Center for Building Infrastructure and Public Space (CBIPS)

Artificial Intelligence in the AEC Industry

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Date: May 5th, 2020

Overview

01 Background

- *Productivity in Construction*
- *Demand for Construction*
- *Safety in construction*
- *Why need new technology*

02 AI Technologies

- *What's the AI*
- *AI technologies*
- *Current status of AI in construction*
- *Category of AI companies*

03 AI Companies

- *Planning and Design*
- *Safety Management*
- *Schedule Optimizer and Progress Monitoring*
- *Autonomous Equipment*
- *Quality and Cost Management*
- *Sustainability*
- *Contract management*

04 Conclusion

- *Trend of AI in the AEC Industry*
- *Laws and Regulations*
- *AI Security*

01 Background

- ***Productivity in Construction***
- ***Demand for Construction***
- ***Safety in Construction***
- ***Why need new technology***

Productivity in Construction

Construction matters for the world economy

… but has a long record of poor productivity

Construction-related spending accounts for

13% of the world's GDP

...but the sector's annual productivity growth has only increased

1% over the past 20 years

(Source: McKinsey, 2017)

Reasons for this poor performance:

- poor project management and execution
- insufficient skills
- inadequate design processes
- under-digitized

"Construction is one of the most **under-digitized industries** in the world and is **slow to adopt new technologies** "

(Source: McKinsey, 2017)

Demand for Construction

Demand for construction is higher than ever

While productivity is stable , demand for construction is higher than ever.
But there aren't enough qualified people to do the work.

$2.1T

Infrastructure funding gap

Unfunded required infrastructure spending through 2025

(Source: American society of civil engineers,2017)

7.3M

Shortfall in new housing units

New families are forming faster than houses are being built

(Source: Wall Street Journal,2018)

80%

Contractors struggling to hire

Nationwide labor shortage is "significant and widespread"

(Source: Associated General Contractors, 2018)

Safety in construction

The number of worker fatalities is the highest of all other sectors

(Source: U.S. Bureau of Labor Statistics)

Why need New technology?

We need a new way to build

1. **Productivity**: Poor Performance

2. **Demand** for Construction: Increased

3. **Worker fatalities**: Highest

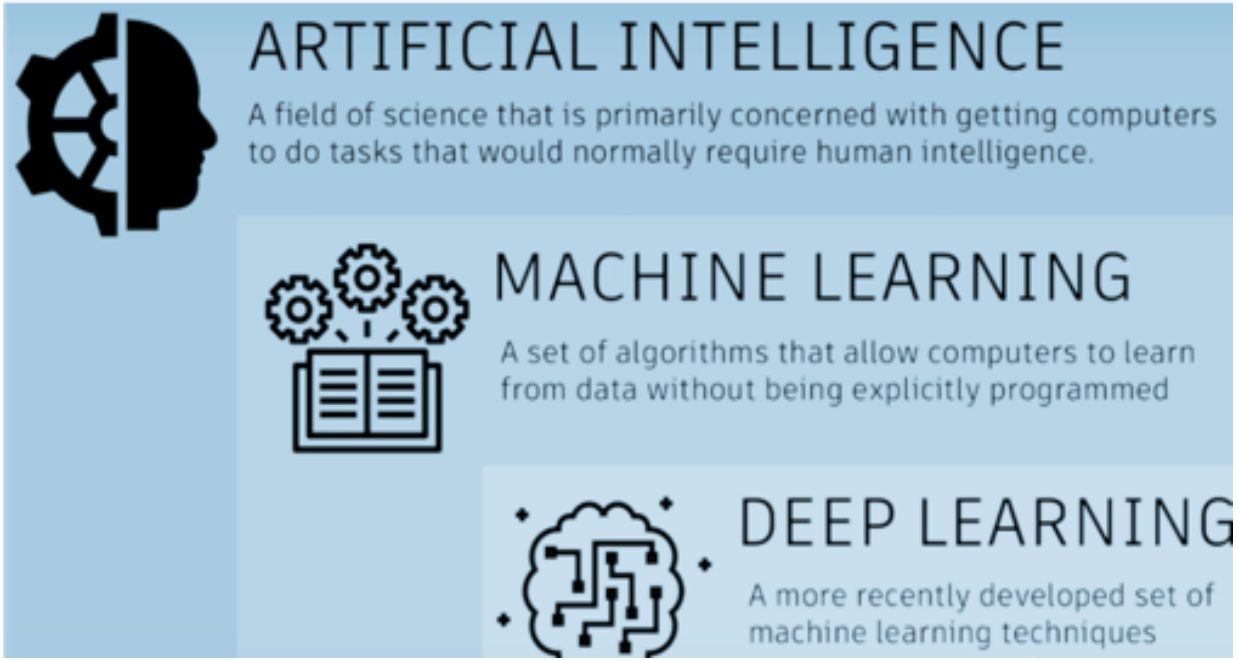
4. **Financial returns** for contractors: Relatively low and volatile

(Source: Towards data science, 2019)

02 AI Technologies

- ***What's the AI***
- ***AI technologies***
- ***Current status of AI in construction***

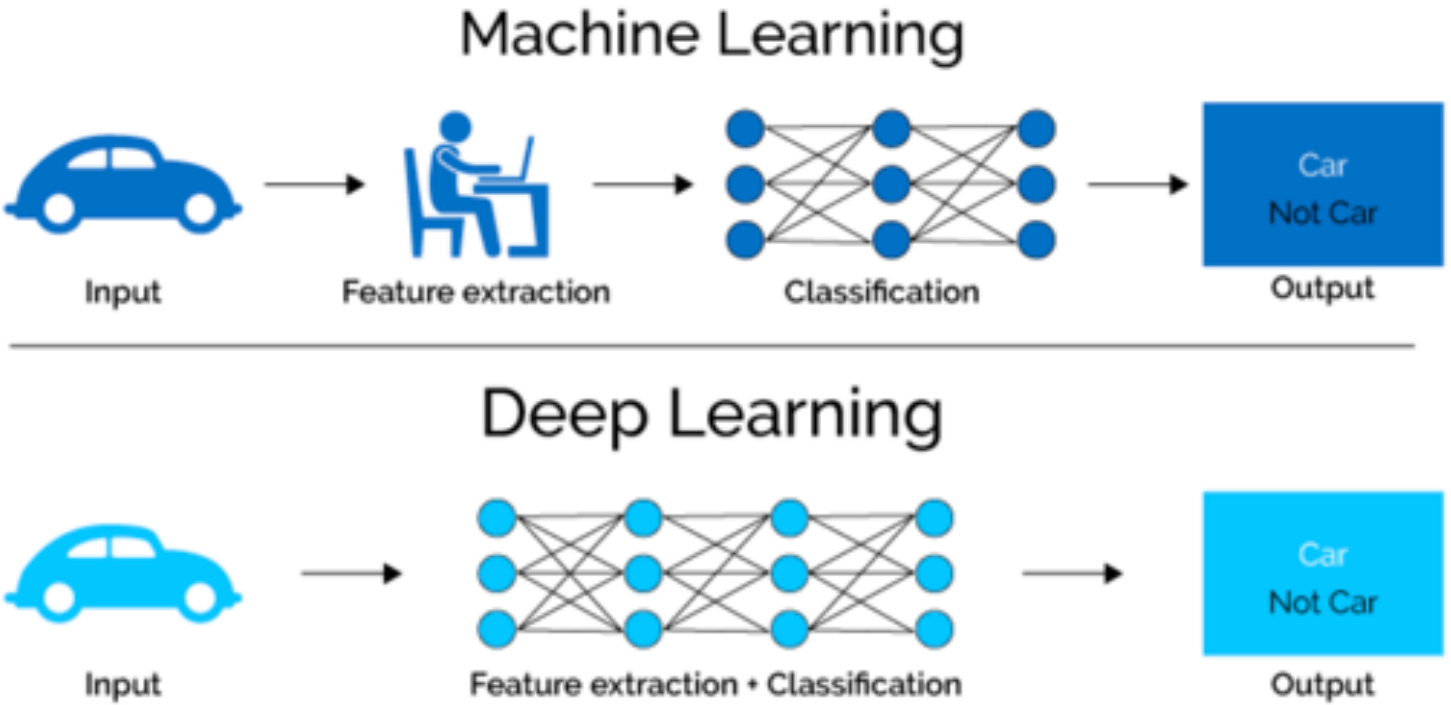
What is the Artificial Intelligence



“ Creating algorithms makes it possible to simulate a kind of human intelligence ”

(Source: Autodesk University, 2018)

