Module 12

Automation and Artificial Intelligence

Digitalisation in Construction

24 partners

12 countries

Date of Event

*Author/ **Institute***

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Automation and Artificial Intelligence | Summary

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To equip the learner with the relevant knowledge required to understand the use of new technologies such as automation, artificial intelligence and extended reality for the construction industry.

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Automation and Artificial Intelligence | Objectives

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1. Outline the principles and benefits of automation in construction for Health & Safety, cost and time management and communication (drones, 3D printing, robotics)
2. Discuss the use of technologies, robotics and drones, and outline how the digital information and data can be transferred for construction
3. Outline the benefits and opportunities of extended reality for Health & Safety, cost and time management, communication and training (VR, AR, laser scanning, MR)
4. Discuss the uses of Artificial Intelligence (AI), VR and AR, and outline how the digital information and data can be transferred and used for construction
5. Outline the principles and benefits of Modular Construction

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1. Automation

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- Construction technology is a rapidly changing with the potential to remove incredible amounts of waste from the process and speed up processes.
- Companies will achieve huge efficiency gains over their competitors through technology and digitalisations.
- Incorporating and understanding digital technologies, tools and sustainable green materials within your workplace, using innovative approaches is the way forward.
- Well trained, especially young talent, will want to work at the companies with the most innovative systems and processes.

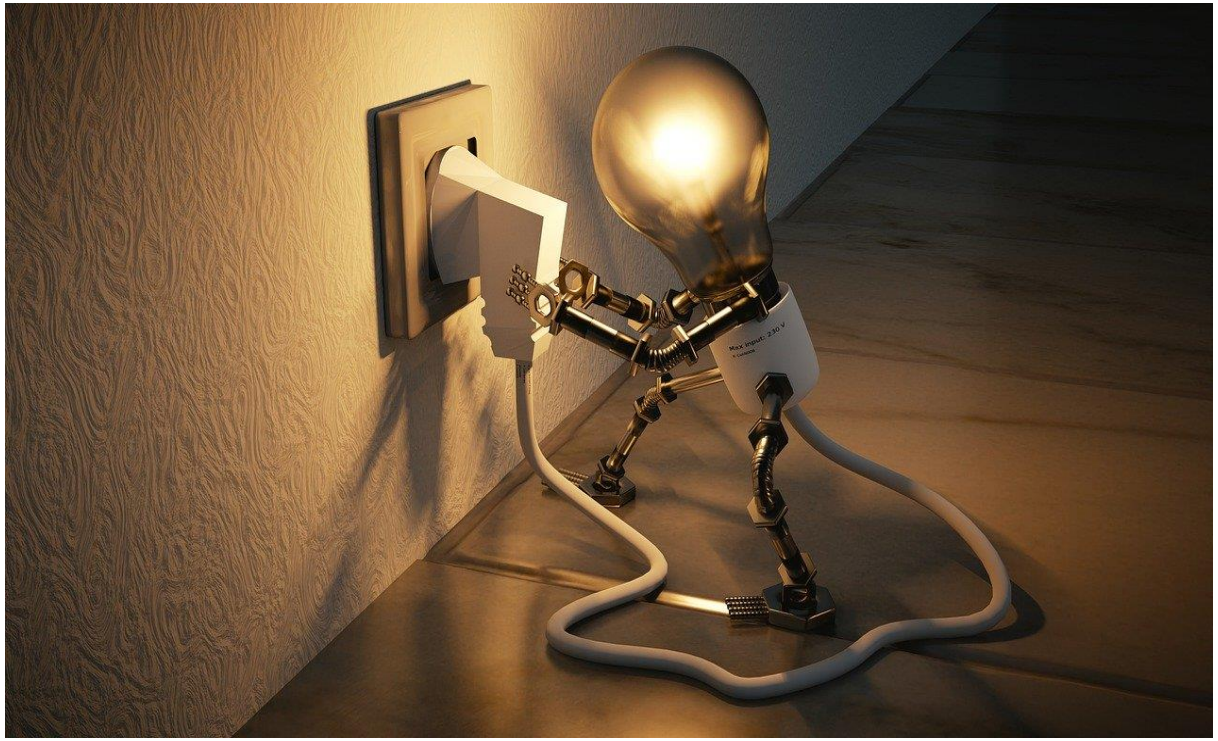

Image Source: Colin Behrens from Pixabay

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"The Manufacturing Industry and Internet of Things, IoT are at the centre of new technological approaches for development, production, and management of the entire logistics chain, - known as smart factory automation.

The acceptance of IoT in manufacturing allows people to adopt agile, smarter, and innovative ways to advance production with technologies that complement and augment human labour with robotics."

