

 USC University of Southern California

The Architectural, Engineering and Construction Industry and the Fourth Industrial Revolution
University of Huddersfield
02/07/2024

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University of Southern California

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About USC



- Founded in 1880 – 53 students and 10 teachers
- Undergraduates: **21,000**
- Graduate and professional: **28,500**
- Faculty (full-time): **4,624**
- University Budget: **\$7.4 billion**
- Sponsored Research: **\$1 Billion+**

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Faculty Distinctions



- 8 MacArthur Fellows (genius grants)
- 84 Academy Members (Sciences, Engineering, Medicine)
- 6 Nobel Prizes
- 10 National Medals

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Viterbi School of Engineering

- Undergraduates: **2,985**
- Graduate: **7,187**
- Full time Faculty: **199**
- NAE: **39**
- NSF Early Career: **99**
- NAI: **23**
- Emmy Awards: **2**
- Oscars: **3**
- Research Expenditures: **\$183,000,000.00**

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AI

- Inflection point is everywhere:
 - Driverless cars
 - Advanced robotics
 - Not just advanced computer power but the power of connectivity, sensors, GPS, gyroscopes
 - Computers don't provide only AI but artificial eyes, ears, hands, feet....
 - Many “knowledge economy” jobs are now within the purview of machines like interpreting medical images, doing legal research, finance jobs, etc....
 - Many jobs are about to disappear under the rising tide of technology

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Don't believe me?



UBS Trading Floor
2008


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The image shows a large, crowded trading floor with many people seated at desks, working at computers. The room has a high ceiling with a grid of lights.

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Don't believe me?



UBS Trading Floor
2016

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The image shows the same trading floor as in 2008, but it is now mostly empty. Only a few people are visible, and the desks are mostly unoccupied. The room appears much less busy.

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Data Mining framework for Construction Processes



- Construction managers often rely on past experiences to be able to perform their daily tasks.
 - How can we build knowledge base from previous projects?
- Construction industry is facing an explosive growth in its capabilities to both generate and collect data.
 - The construction industry is starving for knowledge while it is drowning on data.

Data Mining framework for Construction Processes



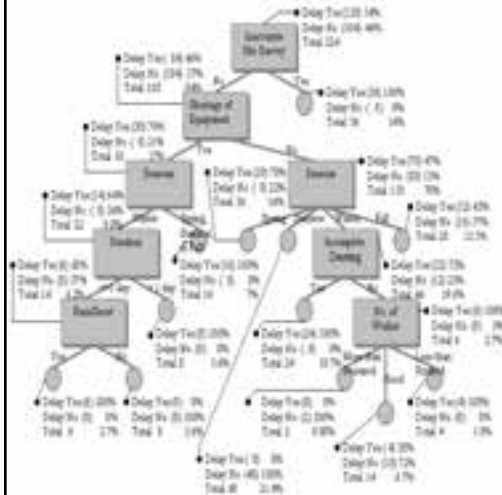
- Fort Wayne – IN: Flood Control Project
 - Phase I: CTRL-EAST, \$4,488,450.21, 11/1/95-10/23/98
 - Phase II: East-North, \$12,107,880.46, 1/6/97-11/5/98
 - Phase III: CTRL, \$ 6,018,981.54, 9/14/98-8/6/99
 - Phase IV: West, 5/28/99-



Data Mining framework for Construction Processes



• Results from C4.5 Decision Trees



- Weather considered responsible for delays by site managers, appear not to be the most important cause in determining delays.
- Activities with “ Inaccurate Site Surveys” are always delayed in the schedule.
- Shortage of Equipment, Seasons, and Incomplete Drawing are also very significant factors compared to other factors.

