Historic Digital Survey

Digital Data Acquisition and Processing for Historic Building Fabric Condition Survey and Interpretation

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Rationale & Vision

- Condition survey adopting visual strategies:
  - Time consuming & costly (esp. access provision)
  - Subjective and inaccurate reporting
  - Inconsistent conclusions for defect classification and ultimately the repair needs.

Rationale & Vision

- Extracting value from point cloud data
- Strategy for monitoring the evolution of masonry walls of historic buildings through reality capture & data processing (including machine learning)
- 3 Co-funded projects – Historic Environment Scotland & Heriot Watt University, Edinburgh

Contents

Reality capture – comparative analysis

Technologies

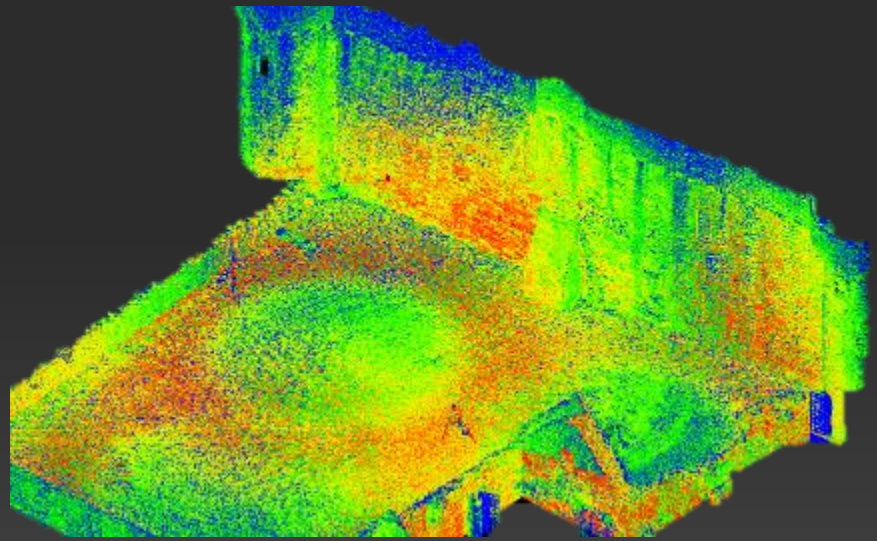
- Terrestrial Laser Scanning
- DSLR Cameras
  (UAV and pole-mounted)

Reality Capture

Craigmillar Castle

Reality capture

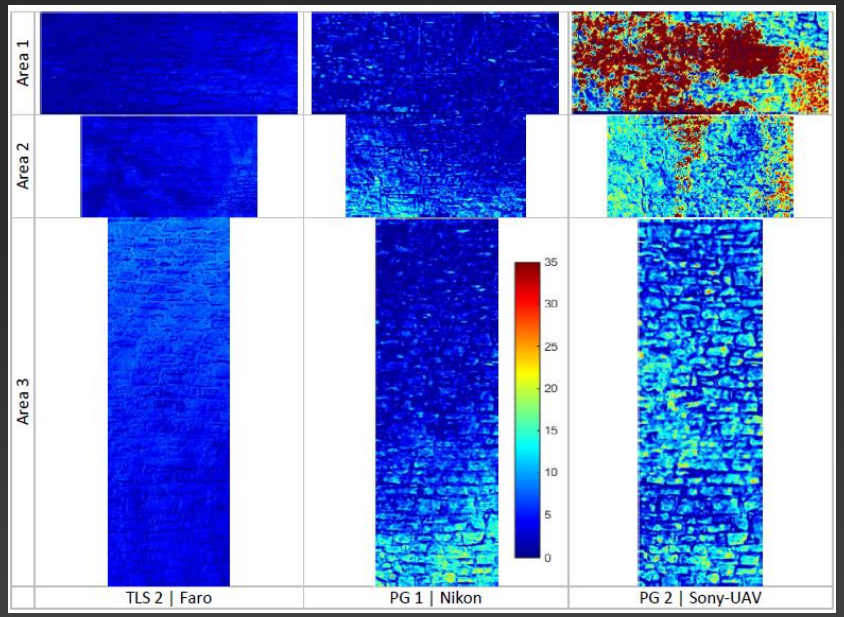
Some numbers…



	TLS	PG
Data acquisition & pre-processing time (hours)		
Data	3 scans 180M points	260 pics 51M points
Resolution	3mm at 50m	GSD: 2mm
Price	£60k	£2k