We need to adopt IoT in construction to advance and improve production, ensure quality energy efficient designs and achieve compliant healthy buildings.

https://upload.wikimedia.org/wikipedia/commons/thumb/c/cf/Manufacturing_equipment_094.jpg/800px-Manufacturing_equipment_094.jpg?20121218174044

Source: Industry 4.0 and Smart Manufacturing Technology Solutions

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We also need better connectivity within the construction chain – giving clear concise instructions and relevant information, efficient transfer of knowledge, working together (System Thinking) and communication between all parties involved from (Clients, Architects, Engineers, Site Supervisors, Contractors and operatives on site).

So what does IoT mean?

We will look at how IoT and digitalisation will help us on site

- connected cars,
- smart energy projects,
- home automation,
- smart modular manufacturing.
- knowledge transfer
- collaboration

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Internet of Things

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Internet of Things:

The Internet of things (IoT) describes the network of physical objects—"things"—that are embedded with sensors, software, and other technologies for the purpose of connecting and exchanging data with other devices and systems over the Internet.

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Internet of Things

- IoT helps to connect smart devices together, sharing data between each other. Smart devices, such as sensors, smartphones, and wearable technology all collect the necessary data.
- The adoption of IoT technology across all industries, such as manufacturing, automotive, and healthcare, is driving the market's growth positively.
- The construction industry is starting to adopt this IoT technology, so we need to be ready.
- With the traditional construction sector in the middle of a digital transformation, IoT is fuelling the next industrial revolution of intelligent connectivity.
- This is changing the way we approach complex processes of systems and technologies to improve efficiency and reduce downtime.

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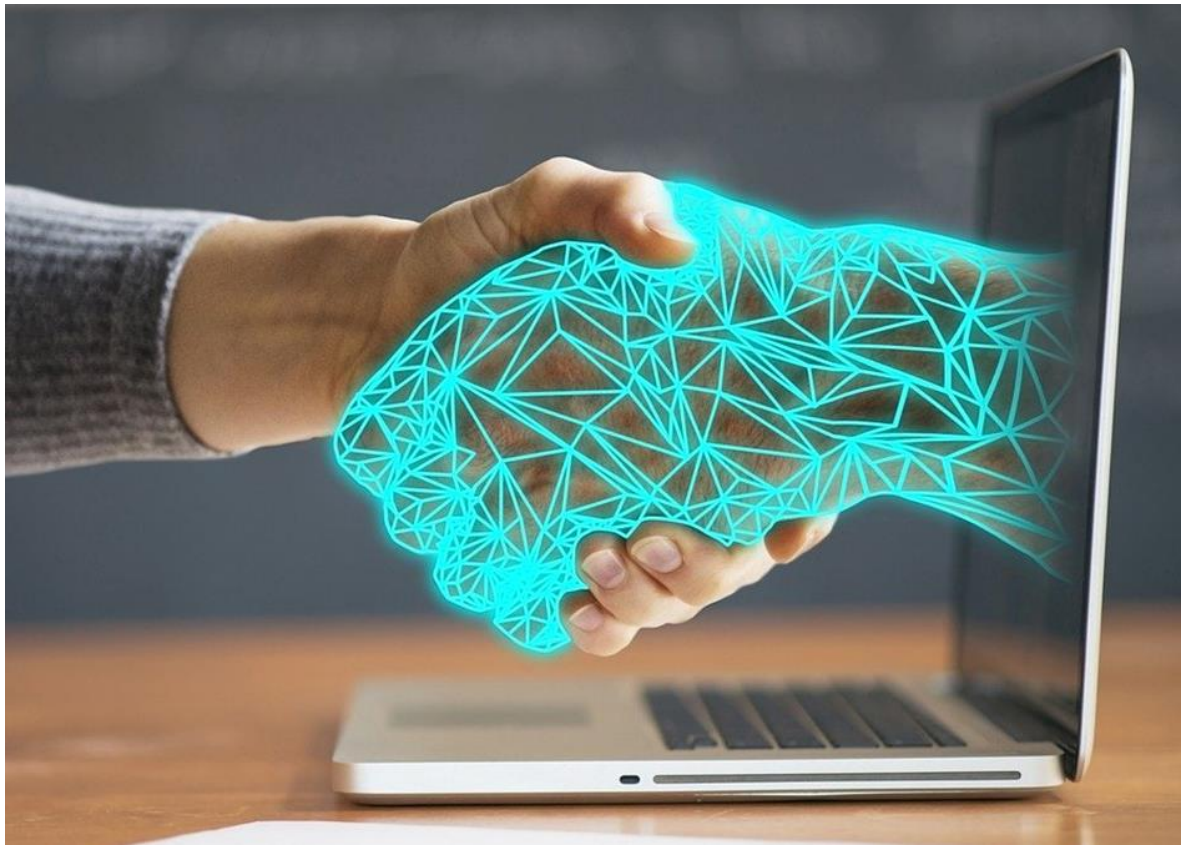
Collaboration

We all know that one of the major issues within construction projects is having a highly fragmented industry. With workers, engineers, and equipment distributed around a site, plus offsite architects and clients, it can be hard to get everyone on the same page when a decision needs to be made.

