictions enable superintendents to plan more effectively, making sure resources are properly allocated efficiently. This will help prevent resource shortages or excesses, which will result in delays and cost overruns.

Real-Time Inventory Tracking

In construction, having the right materials at the right time is critical. AI-driven real-time inventory tracking systems provide an eagle-eye view of all materials, tools, and equipment. This continuous monitoring helps superintendents maintain optimal inventory levels, reducing instances of overstocking or stockouts. Such precise tracking ensures that projects don't face unexpected pauses due to material shortages, leading to smoother project execution.

Automated Scheduling and Task Allocation

The complexity of managing a construction workforce is well known. AI simplifies this by automating scheduling and task allocation. These systems assess the workforce's skills, availability, and other project parameters to assign tasks efficiently. This optimization ensures that the right people are working on the right tasks at the right time, maximizing productivity and minimizing idle time or workforce burnout.

Efficient Use of Machinery and Equipment

Machinery and equipment represent significant investments in any construction project. AI optimizes their usage by analyzing patterns and predicting the best deployment strategies. This approach not only reduces wear and tear but also ensures machinery is used efficiently, avoiding situations where expensive equipment lies idle or is underutilized.

Labor Assignment

AI systems are adept at determining the optimal number of workers required for various tasks, considering factors like skill levels, project timelines, and labor costs. This precision in labor allocation helps in reducing unnecessary labor expenses while ensuring that the project doesn't suffer from manpower shortages.

Supply Chain Management

Seamless integration with the supply chain is another area where AI excels. By synchronizing with suppliers' systems, AI-based management tools ensure that materials are ordered, delivered, and replenished just in time. This integration reduces the need for large storage spaces and minimizes the risk of material wastage due to spoilage or obsolescence.

Energy and Utility Management

AI systems offer robust tools for monitoring and optimizing the use of utilities on construction sites. These systems track energy consumption patterns and suggest ways to reduce wastage, leading to cost savings and a smaller environmental footprint. Efficient utility management is especially crucial in large-scale projects where the costs and environmental impact of utilities can be significant.

Risk Management and Mitigation

In the construction industry, risk is a constant companion. AI systems excel in identifying and assessing potential risks, whether they are related to resource allocation, safety, or project timelines. By providing superintendents with early warnings and mitigation strategies, these systems play a crucial role in keeping projects on track.

Project Actualization, Part 1 – REVIEW QUESTIONS

34. How does AI assist structural engineers in analyzing structures?

A. By replacing engineers entirely in the design process

B. By eliminating the need for parametric and generative tools

C. By manually testing materials for structural failures

D. By creating 3D models that show load paths and deformations

35. What is the primary purpose of Structural Health Monitoring (SHM)?

A. To replace structural engineers with AI systems

B. To design new buildings with advanced AI tools

C. To eliminate the need for retrofitting older structures

D. To monitor and analyze the structural and mechanical health of buildings and bridges

36. Which type of sensor measures small changes from the vertical in a structure?

A. Inclinometers

B. Displacement sensors

C. Geophones

D. Hydraulic settlement gauges

37. **How does AI contribute to optimizing building performance?**
    A. By replacing IoT devices with manual monitoring
    B. By scheduling labor and equipment for construction projects
    C. By using IoT data to optimize systems like HVAC and electrical systems
    D. By eliminating the need for preventative maintenance

38. **What is one benefit of AI-driven real-time inventory tracking systems?**
    A. They eliminate the need for supply chain management
    B. They replace the need for Gantt charts in scheduling
    C. They ensure materials, tools, and equipment are available when needed
    D. They automate the design of construction projects

39. **How does AI improve labor assignments in construction projects?**
    A. By eliminating the need for skilled workers
    B. By determining the optimal number of workers required for tasks
    C. By automating the design of construction schedules
    D. By replacing human workers with robots

40. **What is one way AI helps with supply chain management in construction?**
    A. By synchronizing with suppliers' systems to ensure just-in-time delivery
    B. By eliminating the need for material storage spaces
    C. By automating the design of construction machinery
    D. By replacing suppliers with AI systems

PROJECT ACTUALIZATION, PART 2

In the next section on project actualization, we will focus on:

- Labor Shortages
- Technological Advances of the Jobsite
- Robotics in Construction
- Off-Site Construction

Labor shortages

Labor shortages in the construction industry are becoming a major issue. Although efforts to attract workers to the industry and education programs to train younger workers are underway, significant shortage of workers is a very present problem. Construction companies are using AI to better distribute both labor and machinery across concurrent projects, ensuring all available resources are located where they are most needed. Of course, another solution to human labor deficits is the assignment of some tasks to robots which are controlled by AI. While some robots are doing the work on the jobsite, other robots are being tasked with the job of monitoring the efficiency of the human workers.