Reality Capture – Accuracy & Completeness

- Superiority of TLS over PG systems in terms of accuracy
- Cheaper pole-mounted PG system performed remarkably well with results not too dissimilar to one of the TLS systems
- UAV system's performance was poorer, but this was identified to be most likely the result of an insufficient overlap between images (lens focal length and the acquisition of too few pictures)
- Limitations of ground-based TLS was visible at the top of the rampart (~10m) – stones / mortar occlusions
- Mobility of the UAV, and to a lesser extent the use of the pole, ensured that all parts of the wall were acquired with the same level of point density with PG systems



TLS2
Leica

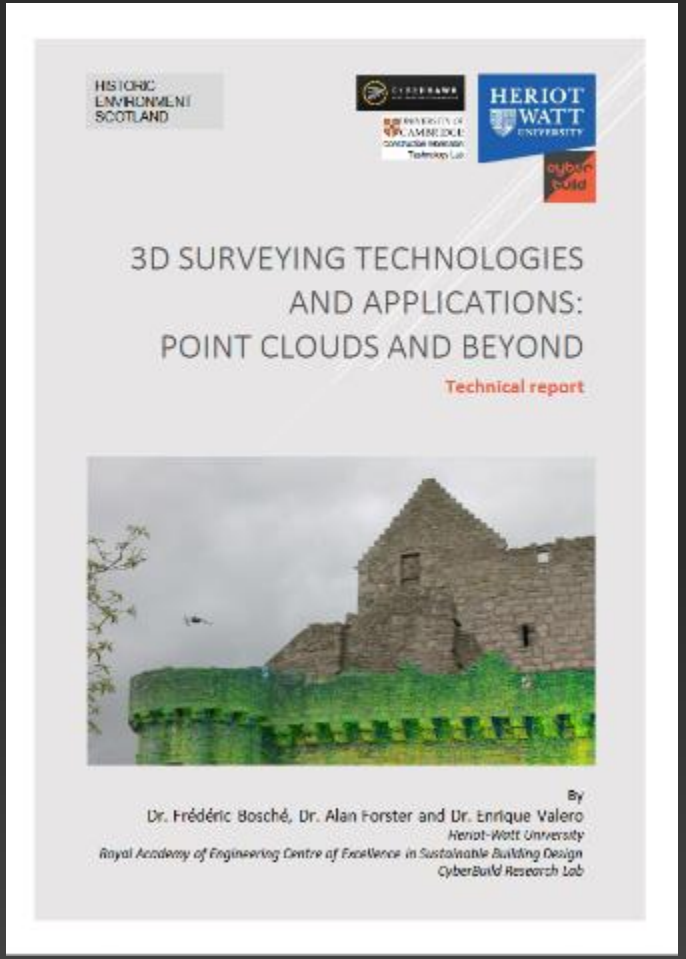
TLS1
Faro

Camera 2
Nikon - Pole

Camera 1
Canon - UAV

Considerations

- Pre survey planning very important
- Positioning and consistency of location
- Lens size and distance from element with PG critical



Contents

Automatic segmentation of masonry

- Data Processing: Segmentation of rubble & ashlar stonework

- Bespoke algorithms developed for both types of masonry

- Extract value from point cloud data
  - Labelling - identification
  - Quantities
  - Defects