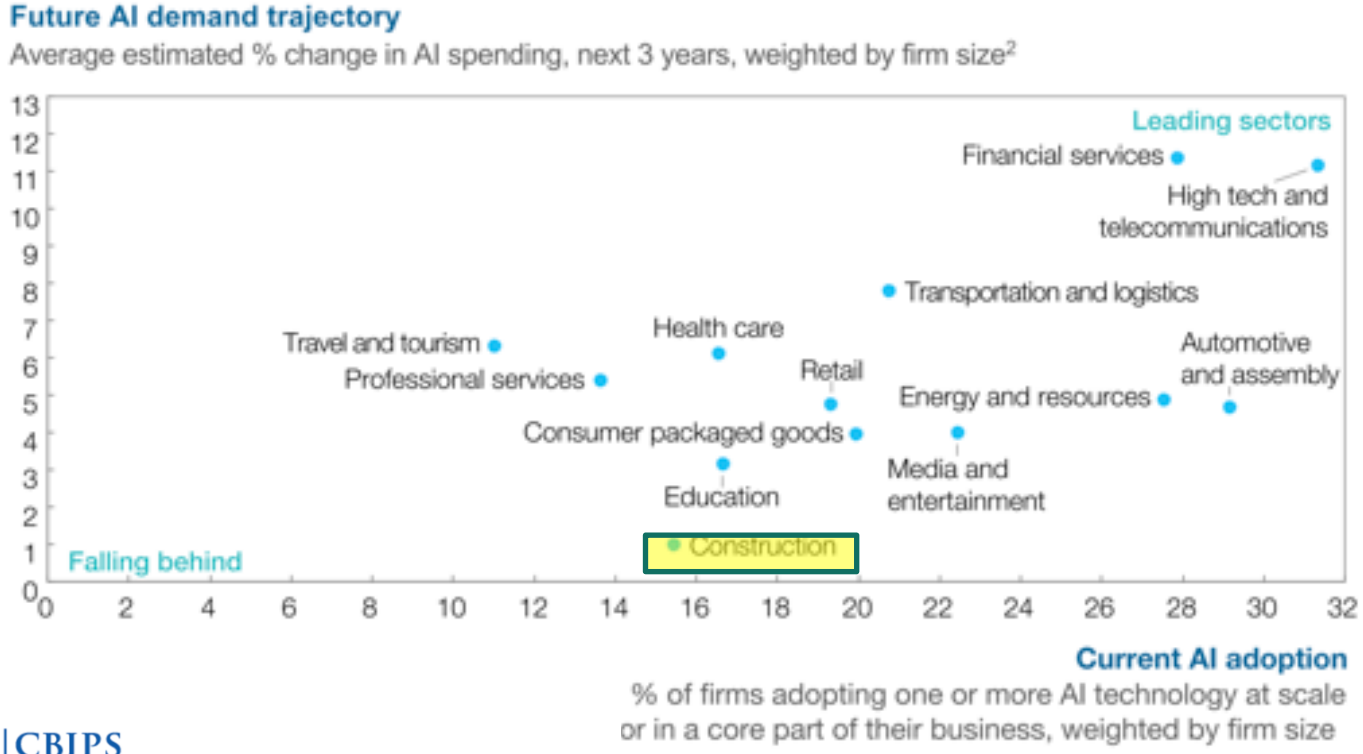
What is the Artificial Intelligence



(Source: Jagreet Kaur Gill, Automatic Log Analysis using Deep learning and AI, 2018)

Current State of AI in the AEC Industry

Adoption of AI solutions is quite low



(Source: McKinsey, 2018)

Current State of AI in the AEC Industry

Technology Companies

Autodesk, Microsoft, IBM, 3DR, AltaML, AirWorks, Building System Planning, LayoutNet, TestFit, Spacemaker, Hyper Explore, Dar, Smartvid.io, Glodon, Alice, Kwant.ai, One Space, Dusty Robotics, Intsite, Built Robotics, Indus.ai, Astralink, Swig, Gridium, Evisort, Contract Logix, etc

AEC Companies

Aecom, Arup, Thornton Tomasetti, Mott MacDonald, Skanska, Komatsu, JLL, CBRE, Fluor, Kiewit, PCL

Seven Categories:

- Planning and Design
- Schedule Optimizer and Site Monitoring
- Safety Management
- Autonomous Equipment
- Quality and Cost Management
- Sustainability
- Contract Management

03 AI Companies

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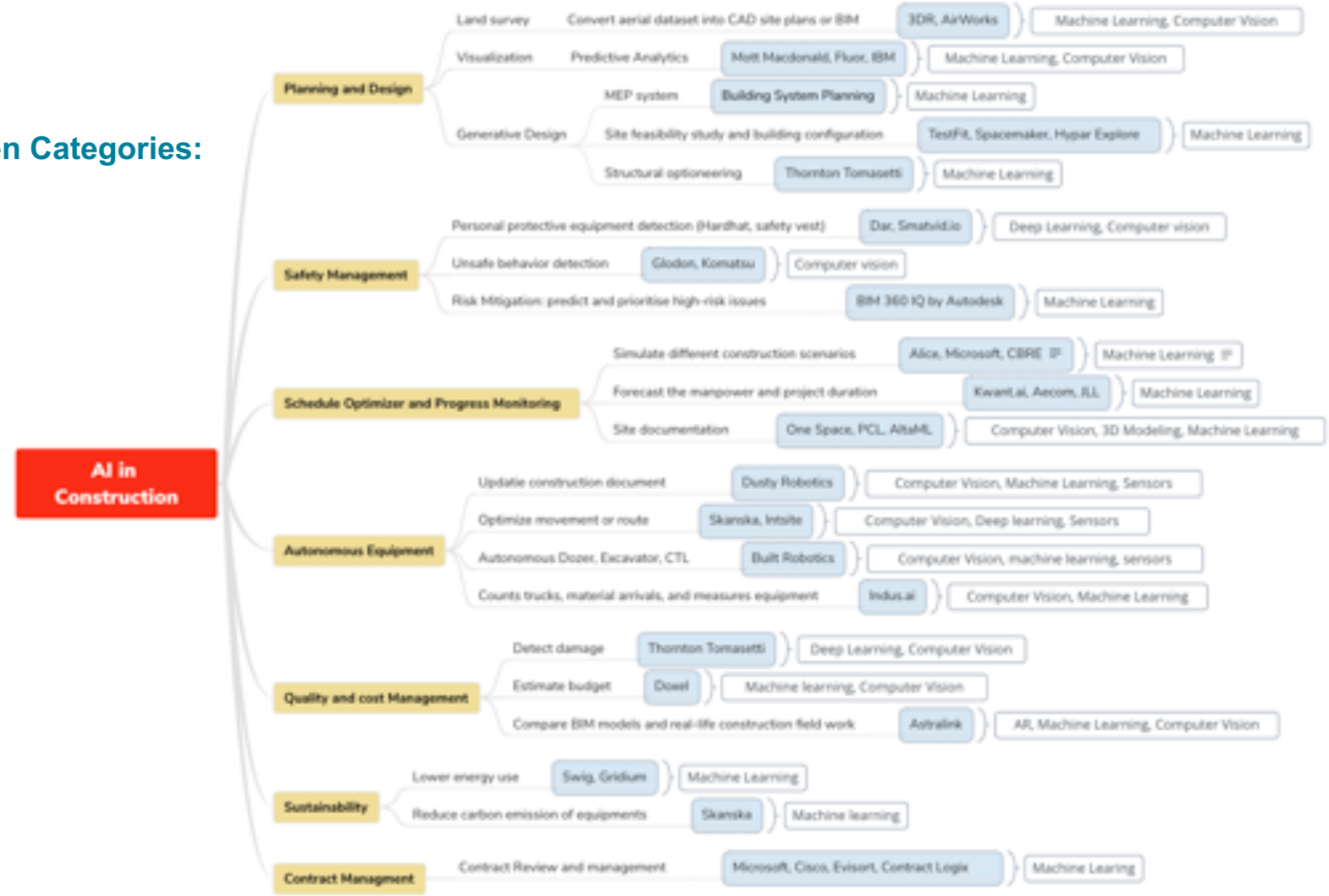
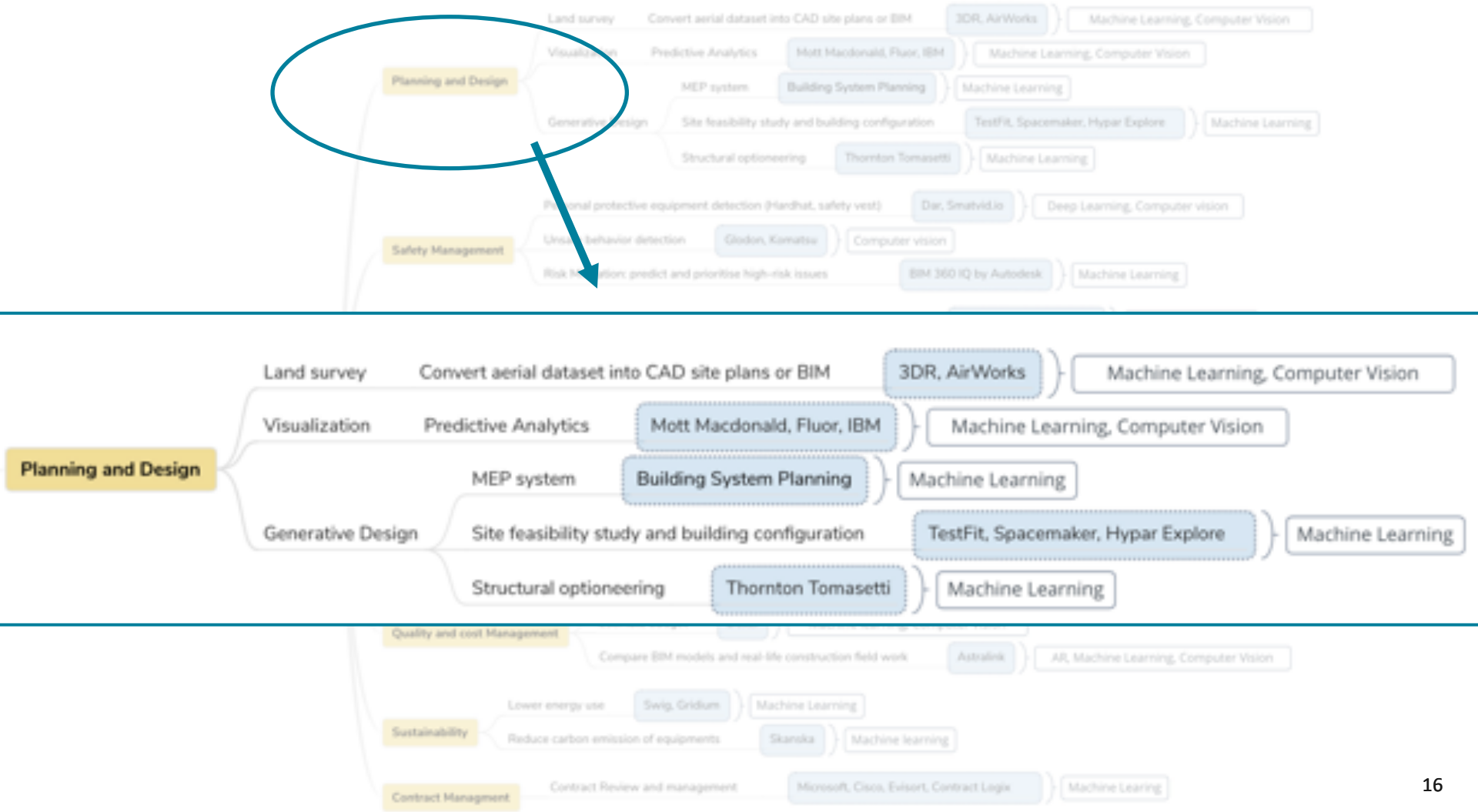



