Feature Descriptors for Spotting 3D Characters on Triangular Meshes

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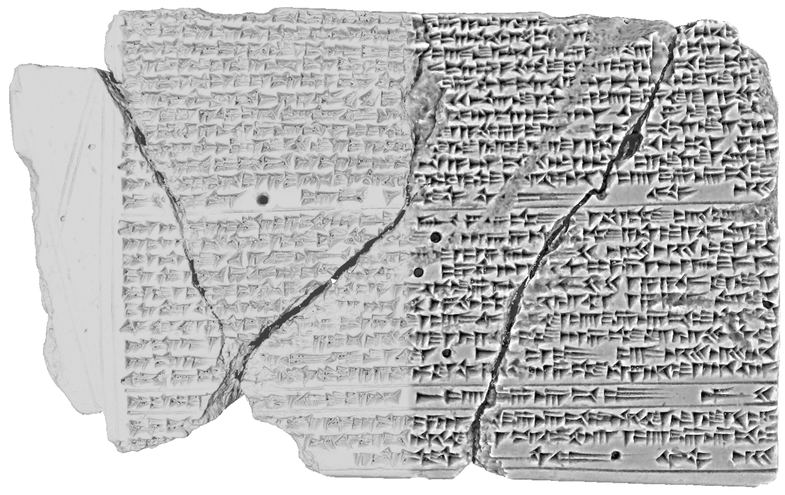
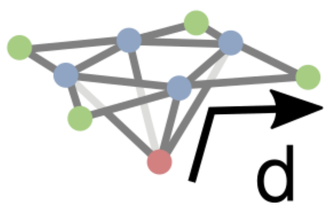
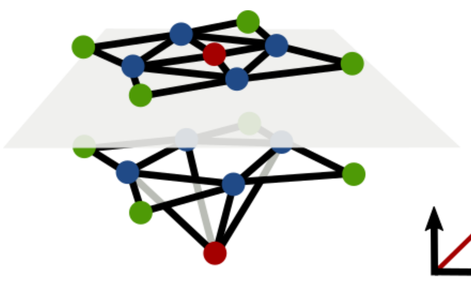
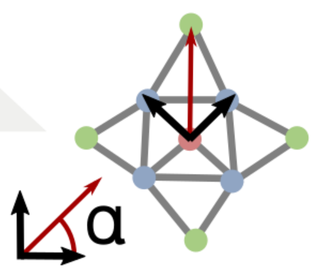
- Used from 3.200 B.C. to 75 A.D.
- At least half a million documents
- Large amount not translated
- Insight about politics, art, and economics, even hints about change in climate
- Cuneiform symbols are sets of wedge-shaped impressions
- Used by many different languages in the ancient Near East

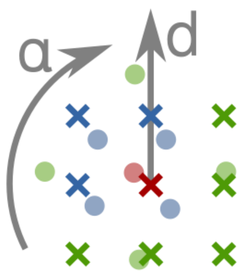
- Acquired with structured-light 3D-scanner
- Tablet contains 2 million faces and 1 million vertices
- Query symbol is 8.362 faces and 4.448 vertices
- Symbol spotting on meshes is challenging and not well-researched:
- No intuitive means of traversing a mesh
- No inherent notion of features (i.e. color)
- Significant amount of data without inherent order







