Utilisation of Artificial Intelligence and Machine Learning Application in Construction Project Controls

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Agenda

1. Project Controls Framework
3. AL/ML in Construction Industry
4. Machine Learning Applications in Project Controls
• **Project Control Framework**

Project controls defined as collection of information, Analyse data and build the prediction based on the status, Forecast and direct the project decisions in terms of time and cost. This is done by implementing a process to integrate data to drive the decision.

The process of project controls required to integration between many systems from different discipline;
• Delivery progress.
• Planned and actual Duration.
• Planned and actual cost.
• Risks and control actions from risk register.
• **Project Control Framework**

**Problem with the current Project Controls Process**

• Unavailability of real-time progress updates leads to delay in decisions.
• Project controls process done on a monthly basis with a recommendation for recovery actions and mitigations proposed for future actions.
• There is a lack in level of development between design outcome -Building Information Model- and tools and platforms used for project controls.

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• **Project Control Framework**

**Challenges during project controls process implementation:**

For each step on the project controls process there is a different system being used to deliver the function, the main issues for this proposed integrated system are:

• Different data set required for each system.
• Required too many manual adjustments and a lot of effort at the implementation stage.
• Special skills required to be able to manage the process with understanding of different aspects related to ICT, risk management, cost management and control, planning and time control with quality control understanding.

*Project Controls NOT just a software it’s a process, system and PEOPLE*
**Machine Learning Framework**

- **Artificial Intelligence**
  - **ANI (Artificial Narrow Intelligence)**
    - Do one thing such as a smart speaker or a self-driving car
  - **AGI (Artificial General Intelligence)**
    - Super Intelligence

**Artificial Neural Networks (ANN)**
- Supervised learning
- Unsupervised learning
- Classification
- Regression
- Pattern Search
- Clustering
- Dimensional Reduction

**Reinforcement Learning**
- No data, we have an environment to interact with
- Genetic Algorithm
- Q-Learning
- Deep Q-Networks (DQN)

**Classical Learning**
- Simple data and clear features

**Neural Networks**
- Complicated data, unclear features
- Recurrent Neural Network (RNN)
- Convolutional Neural Network (CNN)
- Generative Adversarial Networks (GAN)
- Autoencoders
- Multi-Layer Perceptron (MLP)

**Ensemble Methods**
- Quality is a real problem
- Stacking
- Bagging
- Boosting
**Machine Learning Framework**

**Steps for Machine Learning Implementation**

1. Collect Data
2. Train Model (Iterate many times until getting a good result) – A to B mapping
3. Deploy Model (get data back and maintain/update your model)

**Steps for Data Science Implementation**

1. Collect Data
2. Analyse Data
3. Recommend Action

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**What is the ML Can Do and Cannot Do**

<table>
<thead>
<tr>
<th>Can</th>
<th>Cannot</th>
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<tbody>
<tr>
<td>Forecast</td>
<td>Creating new things</td>
</tr>
<tr>
<td>Re-Plan</td>
<td>Get smart very fast</td>
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<tr>
<td>Select from alternatives</td>
<td>Go beyond their tasks</td>
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<tr>
<td>Memorize</td>
<td>Understand your intention</td>
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</tbody>
</table>

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**Application to predict information for the same projects in delivery**

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**AI/ML Technology and Capabilities**

- Baseline for number of projects and updated information for the same projects
- Application to predict information for the same projects in delivery

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**Machine Learning Framework**

**Supervised learning**

- Commercial excellence
  - Refinement of go/no-go ratios
  - Linear/quadratic discriminant analysis
  - Pricing of fixed price contracts
  - Simple neural networks
  - Future bids optimization
  - Reinforcement learning
- Operational excellence
  - Solutions offering refinement
  - Decision trees, random forest
  - Contractor segmenting and management
  - Logistic regression models
  - 3D twin modeling
  - Neural networks
  - Constant design optimization
  - Cluster behavior production
- Stakeholder management
  - Sentiment analysis
  - Naïve Bayes

**Unsupervised learning**

- Talent retention
  - Segmenting employees for targeted plans
  - Gaussian mixture models
- Business development
  - Segmenting clients to prioritize development
  - Gaussian mixture models
- Recruiting
  - Segmenting candidate pools for tailored campaigns
  - K-means clustering

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McKinsey & Company
• **Machine Learning Framework**

ML Researches in Construction

- 1990
- 2000
- 2010

- Large Neural Nets
- Medium Neural Nets
- Small Neural Nets
- Traditional AI

- Performance
- Amount of Data
- Big Data

• **Sectors leading to Artificial Intelligence adaptation**

Sectors leading in AI adoption today also intend to grow their investment the most

Future AI demand trajectory

Average estimated % change in AI spending, next 3 years, weighted by firm size

1 Based on the midpoint of the range selected by the survey respondents.
2 Results are weighted by firm size. See Appendix for an explanation of the weighting methodology.

• **AL/ML in Construction Industry**

- Digital Design — Building Information Model
  - Applications developed and functioning effectively in the design field—Autodesk Dynamo with Rhino as an example

- Digital Execution and Delivery
  - Field Progress Tracking
  - Document Management
  - Quality Control
  - Risk Management
  - Cost Control
  - Time Control
  - Equipment Tracking
  - No Progress in AI utilization in cost control field. Many researches available but there is no commercial app available.
  - No Progress in AI utilization in time control field. Few applications on the market now—Alceo, Beca, Aurora

- Digital Facility Management
  - Predictive maintenance approach with utilization of IoT progressing very well now in maintenance and facility management
  - No Progress in AI utilization in field productivity.

- Development started earlier for progress tracking with many apps available commercially now.
- Recently progressed and start getting few commercial apps in the market such as "Dive!"

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**AL/ML in Construction Industry**

- Largest
- Smallest

<table>
<thead>
<tr>
<th>Cluster and use case</th>
<th>Number of companies</th>
<th>Number of investments</th>
<th>Total amount invested</th>
<th>% of companies founded within last 5 years developing tools</th>
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<tbody>
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<td>Digital collaboration</td>
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<td>Design management</td>
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<td>Document management</td>
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<td>Contact management</td>
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<td>Performance dashboard</td>
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<td>On-site execution</td>
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<td>Quality control</td>
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<td>Safety</td>
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<td>Field productivity</td>
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<td>Operations and management</td>
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<td>Enterprise-resource-planning systems</td>
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McKenzie Company
- **AI/ML in Self-Driving Car**

- **AI/ML Project Controls**
• **AI/ML Project Controls**
  
  Time Series Forecasting

Sources: McKinsey Startup and Investment Landscape Analytics, PitchBook, Capital IQ. Data as of Q2 2018. Number of companies per use case includes all companies that provide that technology, even if it is not their primary offering.

For more on this research, see our article: "Seeing opportunity in today’s construction technology ecosystem"