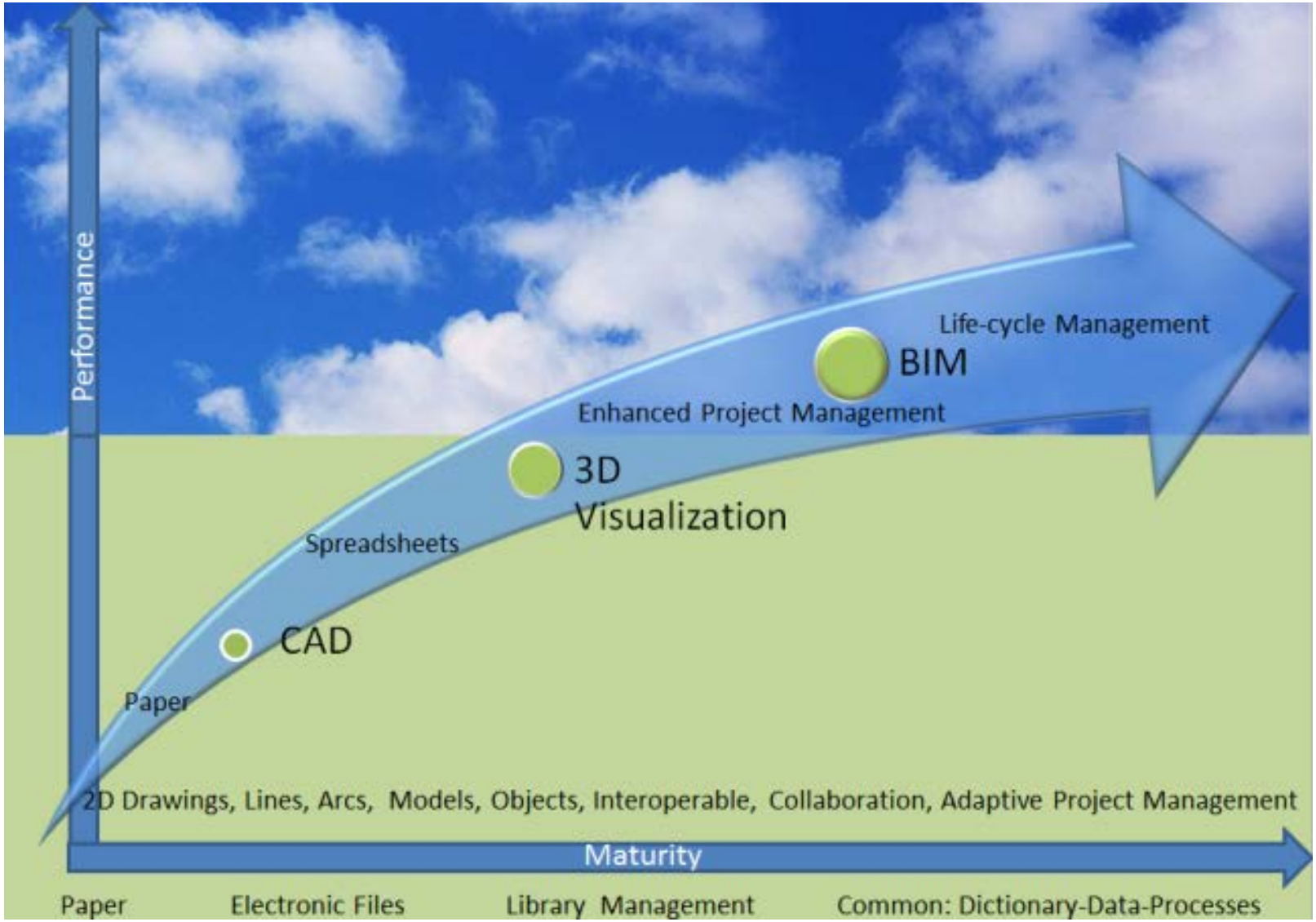
# BIM for existing infrastructure

**Prof. Campbell Middleton**
**Prof. Roberto Cipolla**
**Dr. Ioannis Brilakis**

**Viorica Pătrăucean, Ph.D.**

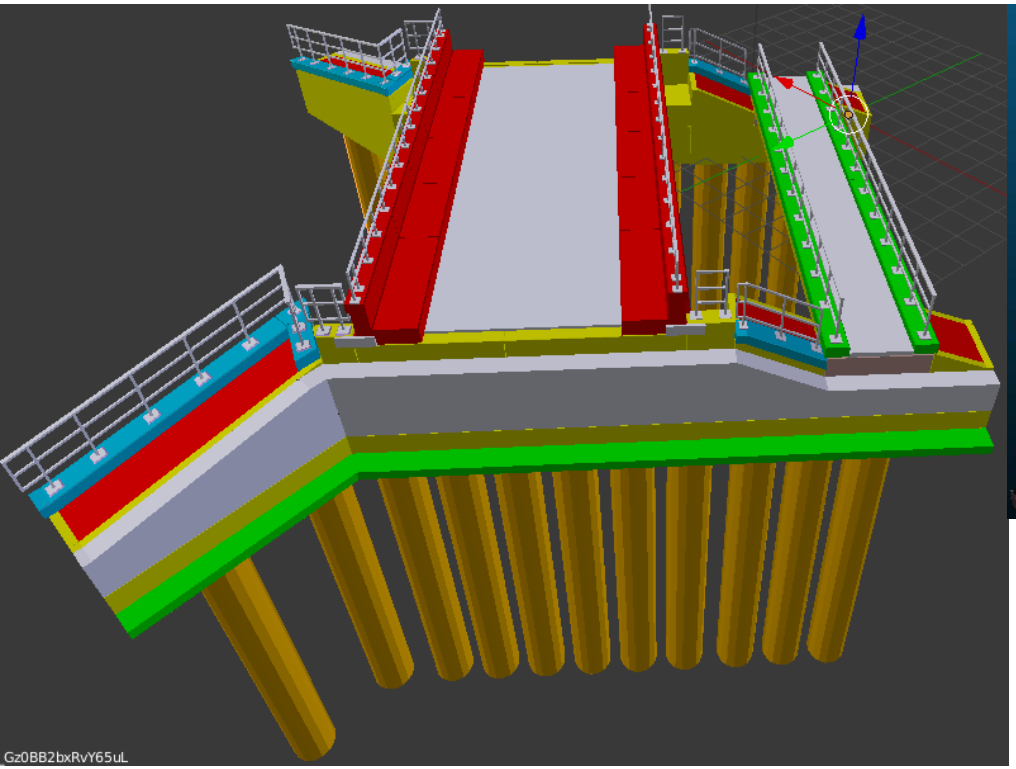
CSIC Cambridge Centre for Smart Infrastructure and Construction
EPSRC Engineering and Physical Sciences Research Council
Innovate UK Technology Strategy Board
UNIVERSITY OF CAMBRIDGE