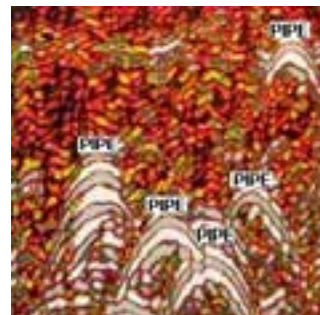
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Data Mining framework for Construction Processes



- Ground penetrating radar is a good investment




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BIM



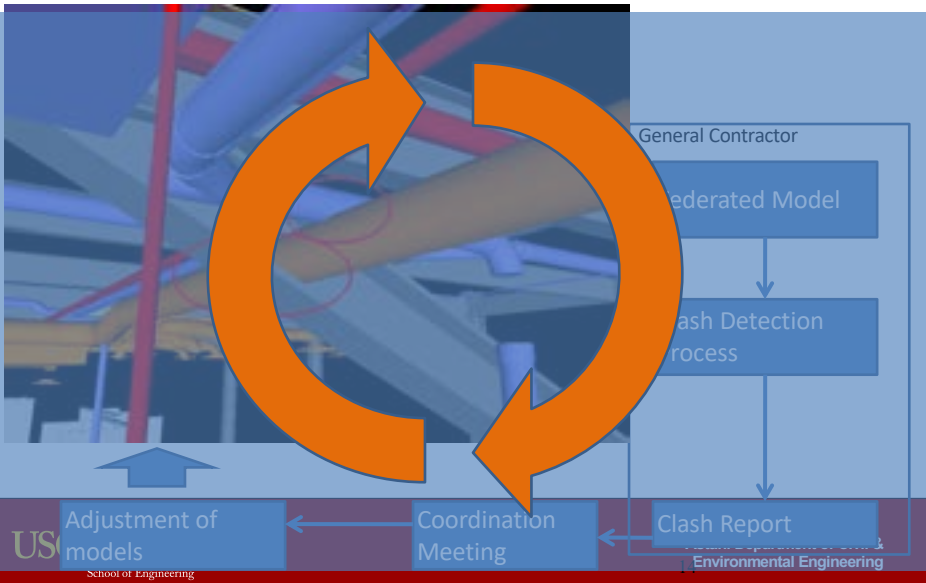

B | M

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Present— From Jan Reinhardt



General Contractor

Federated Model

Clash Detection
process

Clash Report

Environmental Engineering


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Adjustment of
models

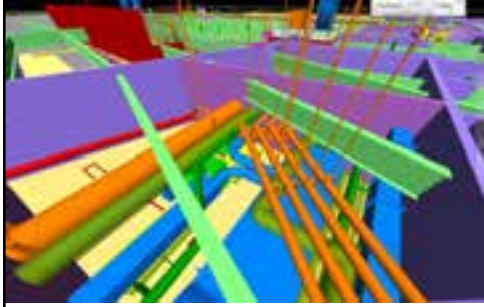
Coordination
Meeting



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Timely identification of penetrations and embeds



- L.F. Driscoll - ADEPT


➔




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Case Study – LF Driscoll Construction




- Hershey Medical Center



10 days per floor

➔



Duct-Hangers
1 day per floor
Elimination of errors

Bang-It Embed

Slab Penetrations

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Construction Process



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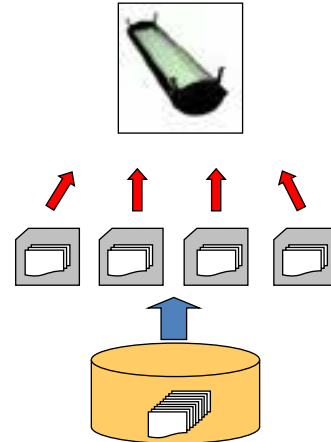
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Text Integration Model



- **Classification**
 - Classes are defined in the model.
 - Project documents are classified.
- **Retrieval and Ranking**
 - Object data are extracted from the project model and used as input.
 - Relevant documents are identified, ranked, and retrieved.
- **Association**
 - Selected documents are linked to project model objects.