Planning and Design


Planning and Design
Land survey
Convert aerial dataset into CAD site plans or BIM
3DR, AirWorks
Machine Learning, Computer Vision
Visualization
Predictive Analytics
Mott Macdonald, Fluor, IBM
Machine Learning, Computer Vision
MEP system
Building System Planning
Machine Learning
Generative Design
Site feasibility study and building configuration
TestFit, Spacemaker, Hypar Explore
Machine Learning
Structural optioneering
Thornton Tomasetti
Machine Learning

Planning and Design

- Visualization in the early design

- Land Survey
  - Drones convert aerial dataset into CAD site plans fully autonomously

- Generative Design
  - MEP System
  - Site feasibility study and building configuration
  - Structural optioneering

Typical Companies

MOTT MACDONALD

AIRWORKS

3DR

BUILDING SYSTEM PLANNING, INC.

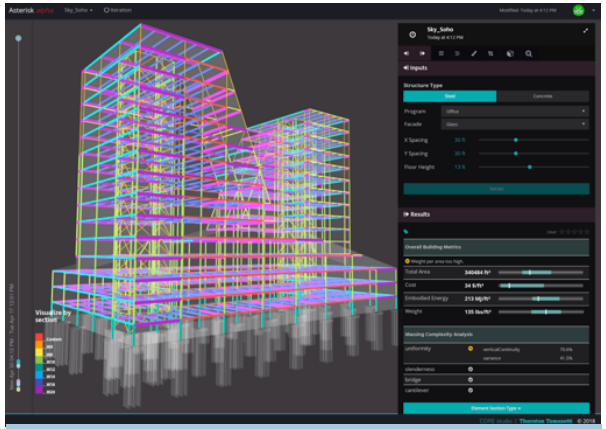
SPACEMAKER

testfit.io

HYPAR

CORE studio | Thornton Tomasetti

Asterisk (alpha)

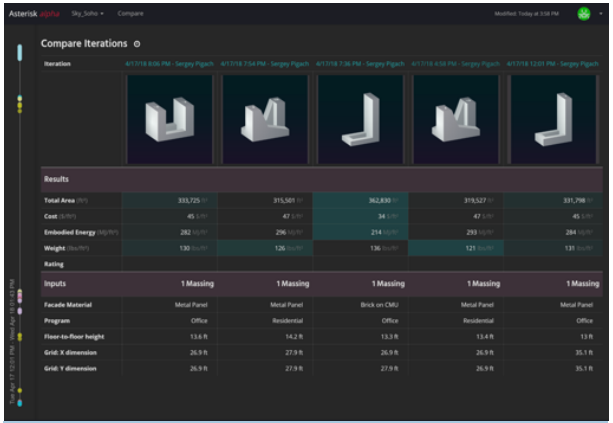


Iterate

through user-defined parameters, such as program, bay spacing, and material, to build up design space. Upload masses from Rhino, iterate and download wire-frames back into a modeling workflow.

Explore

structural iterations in filterable design space with the integrated Design Explorer interface. Set limits to results, like weight and cost or floor-to-floor height inputs, and get back the iterations meet project criteria as they evolve.



Compare

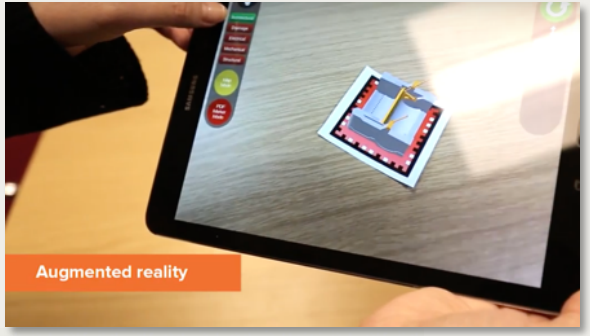
user-selected sets of iterations to better understand their relative performance. See trade-offs between options in a comparative matrix that visually highlights the top-performing metrics in each category.

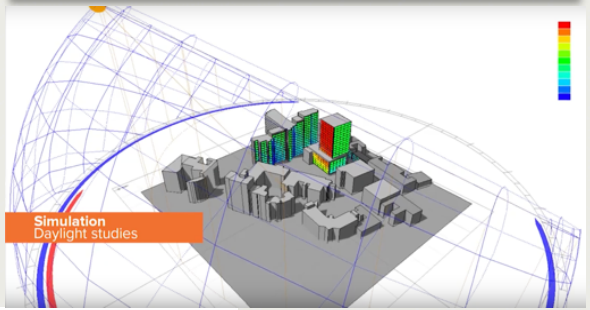
(Source: CORE.AI Newsletter vol.2, 2019)

MOTT MACDONALD

Visualisation

- Photomontage/virtual verified imagery
- Computer generated imagery
- Animation
- Video production
- Post production/video compositing
- Virtual reality/Realtime 3D
- Augmented reality





(Source: Mott Macdonald, 2020)

AIRWORKS

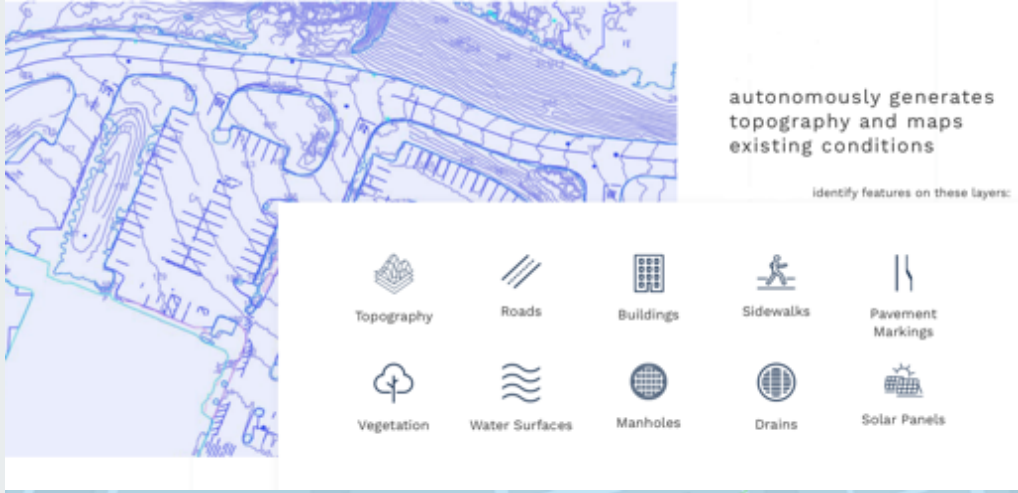
“The fastest and easiest way to convert aerial data into CAD linework”

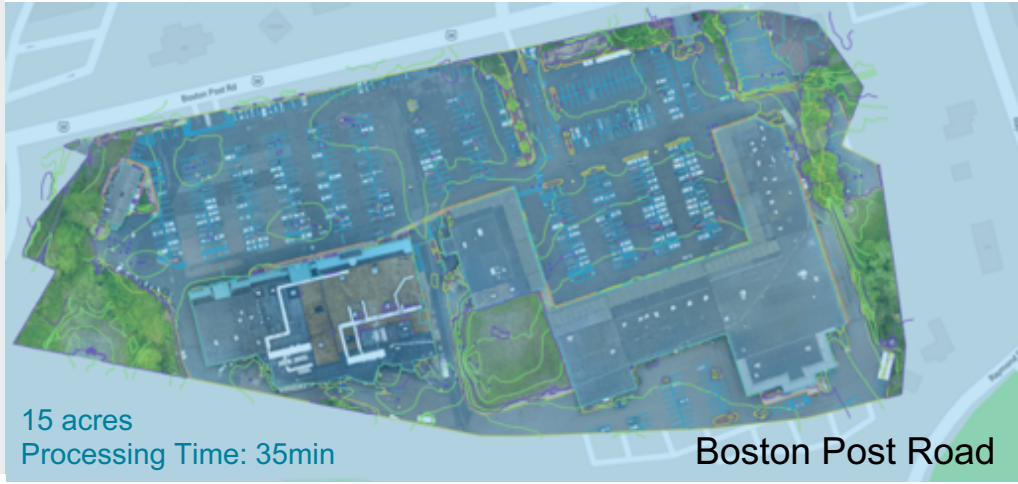
How it works:

