Geometric and Semantic Matching for Cultural Heritage Artefacts

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IT Innovation
Jigsaws in 3D

*most* pieces missing

*all* the edges worn off

many puzzles jumbled together

pieces spread across many countries
Re-Assembly
Re-Unification
Re-Association

Similarity Search
Re-Assembly

You have some (eroded) pieces.
The computer fits them together.
This is hard in 2 dimensions, never mind in 3D!
Re-Unification

- Re-unify 3D models of the statue
- 3D print copies for re-unification
- Re-unify statue in a virtual museum

Head in the British Museum

Statue in the Cyprus Museum
Re-Association

Data in another museum catalogue

Artefact with semantic description
Material, decoration, size, shape, period, style, glaze, ...
Find similarities leading to new insights about past cultures
How?
What’s the data?
Fragments of Terracotta Statues from Salamis
We need to Gather all the Knowledge

Catalogue data with text descriptions

Archaeological papers

Excavation notes

Chemical analysis

X-ray fluorescence

3D scanning → models
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- Chemical analysis
- Archaeological papers
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- Excavation notes
- 3D scanning → models
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The British Museum has 2.5M objects described in CIDOC CRM

Catalogue data from Ashmolean, Fitzwilliam and Cyprus museums is now mapped to the same data model

Object → hasNote → “...lots of free-form text added by the curator”

Using Natural Language Processing to extract and encode meaning from this text:
• References to papers, to catalogue entries
• Parts and features
• Conservation condition
• Measurements
• ...
→ CIDOC CRM / CRMarchaeo / etc
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All fragments (211) are scanned, in a variety of resolutions and with a variety of scanners.

- Volume, area thickness, curvature, ...
- Colour, texture, distance from convex hull, ...
- Chemical analysis
- X-ray fluorescence
- 3D scanning → models
- Feature detection
- Faceting: front / back / fracture
- CH Artefact Partonomy
- CRMdig

Part annotation
Faceting

- Assume local fold model
- Measure local fold angle
- Select locally salient angles
- Connect to form facet curves
- Determine the facet types
- Robust for our fragments
- Very few parameters
Feature Detection

- Morphological and stylistic feature detection and characterization

- Reasoning on similarity among fragments
Using CH Artefact Partonomy within CIDOC-CRM
How do I use it?
Six views in the dashboard

- Inspection
  - Users can inspect 3D fragments and metadata and run a search
  - 3D assets can be processed (faceting, geometric characterisation, feature identification) and annotated

- ReAssembly
  - Exploration
  - Datasets can be explored according to specific selected properties

- History
  - To preserve the list of operations performed in the session

- Clipboard
  - To save all the data the user is interested in (e.g. notes, models, annotation)
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- History
  - To preserve the list of operations performed in the session
    - Provenance and argumentation

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Prototype

GRAVITATE Dashboard
Proof of concept prototype v0.2

Tools
- Search
- Data

Selection

Metadata
- **Description**: Fragment of head of terracotta over-lifesized figure, left eye and eyebrow in relief with black painted detail
- **Id**: <http://collection.britishmuseum.org/id/object/GAA08922>
- **Model URL**: <publik/review-data/19 68_12-13_28/LR/3D_ModelPLY/19 68_12-13_28_im_Ai.ply>

Metadata
- **Description**: Fragment of left ear broken from terracotta over-lifesized figure, pierced lobe, hair visible behind painted black
- **Id**: <http://collection.britishmuseum.org/id/object/GAA08895>
- **Model URL**: <publik/review-data/19 68_12-13_4/LR/3D_ModelPLY/19 68_12-13_4_im_Ai.ply>
And Finally: ReAssembly

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Use all the data to guide the process
Mannequin
Matching: geometry-based
Mating

- Mating digitally mimics gluing of the fragments
- We place selected fragments in their optimal relative position based on:
  - Geometric complementarity
  - Skin pattern continuity
  - Semantic constraints
  - Global alignment
- Mathematical morphology used
- Final approval of proposed assemblage is requested of the user

(SotA mating from predecessor PRESIOUS)
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