Mobile Technology

Smartphones and mobile apps have made communication and collaboration on projects easier. Instead of driving to the office for meetings, companies now hold meetings using mobile technology, sync in real-time, add notes, change drawings and respond to RFIs instantly and then share that information with everyone involved with the project at the same time



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Software & Mobile Solutions

- Today there are software and mobile solutions to help manage every aspect of a construction project. From pre-construction to scheduling, from project management and field reporting to managing your back office.
- Most software solutions are cloud-based, allowing changes and updates to documents, schedules, and other management tools to be made in real time, facilitating better communication, collaboration and productivity.
- This can save hundreds of hours per year in data entry and automatically organises critical files—no more shuffling through files looking for old reports or drawings

AUTOMATION

Changes in the construction industry has led to workers needing to learn to work side by side with machines.

Benefits include more efficient on-site construction, allows project teams to eliminate mistakes and better coordination of the workforce.

AUTOMATION IMPACTS

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Three primary opportunities for automation in construction.

- 1. **Digitisation** - and the subsequent automation of design, planning, and management procedures, For example, building information modelling—which essentially brings together the designers, coordinators and general contractors to identify clashes before they move to the site—makes the planning process more efficient.
- 2. **Auto-machines** - of what are considered traditional physical tasks on-site—for instance, robots laying bricks and machines paving roads.
- 3. **Production** - comes from the automation of modular construction produced in factories, including 3-D printing of components such as facades and window details to reduce thermal bridging.

To Summarise, it makes the on-site execution more efficient, allows project teams to eliminate mistakes and better coordinate the workforce.

What impact will automation have on work for builders?

- A substantial shift to modular construction off-site could have a significant impact on the construction workforce, but the transition will take decades. Producing individual components, or modules, in factories lends itself to much more machine use than what can be done on-site.
- This means workers will need to learn to work side by side with machines. For example, even the average construction worker will be expected to use a tablet to access building plans or operate a drone in place of doing a physical site walkthrough.
- Automating more of the construction process could also help deliver infrastructure and buildings faster — without needing to reduce headcount. In the long term, automation is likely to increase productivity

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Off-site and Modular Construction

- Offsite and modular construction fundamentally changes the approach to the design and build.
- It refers to construction carried out in a workshop/factory specifically designed, with individual modules or components of the building assembled in the factory and then transported to the site. It can be used for both new build and retrofitting.
- Minor finishing works are completed on site such as joints between each modular section.
- Offsite and Modular Construction delivers low-carbon prefabricated buildings and can reduce the embodied energy of a building by up to 30%, as well as provide accurate quality detailing.

Benefits include:

- Efficiency and Predictability
- Quality Assurance
- Sustainability
- Streamlined Scheduling

Examples of modular offsite construction projects

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2. Artificial Intelligence and 3D printing

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Artificial Intelligence and 3D printing

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Artificial Intelligence:
It is the theory and development of computer systems able to perform tasks normally requiring human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages.