# BIM costs vs. benefits




*Peter Cholakis's blog*

# BIM for future constructions – 3D design



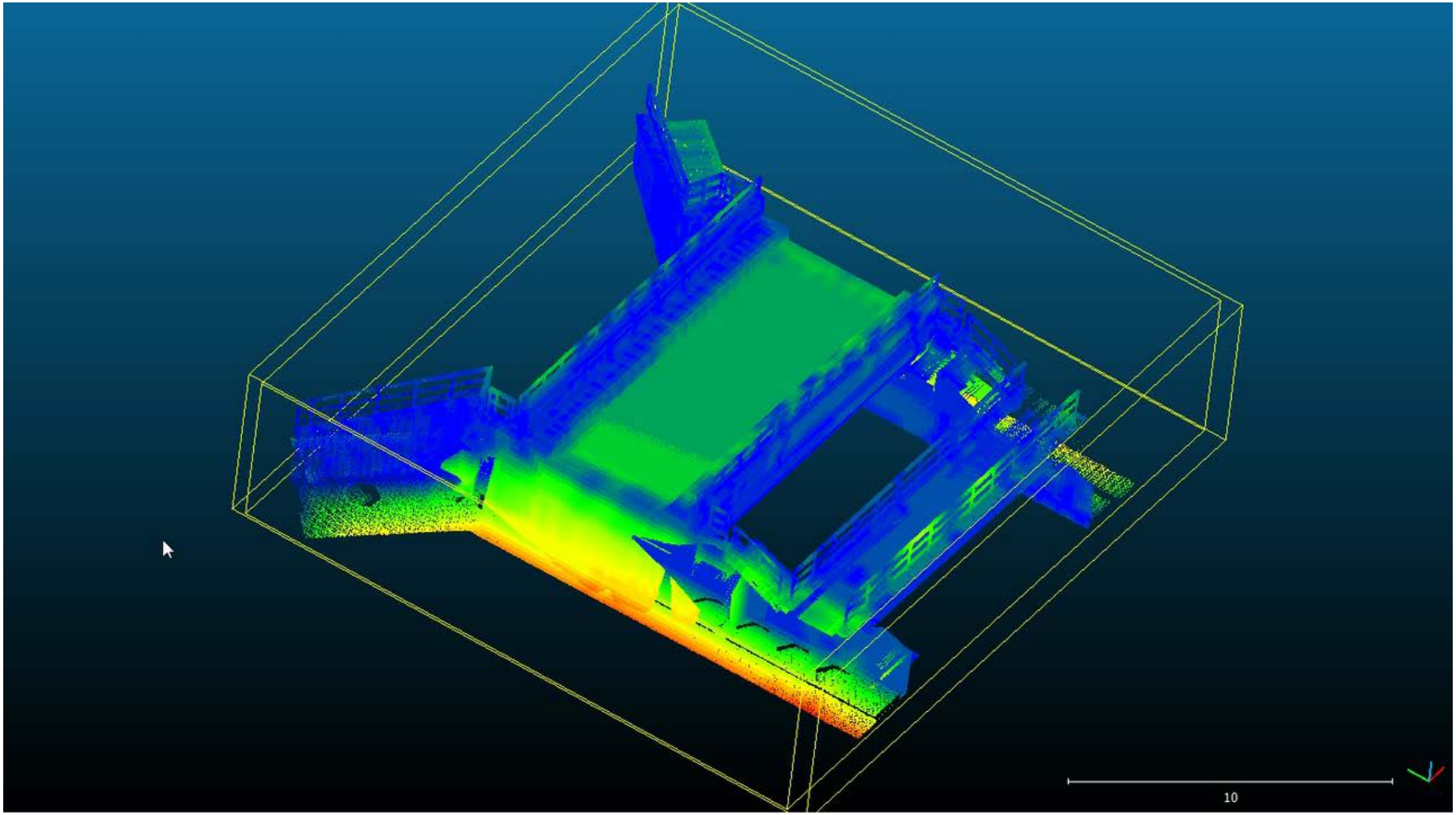

Designed IFC model

As-Built Point Cloud

**Staffordshire case study**

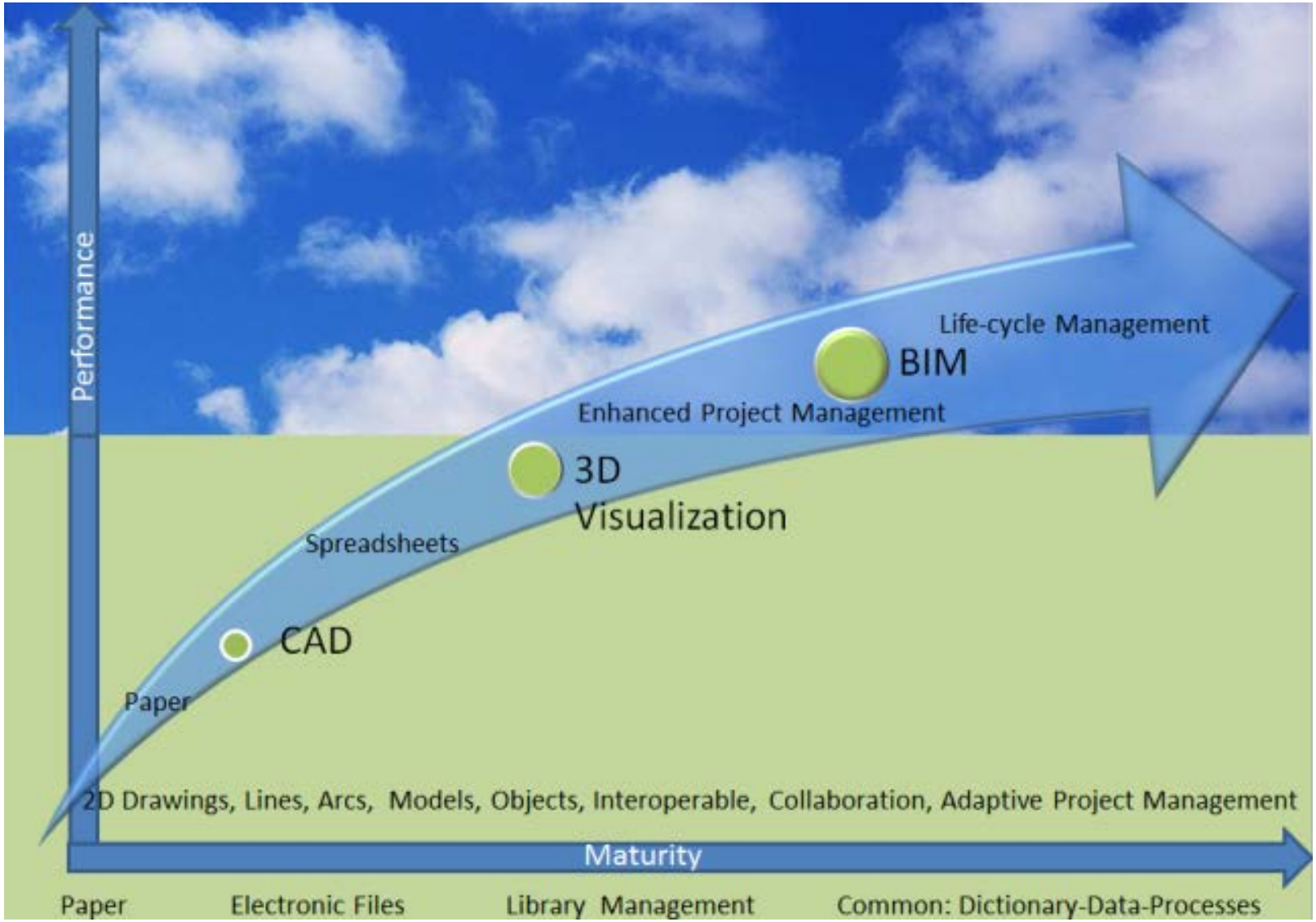
**Design software:** Autodesk, SolidWorks, CloudCompare, Blender