Object: Light Fixture (IFCLightFixture)
Class: Electrical



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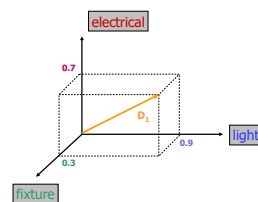
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Document Representation



- Project documents are represented as vectors in a multi-dimensional space.
- Vector coordinate values are defined by the index terms weights.
- Project document collection can be represented as a $m \times n$ matrix.
- Project document collection is parsed and indexed.



$$d_1 = (0.9, 0.7, 0.3, \dots, 0.0)$$

→

	document 1	document 2	document 3	document n
term 1	0.8	0.0	0.1			0.0
term 2	0.7	0.0	0.7			0.0
term 3	0.3	0.3	0.0			0.0
...						
term m	0.0	0.0	0.0			0.1


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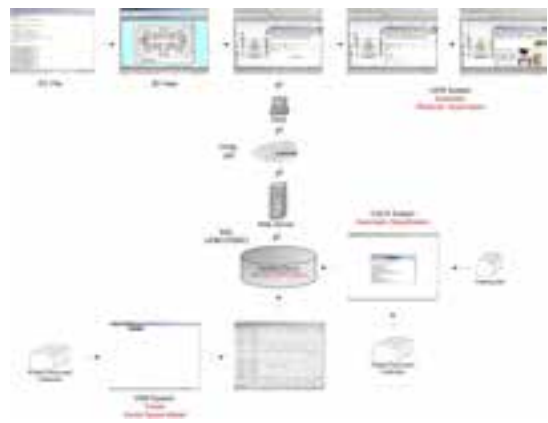
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Implementation of the Integration Model



- Model-based system used for validation and proof of concept

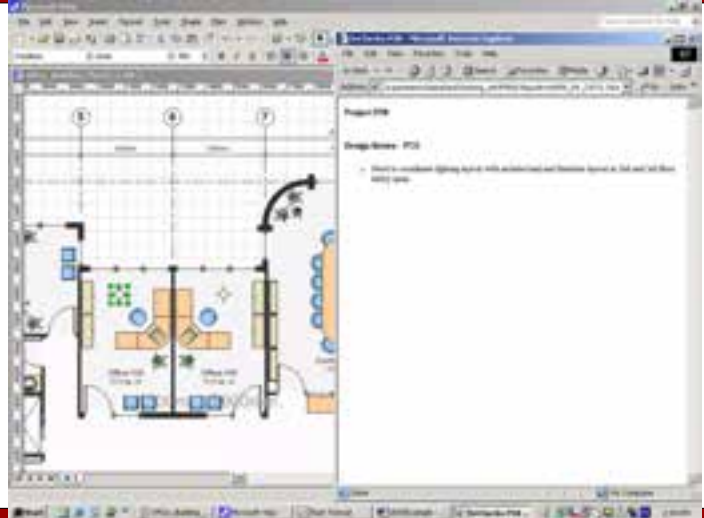




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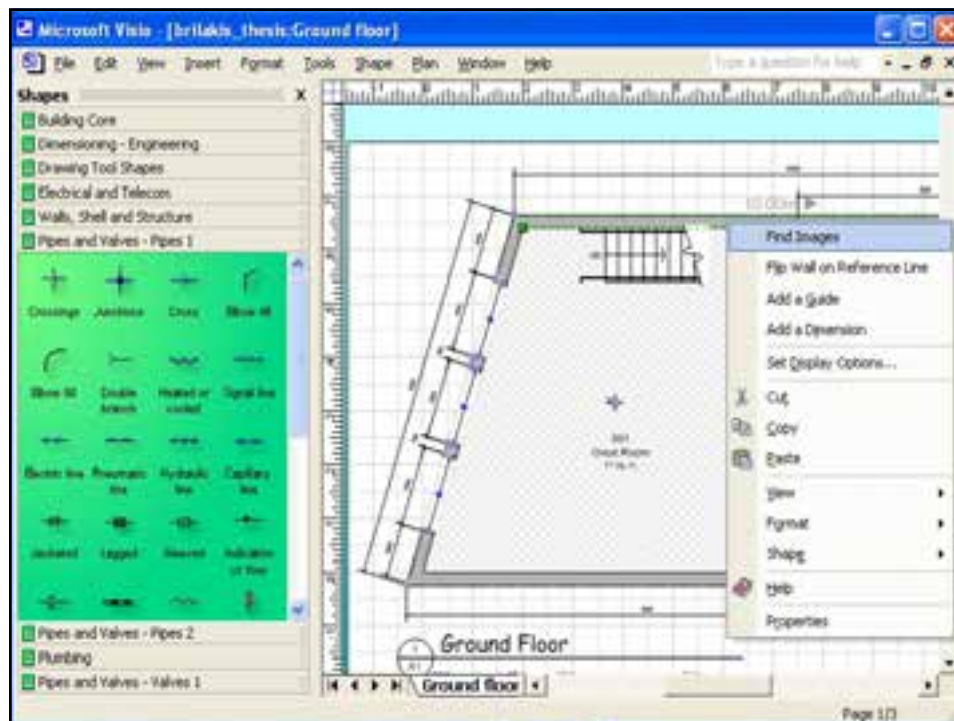
- Number of Objects visible in a picture is large
 - Construction of Perelman Theater, 2002
 - Range: 0 to 300, Mean: **45.4** (objects/picture)
 - Mode: 20, Standard Deviation: 71
 - Average number of links/project > **45,400**
- Labeling is not enough
 - Example
 - W.E. O'Neil Casino Project image
 - 53 objects
 - Engineer's labeling: domesticwatermains.jpg
 - Complete label:
steel_column13+steel_column22+steel_beam09+steel_beam10+steel_beam11+...+concrete_column05+concrete_column08+...+steel_roof02+...



