

# 3D Pots Configuration System by Optimizing over Geometric Constraints

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Color Match detected

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### Introduction

- Potteries are frequently excavated artifacts, but they are usually found in broken fragments.
- Manual reassembly is exhaustive and inaccurate.
- There have been efforts to virtually assemble the 3D scans of fragments, but a practical and efficient method for large-scale implementation is yet to be established.
- We propose a simple yet effective algorithm to reassemble broken pottery pieces.

#### **Proposed Method**

- 1. Feature Extraction
  - From each scanned fragment, extract sampled break line.

Scanned 3D Mesh(Left) and Sampled Break Line(Right) of a Pottery Fragment

- Extract feature vector of each sampled point *p*, *F*(*p*).
- Build a **Matching-Score Matrix** *M* such that point pairs with similar features have score approximately 1 and others 0.

#### 2. Optimization

• Binary optimization problem:

 $\underset{X}{\operatorname{arg\,min}} \frac{\|X - M\|_F^2}{\|X - X_{i,j}\|} + \sum_{i,j} s_i s_j \|X_{ij} - X_{(i+1)(j+1)}\|_2^2$ Similar to match score Continuity

subject to  $X^{\top} \mathbf{1} \leq \mathbf{1}, X\mathbf{1} \leq \mathbf{1},$ Bijection  $X_{ij} \in \{0,1\}, \forall i, j.$ 

- Find a binary matrix X where matched pairs of points on the break lines are encoded as 1 and other elements are 0.
- Geometric constraints
  - Bijection : Each point will be matched to at most one other point. (At most one element of 1 in each row and column, and other elements should be 0.)
  - Continuity : Matched points form a continuous segment on the break line. (The segment creates diagonal 1's.)
- Binary constraints are relaxed to X<sup>T</sup>1 ≤ 1, X1 ≤ 1, 0 ≤ X. -> Convex Quadratic Programming

## Experiment Results

- Result on Real Pottery Data
  - ✓ Without optimization, the feature matching scores result in hundreds of false-positives.
  - ✓ The potteries are reassembled by attaching break lines that correspond to the peaked diagonal sequences of the optimization output X.



Reassembly of each pottery : 3 false-positives ✓ Hierarchical extension : Start with a large sampling interval and iteratively solve the optimization problem, decreasing the sampling interval after each iteration.







The original diagonals are recovered after our optimization for noise of standard deviation up to 0.6.