# BIM for future constructions – Geometry checker

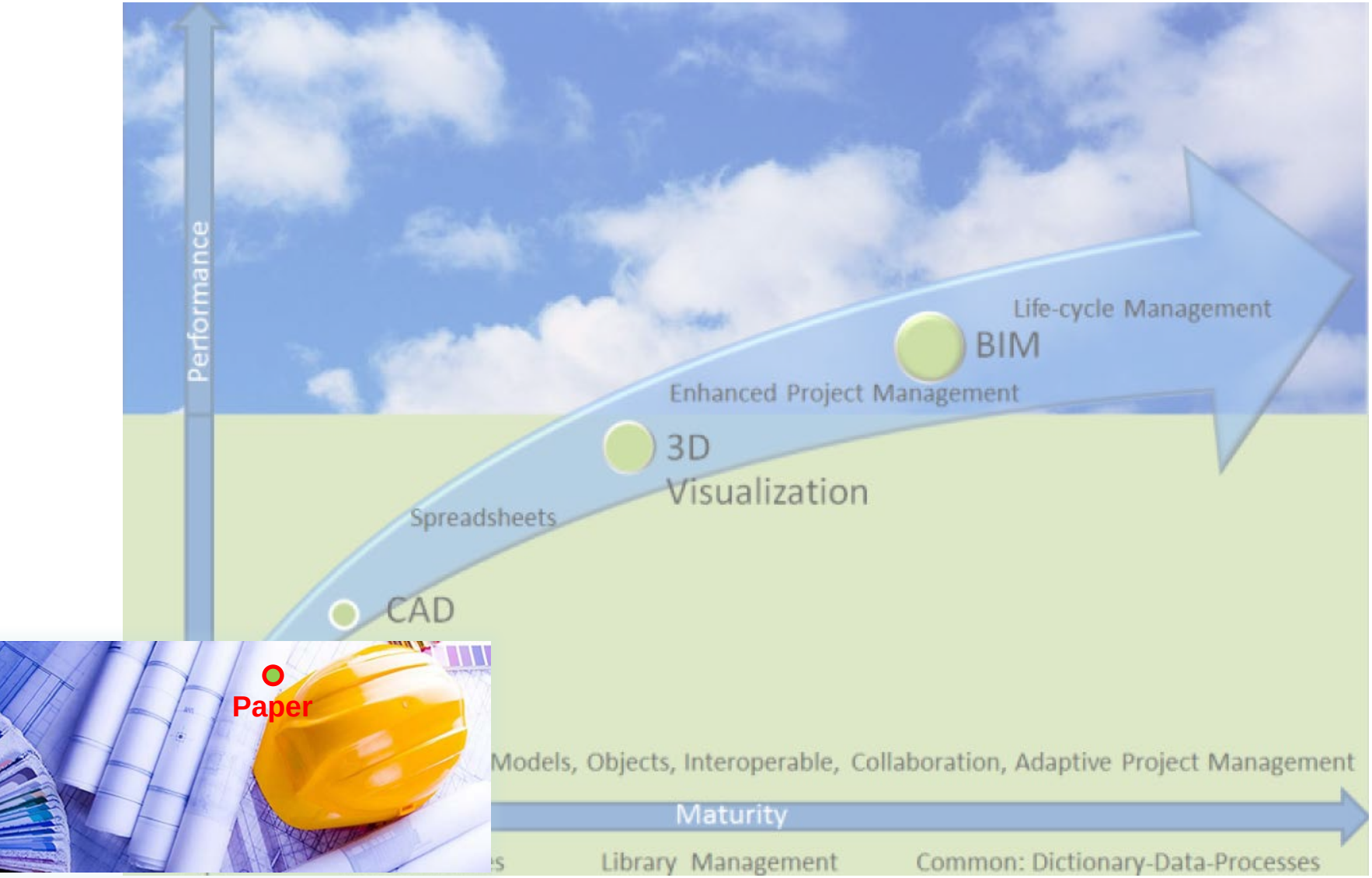



**Progress monitoring** – use BIM's temporal dimension

# BIM for existing infrastructure



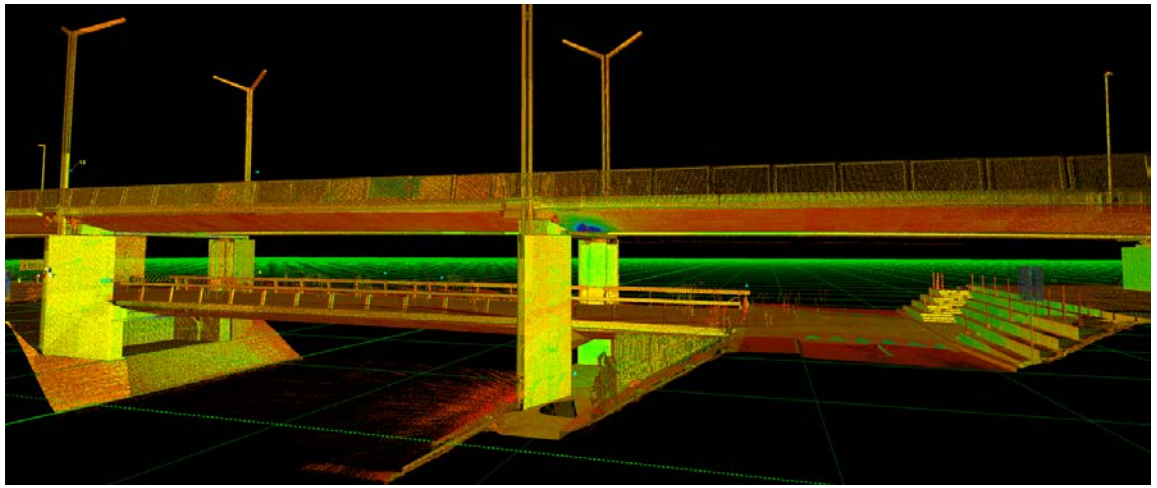
# BIM for existing infrastructure



# Reverse-engineer 3D design

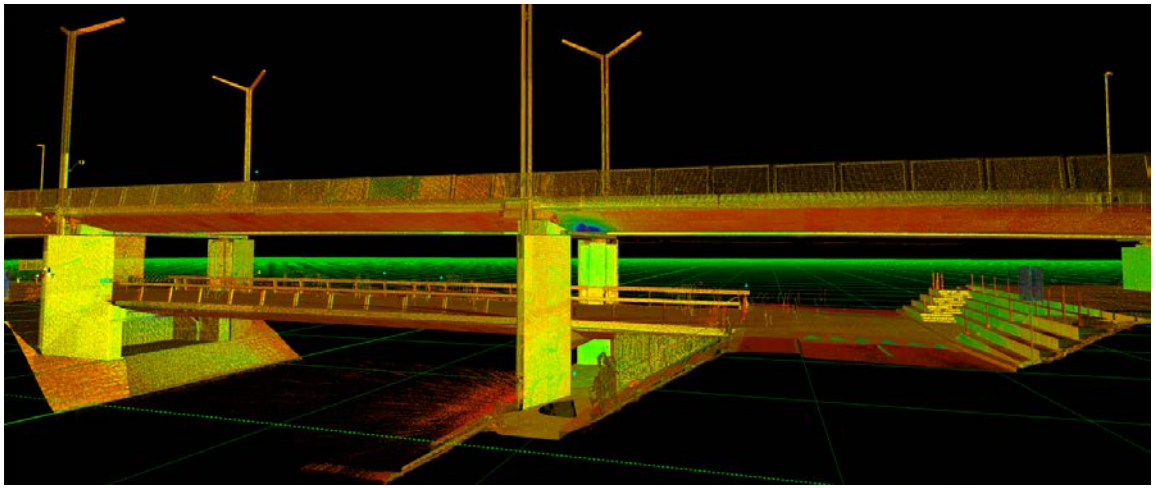
*Images courtesy of 3D ATA, Slovenia*

# Reverse-engineer 3D design

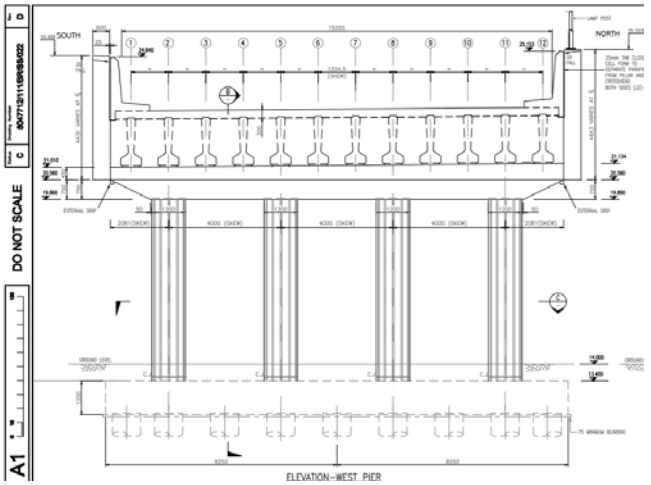


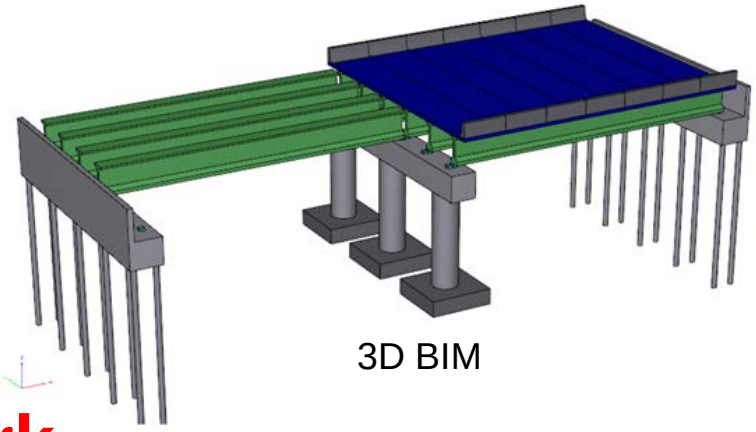

*Images courtesy of 3D ATA, Slovenia*

# Reverse-engineer 3D design

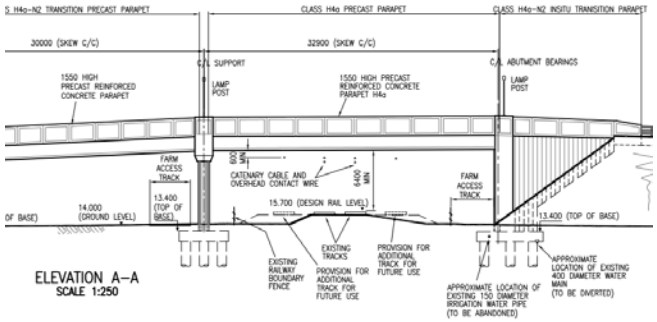


3D point cloud



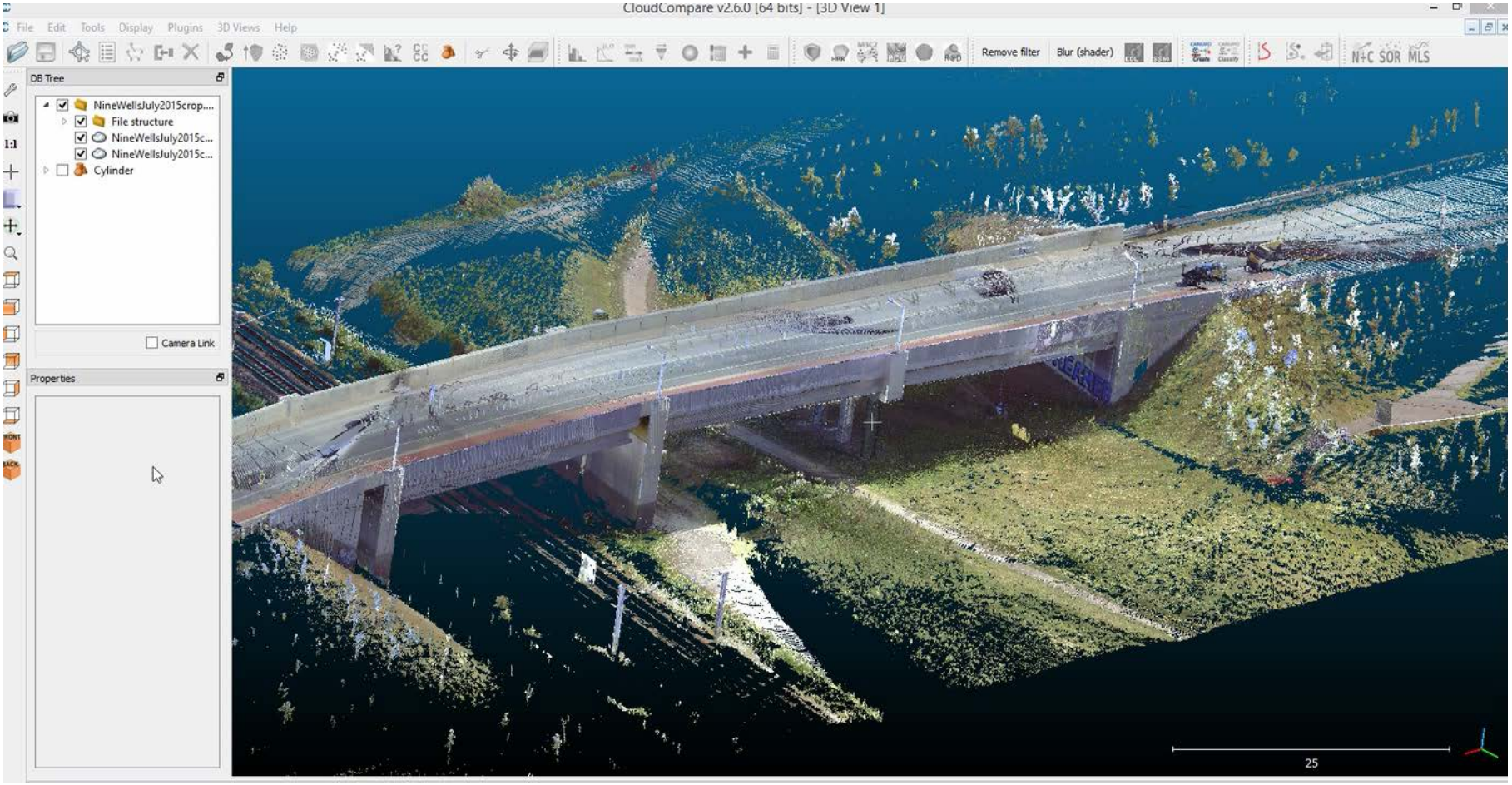