Anyone visiting a construction site will encounter a few people doing a myriad of skilled tasks. Erection crews, masons, plumbers, electricians, carpenters, and mechanical technicians who have been trained and licensed to do specialized jobs use their brains and their brawn to get the job done. Unfortunately, there is a growing dearth of people to do these jobs. For whatever reason young people who are entering the job force are eschewing construction jobs and gravitating to jobs that are considered more "high tech". Fortunately, many of these jobs that people no longer want to do can be done by intelligent agents we have called robots. The term "robot" derives from a Czech word, *robota*, which means forced labor. We generally think of robots as "mechanical" humans, like the glass headed, "dryer vent" armed character Model B-9 in *Lost in Space*. Robots don't have to be human simulations, just as Artificial Intelligence does not have to mimic human intelligence. Robots used to be curiosities. Now they are ubiquitous. They assemble our cars; they sweep our floors when we are at the office, they retrieve and ship our purchases in Amazon fulfilment centers; they even perform surgeries.

In the construction industry, robotic masons such as SAM (Semi Automated Mason) 100 can lay 6 times as many bricks as a human mason and with far greater accuracy. SAM takes CAD and 3D model information and uses Cartesian coordinates and parametric design to determine where each brick should be placed. Early generation robotic masons required a human to work alongside to point up mortar and keep the work clean but newer generation robotic masons can work entirely autonomously and never take lunch breaks.

Whereas SAM 100 is a bricklayer, a machine that lays concrete block has been developed in Australia. The Hadrian X (named after Hadrian's Wall that was the northernmost border pf the Roman Empire and separated northern England from Scotland) can lay over 300 blocks per hour. Having been successfully used in Australia and parts of Europe, Hadrian X will be introduced to US construction sites in 2024.

Masonry is a difficult trade; the block and bricks are heavy, they are rough on the hands, and they really hurt if they fall on you. The craft of artistic brickwork and stone masonry will no doubt remain in the hands of talented humans, but for the major part of masonry work, the use of robotic masons can result in greater quality control and safer job sites for humans.

AI controlled robotic self-driving heavy equipment such as front-end loaders, backhoes and graders are also becoming more common. These machines use GPS equipment to measure excavation parameters and are sensitive to underground obstacles that may be dangerous to a human operator such as electrical wires and gas lines. Grading can be accomplished with accuracy within eighths of an inch.

Companies like Built Robotics offer a full toolbox for heavy equipment operators that can be retrofitted to existing equipment. Their products can be installed on excavators to enable the machines to operate autonomously. It includes a controller computer, proximity radar, 360° cameras, and GPS. Using a laptop, an operator can operate the equipment from anywhere in the world and can monitor the work in real time by the use of cameras. No mud on your boots while enjoying a cappuccino.

In reinforced concrete jobs that require precise reinforcement placement and stabilization TyBots are useful in the tying of rebar.

Many professionals in the construction industry are familiar with CNC (computer numerical control) machines. CNC machines cut materials such as wood, plastic, and metal with routers, plasma cutters, and lasers using the data from computers to guide the cutting heads. The material is usually placed on a table and the cutting head moves over the material to cut it in the pattern communicated to the cutting head by a computer. This method is limited to the size of the table and its location.

To overcome this limitation, a team at MIT has created AutoSaw, which uses mobile "bots" which can work with lumber in the field

just like a human carpenter. They lift and locate the material on the saw table and cut it just as a human carpenter would do. Well, that's a little more advanced than a CDC machine, but so far it has only cut wood. It still cannot position it and fasten it as any skilled carpenter knows is the real skill and art of the craft.

Off-site construction

Off-site factories use AI to design and schedule the assembly of components and modules and to control any robotic processes.