The software makes converting aerial data to CAD drawings easy as 1 - 2 -3

1. Upload your orthomosaic and pointcloud files
2. Define the site boundaries
3. Download your CAD files

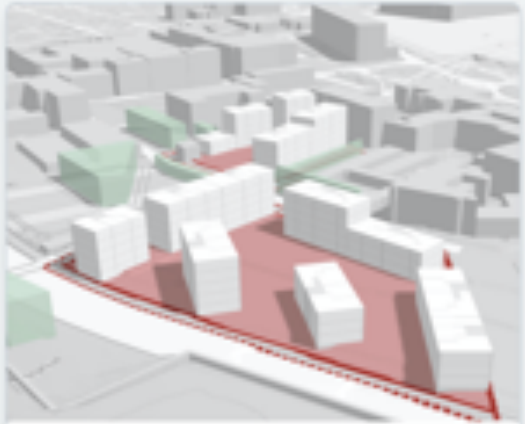
Technology: Machine Learning





(Source: Airworks, 2020)

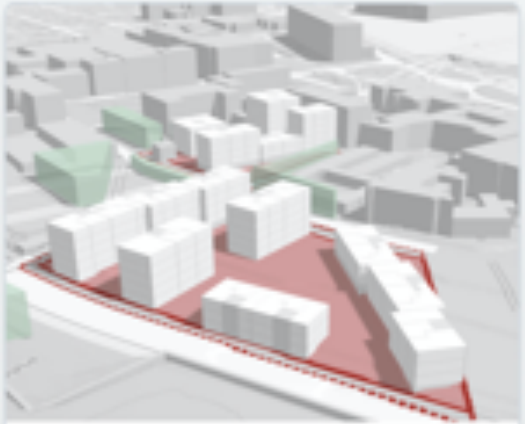
SPACEMAKER



Lamellas #1

12 AUG · 7:31

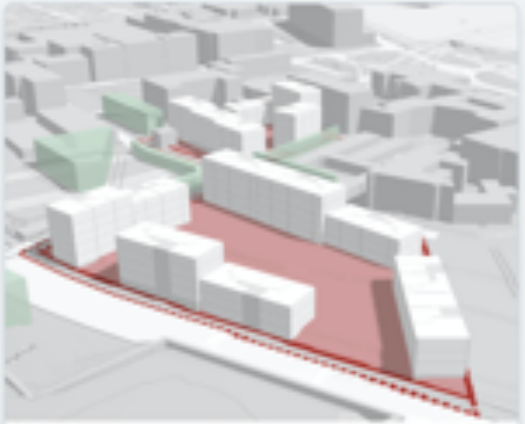
Area	19 720 m²
Sun	7.8 h
View distance	202 m
Noise	7.3 %



Lamellas #2

12 AUG · 7:33

Area	19 788 m²
Sun	7.5 h
View distance	191 m
Noise	3.4 %



Lamellas #3

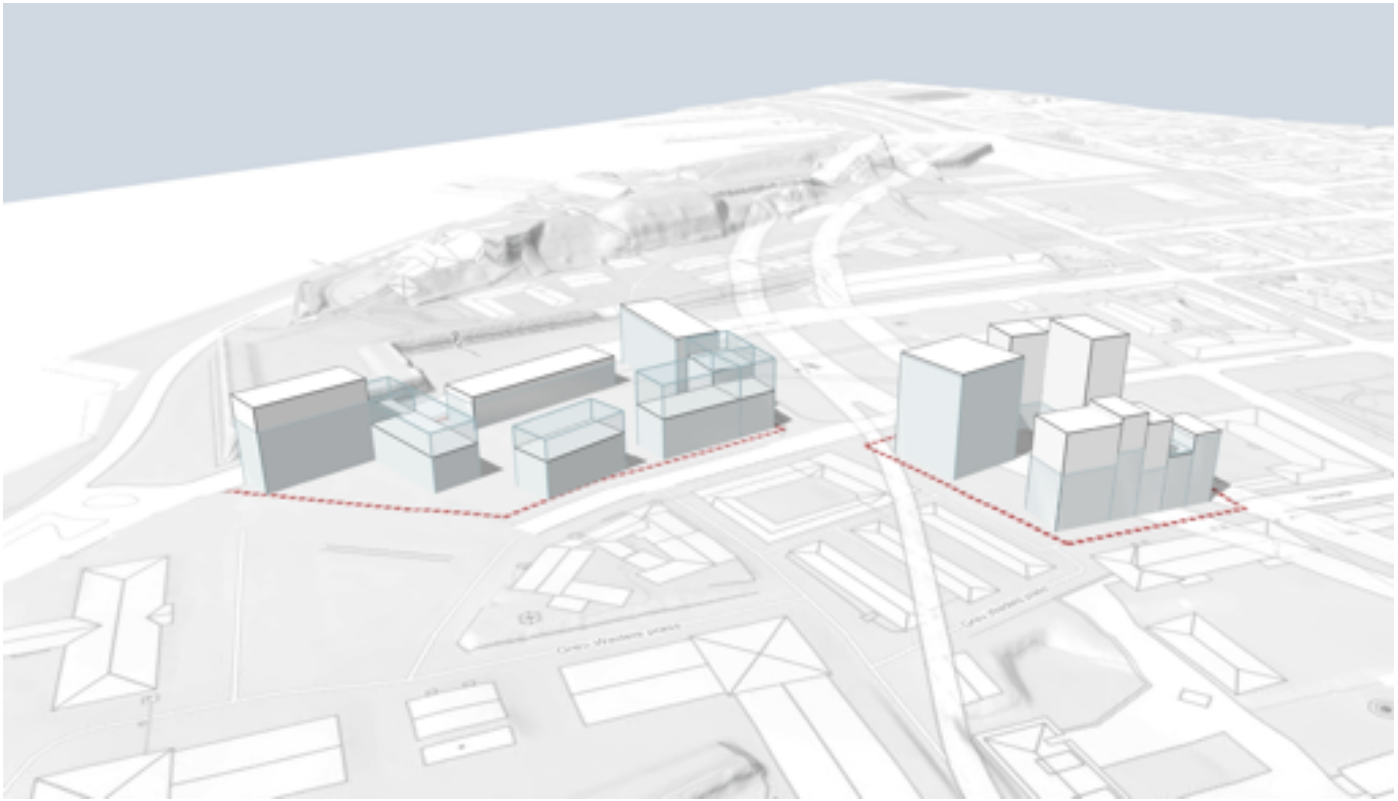
12 AUG · 7:35

Area	20 684 m²
Sun	7 h
View distance	178 m
Noise	2.1 %

Generate and Optimize

(Source: Spacemaker, 2020)

SPACEMAKER

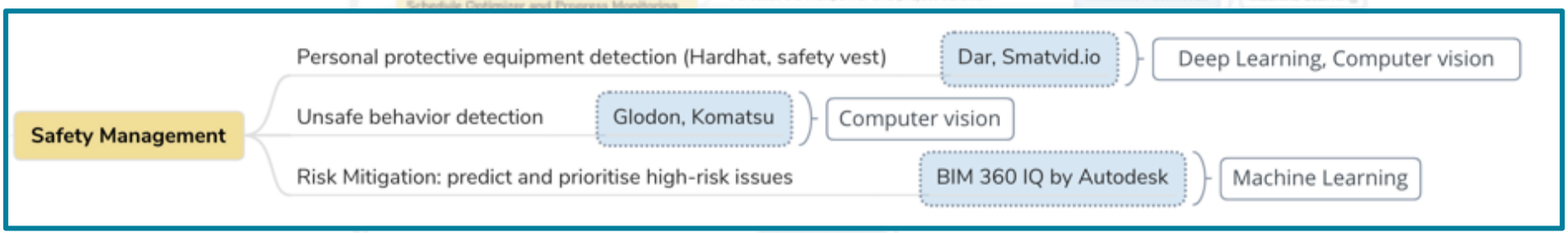


Height optimization with fixed building footprint

(Source: Spacemaker, 2020)

Safety Management

(Source: http://www.mit.edu/archive/spotlight/path-predictor-robots/)


Safety Management
Personal protective equipment detection (Hardhat, safety vest)
Dar, Smatvid.io
Deep Learning, Computer vision
Unsafe behavior detection
Glodon, Komatsu
Computer vision
Risk Mitigation: predict and prioritise high-risk issues
BIM 360 IQ by Autodesk
Machine Learning

Safety Management

Typical Companies

- Detect Personal Protective Equipment (Hardhat, Safety Vest, etc.)

