3D Object Recognition and 2-Simplex Meshes

By Gerald Dalley

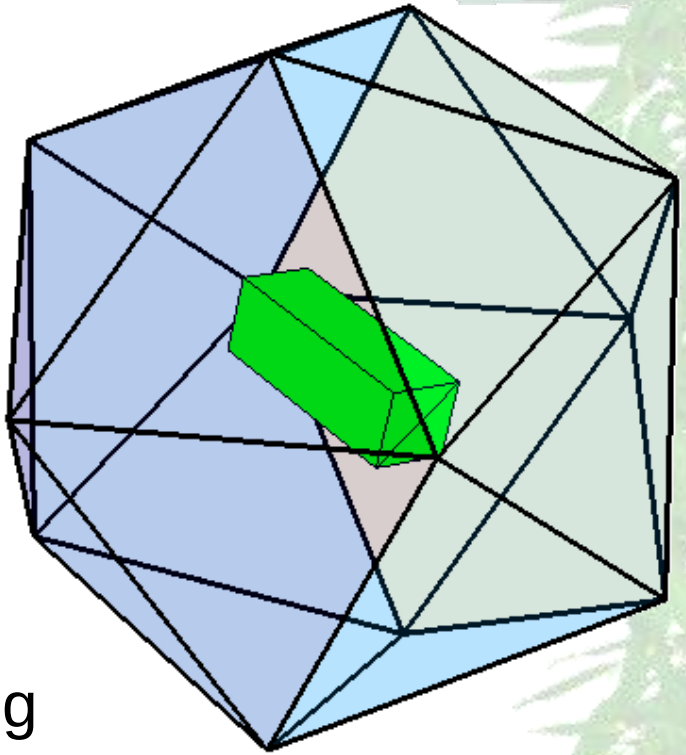
Overview

- Some popular 3D object recognition techniques
  - Appearance-based matching
  - Feature matching
  - **Regular mesh tesselation**
- 2-Simplex Meshes
- Spherical Attribute Images
- For further reading

Popular Recognition Techniques:

Appearance-Based Matching

- Basic steps
  1. Sample a view-sphere
  2. Record feature measurements as observable from a camera at each view-sphere sample point (create templates)
  3. Compare observed data with each template from each model
  4. Choose the model and orientation that provides the best match
- Requires sufficiently fine sampling of the view sphere



Popular Recognition Techniques:

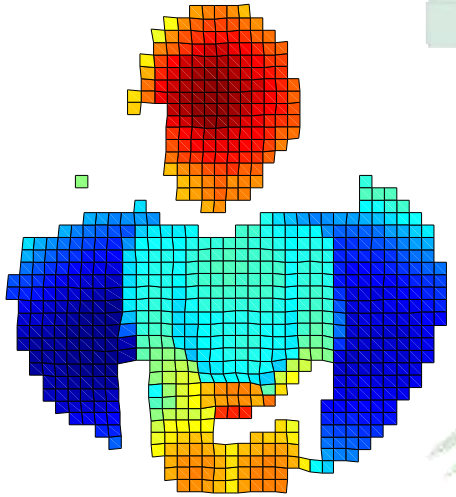
Feature Matching

- Ravi's work, Rick's local features
- Basic steps
  1. Find features invariant to rotation and translation
  2. Build an attributed graph
     - Nodes: features
     - Arcs: spatial arrangement
  3. Choose the model whose graph is most similar

Popular Recognition Techniques:

Regular Mesh Tesselation

- "Regularly" sample the mesh
  - Square grid
  - Triangularization
  - 2-Simplex
- Measure feature values at mesh vertices
- Vertex-by-vertex comparison



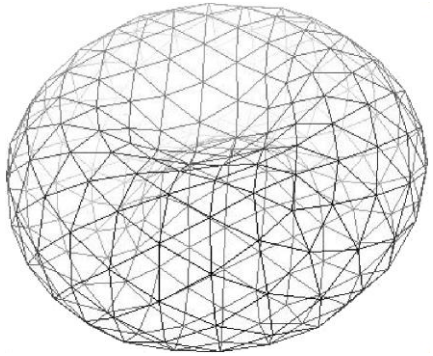
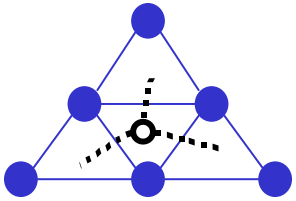