3D BIM




2D CAD drawings

**Manual work**

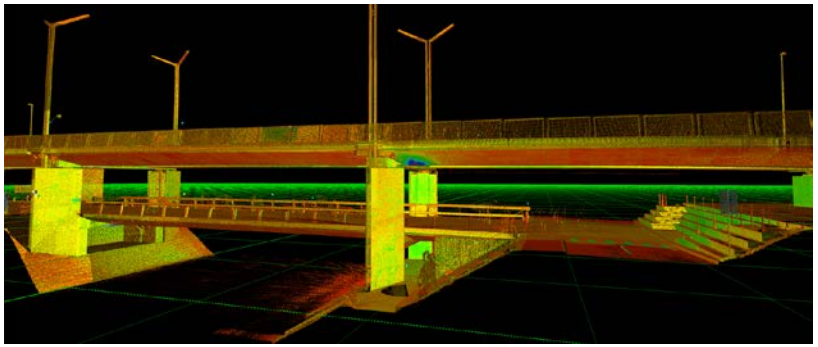
# Reverse-engineer 3D design




**Time consuming and error prone**

# Reverse-engineer 3D design

## Automated approach: Machine learning

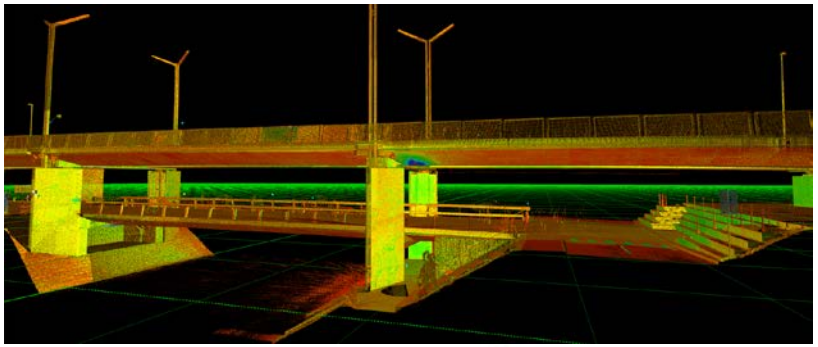


3D point cloud


**BIM**

# Reverse-engineer 3D design

## Automated approach: Machine learning



3D point cloud

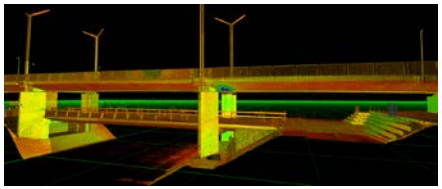
**traditional**

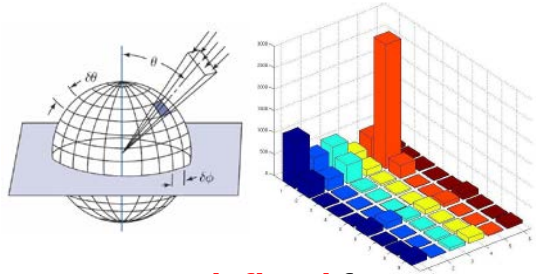
**modern**

**BIM**

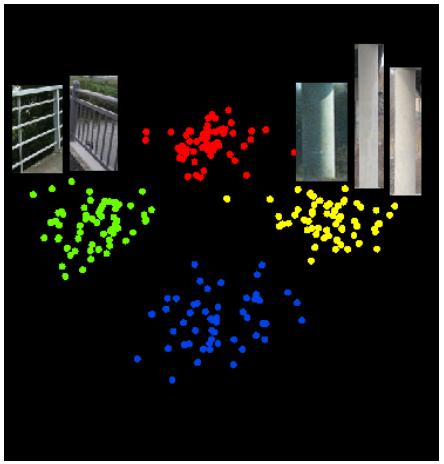
# Traditional machine learning approach

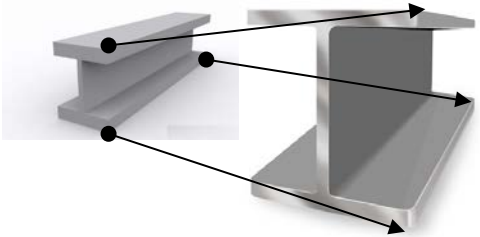