- Detect unsafe Behavior

- Risk Mitigation: predict and prioritize high-risk issues or project subcontractor risk

- Annotate the images with three labels: Helmets, Persons With Helmets, and Persons Without Helmets
- Technologies: Deep Learning, Computer Vision

(Source: Dar, 2019)

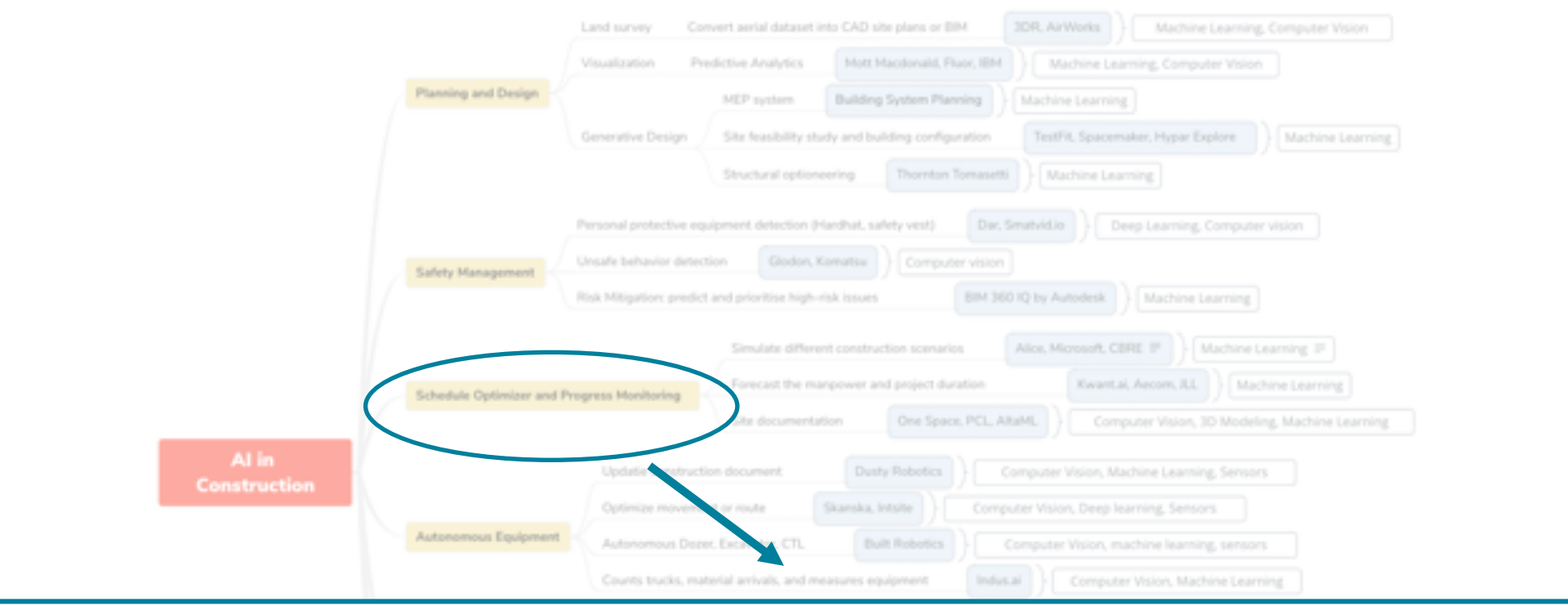
- Monitoring workers' activity
  identify whether their behaviors are legal and meet the requirement of safety

- Technology: Computer Vision

(Source: Glodon, 2020)

Schedule Optimizer and Progress Monitoring

(Source: https://www.ellisdon.com/subservice/construction-visualizations-4d/)



Schedule Optimizer and Progress Monitoring

Simulate different construction scenarios — Alice, Microsoft, CBRE — Machine Learning

Forecast the manpower and project duration — Kwant.ai, Aecom, JLL — Machine Learning

Site documentation — One Space, PCL, AltaML — Computer Vision, 3D Modeling, Machine Learning

Schedule Optimizer and Progress Monitoring

- Simulate different construction scenarios quickly and see the impact on cost and schedule.
- Accurately plan and establish forecasts of the manpower and project duration
- Site documentation (automatically maps images to project plans)

Typical Companies

ALICE

KWANT.AI

AECOM

OPENSPACE

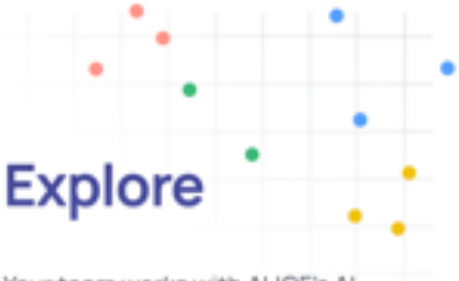
Capture: an AI-powered web-and-mobile platform, brings 100-percent accuracy to conventionally cumbersome, time consuming and subjective project management processes

(Source: Aecom, 2019)

ALICE

Gather

Members of your team with key knowledge about your project and your firm's means and methods collect this information inside of ALICE.

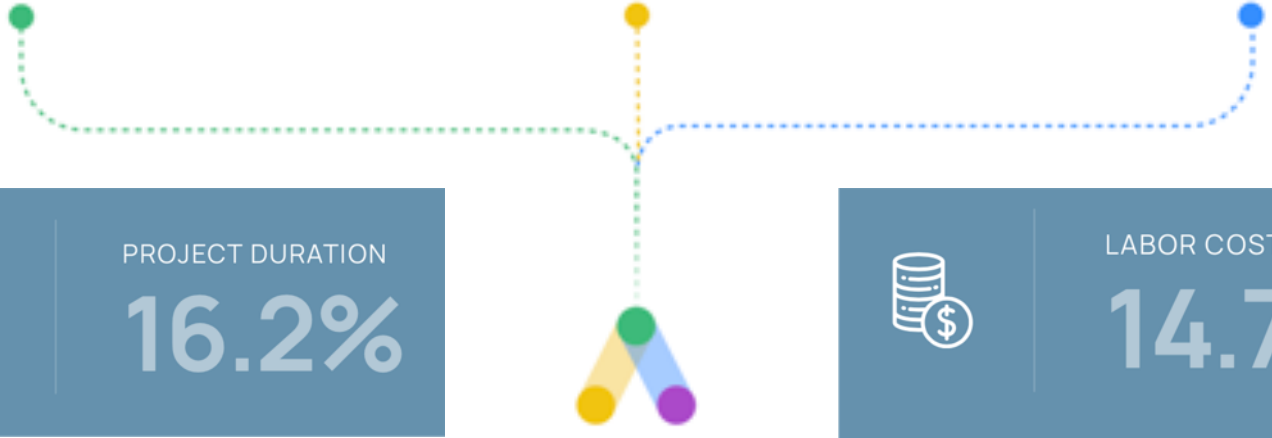


Explore

Your team works with ALICE's AI platform to explore hundreds of different construction scenarios and millions of different schedules to find an optimal plan.

Manage

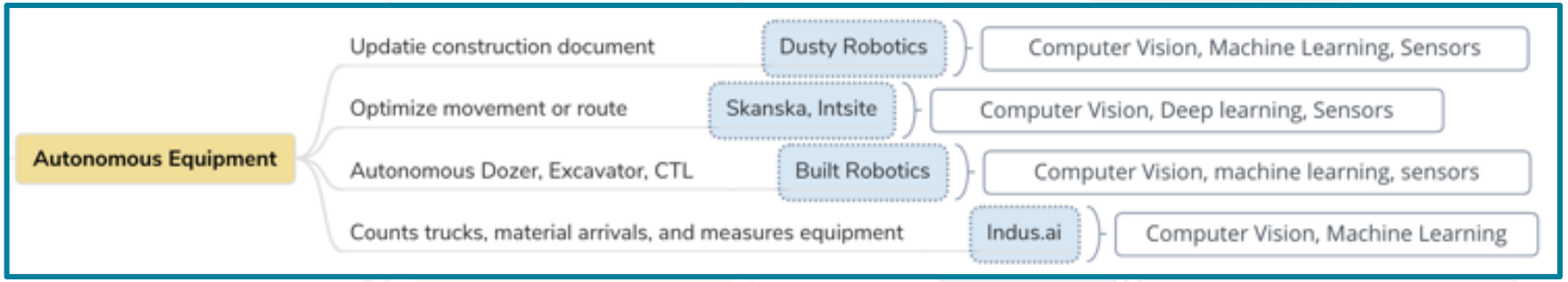
ALICE generates a cost loaded 4D schedule to communicate and manage your project easily. ALICE can even help you reschedule in minutes to resolve issues and delays.