Segmentation

Rubble

Linlithgow Palace

3,100 stones

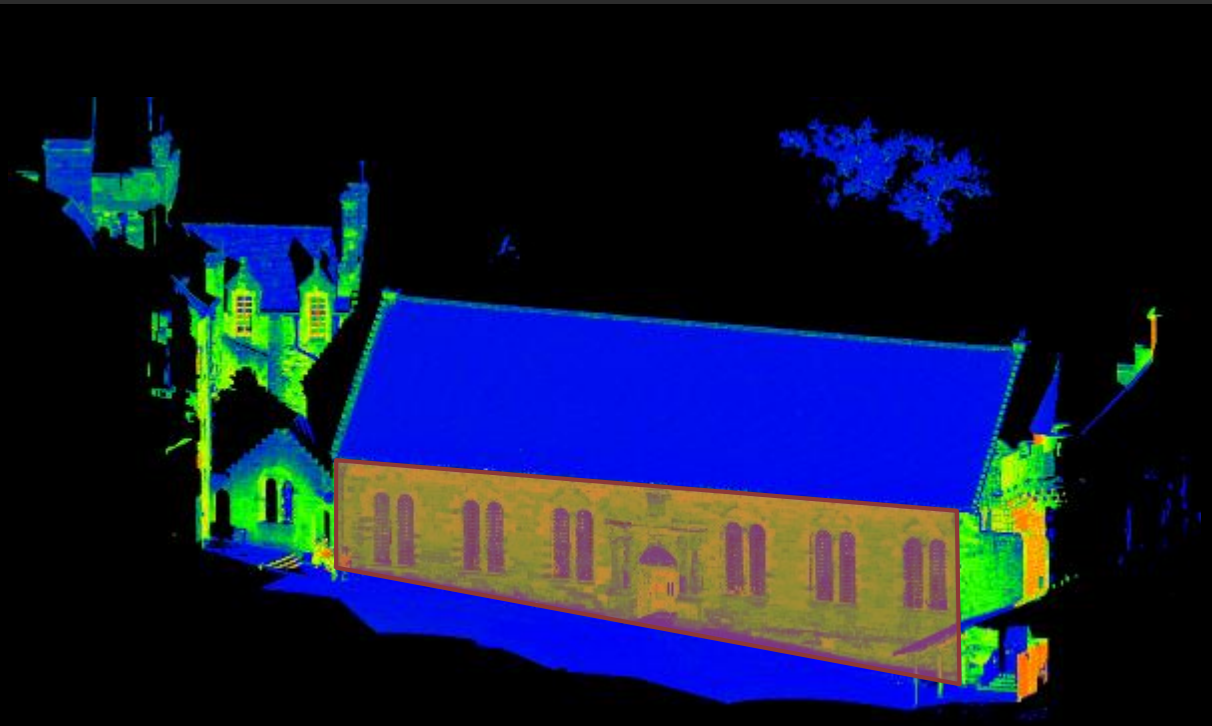
1,44 km mortar

Segmentation

HISTORIC ENVIRONMENT SCOTLAND

Ashlar

Chapel Royal, Stirling Castle

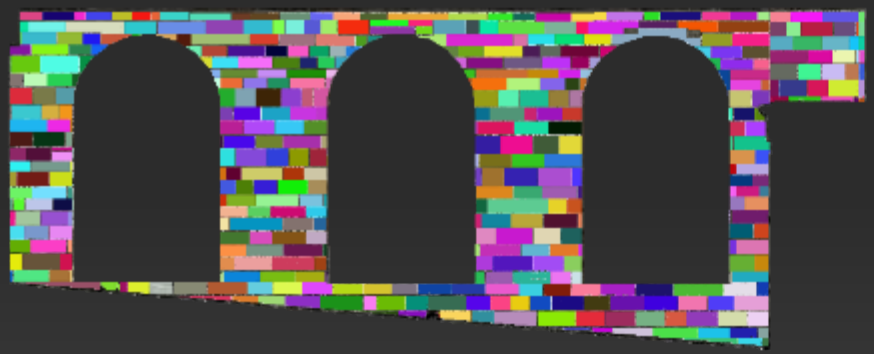