**Input point cloud** → **Feature extraction** → **Voxel-wise classification/segmentation**

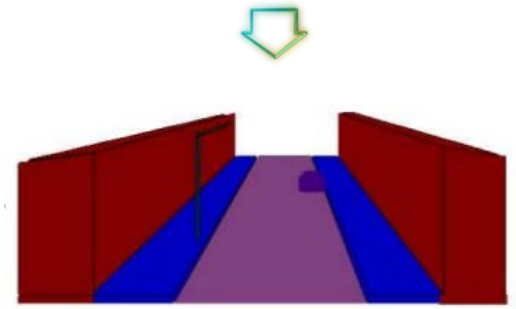




**User-defined features**



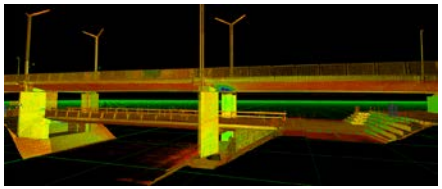





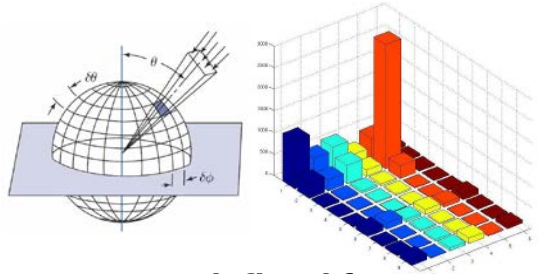
**Output** ← **Part/model fitting: non-rigid ICP** ← **Smoothing: Dense CRF**

# Traditional machine learning approach

**Input point cloud**

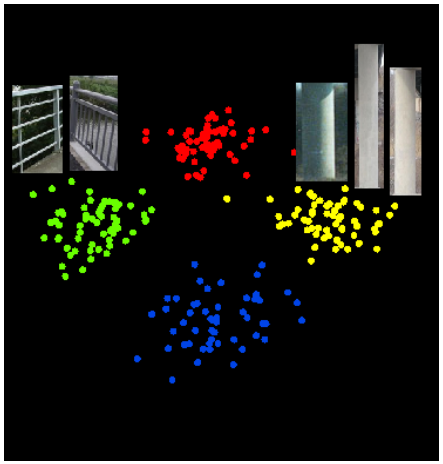


**Feature extraction**

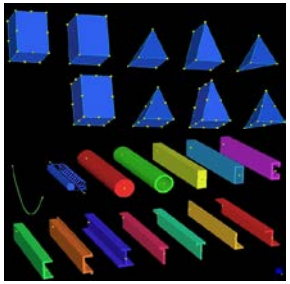


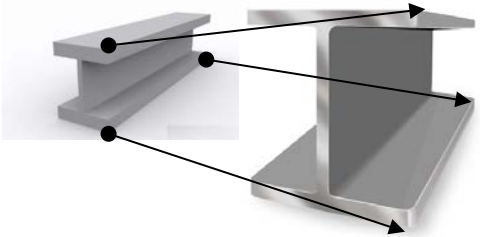
**User-defined features**

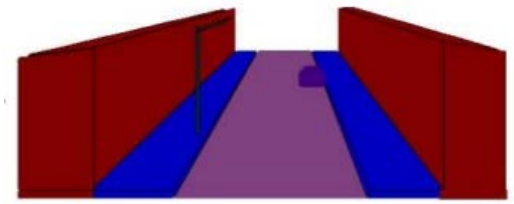
**Voxel-wise classification/segmentation**