Advanced AI

(Source: Alice, 2020)

(Source: https://www.stambol.com/2017/12/18/xr-series-ar-enterprise/)


Autonomous Equipment
Updatie construction document
Dusty Robotics
Computer Vision, Machine Learning, Sensors
Optimize movement or route
Skanska, Intsite
Computer Vision, Deep learning, Sensors
Autonomous Dozer, Excavator, CTL
Built Robotics
Computer Vision, machine learning, sensors
Counts trucks, material arrivals, and measures equipment
Indus.ai
Computer Vision, Machine Learning

Autonomous Equipment

Typical Companies

- Autonomous robots marking site layout and updating construction document → Dusty Robotics
- Optimize movement: guidance system and smart dashboard for construction cranes → INTSITE
- Autonomous Dozer, Excavator, CTL → BUILT ROBOTICS
- Counts trucks, material arrivals, and measures equipment → INDUS.AI

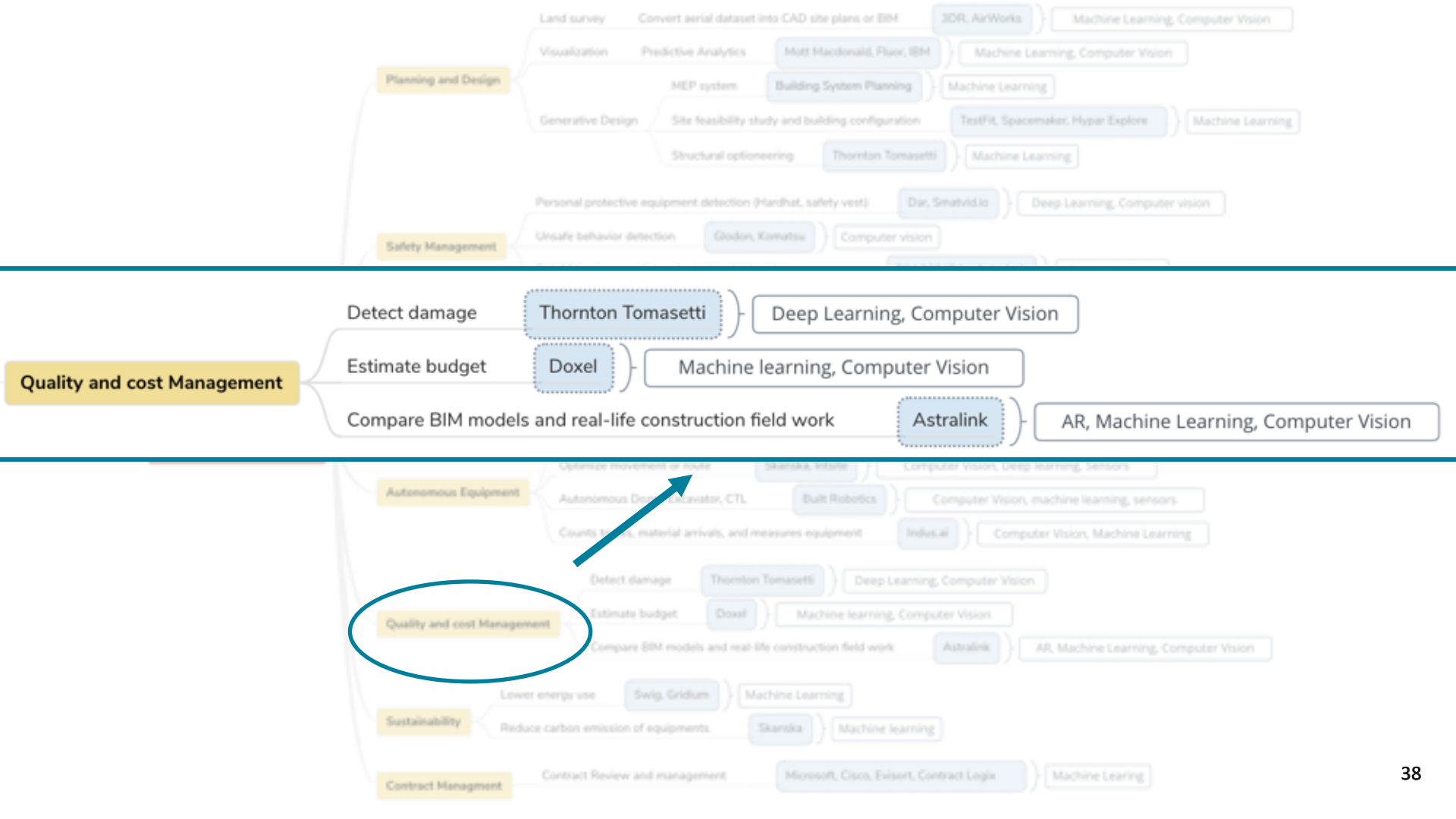
INDUS.AI

- Track material arrival and departure insights for project cost controls.

- Track equipment uptime to better manage schedule dependencies.

(Source: Indus.Ai, 2019)

(Source: https://www.clemson.edu/cecas/departments/ce/research/cm/index.html)


Quality and cost Management
Detect damage
Thornton Tomasetti
Deep Learning, Computer Vision
Estimate budget
Doxel
Machine learning, Computer Vision
Compare BIM models and real-life construction field work
Astralink
AR, Machine Learning, Computer Vision

Quality and Cost Management

- Detecting damage (spalls, cracks, vegetation growth, etc.)
- Bridge the gap between 3D digital blueprints (BIM models) and real-life construction field work.
- Estimate Budget

Typical Companies

CORE studio | Thornton Tomasetti

astralink

DOXEL

T2D2©: Thornton Tomasetti Damage Detector

Existing Facade at St. Paul's school

Using T2D2, detecting damage (spalls, cracks, vegetation growth, etc.)

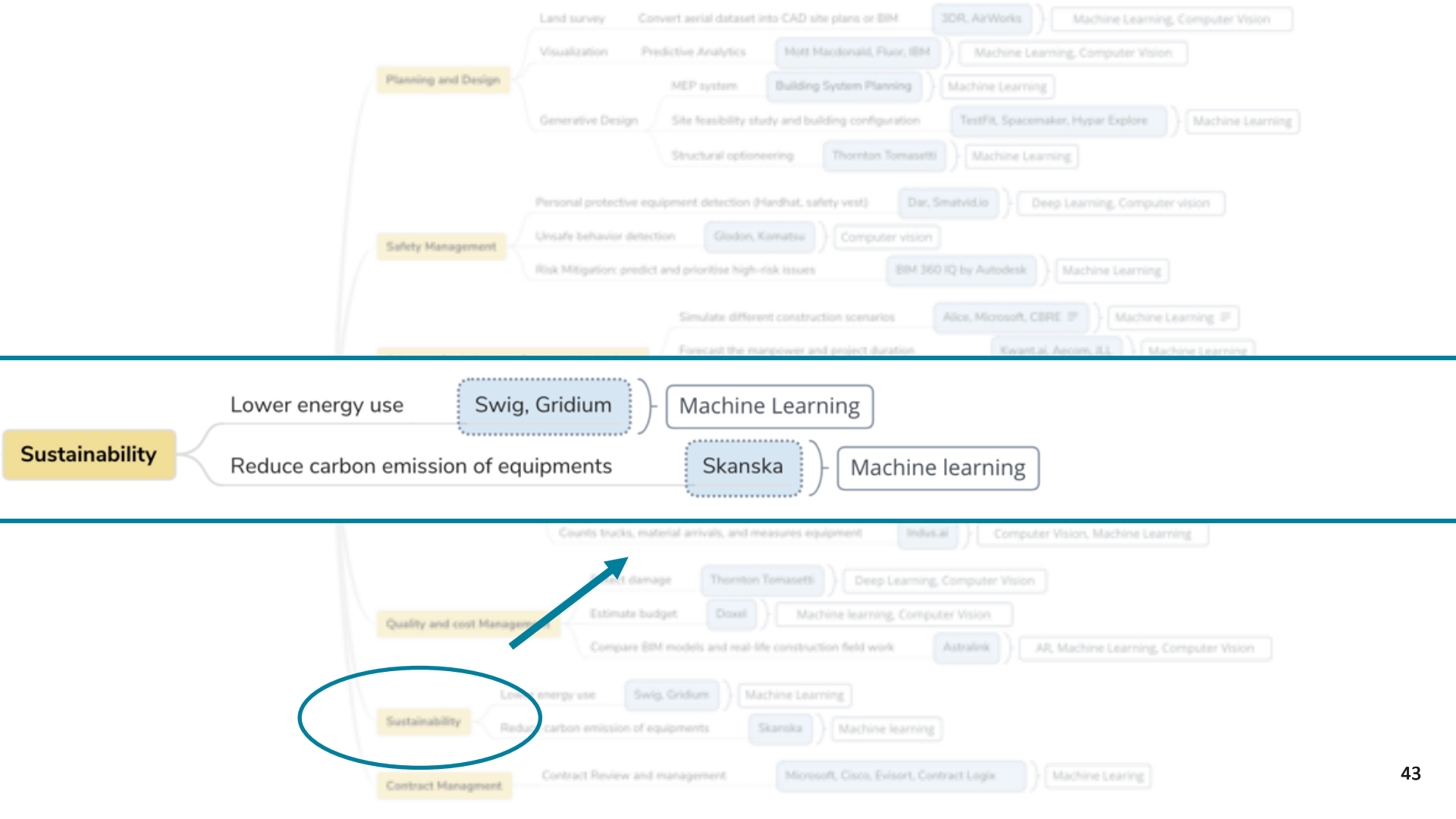
Technology: Deep Learning
Application Areas: buildings, bridges, tunnels, nuclear reactors, and petrochemical facilities

(Source: CORE.AI Newsletter vol.2, 2019)

astralink

(Source: astralink, 2020)

(Source: https://www.environmentalleader.com/2019/02/california-real-estate-company-using-ai-to-increase-sustainability-in-operations/


Sustainability
Lower energy use
Swig, Gridium
Machine Learning
Reduce carbon emission of equipments
Skanska
Machine learning