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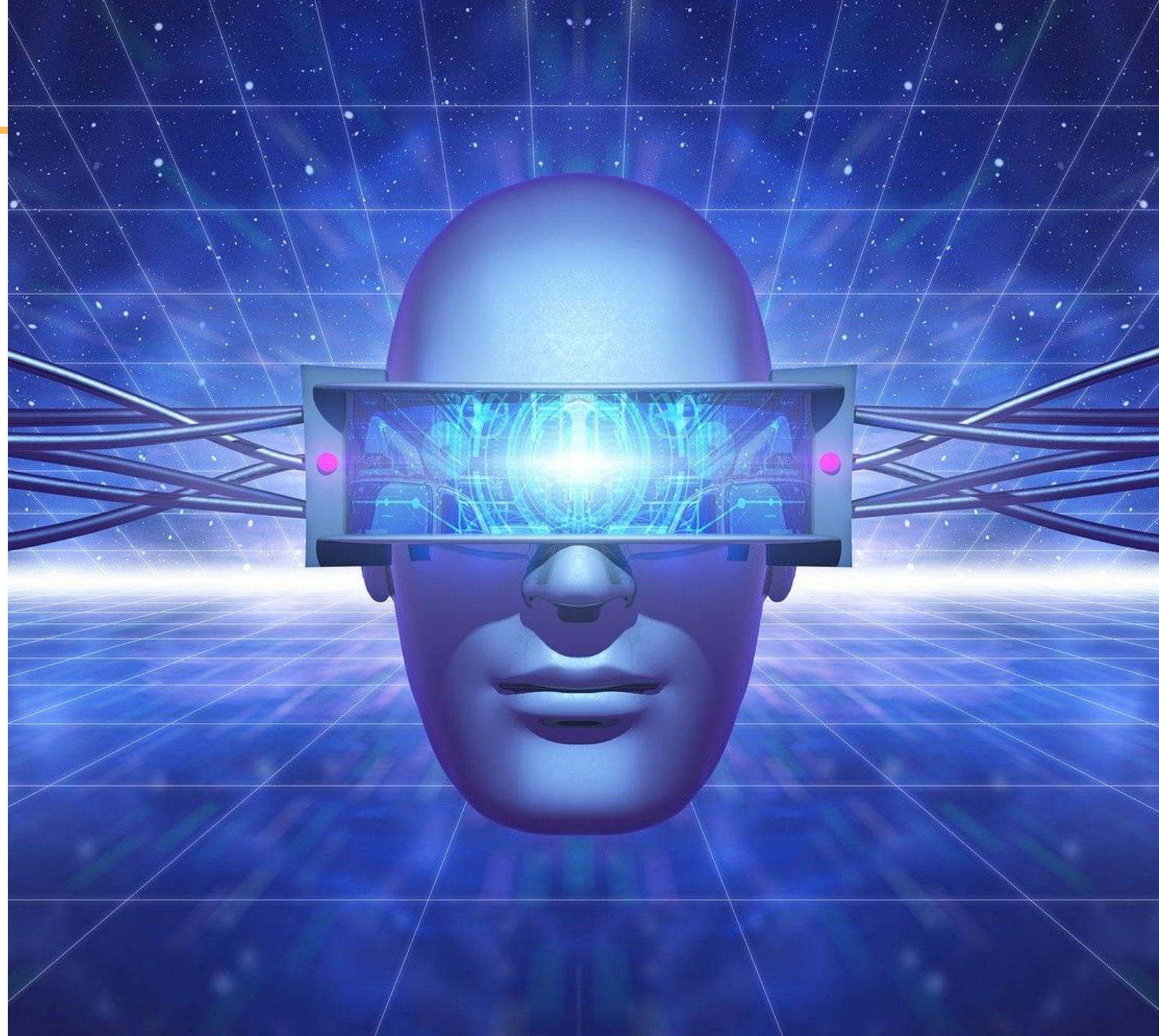
Artificial Intelligence (AI)

See how autonomous machines, Robots and Drones can be used to improve productivity and quality of buildings.

New jobs are being created in these areas, and young people could be encouraged into construction with the aid of IT and AI systems.



ARTIFICIAL INTELLIGENCE

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Autonomous Machines on the Construction Site

- Perhaps the most common example of automation in construction is the use of autonomous machines.
- These are essentially self-driving machines that can be used to transport materials across the work site and to haul heavy items without posing a risk to workers.
- For example, machines can be fitted with robotic technology solutions and sensors that enable forklifts, diggers, trucks, and other similar equipment to operate without a driver in the cabin.
- With GPS capabilities construction site workers can remotely operate machinery and enjoy more efficient processes.
- Consider automated lawnmowers and vacuum cleaners and of course automated self drive cars. All these use sensors and software to control.

Image Source: https://roboticsbiz.com/barriers-to-automation-and-robotics-in-construction/

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Artificial Intelligence

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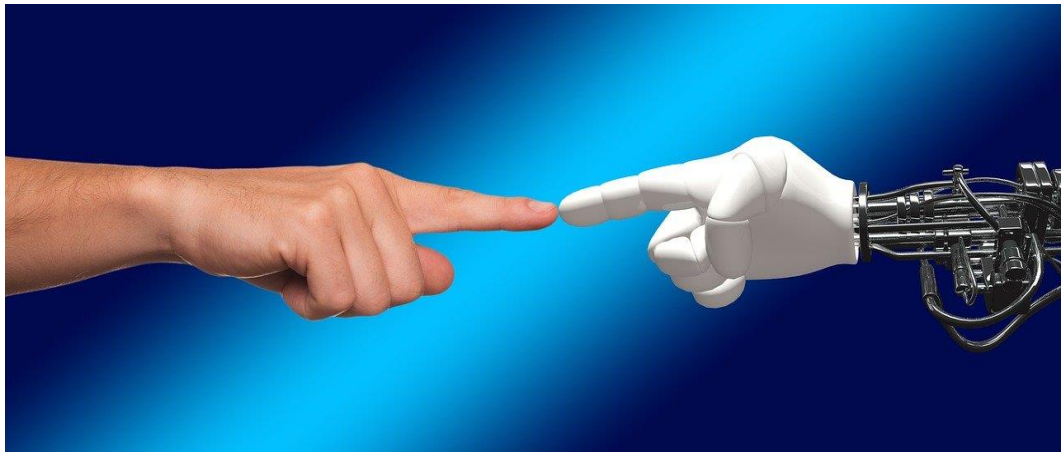
Automating processes in the construction sector refer to the use of robots, drones and 3D printing to automate specific tasks in the construction sector. These technologies differ significantly in terms of development.