**Library of parts**

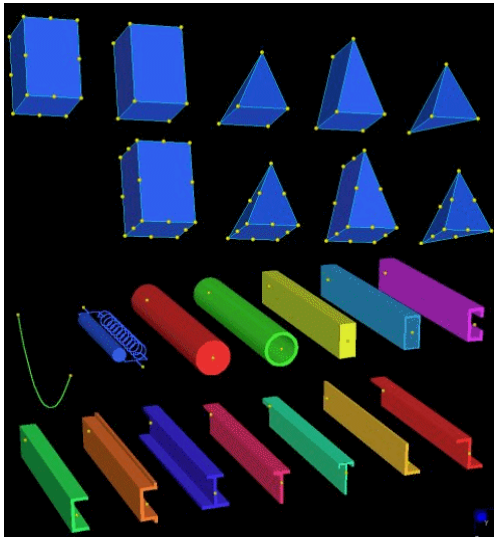


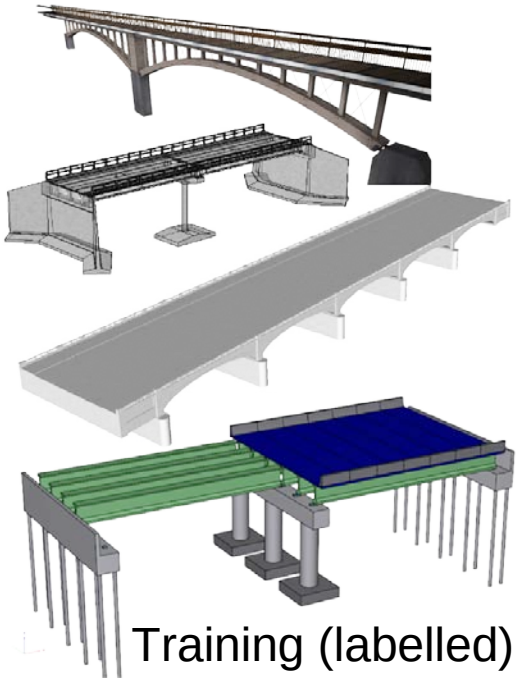


**Output** ← **Part/model fitting: non-rigid ICP** ← **Smoothing: Dense CRF**

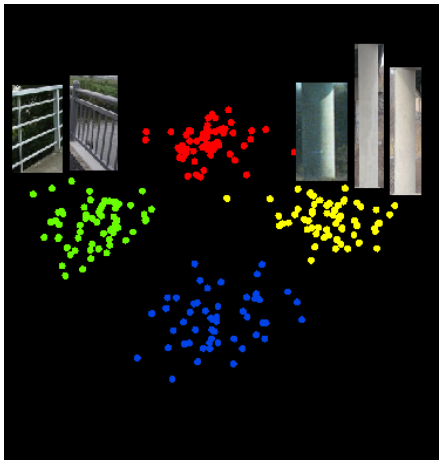
# Machine learning = Training



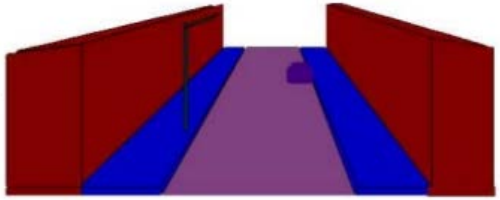
Library of parts



Training (labelled) set



Classification & segmentation



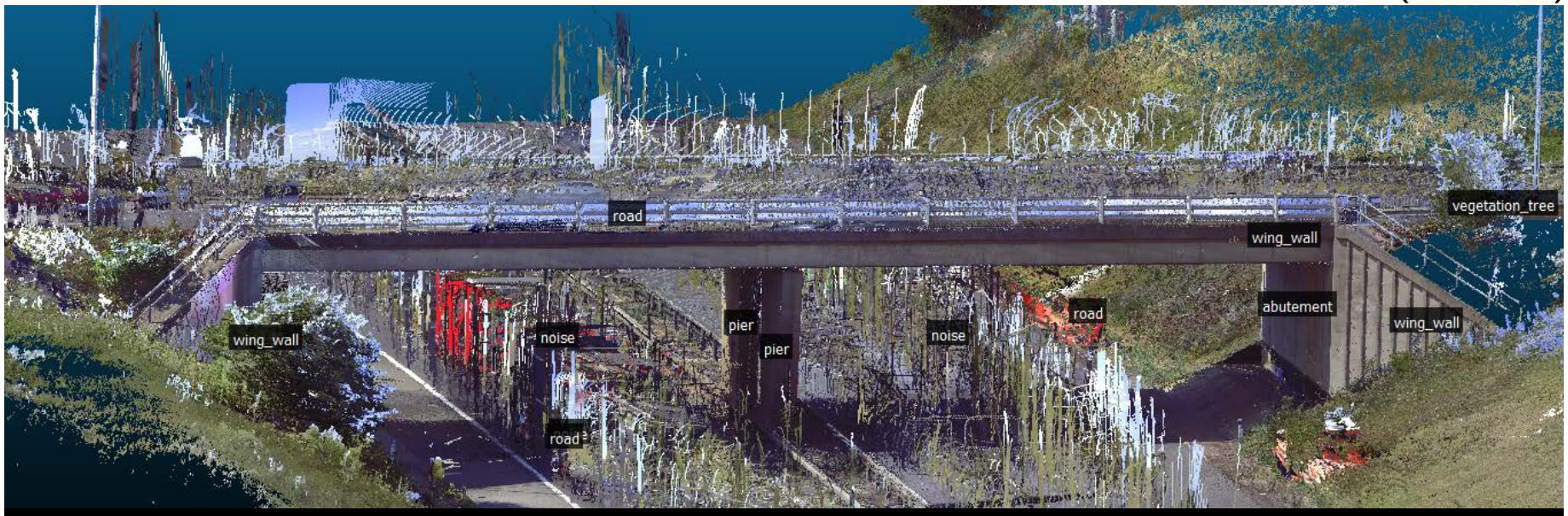
Parts in context

CSIC Cambridge Centre for Smart Infrastructure and Construction

UNIVERSITY OF CAMBRIDGE

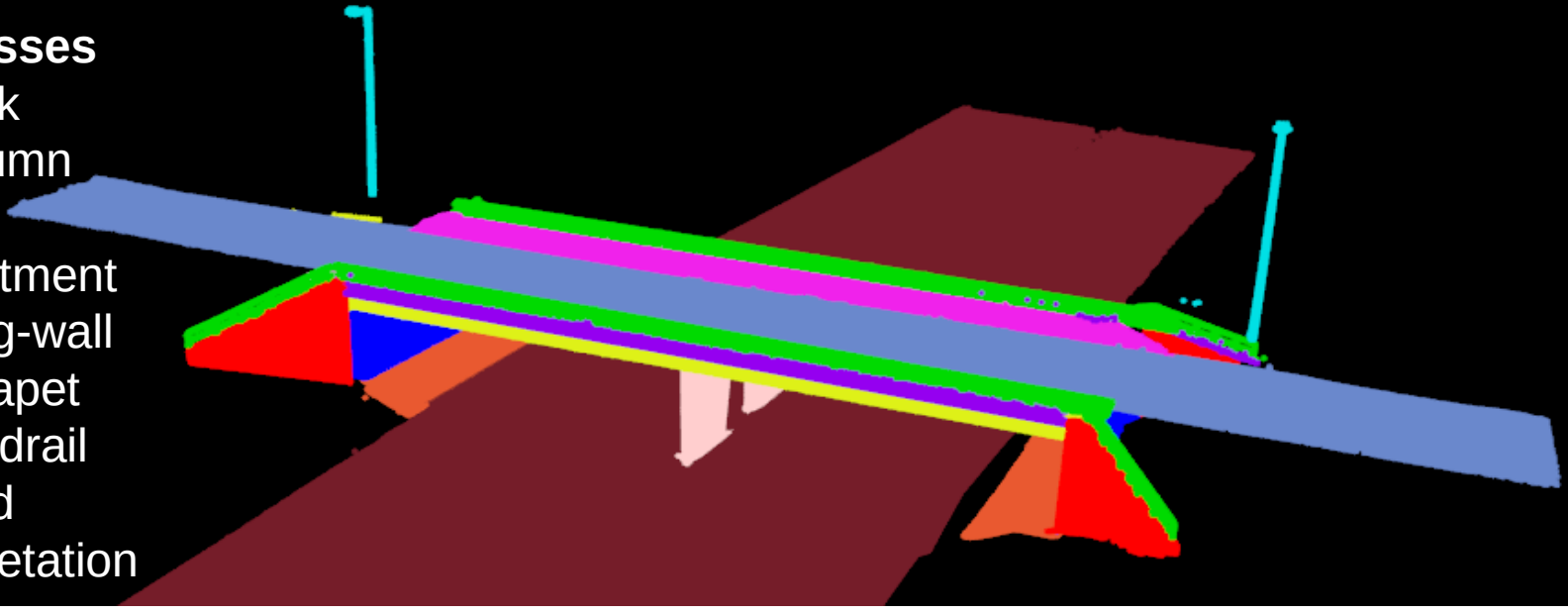
# Training data: Labelled real point clouds

M11 (11 scans)