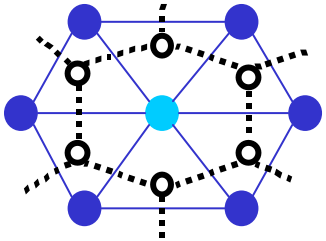
Image from [3]

2-Simplex Meshes

- Dual of triangularization
  - Triangle face → simplex vertex

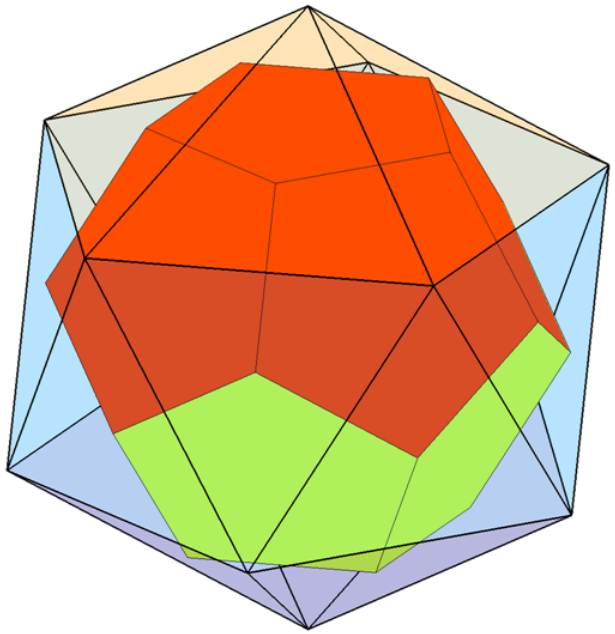


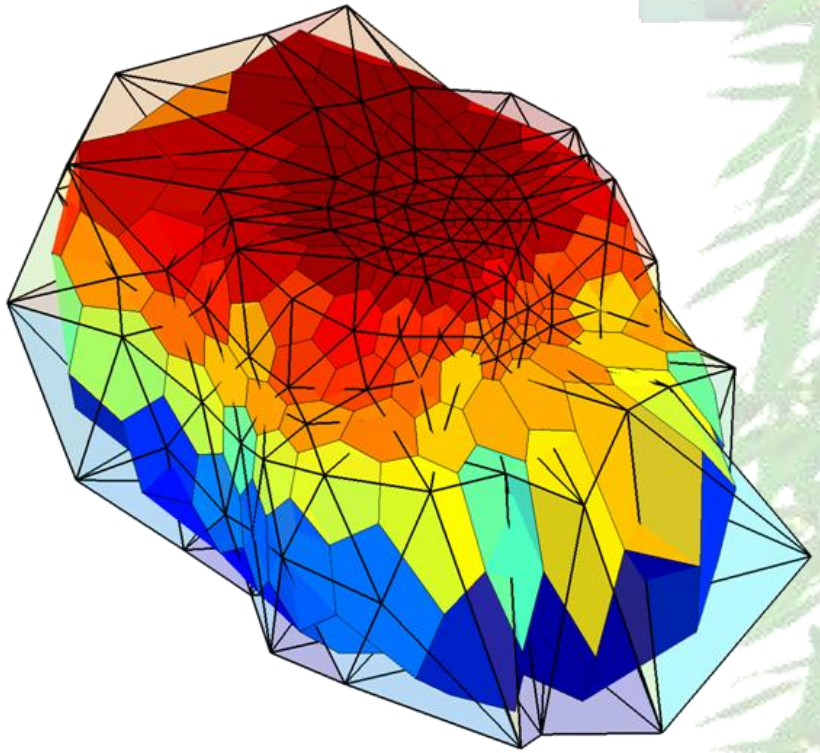
  - Triangle vertex → simplex face



2-Simplex Meshes:

