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

- 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
- MSII features 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

- Future work focuses on main challenges and limitations:
  - Area Integral Invariants to reduce noise around edges
  - Significant 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