Drones are being increasingly used, notably through the development and improvement of the sensors that they are equipped with, while robots in construction are still at the development phase and utilised only for very specific and limited tasks, especially in the support of health and safety.

The low market readiness of automating technologies reflects on the fact that the construction and maintenance phases of the value chain, less inclined to acceptance when it comes to digitalisation.
But this is starting to change….



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Machine Learning

No drone, or robotic arm will be of much use without quality software.
For robotics to successfully work on the construction site, they need good intelligence, of the artificial kind.
With AI constructors, “bots” will know where they and each others are at all times.
They’ll also learn as they go.

Construction companies are now using data to make better decisions, increase productivity, improve jobsite safety, and reduce risks. With artificial intelligence and machine learning systems, companies can turn the mountains of data they have collected over the years on projects, to predict future outcomes and gain a **competitive advantage when estimating and bidding for future construction projects.**

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Robotics in Construction - Robots

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Robotics is an multi-disciplinary research area at the heart of computer science and engineering.
Robotics are involved in the design, construction, operation, and maintenance of robots.

Robots have many applications in the construction industry, mainly in the construction and maintenance phases. For example, in the construction phase, robots can deliver more precise and uniform work where required. They can support human workers in tasks that involve difficult physical labour and / or presence in hazardous environments, or replace tasks that are repetitive. These all assist with health and safety concerns on site.

The scope of robots in construction is broad, encompassing the majority of the stages of construction, from initial construction, to its operation and maintenance, to the eventual dismantling and recycling.

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ARTIFICIAL INTELLIGENCE - ROBOTS

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Current robots are good at doing simple, repetitive tasks – such as bricklaying, rebar tying, heavy concrete works or demolition.
Once set up, these robots can work faster and continuously without stopping.
In all these examples, humans are still needed to perform some of the work.
Both still require workers to set up the robots, get them started and oversee the work.
For the **bricklaying robot**, a mason is needed to oversee the work, ensure bricks are correctly placed and clean up the mortar after they've been set.
The **rebar tying robot** still needs humans to correctly place and space the rebar before it gets set in motion.
Concrete works robot are being used to mix concrete, lay the cement, polish floors, and remove surface water.
Demolition robots are being used to bring down walls and to dismantle concrete slabs.

Instead of replacing workers, most construction robots are there to support and increase a worker's performance, enabling them to be more productive

Image: NCCR Digital Fabrication

Artificial Intelligence - Drones

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Drones:

Drones are unmanned aerial vehicle (UAV) - an aircraft without a human pilot on board. (or un-crewed aerial vehicles, commonly known as a drone)

The value of drones relies not only on the data gathering per se, but also on their ability to access areas particularly challenging for traditional machineries (e.g. structures built over water, roofs, etc.).

Drones can also improve communication and management activities by providing precise real-time data that can be exchanged between different actors, thus reducing the time required for implementing change and assessing the progresses of the work

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ARTIFICIAL INTELLIGENCE - DRONES

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Drones in Construction

Drones are being used on site in a number of ways:

- Conduct daily site inspections and **identify potential hazards** each day.
- **Monitor the safety of workers** throughout the day
- **Take photos of the progress of work** to create as-built models of sites to keep everyone informed of developments.
- Conduct **pre-project inspections** and other important site monitoring activities.

Autonomous drones and rovers are equipped with high-definition cameras with LiDAR to photograph and scan the construction site each day with pinpoint accuracy. Artificial Intelligence, AI then uses the scans, to compare against the BIM models, 3D drawings, construction schedule, and estimates to inspect the quality of the work performed and to determine how much progress has been made each day

Drones can also be used for pre-investigation of a site, to determine where services are, topography and levels of the land and if there will be any transport issues.

Source: Jonathan Blackmore – TUS Thurles campus

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3D Printing

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3D Printing:

3D printing, or additive manufacturing, is the construction of a three-dimensional object from a CAD model or a digital 3D model.