Sustainability

- Lower energy use
- Reduce carbon emission of equipment

Typical Companies

→ THE SWIG COMPANY

→ SKANSKA

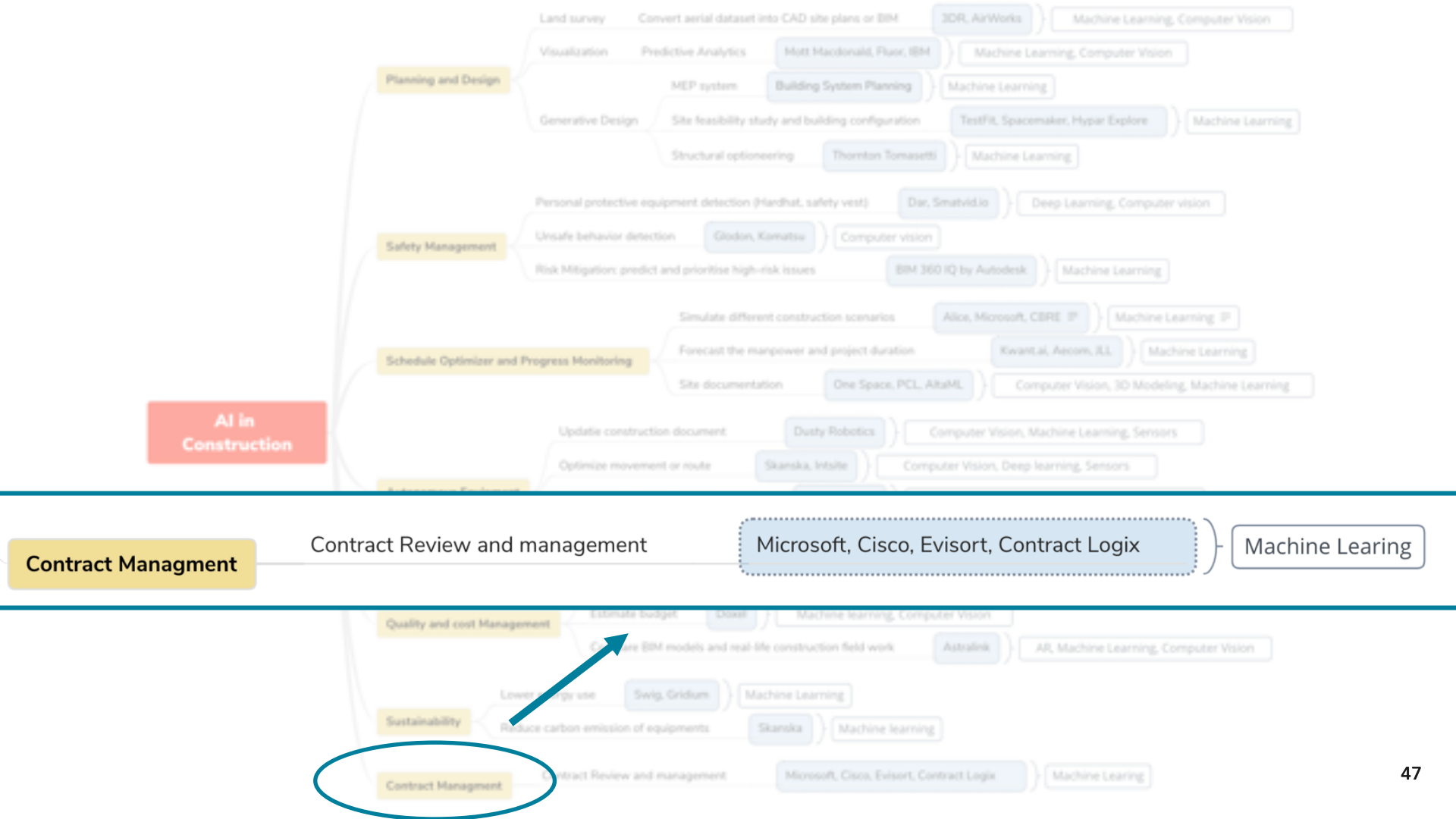
SKANSKA

- Route optimization and artificial intelligence to enable heavy equipment to perform more efficiently and with lower emissions.
- Construction equipment accounting for a significant amount of the industry's carbon emissions.
- It is key to Skanska and society achieving climate emissions targets.

Technology: Deep Learning, Route Omptimization
Application Areas: buildings, bridges, routes, machinery.

(Source: Skanska, 2020)

(Source: https://www.clemson.edu/cecas/departments/ce/research/cm/index.html)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Computer Vision, Machine Learning, Sensors
Optimize movement or route
Skanska, Intsite
Computer Vision, Deep learning, Sensors
Contract Managment
Contract Review and management
Microsoft, Cisco, Evisort, Contract Logix
Machine Learing
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Astralink
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Sustainability
Lower energy use
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Machine Learning
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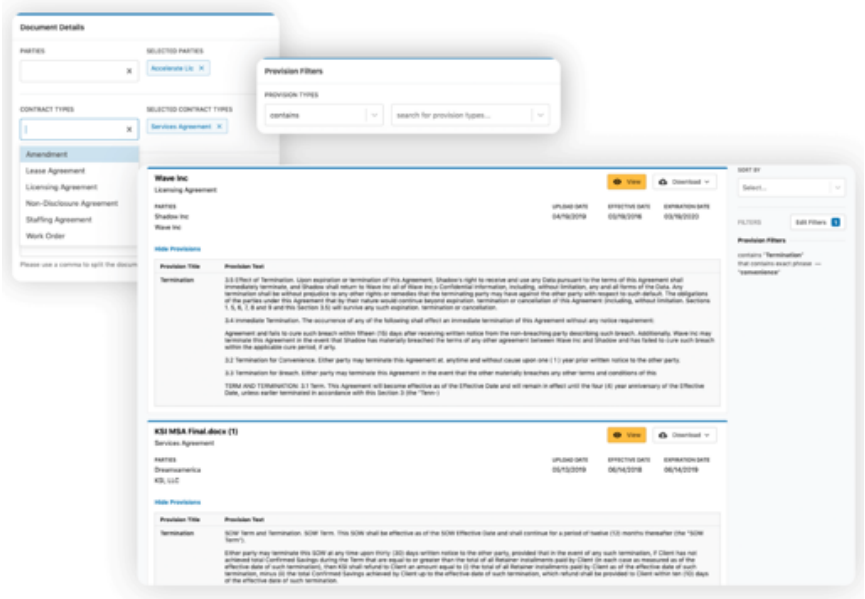
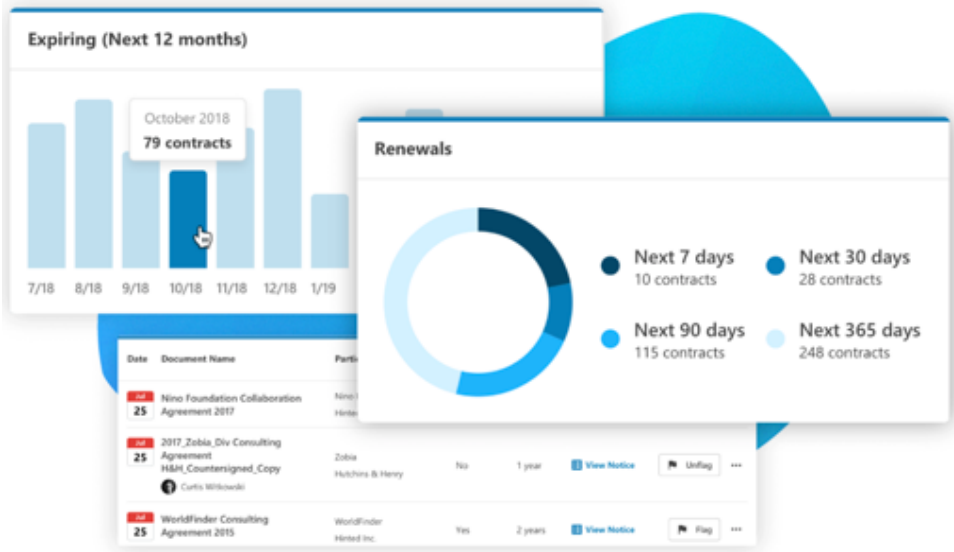
Machine Learing

EVISORT



Artificial intelligence for precise visibility into any contract



Auto-identify key expiration and renewal dates

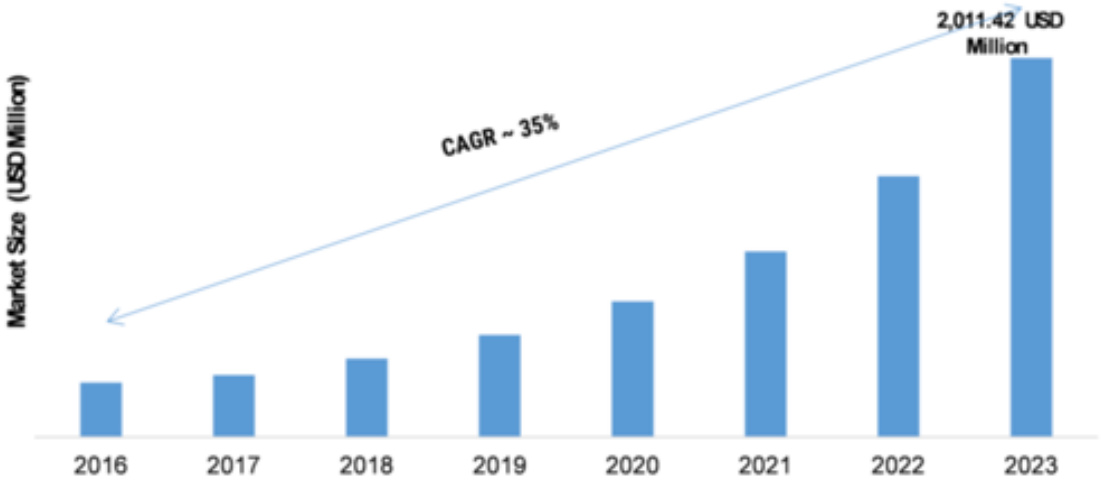
(Source: Evisort, 2020)