More construction projects are being assembled on site with components that are built off site in factories by robots much like the manufacture of automobiles. Components of complex buildings are built by CAD/CAM processes where AI designs unique and irregular shapes components that are optimized to carry complex load paths. AI can direct robots in the fabrication of even more traditional components of buildings more accurately and more economically than they would be built on site by humans even if humans were available.

Project Actualization, Part 2 – REVIEW QUESTIONS

41. One solution to human labor deficits is the assignment of some tasks to _____ which are controlled by AI.

A. Humans
B. Robots
C. Animals
D. None of the above

42. In the construction industry, robotic masons such as SAM 100 can lay ___ times as many bricks as a human mason.

A. 2
B. 4
C. 6
D. 8

43. What is true of companies like Built Robotics?

A. They offer heavy equipment operators than can retrofitted to existing equipment
B. Their products can be installed on excavators to enable autonomous machine operation
C. Operators control equipment remotely
D. All the above

44. TyBots specialize in:

A. Laying brick
B. Tying of rebar
C. Pouring foundation
D. Painting walls

45. Which construction robot uses mobile "bots" that can work with lumber in the field similar to a human carpenter?

A. TyBots
B. CNC Machines
C. AutoSaw
D. SAM 100

46. How does AI contribute to off-site construction?

A. By replacing the need for CAD/CAM processes
B. By designing and scheduling the assembly of components and controlling robotic processes
C. By eliminating the need for human involvement in on-site assembly
D. By manually fabricating components for complex buildings

PROJECT ACTUALIZATION, PART 3

Lastly, part 3 of project actualization will focus on:

- Cost Control
- Augmented Reality
- Drones
- Safety Management

Cost Control

According to a McKinsey report, the construction industry is worth more than $10 trillion a year. That is equivalent to 13% of the world's GDP. Using AI, that market capitalization can be raised to $11.6 trillion per year, making the construction industry one of the largest in the entire world economy.

From data and invoice entry to analysis of current project cost, there is much to do when it comes to project financial administration. Legacy construction cost accounting often results in "siloed" departmental specific reports that can obscure the overall financial condition of a project. AI is able to connect all the data and information onto a unified platform that any department can access and understand. It can red flag areas of cost overrun when they occur and to make suggested courses of action to bring the project back to budget.

In the construction industry, cost control is extremely difficult because of the frequency of unforeseen expenses. Sometimes these are a result of a change order and can easily be accounted for. But often it is not a requested change order, but a need for additional materials or increased cost of materials or a need for extra or more expensive labor needs.

If these changes or not monitored and recorded, these costs will result in overruns of established budgets.

What is Cost Variance in Project Management?

In the construction industry cost variances are based on the difference between:

- The estimated budget - Budgeted Cost of Work Performed (BCWP) and
- The actual expense - Actual Cost of Work Performed (ACWP)

It is important to track cost variances in projects to keep track of finances and control costs as the project progresses.

For employees:

- Time-intensive expense reporting procedures
- Challenges for employees to track and save expense receipts

For project managers:

- Waiting for approvals for necessary expenses to keep the job going
- Tasked with remembering project budgets and expense policies
- Countless hours spent on manually reporting expenses

For accountants:

- Lack of communication with on-site management
- Delayed access to actual project expenses

AI tools allow project supervisors and managers to report expenses as simple as taking a photo with a phone or tablet. AI will extract the pertinent data and update the project database and report to all stakeholders in the project in real time.

If an expense is non-compliant, it is flagged and a request for a correction or explanation is generated.

If an expense is compensation or a reimbursement, the payee can check on the status of the payment eliminating the need for the employee, subcontractor, or vendor to call in or visit the office.

Real time estimate/actual cost reports make it possible to prevent excessive overruns and even propose opportunities to optimize costs going forward.

Augmented Reality

Augmented Reality (AR) uses cameras or smartphones to add digital information or images to live views of the natural world. A good example is the popular game Pokemon Go. The game is played with the use of smartphone cameras where images are seen on the viewer that sets an imaginary character in a real-world setting. Another example of AR is aiming a camera at a product in a store and having the product information displayed on the screen. AR can be useful for a supervisor or inspector as he or she gathers information from real world conditions while inspecting a job site.