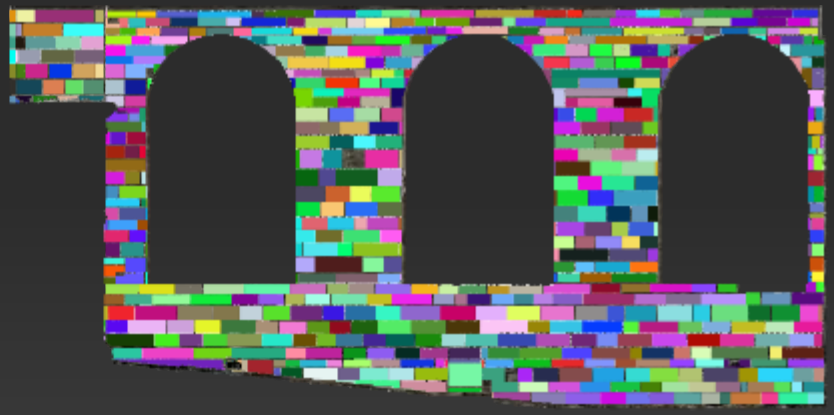
Segmentation

Ashlar

763 ashlar units

Chapel Royal, Stirling Castle





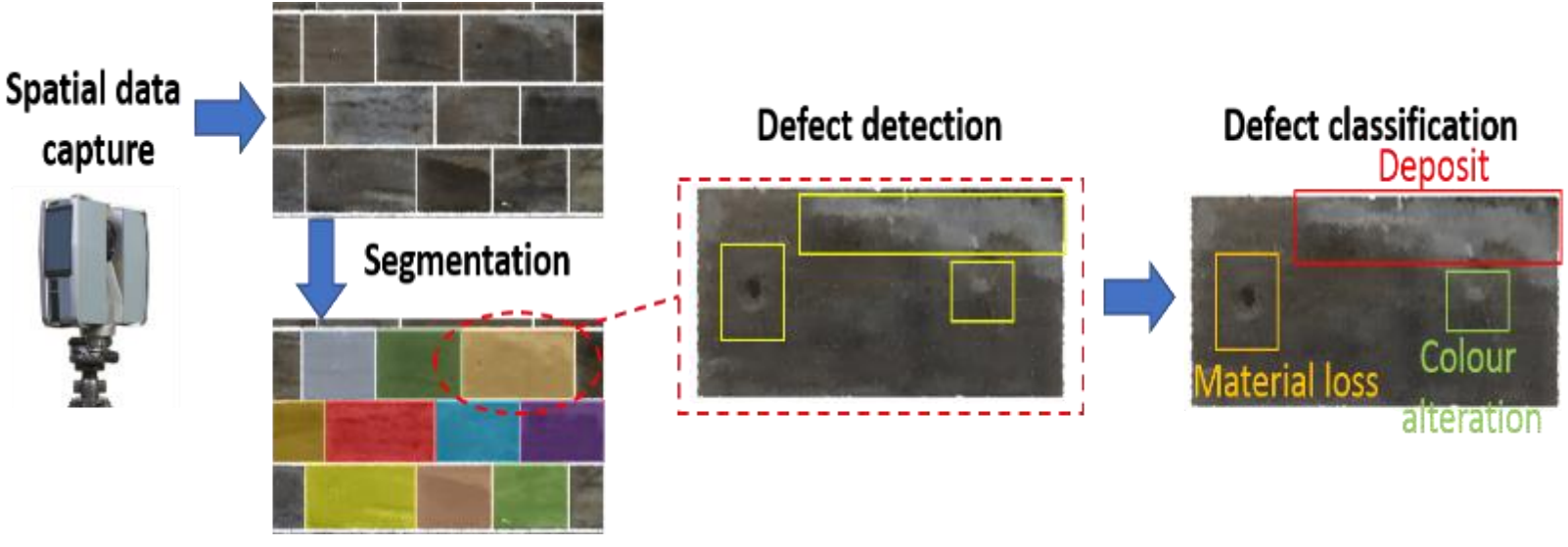
Segmentation

- Ashlar
  - Accurate sizes for dimensional stone
  - 2D CWT using both 3D + Colour