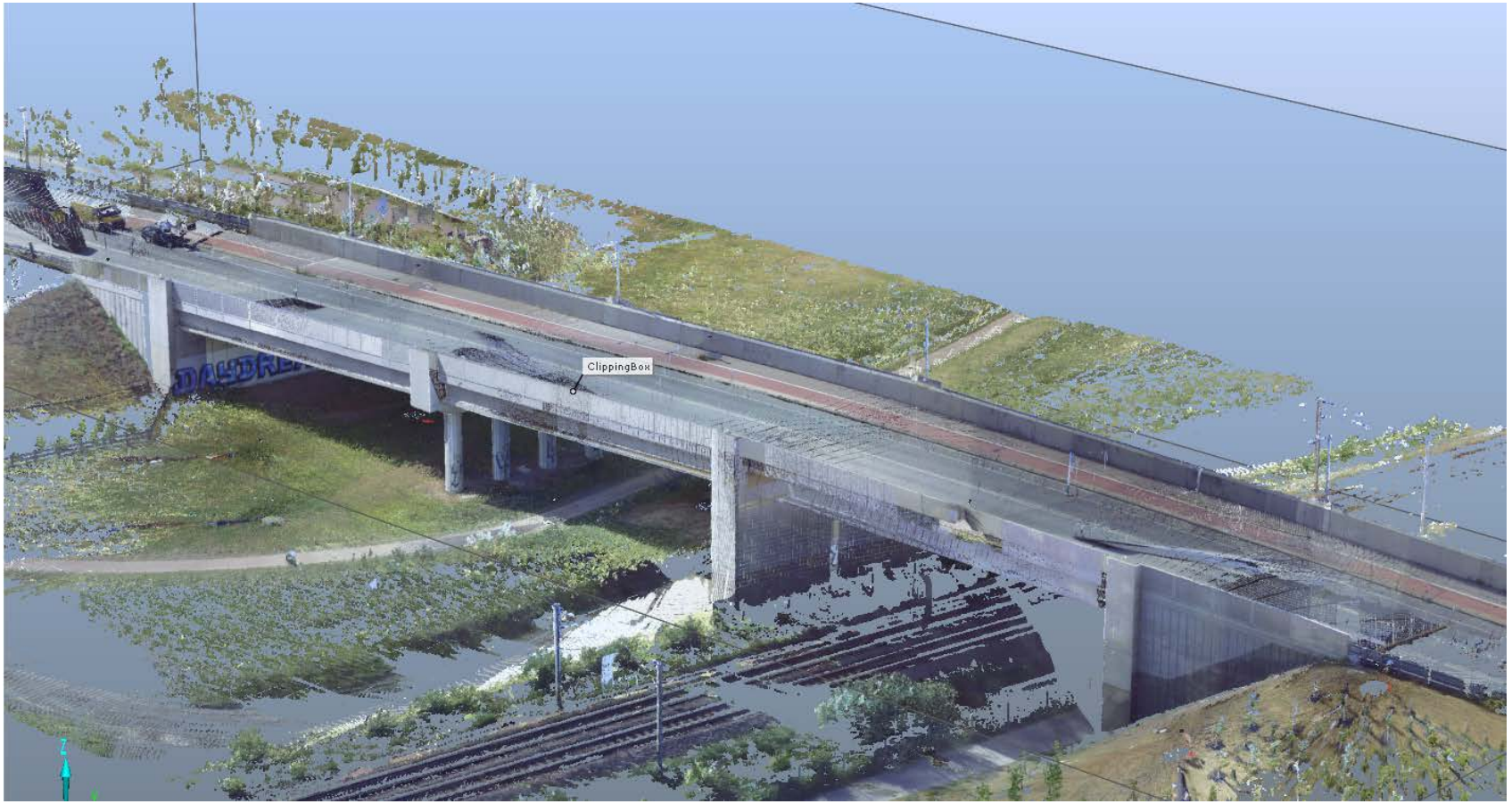

**10 classes**

- deck
- column
- pier
- abutment
- wing-wall
- parapet
- handrail
- road
- vegetation



# Training data: Labelled real point clouds

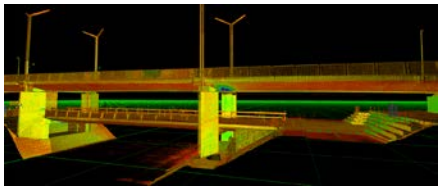
Addenbrooke's bridge (14 scans)

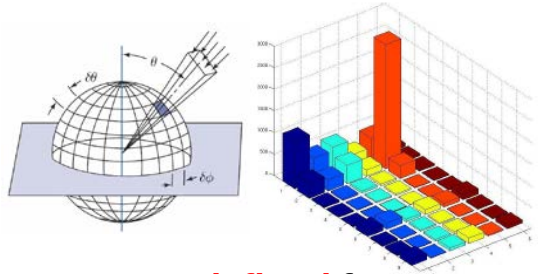


# Training data: Synthetic models (3D Warehouse)

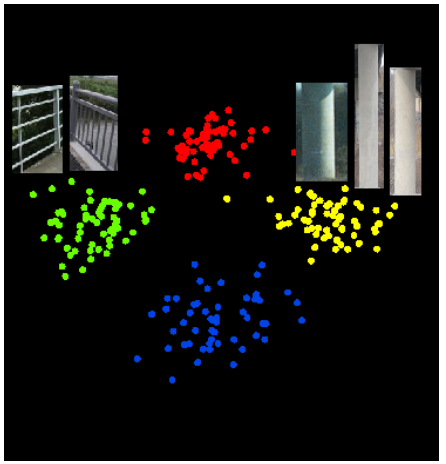
# The future of data modelling: Deep learning

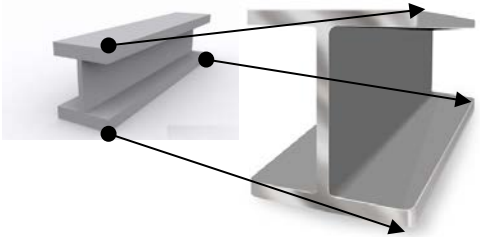
**Input point cloud** → **Feature extraction** → **Voxel-wise classification/segmentation**

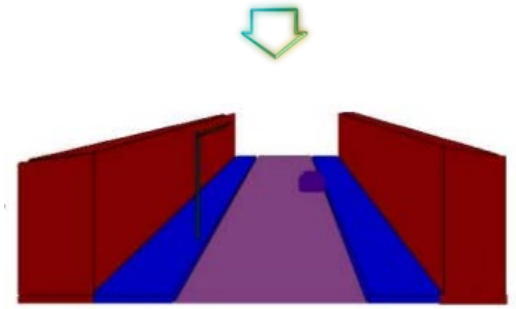




**User-defined features**



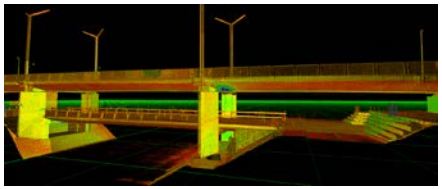





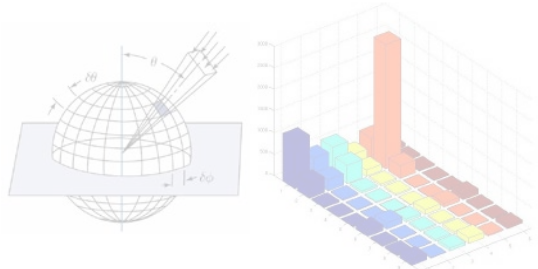
**Output** ← **Part/model fitting: non-rigid ICP** ← **Smoothing: Dense CRF**