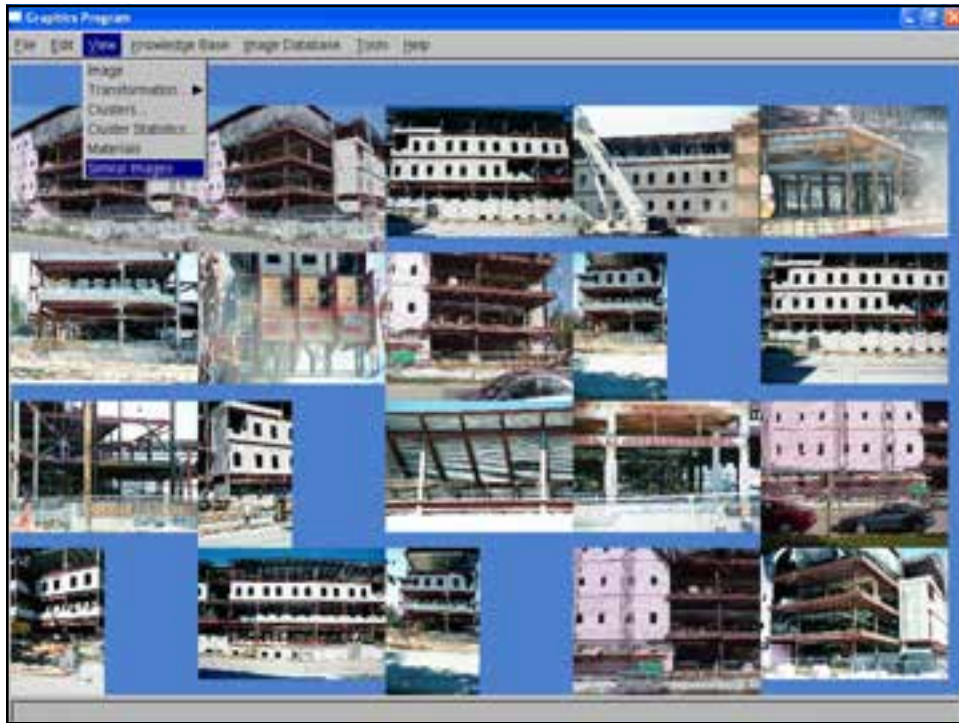


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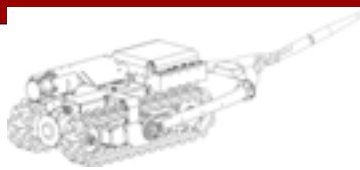
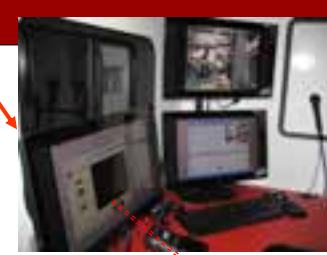