Contents

Defect Detection & Classification

- Masonry wall surveying requires identification of its sub-components, i.e. stones and mortar



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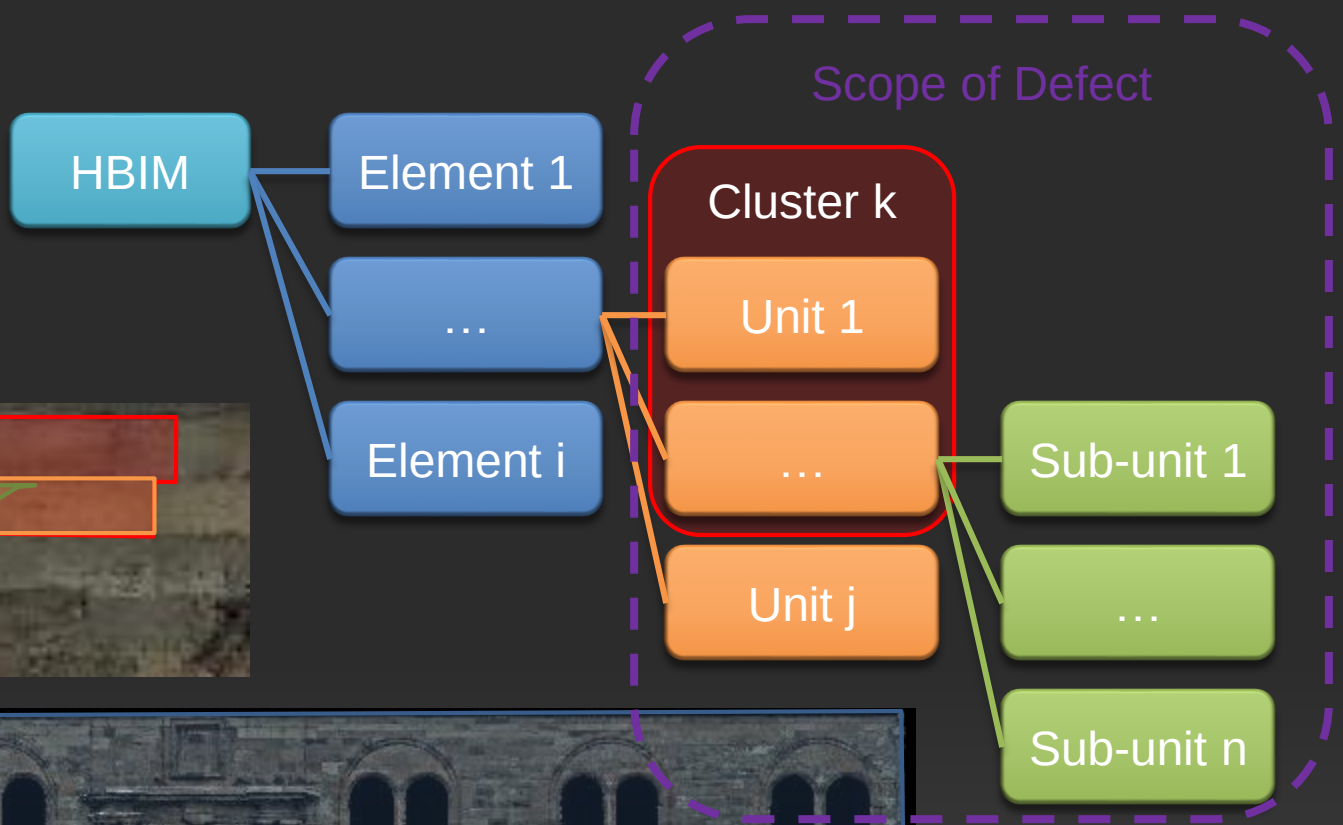


Defect Labelling & Classification

- Parameters – machine learning input

Boundary


Rectangleness


Circleness


Elongation


Area

3D Texture


Volume


Roughness


Isolines

Blistering/bursting
Delamination


Pattern (holes)