04 Conclusion

- ***Trend of AI in the AEC Industry***
- ***What's the Challenge?***
- ***Opportunity for CBIPS***

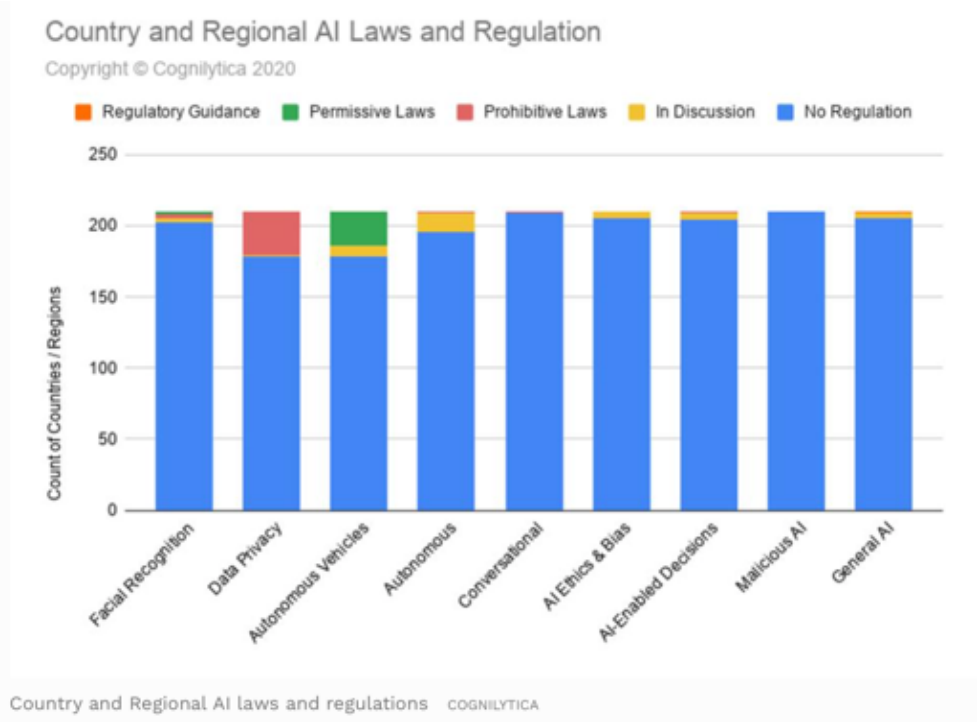
Trend of AI in the AEC Industry

- AI development in the construction market is assumed to acquire USD 2,011.4 million during 2017-2023.
- The global market is anticipated to record 35% CAGR owing to the surging demand for safety considerations



(Source: Market Research Future, 2019)

Laws and Regulations



Nine different areas:

- facial recognition and computer vision
- AI-relevant data privacy
- autonomous vehicles
- autonomous weapons systems
- conversational systems and chatbots
- AI ethics and bias
- AI-supported decision making
- malicious use of AI,
- General AI

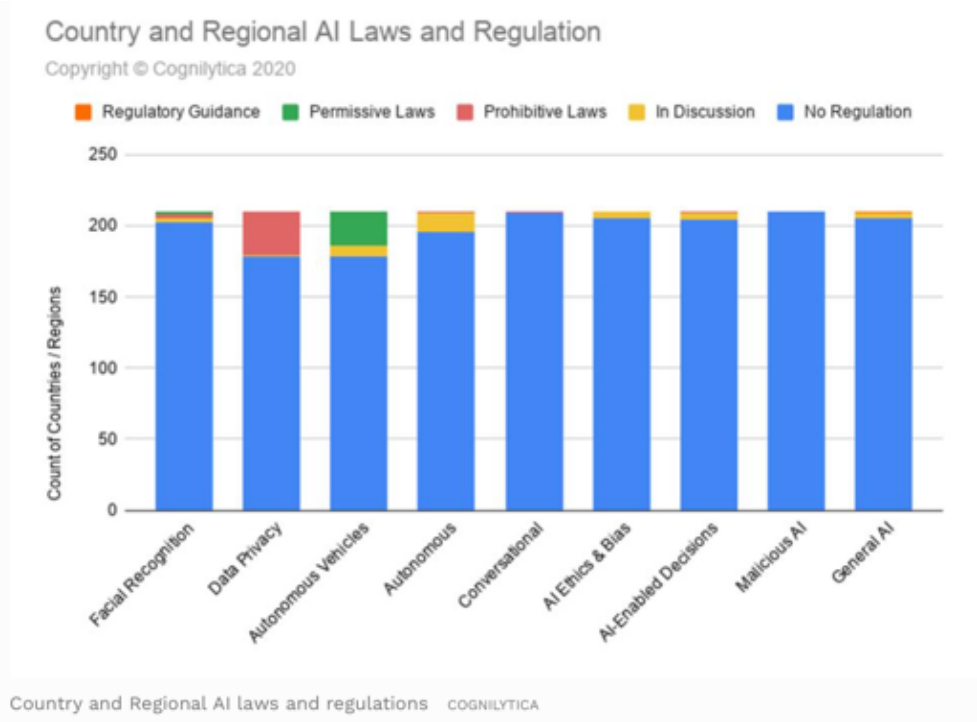
Most governments --"wait and see"

The European Union --the most active in proposing new rules and regulations

The United States -- maintains a "light" regulatory posture

(Source: Cognilytica, 2020)

Laws and Regulations



- 24 countries have put into place ***permissive laws for autonomous vehicle operation***, and 8 are currently in discussions

- 13 countries have advanced some level of discussion with regard to restrictions on the use of ***lethal autonomous weapons systems (LAWS)***. Only one country has already prevented the use or development of LAWS.

- ***No countries*** yet have specific laws in place around ethical and responsible AI, malicious use of AI.

(Source: Cognilytica, 2020)

10 Principles — the White House

Subject: ***Guidance for Regulation of Artificial Intelligence Applications***

Date: ***January 13, 2020***

White House has released 10 principles for government agencies to adhere

Provide official guidance and reduce uncertainty for innovators

10 Principle:

- Public trust in AI
- Public participation
- Scientific integrity and information quality
- Risk assessment and management
- Benefits and costs
- Flexibility
- Fairness and nondiscrimination
- Disclosure and transparency
- Safety and security
- Interagency coordination

(Source: the White house, 2020)

Security in the AEC Industry

1. Low Investment and Awareness

The reality is that investment in high-level cyber security and awareness are low in the industry. Making this industry vulnerable and attractive to malicious hackers.[1]

2. AEC Industry is embracing new technologies

Even though the AEC is one of the least advanced industry in terms of technology, it's becoming more digitized and automated; more connected. So its imperative to discuss cyber security in the construction Industry.[1]

3. Different phases, different cybersecurity threats

The lifecycle of an AEC project has different stages that possess different type of data and analytical tools. This also presents different possibilities of cyberattacks in the different phases of a project: design, construction, and O&M.[1]

(Source: [1]Mantha, Bharadwaj R.K. June 2019)

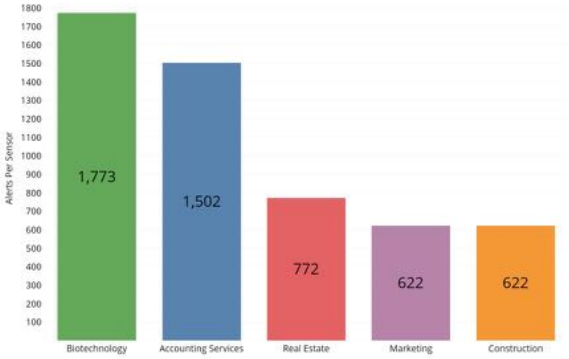
Security in the AEC Industry

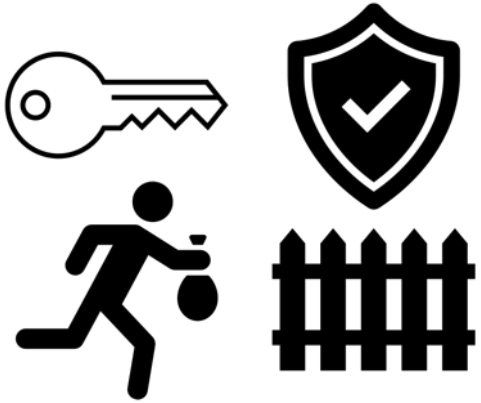
1. Turner Cyberattack

In March 2015, Turner Construction Co, headquartered in New York; was victim of a cyber attack where personal and financial information of workers was stolen using phishing.[1]

2. Cyber-attacks against construction increase

According to the cybersecurity eSentire in their Q2 2018 threat report, Construction is experiencing more confirmed phishing attacks than any other sector.[2]





(Source: [1]Jones, Kendall. May 2016
[2]The Construction Index, Oct. 2018)

Security in the AEC Industry

1. The AEC needs more investment in cybersecurity

The industry requires to look at cybersecurity as the threat it is and use the correct tools to provide security against them.[1]

2. AEC Industry is embracing new technologies

Several cyberattacks have already occurred in the AEC industry with an intention steal proprietary information, gain access to unauthorized files, and tamper existing records.[1]

3. Cyberattacks in the industry

Cyberattacks are on the rise, and it will only get worst. It is, therefore, imperative to for AEC industry companies to start shielding up against the threat of cyberattacks[1]

(Source: [1]Mantha, Bharadwaj R.K, June 2019)

Thank you

Q & A

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