Drones

In addition to on the ground inspections with augmented reality tools, drones have proven to be invaluable to job site surveillance.

Drones are familiar to us all. They have become pervasive in their utility. Film directors use them for artistic purposes, real estate agents use them to advertise their listings, and drones have become a prominent weapon of warfare not only for surveillance photography, but also for the delivery of explosive ordinances.

The use of drones for overall project supervision has become a reality. Using hi-def cameras and LiDAR (light detection and ranging) scans, drones can monitor daily progress on the job site and determine whether or not the construction is in compliance with the BIM model. Even if a component is only partially visible, AI can identify it. Everything on the job can be inspected and analyzed from excavations to structural elements to plumbing, electrical, and mechanical systems.

This degree of real time observation of job conditions is useful for project time and cost awareness, along with safety management.

Safety on the Job

Construction is a dangerous industry. Workers operate dangerous tools and equipment and in hazardous situations from heights to subterranean spaces. In fact, construction workers are killed on the job five times more often than other laborers. This makes safety a priority on any job site.

Many companies have safety manuals, and weekly or daily briefings. But once workers leave the meetings it is difficult to enforce and monitor measures to keep workers safe on the job.

AI makes real time hazard detection possible. This is usually accomplished with the use of drones.

Using drones that can scan and take photographs can use AI algorithms to analyze photos from the job site for possible safety hazards such as spills or debris. It can also identify workers who are not wearing protective equipment or working in unsafe conditions.

AI systems can automatically generate safety alerts making it possible to avert possible accidents or to notify emergency services should they occur. Automatic safety reports can be generated that make it possible for companies to identify problem employees and unsafe practices.

AI's predictive capabilities can also recognize patterns of unsafe scenarios from past experiences to help prevent those scenarios from recurring in the future.

AI is useful in monitoring machine and tool maintenance, reducing the incidence of accidents caused by faulty equipment.

Artificial intelligence can surveil workers to identify safety risks.

Workers are not always compliant with Personal Protective Equipment requirements because they find the equipment uncomfortable to wear. A computer vision solution using AI-enabled cameras can monitor designated workplace areas for PPE noncompliance.

AI can help with monitoring for fatigue symptoms. It is important that workers operating dangerous and heavy equipment are always alert. AI can interpret facial expressions to identify signs of fatigue or drowsiness. The employee can receive an alert and be advised to stop work and resume work after a period of rest.

Fall detection can protect workers from injuries due to falls. AI-powered fall detection devices such as phones or wrist-watch type devices alert management immediately when a fall occurs.

Large Language model tools helpful for employees to answer questions regarding safety procedures and can answer safety-related questions using natural language.

LLMs also make it easier for employees to report incidents using their natural language.

Safety training using Virtual Reality makes it possible for employees to "experience" hazardous situations and even virtual accidents and practice their responses in a safe and controlled environment.

What Does the Future Hold?

What does the future hold? Of course, no one knows for sure, but we can make some reasonable predictions based on the technologies that have emerged in the very recent past. The Macintosh was introduced in 1984 and now personal computers are a way of life for most people. The iPhone was introduced in 2007 and now a

smartphone is like an essential appendage to our bodies. In some states, instead of on-site inspections, virtual inspections are being made by building inspectors using smartphones, saving valuable time and money.

Lasers make our measurements and establish our levels and plumbs. Computers control our heavy machinery, control our crane arms, LiDAR scans tell us what is actually there and informs our CAD systems to how we can modify or add on.

Parametric and generative design can present innumerable possibilities to us, so we don't have to wrack our brains or waste time and material with trial and error. As algorithmic design advances, perhaps humans will provide data to computers which will design buildings that robots will build.

AI has made profound progress in recent years and months and as astounding as some of the capabilities that have emerged, it bodes to be just the tip of the iceberg.

Project Actualization, Part 3 – REVIEW QUESTIONS

47. What is one way AI helps with cost control in construction projects?

A. By eliminating the need for budgets
B. By replacing project managers with automated systems
C. By preventing all unforeseen expenses
D. By connecting all financial data onto a unified platform

48. Cost variance in project management is the difference between the estimated budget, known as _____, and the actual expense, known as _____.