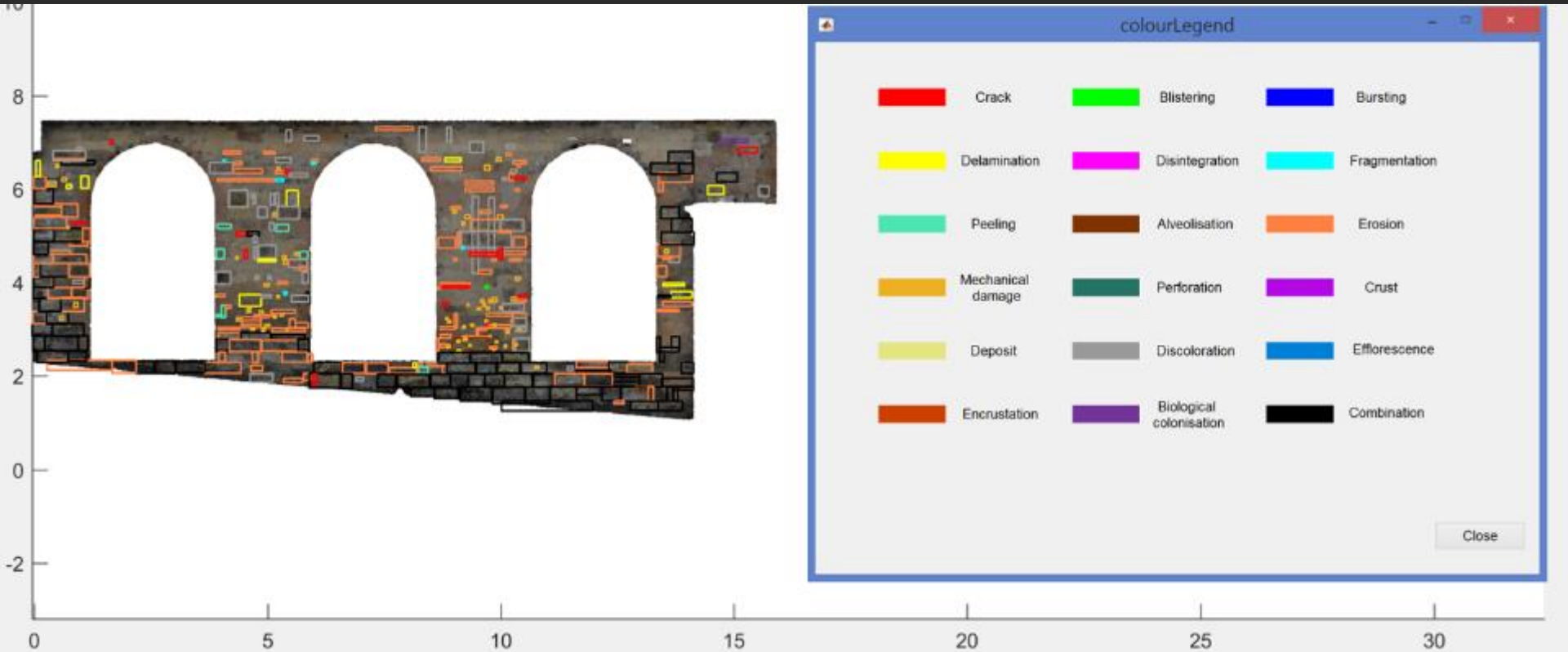
2D Texture


Intensity


RGB

Defect Labelling

- Labelling – ICOMOS stone defect glossary



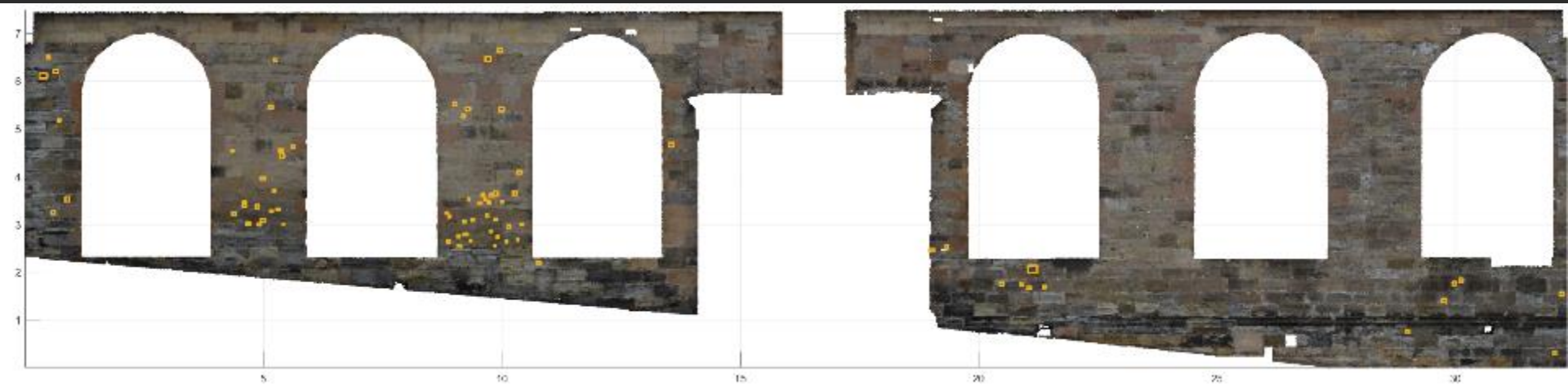
Defect Classification

Classification / detection

93% accuracy

Detection / Classification

Mechanical defects



Chapel Royal, Stirling Castle

Agenda

1. Reality Capture
2. Data Processing – Segmentation
3. Data Processing – Defect Detection & Classification
4. Interpretation

Interpretation – architectural change

- Algorithms developed to evaluate various features / parameters
- Determination of change in materials or constuction techniques fundamental to understanding phasing and attaching cultural significance
- Important tool for architectural analysis