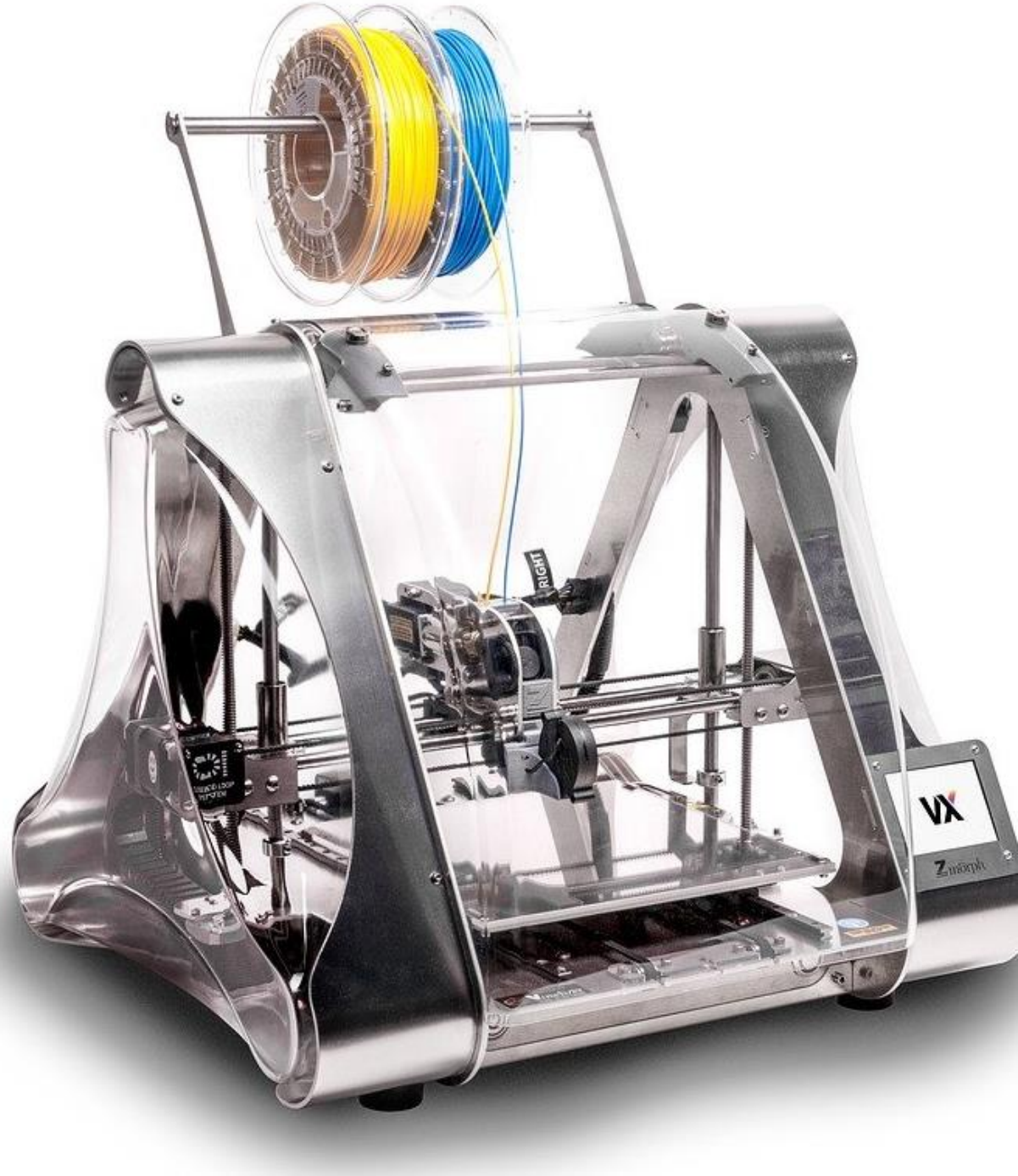
3D Printing

In some cases, such as modular construction, walls are built in sections, transported to site where they are assembled.

Other systems do their printing on site.
Materials used can be recycled products, such as a concrete material made from sand and recycled tiles.
Advantages of 3D printing includes:

- Reduced injury of workers on site
- Reduced material costs
- Faster construction
- Cheaper to build

3D printers are ideal to create elements of the build such as thermal breaks for windows or even complete windows omitting thermal bridging. Although these need to be installed on site by workers, it is likely to ensure quality improved detailing.



3D Printing

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Benefits include:

- Able to use environmentally friendly products
- Recycle plastics, resin, metals, ceramics etc
- Waste reduction
- No pollution
- Flexibility in shapes and designs
- Precision in build
- Strong structural support
- Reduced thermal bridging
- Lower costs
- Potential of using less material
- Fast construction to assist with shortage of housing

Printing onsite: https://youtu.be/69HrqNnrfh4

Low-carbon prototype called Tecla, printed from a mix of locally-sourced clay, soil, water and other materials by two large synchronized arms.