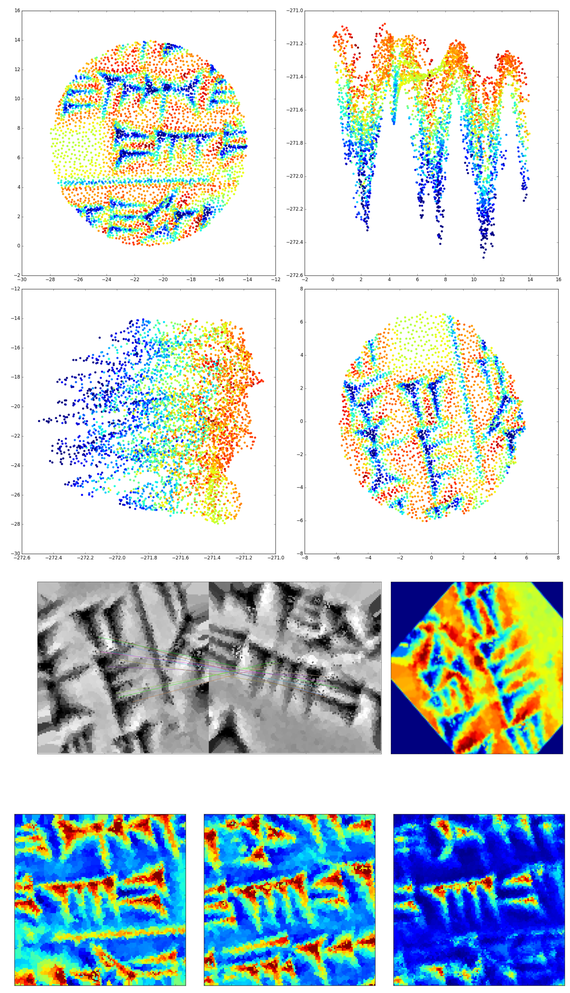




- Extracted patches have between 3.000 and 4.000 vertices
- Faces are discarded
- Vertices are **colorized** according to surface convexity values given by MSII

- Multi-scale Volume Integral Invariants (MSII) provide a measure of undirected **surface concavity**
- Computed by intersecting differently scaled spheres with the surface at each vertex
- Then, at each vertex, compute geodesic graph neighborhood using **Dijkstra's algorithm**
- Project vertices onto a plane using PCA
- Compute angles on plane w.r.t. to arbitrary vector
- Rotation independence is achieved by considering **8 orientations** of each patch
- Layout vertices on new plane, given **geodesic distances** and **euclidean angles**
- Sample vertices with nearest neighbors to generate a 128 x 128 patch

- Query mesh is sampled randomly near its center of gravity
- Query samples are transformed into patches ignoring possible orientations
- For each vertex in the document, 4 x 8 comparisons are performed: 4 query samples x 8 document orientation samples
- Comparisons are carried out with the **following methods:**
- Dot product of the patches themselves
- Euclidean distance of the Histogram-of-oriented gradients (HOG) feature-vectors of the patches
- Keypoints extracted from the patches with ORB and rigidly matched with RANSAC
- General distance transform (GDT) followed by the dot product

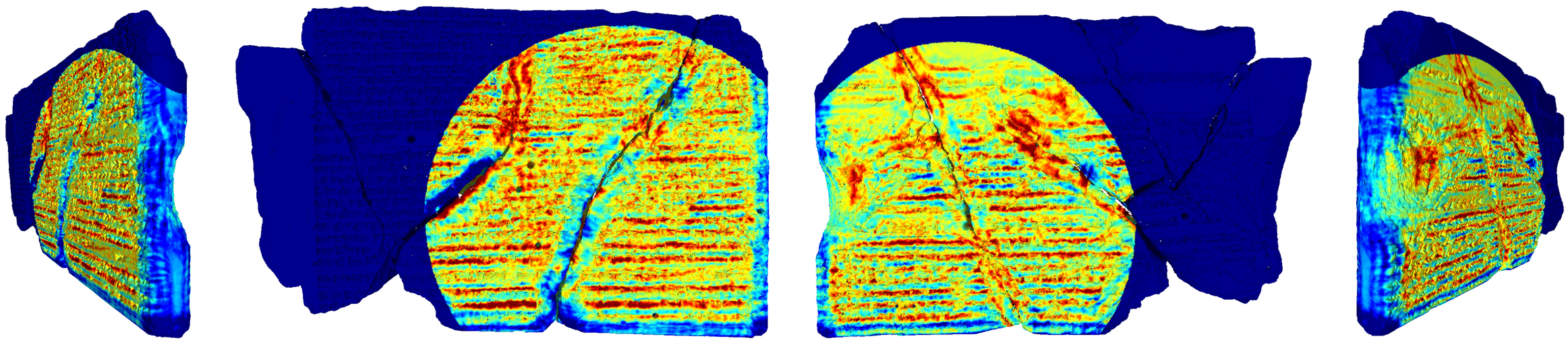


- MSII features computed and visualized in GigaMesh

- Spotting proceeds by sampling random locations on the mesh
- Mesh vertices are colorized by computed similarity
- Proper instances can be found by **non-maximum suppression**

- Future work focues on main challanges and limitations:
- Area Integral Invariants to reduce noise around edges
- Siginifcant computation due to un-optimized implementation
- Weak feature extractors and object detectors

- Simple approach provides interpretable and accountable results
- Patch-based approach makes many standard image processing methods **trivially transferable**
- For example, employing widely used convolutional neural networks (CNN) for learning better feature extractors



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