Boundary


Rectangleness


Circleness


Elongation


Area

3D Texture

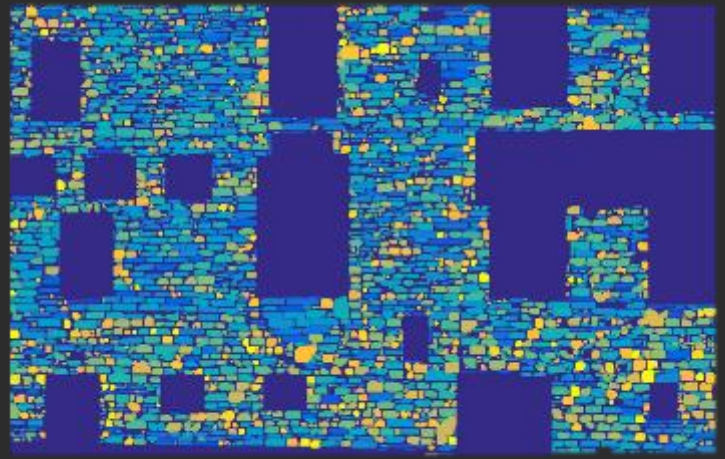
2D Texture

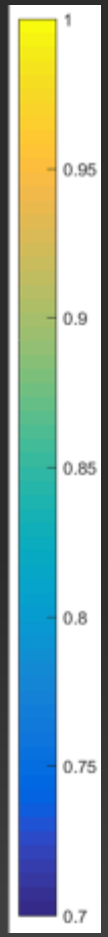
Interpretation

HISTORIC ENVIRONMENT SCOTLAND

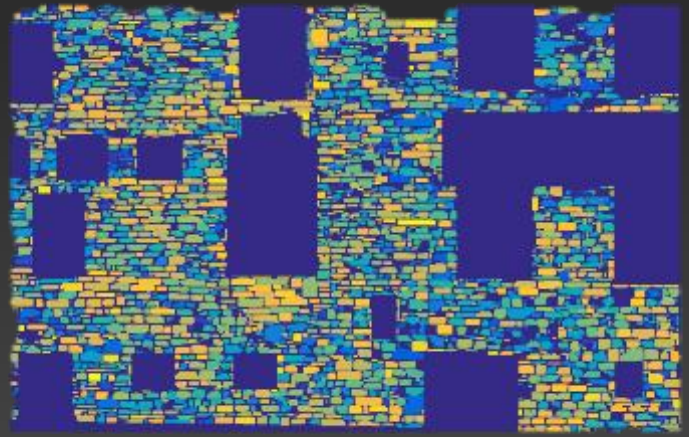
Linlithgow Palace

Circularity

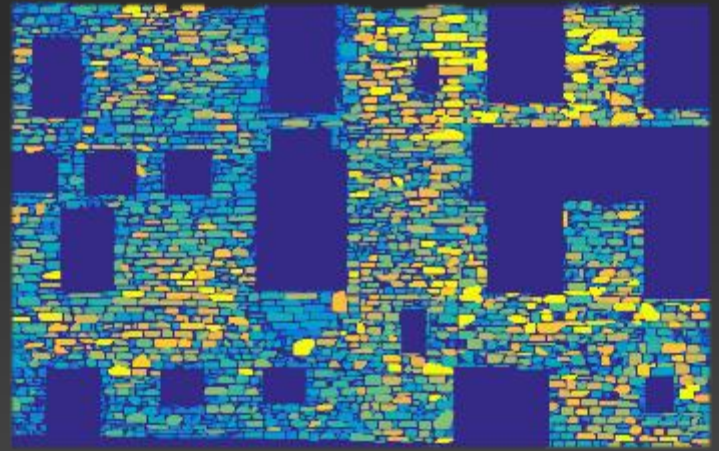




Ashlarness



Roughness



Cyberbuild team

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https://cyberbuild.hw.ac.uk
(soon to move to University of Edinburgh domain)

Thank you & list of publications

- Valero, E, Bosche, F, & Forster, A.M; (2019) Automated Defect Detection and Classification in Masonry Walls using Machine Learning, Automation in Construction. (In Press)
- Forster A.M, Bosche, F & Valero, E (2019) ‘The changing face of conservation’ RICS Built Environment / Building Conservation Journal Feb - March p52-53.
- Valero, E., Bosché, F. & Forster, A. (2018). “Automatic Segmentation of 3D Point Clouds of Rubble Masonry Walls, and its Application to Building Surveying, Repair and Maintenance”, *Automation in Construction*. 96, p. 29-39 11.