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3D Scanning and BIM

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3D Scanning:

3D scanning is the process of analysing a real-world object or environment to collect data on its shape and possibly its appearance (e.g. colour).
The collected data can then be used to construct digital 3D models.

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3D Scanning and BIM

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How does it work?

Artificial Intelligence creates a digital 3D copy of the site or building. The scan has a superior quality, yet minimal size – 90% less data than usual photography based models. Its easy to resize, scale, adapt and apply in any format for virtually any user case.

The object is stored in a data format in a virtual 3D library (cloud). This can be used to record existing structures, to assess the materials, determine defects or create an overall layout of the site on BIM.

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3D Scanning and BIM

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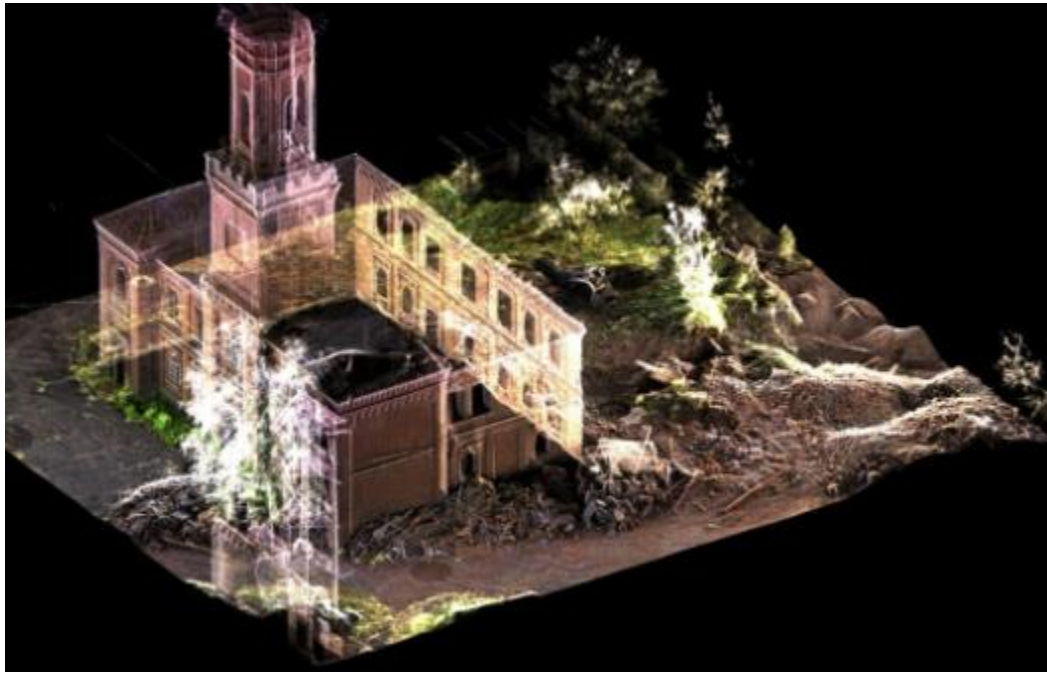
Case Study

"Laser scanning, now an established technology for historical preservation, provides visually impactful and forensically, architecturally, and historically valuable data to document and communicate the impact of…….

Using hand held imaging laser scanner
https://leica-geosystems.com/case-studies/reality-capture/scanning-damaged-heritage-sites-in-ukraine



Source: Leica geo systems.com

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3. Wearables and Extended Reality

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Leading to greater Health and Safety in Construction

Physical building can be motorised and automated by combining sensors, software, and robotic elements

According to the European Agency for Safety and Health at Work, 52% of construction workers report backaches, 54% show Musculoskeletal Injuries and Disorders in the upper limbs, and 41% show them in the lower limbs.

Automation can increase productivity and work efficiency by streamlining operations, thus improving health and safety on-site.

Think of Ironman, when visualising exoskeletons. Working with robotic features as stronger extensions of the bodies and minds of construction personnel, we're working toward stepping up safety, reducing injury, and increasing efficiency. Plus, who doesn't want to try out a robotic arm?

Exoskeleton suits in construction

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Wearables on Site

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There are some technologies currently available, and many more examples are also available or on the way to improve H&S and efficiency on site.

Smart Vests –
Traditional safety vests are one of the most common pieces of construction safety clothing outside of hardhats and safety glasses. Generally, they keep workers visible and are made of a lightweight material.
Smart vests feature GPS location and emergency alert systems. They can be tracked in tandem with project progress to monitor inefficiency points on certain teams and can be used to monitor health conditions on site.

