POTTERY CLASSIFICATION

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AUTOMATIC 3D REPRESENTATION OF POTTERY FROM PAPER CATALOGUE DRAWINGS

Based on a paper by:
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POTTERY CLASSIFICATION

Classifying the type of a ceramic artifact (sherd) based on appearance and shape (decoration and profile)
MOTIVATION

Pottery classification is a crucial operation. In the absence of organic material, it provides valuable information about:

• historical period
• commercial routes
• eating habits
• industrial production
• etc.
MOTIVATION

• Today, the classification of ceramics is carried out manually, through the expertise of specialists and the use of analogue catalogues held in archives and libraries.

• Takes a considerable amount of time, effort and funding
POTTERY CLASSIFICATION IN COMPUTER SCIENCE

• has been a topic of interest in computer science for several years

• several typologies of pottery were manufactured on an industrial scale – a “gold mine” for machine learning
PREVIOUS WORK

Several projects in which:
- a 3D representation of a sherd was obtained via 3D scanning
- the 3D model was used for analysis and reconstruction of the full vessel
SO ARE WE DONE?

• 3D acquisition of sherds is not an easy task

• any classification was based on extraction of the descriptive profile from the 3D model.

• requires intervention by an experienced user to position the sherd before profile extraction
THE ARCHAIDE PROJECT

• “Aims to change the global practice of archaeology”

• Optimize the process of classification

• Make knowledge accessible wherever archaeologists are working

• Funded by the European Union
why would the European Union fund such a project? (and what is the real motivation)
THE PROJECT GOALS

• Automate most of the classification process

• Given a photograph of a sherd identify the pottery class it belongs to

• Classes are based on either decoration or profile
BUT THERE ARE SOME PROBLEMS...

• Needs many samples of labeled data

• There’s not a lot of labeled archaeological data (meaning classified images of sherds)
DECORATION BASED CLASSIFICATION

• Feasible with the amount of images that exists

• There are trained neural networks that do it well and could be use (ImageNet)
SHAPES AND PROFILES

• Based on the fracture shape of the sherd

• Classes are based on profile drawing (from catalogues)
BUT...

• Impossible to use pre-trained networks

• We need a large amount of data – which we don’t have!
SO...

• We will generate more data!

• And train the classifiers on the simulated data
GOALS

• constructing a 3D model of the pottery using a 2D drawing

• Breaking the 3D model into synthetic sherds

• Capture a 2D “photograph” of the sherd

• Train classifiers on the synthetic sherds (which we won’t discuss)
WORKFLOW

1. Geometric features extraction from initial drawing

2. Simplify the model

3. Generate a 3D representation of the drawing

4. “Break” the 3D model into a set of sherds

5. Capture 2D sherd images
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GEOMETRICS FEATURES (AND THEIR EXTRACTION)

- Pottery drawings in catalogues are fine for human interpretation
- But are not suitable for automatic algorithms
- We would like a more suitable representation
GEOMETRICS FEATURES - REPRESENTATION

1. Describe the features that archaeologists use when analyzing a sherd

2. Contain features that could be extracted in a semi-automatic way

3. Be complete enough to allow an automatic 3D reconstruction of its class.
- **Outer profile** – green outline in figure.
- **Inner profile** – red outline in figure.
- **Handle outer profile** (if present) – yellow outline in figure.
- **Handle inner profile** (if present) – blue outline in figure.
- **Handle section** (if present) – cyan outline in figure.
- **Rim point**: the top point in the profile.
- **Base point**: the bottom point in the profile.
- **Scale factor**: the scaling value to bring all features to real scale.
FEATURES EXTRACTION

1. Image De-noising and Binarization
2. Finding the Rotation Axis
3. Extracting the Inner Profile
4. Extracting the Outer Profile and Handles
IMAGE DE-NOISING AND BINARIZATION
FINDING THE ROTATION AXIS