A. ACWP; BCWP
B. BCWP; ACWP
C. Actual Cost; Budgeted Cost
D. Budgeted Cost; Estimated Cost

49. What is one benefit of AI tools for employees in expense reporting?

A. Eliminating the need to track receipts
B. Automating all approvals without human oversight
C. Replacing accountants in financial administration
D. Allowing employees to report expenses by taking a photo

50. Which of the following is an example of Augmented Reality (AR) in construction?

A. Adding digital information to live views of a job site using a smartphone
B. Using drones to monitor job sites
C. Replacing physical inspections with virtual reality simulations
D. Using AI to automate cost variance calculations

51. According to the text, how do drones contribute to job site safety?

A. By replacing safety manuals and briefings
B. By delivering safety equipment to workers
C. By scanning job sites for hazards and PPE noncompliance
D. By eliminating the need for on-site supervisors

52. AI-powered fall detection devices, such as phones or wrist-watch type devices, alert _____ immediately when a fall occurs.

A. Emergency services
B. The worker's family
C. Management
D. The insurance company

53. What is one way AI helps prevent accidents caused by worker fatigue?

A. By replacing workers with robots
B. By automating all heavy equipment operations
C. By monitoring facial expressions to detect signs of drowsiness
D. By requiring workers to wear fatigue-detection wristbands

54. Which of the following is a benefit of using drones with LiDAR technology on construction sites?

A. Monitoring daily progress and ensuring compliance with BIM models
B. Eliminating the need for BIM models
C. Automating the design of structural elements
D. Replacing human workers in all inspections

55. What is one way AI improves safety training for construction workers?

A. By replacing in-person training with safety manuals
B. By using Virtual Reality to simulate hazardous situations
C. By automating the enforcement of safety rules
D. By eliminating the need for safety training altogether

56. What does the future of AI in construction potentially include?

A. Humans designing buildings while robots build them
B. Eliminating the need for inspections entirely
C. Replacing all construction workers with AI systems
D. Halting the use of parametric and generative design

SUMMARY

In the digital age that we have all come to live in, we have learned to accept and even embrace many technological advances, most notably computers and smart phones. It's hard to imagine life without them.

Artificial Intelligence is "the new kid on the block". It takes all the technologies that have come before and raised them up a notch. In some cases, it has revolutionized how decisions are made and what can be created and all at warp speed.

Almost every aspect of life will be utilizing AI in some way from simple decisions to decisions that could profoundly change life as we know it.

Without a doubt, Artificial Intelligence is an important force to be reckoned with. It is arguably the most important development in the

past few centuries and will greatly impact the lives of humans both now and in the future.

It is a watershed moment where many jobs will be eliminated simply because AI can do them so much better and cheaper. It is hoped that the increased efficiency that AI provides will open new horizons and employment opportunities for those who jobs will be replaced.

Above all, it is important to never forget that AI is just another tool that humans have developed to further advance our civilization. It will no doubt be abused and exploited by bad actors, but it will never rise up against humans by its own devices, because it does not have its own devices, only those bestowed on it by humans.

Summary – REVIEW QUESTIONS

57. What is one of the key impacts of Artificial Intelligence as described in the summary?

A. It will eliminate all human jobs without creating new opportunities

B. It will revolutionize decision-making and creation processes

C. It will replace all existing technologies entirely

D. It will develop its own devices to rise against humans

58. Artificial Intelligence is described as a _____ moment, where many jobs will be eliminated but new opportunities may arise.

A. Revolutionary

B. Watershed

C. Temporary

D. Catastrophic

59. Imagine a company is considering replacing a manual process with AI to improve efficiency. Based on the summary, what is a potential benefit and concern they should consider?

A. Benefit: AI will eliminate inefficiencies; Concern: AI may develop its own agenda

B. Benefit: AI will reduce costs; Concern: AI will replace all human workers permanently

C. Benefit: AI will create new job opportunities; Concern: AI may be abused by bad actors

D. Benefit: AI will make decisions slower; Concern: AI will require constant human oversight

60. What is a key characteristic of Artificial Intelligence as mentioned in the summary?

A. It can independently create its own devices

B. It will completely replace computers and smartphones

C. It will only impact simple decision-making processes

D. It is a tool developed by humans to advance civilization

Notes