Boots –
Use of wearable technology integrated into work boots. Complete with GPS, WiFi access, safety lighting, motion sensors, and real-time task updates to a mobile platform,. Charged by the energy collected from walking.

Extended Reality

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Virtual Reality: Virtual reality (VR) is a simulated experience that can be similar to or completely different from the real world.

Augmented Reality (AR) is an interactive experience of a real-world environment where the objects that reside in the real world are enhanced by computer-generated perceptual information, sometimes across multiple sensory modalities, including visual, auditory, haptic, somatosensory and olfactory.

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Virtual Reality (VR)

VR allows for construction companies to plan for a project even before they lay down a single brick.

Virtual reality simulates a realistic environment that allows workers to interact with a particular structure using a series of 3D scanned images. Workers can interact with a computer-generated simulation 3D image (both auditory and visually) using special electronic equipment, such as a helmet with a screen inside or gloves fitted with sensors.

VR paired with BIM will lead to better collaboration and communication. Most virtual reality applications are using BIM models as the basis to create virtual environments.

No matter how accurate drawings or concept renderings are, there's no better way of seeing how a project will turn out than an accurate, detailed virtual render viewed with virtual reality technology.

For example, workers can virtually crawl through pipes in the building to determine if they have enough room for repair and maintenance.

VR Source: Duurzaam Gebouwd

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Augmented Reality (AR)

- AR is the incorporation of a computer-generated image on a person's view of the real world. It provides a view of both what the world and work actually looks like and what it could look like.
- With AR, a project manager or contractor could walk through a construction site and easily view an overlay of a BIM model on top of as-built construction and compare the two.
- At the same time, they could be accessing checklists completing a daily report using a heads-up display.
- The project manager could instantly take photos or record the augmented reality walkthrough and send it back to the design team for clarification as issues arise.

The most popular augmented reality wearable in construction is the Microsoft HoloLens, but there are a growing number of companies developing their own wearables.

Source: Microsoft HoloLens (www.microsoft.com/en-gb/hololens

EXTENDED REALITY

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Training

- The worker can use VR in training simulation to get more skilled in a certain task or when a project task is complex or time sensitive. Workers need extra training for using VR effectively.
- Safety training and equipment operator training are two areas where virtual reality (VR) could have a strong impact on the construction industry. With VR, workers could get exposure to situations such as confined spaces or working at height in a safe, controlled manner.
- Augmented reality (AR) is another technology that can greatly improve safety on the construction site. Whether it's allowing for a more detailed safety plan to be developed or providing training on heavy equipment using actual equipment on real sites with augmented hazards, there are a number of ways that AR can be deployed on the jobsite.

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4. Smart Controls

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Smart Controls

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Sensors: sensor is a device, module, machine, or subsystem whose purpose is to detect events or changes in its environment and send the information to other electronics, frequently a computer processor.

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IoT Sensors to Collect and Process Data

- Sensors are key for automation.
- These devices take real-time readings of location, temperature, pressure and other conditions.
- Sensors allow construction companies to automate many different machines and robots according to their preferences.
- Sensors can transmit signals to machines to trigger a specific action.
- For example, automation is typically achieved in welding and fabrication machines through the use of sensors. These sensors collect important environmental data that can be used to trigger a relevant action in the welding machine.

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IoT Sensors on Site

IoT Devices to Track Assets and Usage:
Applying IoT sensors to construction site assets is a practical way to reduce the chances of those items getting lost or misused.

Use IoT Sensors to improve Cost Control:
Connecting sensors feeds from around the site and transmit data from people and equipment to a digital twin to assess accurate stages of build and performance information.

Safer Sites with IoT Sensors:
IoT devices continually collect environmental data while people use heavy equipment, helping them adjust their actions to get the best results while maintaining safety.

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IoT Sensors in Buildings

Fire, temperature, humidity and CO Detection.

- Sensors not only detect both smoke and CO, but also can monitor the overall air quality in your home and watch for pollutants like dust, soot, pollen, temperature, humidity, air staleness, pollution, and particulates. All recorded to monitor from mobile devices.

Leak and Moisture Detection

- A moisture detection sensor can inform you if the building is at risk due to freezing pipes, or even a broken waterline.

Motion Detection

- Motion sensors can save energy. These sensors can be connected to lighting or the thermostat to help control the energy usage in a room based on the occupancy of the room. Other motion sensors are used to capture footage of intrusion.

Sensors can all be connected to a mobile device to assess how a building is being used, maintained and operated.

Assessment

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CONSTRUCTION BLUEPRINT

Thank You

Insert Organiser Logo Here
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