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Sewer Robotic Condition Assessment

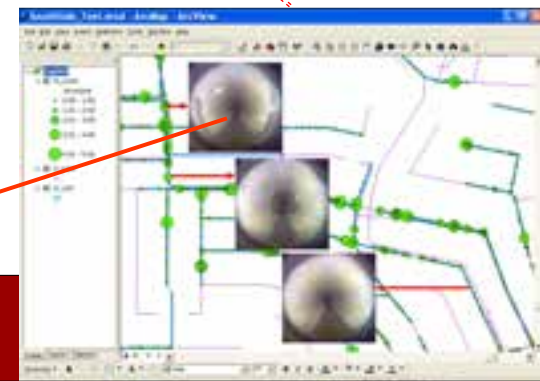
Video Inspection

Digital Image Analysis & Computer Vision

n (or y)

R = 255 G = 200 B = 200	R = 251 G = 200 B = 190	R = 251 G = 200 B = 190	R = 251 G = 200 B = 190
R = 254 G = 220 B = 200	R = 255 G = 220 B = 200	R = 248 G = 220 B = 242	R = 248 G = 220 B = 242
R = 255 G = 200 B = 200	R = 254 G = 200 B = 200	R = 255 G = 200 B = 200	R = 255 G = 200 B = 200
R = 255 G = 200 B = 200	R = 255 G = 200 B = 200	R = 255 G = 200 B = 200	R = 255 G = 200 B = 200

m (or x)

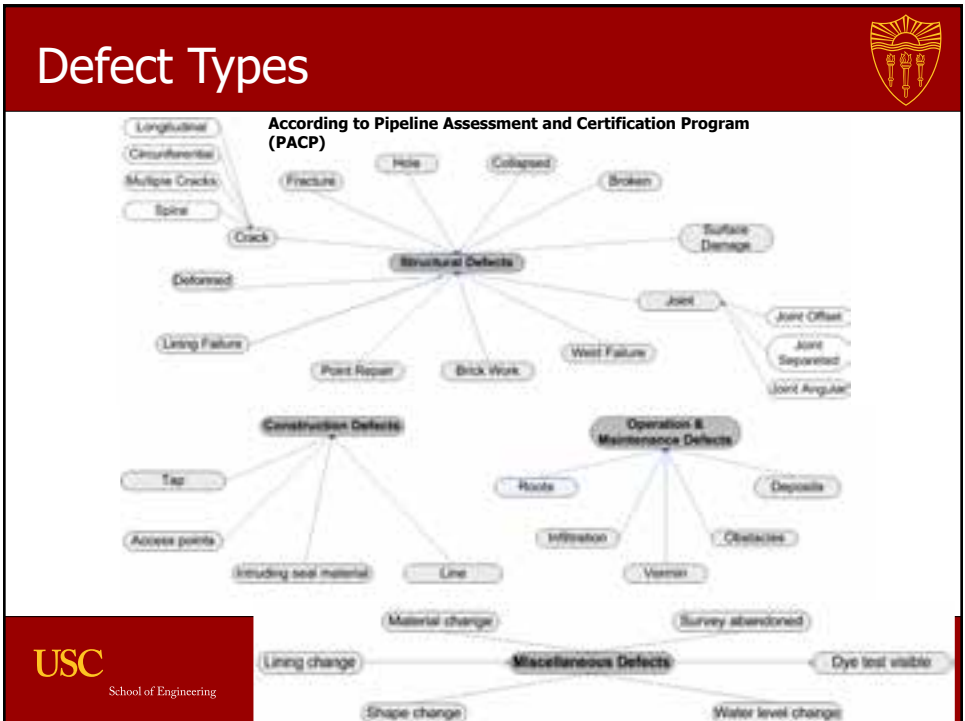


Pictures from RedZone

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Hierarchical Infrastructure Assessment