• the rotation axis of the vessel’s drawing is usually present

• The longest vertical line in the drawing is assumed to be the rotation axis

• Done by using the “Hough transform”
REMOVAL OF SURFACE SKETCHES

the part of the drawing illustrating the surface of the vessel is removed
EXTRACTING THE INNER PROFILE
EXTRACTING THE OUTER PROFILE AND HANDLES
WORKFLOW

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SIMPLIFYING THE MODEL

• **Goal:** reduce the number of points while maintaining the general structure of the model

• **Use line simplification algorithm**

• **Results:** most outlines can be reduced from few thousand points to fewer than 200, with no visible different
4058 points ➔ 188 points

4589 points ➔ 226 points
LINE SIMPLIFICATION - VISVALIGAM’S ALGORITHM
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GENERATING THE 3D MODEL

1. generating the body

2. generating the handles (if present)
GENERATING THE BODY

1. Extract the profile of the body (made by joining the inner and outer profiles)

2. Extract the rotation axis

3. Scale the profile to the real measures

4. Generate the 3D body by rotating the profile around the z-axis.
GENERATING THE HANDLES

• Done similarly to the generating of the body

• Sometimes handles are not included at all (due to the fact that their measures can't always be derived from the catalogue)
FINE TUNING ROTATIONAL RESOLUTION

• Determine the number of times to duplicate the profile around the axis

• could be set to a constant number (200 seems to yield good results)

• could be determine dynamically using the same simplification logic of Visvaligam’s algorithm
WORKFLOW

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GENERATING SYNTHETIC SHERDS:

• “Cell Fracture” plug-in

• Done by generating a 3D Voronoi diagram and computing intersection of each cell with the original model

• The number and size of sherds could be controlled
WORKFLOW

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HOW DOES THE GENERATED IMAGES SUPPOSE TO LOOK LIKE?

• It should be similar to the images that are taken by field archaeologists

• What views are often being used to capture a sherd?
HOW DOES THE GENERATED IMAGES SUPPOSE TO LOOK LIKE?

• “The most indicative picture would be the one looking at a fracture face, trying to align the rotation axis to the vertical direction of the image.”

• Luckily, for such a fracture, the outlines of the inner and outer profiles can be extracted.
VERTICAL FRACTURES

• Fractures that form a small angle with the rotation axis

• Fractures that are more recognizable by archeologists (since there is less distortion compared to the profile)
CAPTURING 2D SHERD IMAGES

1. Righting sherds
2. Finding vertical fractures
3. Capturing the 2D sherd image
RIGHTING SHERDS

• For real potsherds – archaeologists are usually able to guess the axis of rotation.

• For synthetic sherds – we already have all the sherds oriented upwards as desired
FINDING VERTICAL FRACTURES

• When taking a picture of a sherd, the “up” direction is aligned with the true up direction of the rotation axis.

• So only the rotation angle around the rotation axis needs to be determined.
FINDING VERTICAL FRACTURES

• The goal is to take the picture with the largest vertical fracture

• The solution is approximated by considering only orthographic projection (no perspective deformation based on distance from camera).

• Could be formalized as an optimization problem
FINDING VERTICAL FRACTURES – NON TRIVIAL CASES

No vertical fractures:
Some sherds have no vertical fractures – or only small ones.
In this case we will look at the exterior of the sherd
FINDING VERTICAL FRACTURES – NON TRIVIAL CASES

Multiple vertical fractures:
CAPTURING 2D SHERD IMAGE

With the angle that was found in the previous stage, the fracture is projected onto a plane in order to receive a 2D polygon.
Extract the inner and outer profiles
RECAP

• constructing a 3D model of the pottery using a 2D drawing

• Breaking the 3D model into synthetic sherds

• Capture a 2D “photograph” of the sherd

• Train classifiers on the synthetic sherds (?)
FUTURE (PRESENT) WORK

• Train classifiers

• Make the sherd images more “realistic”

• And much more (that I don’t know of)
Thanks for listening!