- Valero, E., Bosché, F., Forster, A., Hyslop, E. (2018). "Historic Digital Survey: Reality Capture and Automatic Data Processing for the Interpretation and Analysis of Historic Architectural Rubble Masonry", *SAHC 2018*, Cusco, Peru, Sep 11-13.
- Valero, E., Forster, A., Bosché, F., Renier, C., Hyslop, E., Wilson, L. (2018). "High Level-of-Detail BIM and Machine Learning for Automated Masonry Wall Defect Surveying", *ISARC 2018*, Berlin, Germany, Jul 20-25.
- Forster A.M., Bosche, F. Valero, E (2017) ‘Digitally Surveying the Damage’ RICS Building Surveying & Building Conservation Journal, May-June p31-33.
- Valero, E., Bosché, F. N., Forster, A. M., Wilson, L., Leslie, A. (2016), "Comparison of 3D Reality Capture Technologies for the Survey of Stone Walls", *Arqueológica 2.0*, Valencia, Spain, Sep 5-7.
- Valero, E., Bosché, F. N., Forster, A. M., Wilson, L., Leslie, A. (2017), "Evaluation of Historic Masonry: Towards Greater Objectivity and Efficiency", Book chapter in *Heritage Building Information Modelling*, 280 pages, Routledge.
- Bosché F., Forster A., Valero E. (2015), *3D Surveying Technologies and Applications: Point Clouds and Beyond*. Technical Report prepared for Historic Environment Scotland.