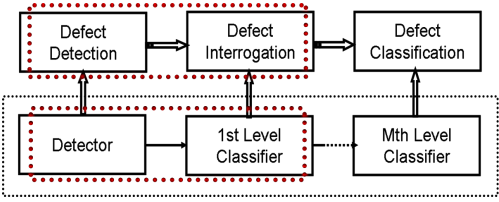
- The Pareto Principle (80/20 rule)
Defective to Healthy Pipe Length
(South Region of PWSA)



■ 80%
■ 20%

■ 315834 ft
■ 78969 ft


■ Defective Length ■ Non-defective Length



```

            graph LR
            subgraph Level1 [ ]
            D[Detector] --> L1[1st Level Classifier]
            end
            subgraph Level2 [ ]
            DD[Defect Detection] --> DI[Defect Interrogation]
            end
            L1 --> DD
            L1 --> DI
            L1 --> MC[Mth Level Classifier]
            DI --> DC[Defect Classification]
            MC --> DC
            style Level1 stroke-dasharray: 5 5
            style Level2 stroke-dasharray: 5 5
            style DC stroke-dasharray: 5 5
            
```

Focus on the problem assets or assets of interest



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Laser Scanning and Imaging Technologies for Generating 3D as-built Models



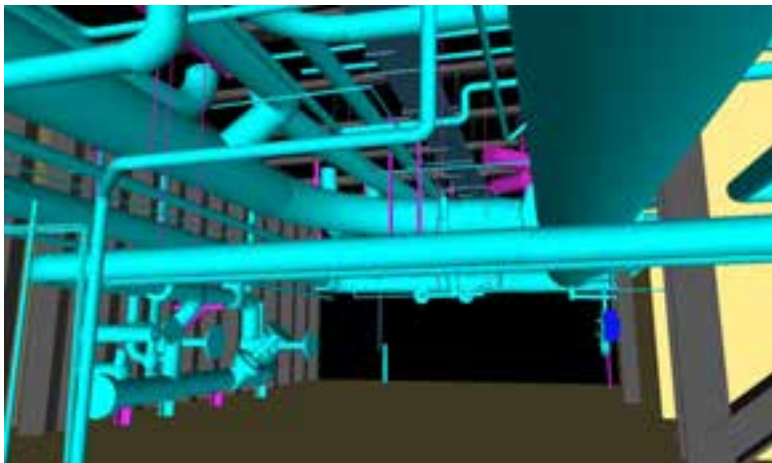
- A laser scan beamed in 360 degrees to generate a cloud of points of the scanned area in 3D
- Today we have sensors with mm accuracy, millions of points per scan, and acquisition rates well below one minute per scan

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3D Model Created From Point Cloud



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Data segmentation and classification



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Bricklaying Robot SAM



Source: Construction Robotics

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Bricklaying Robot SAM



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Demolition Robot




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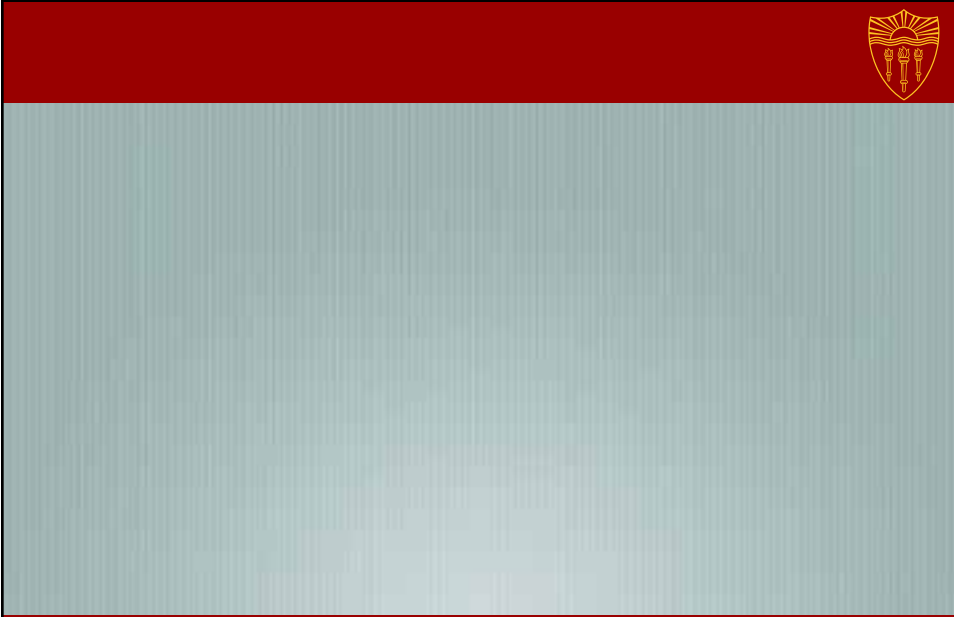
Demolition Robot



