Data thinking for high-performance projects

Martin Fischer
Ram Rajagopal
Stanford University
Expert Systems

• Apply existing knowledge broadly and consistently
  • Guide
  • Check
  • Critique

• Bidding advisor
• Bridge type advisor
• …
Structural Elements

- Beams
  - Level1
  - Level2
  - Level3
- Slabs
  - Level1
  - Level2
  - Level3
- Slabs
- Columns
  - Col's
    - Level1
    - Level2
    - Level3
  - Col's
    - Level1
    - Level2
    - Level3
- Walls
  - Walls
    - Level1
    - Level2
    - Level3
  - Walls
    - Level1
    - Level2
    - Level3
- Drop Caps
  - D.C.'s
    - Level1
    - Level2
    - Level3
  - D.C.'s
  - D.C.'s

Slots representing attributes of structural elements (from CAD database):

- **Bottom Width**: 16"  
  **Area**: 400000 sqin  
  **ID**: Y  
  **Supported**: 10°, 100°  
  **Angles of Beams**: 140°  
  **Supported**: 0  
  **Angles of Walls**: 0  
  **Column Above**: 42  
  **Beam Above**: 0  
  **Beam Below**: 0  
  **Column Left**: 18  
  **Column Right**: 23  
  **Concr. Str.**: 3000 psi  
  **Height**: 120"  
  **ID**: X  
  **ID's of Doors in**:  
  **Column**: 12

- **Clear Span**: 256"  
  **Column Left**: 12  
  **Column Right**: 15  
  **Slab Left**: 0  
  **Slab Right**: 5  
  **Concr. Str.**: 4000 psi  
  **Depth**: 24"
Model-based reasoning

• Connect knowledge across project phases and disciplines
• Expanding from 3D to 4D models
• Considering more and more criteria
Today: Finding new insights and knowledge

• We now have data!
Does your integrated project information environment give you insights like these?

The last five projects that used this detail had fabrication and installation delays of between 1 and 2 weeks.
Does your integrated project information environment give you insights like these?

The cost estimate for this scope still has an expected range between $248,522 and $271,309. If a decision is made on the sequence of installation this range can be cut in half.
Does your integrated project information environment give you insights like these?

There are 32 alternate configurations with comparable cost, but safer installation sequences.
Does your integrated project information environment give you insights like these?

ICE sessions with this focus during this phase of the project were 1 hour shorter when a structural engineer participated.
Does your integrated project information environment give you insights like these?

Do you want to run a full cost, schedule, and lifecycle calculation for the 100 best options considering your high-level decisions? There are 1,000 nodes available in the Amazon cloud in 12 minutes. The analysis will take 8 minutes and cost $400. Do you want to proceed?
WHY is the client doing the project?

WHAT does the project team need to achieve?

HOW is the project team accomplishing the project objectives?

CLIENT PERFORMANCE
- Usable
- Operable
- Sustainable

PROJECT PERFORMANCE
- Buildable
- Safety, Budget, Schedule, Quality

PRODUCTION PERFORMANCE

CONTROLLABLE FACTORS OF PRODUCTION

Integrated Concurrent Engineering (ICE)

Product Modeling BIM++

Project Production Management
There are three ways to improve your predictions

- Increase the number of **virtual** buildings or design options considered
- Increase the number of **real** buildings considered
- Improve the **quality** of analysis and simulation **models**
How will you leverage 3D and other data in 2019, etc.?

- **Visualization**
- **Information Integration**
- **Automation**

Open the whole Eden Valley Medical Center hospital on budget and 30% earlier than typical

Highly reliable construction

Pictures courtesy DPR Construction
Two main applications of AI

Do what you already know how to do automatically.
Do something new.
Automatically generating a BIM from a laser scan

Where is it?  What is it?

construction  post - occupancy

Semantic Building Parser Research
With Silvio Savarese, Iro Armeni, Amir Zamir, buildingparser.stanford.edu
Making BIM for Existing Buildings Affordable
What are tasks you know how to do (or results you know how to get) that you would like to do (get) automatically and consistently?
Data-driven Organizations

Project/Organization

Collect Data

Learn

Act

Optimize

(CIFE)
Data Thinking

Integrate

Act

Goals

Explore

Model
Consumption Patterns

Three key ingredients:

Machine learning methods

Good data

Good questions
What are questions you can’t get answered today you would like to get answered?
What data do you have or could you get?

Challenges in having good data?
In summary, use data science methods to

• Do what you know how to do (and still have to do) more quickly and more consistently

• Start doing things you can’t do today

• Identify the most relevant questions for you
  • → Collect necessary data and make sure that it’s good data
  • → Apply machine learning methods
  • → Act
The Business Perspective
“The automated execution of processes changes everything.”
(Alan Perlis, 1961)

The Scientific Perspective
“Science is knowledge which we understand so well that we can teach it to a computer; and if we don't fully understand something, it is an art to deal with it. Since the notion of an algorithm or a computer program provides us with an extremely useful test for the depth of our knowledge about any given subject, the process of going from an art to a science means that we learn how to automate something.”
(Donald Knuth, Computer Programming as an Art, CACM, Dec. 1974)