# The future of data modelling: Deep learning

**Input point cloud**

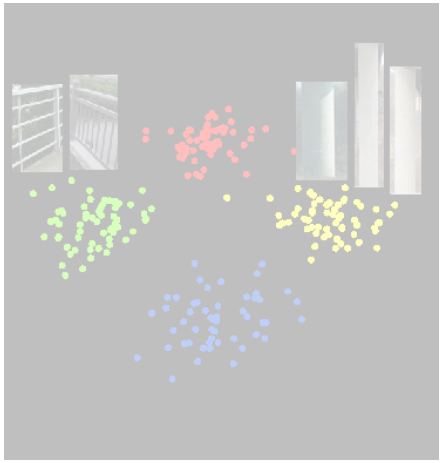


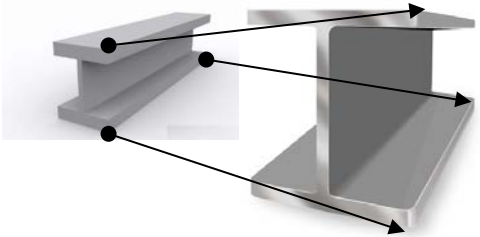
Feature extraction

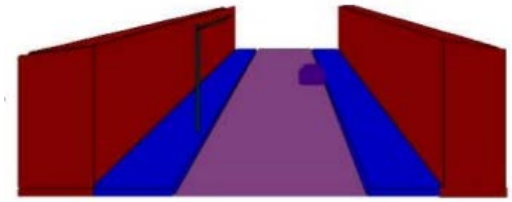


**User-defined features**

Voxel-wise classification/segmentation





**Output**

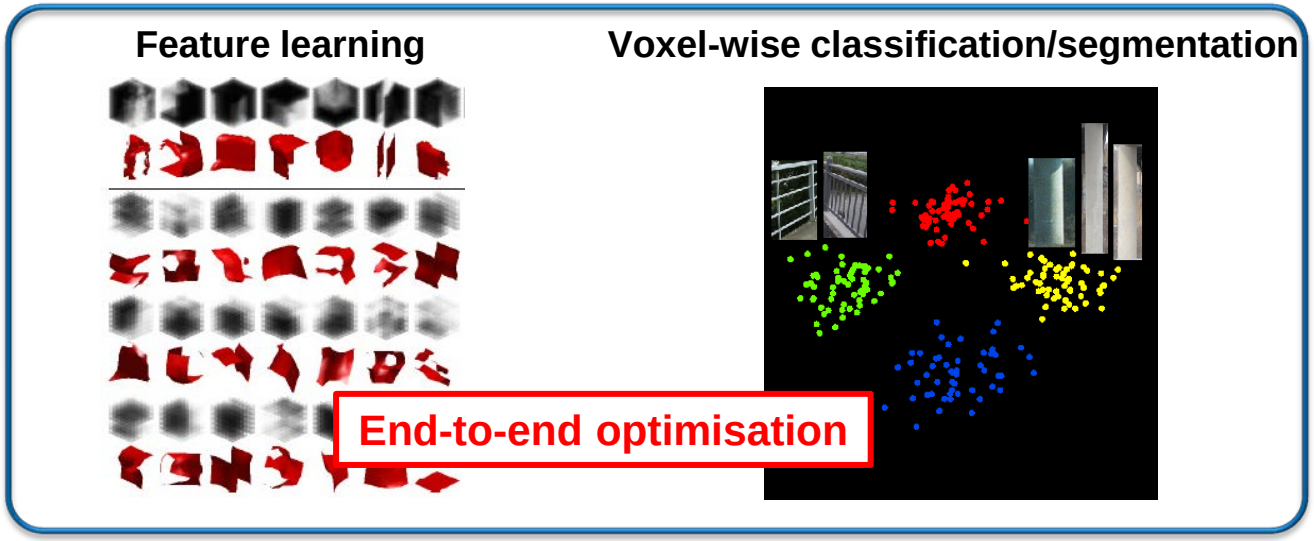
**Part/model fitting: non-rigid ICP**

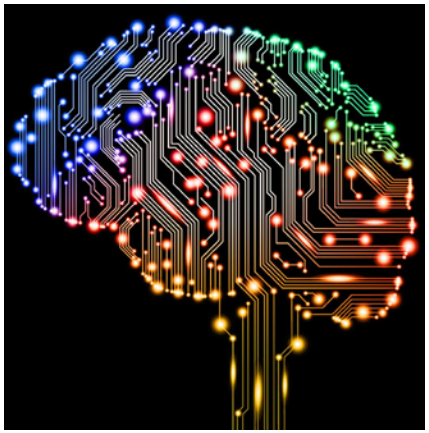
**Smoothing: Dense CRF**

CSIC Cambridge Centre for Smart Infrastructure and Construction

UNIVERSITY OF CAMBRIDGE

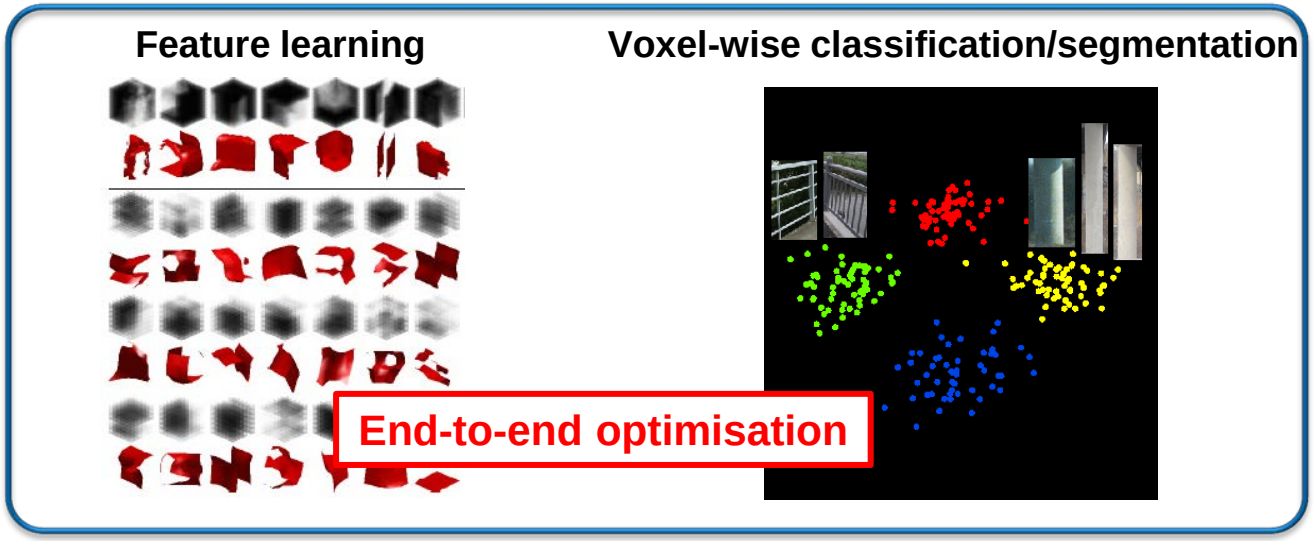
# The future of data modelling: Deep learning

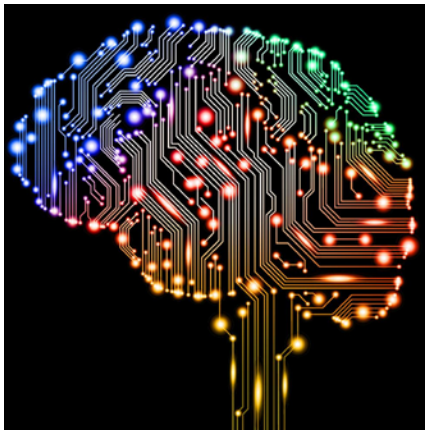


**Deep artificial neural networks**

# The future of data modelling: Deep learning



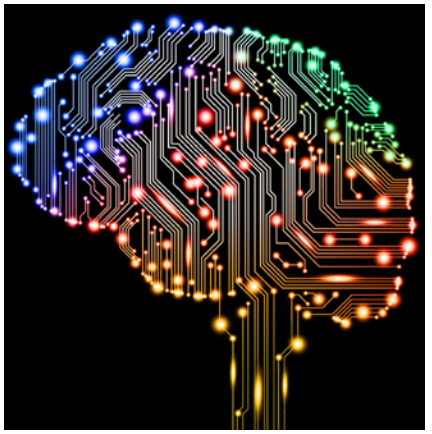



- ~ 20% accuracy increase
- sometimes better than humans
- large number of training examples

**Deep artificial neural networks**

# Conclusion


**Deep learning**



- BIM adoption – highly dependent on its implementation for existing infrastructure
- Current manual modelling methods are overly expensive; costs vs. benefits
- Object recognition systems based on deep learning surpass humans
- Need large amount of training data
- Joint efforts to collect data (point clouds, 3D CAD models)

# Parallel projects


Mobile system for fast scanning (Prof. Kenichi Soga)

As-built bridge modelling and change detection (Dr. Ioannis Brilakis)

LAING O'ROURKE

IFC converter and dedicated tools for bridge design (Prof. Campbell Middleton)

Trimble

Condition monitoring (Dr. Ioannis Brilakis)