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ICON Example





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ICON Example 



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ICON Example



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This slide features a red header with the text "ICON Example" and the USC logo. The main image shows two men in safety gear inspecting a wooden door frame in a construction site. The man on the right is wearing a hard hat and a high-visibility vest, while the man on the left is wearing a dark jacket and a cap. The background shows a corrugated metal wall.

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ICON Example



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This slide features a red header with the text "ICON Example" and the USC logo. The main image shows two men in safety gear inspecting a long metal structure on a construction site. The man on the left is wearing a hard hat and a high-visibility vest, while the man on the right is wearing a white hard hat and a dark jacket. The background shows a construction site with various materials and structures.

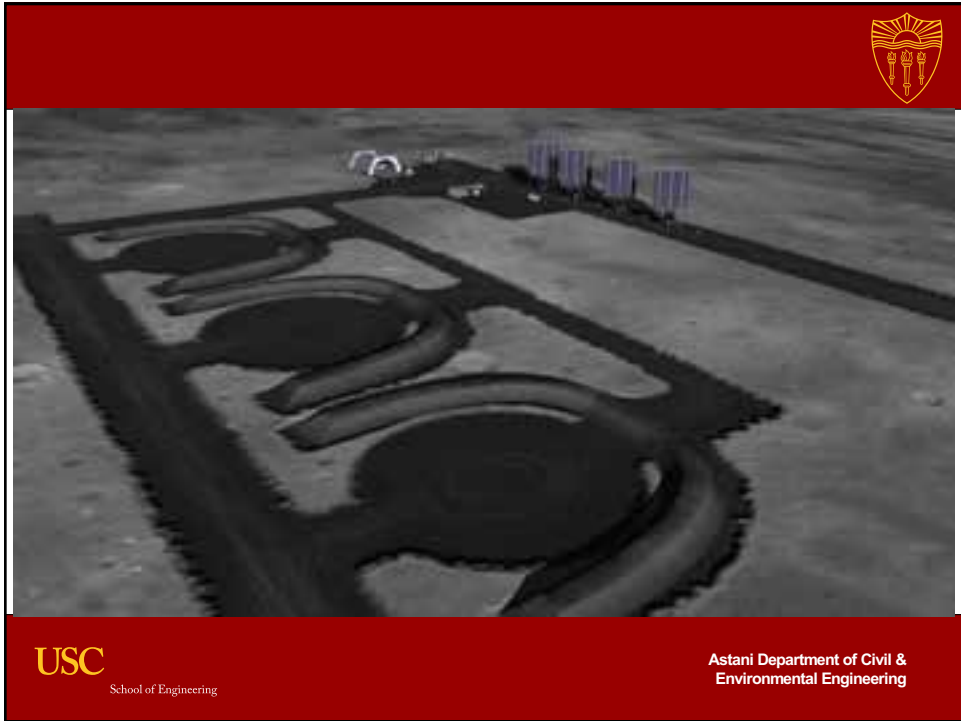
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The image shows an aerial view of a wastewater treatment plant. In the foreground, there are several large, circular aeration tanks arranged in a row. The water in these tanks appears dark, possibly due to the presence of activated sludge. In the background, there are several tall, vertical structures, likely part of the plant's infrastructure. The entire image is framed by a red border. In the top right corner of the red border is the USC logo. In the bottom left corner of the red border, the text "USC School of Engineering" is displayed. In the bottom right corner of the red border, the text "Astani Department of Civil & Environmental Engineering" is displayed.