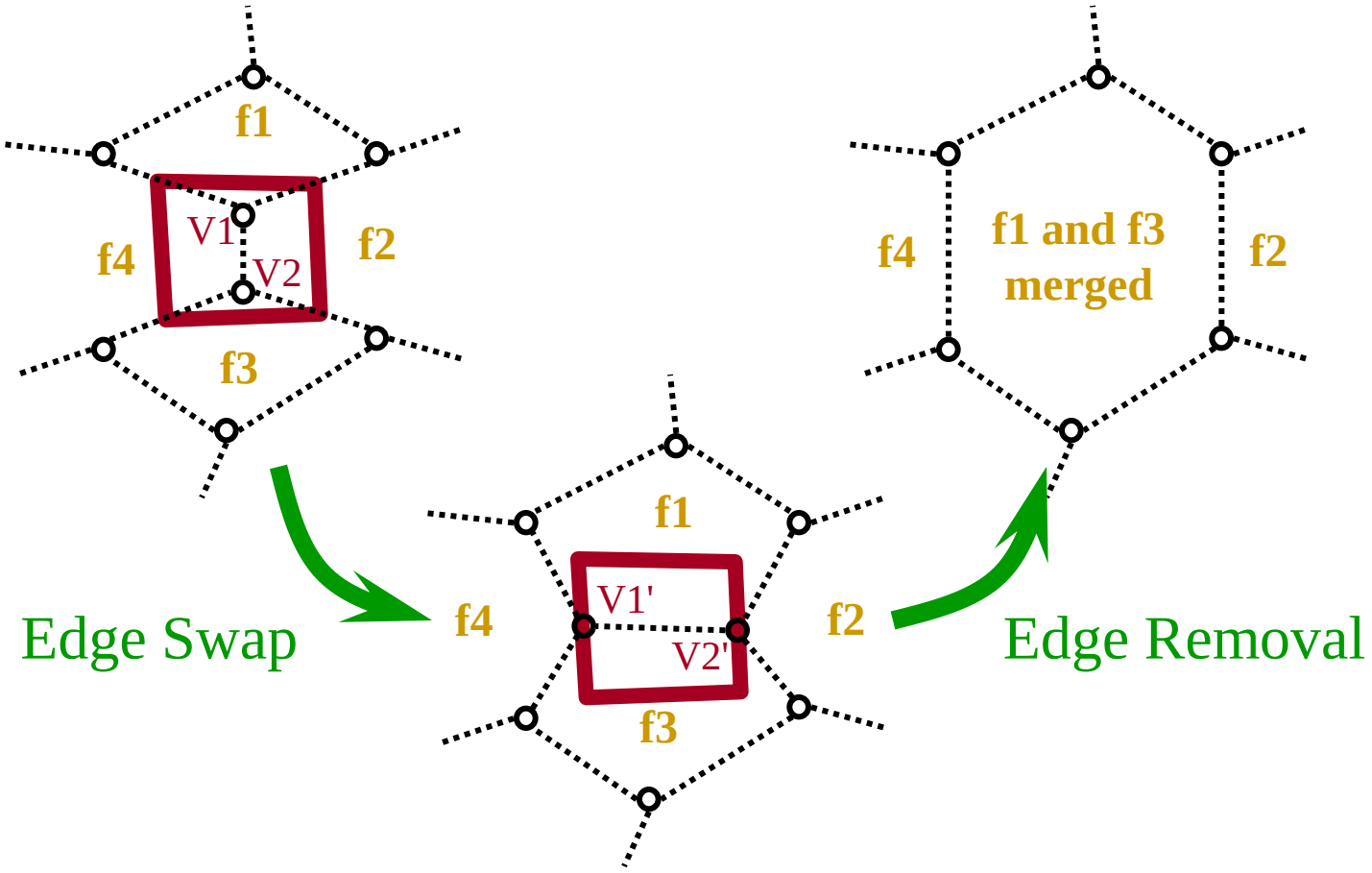
Two Examples





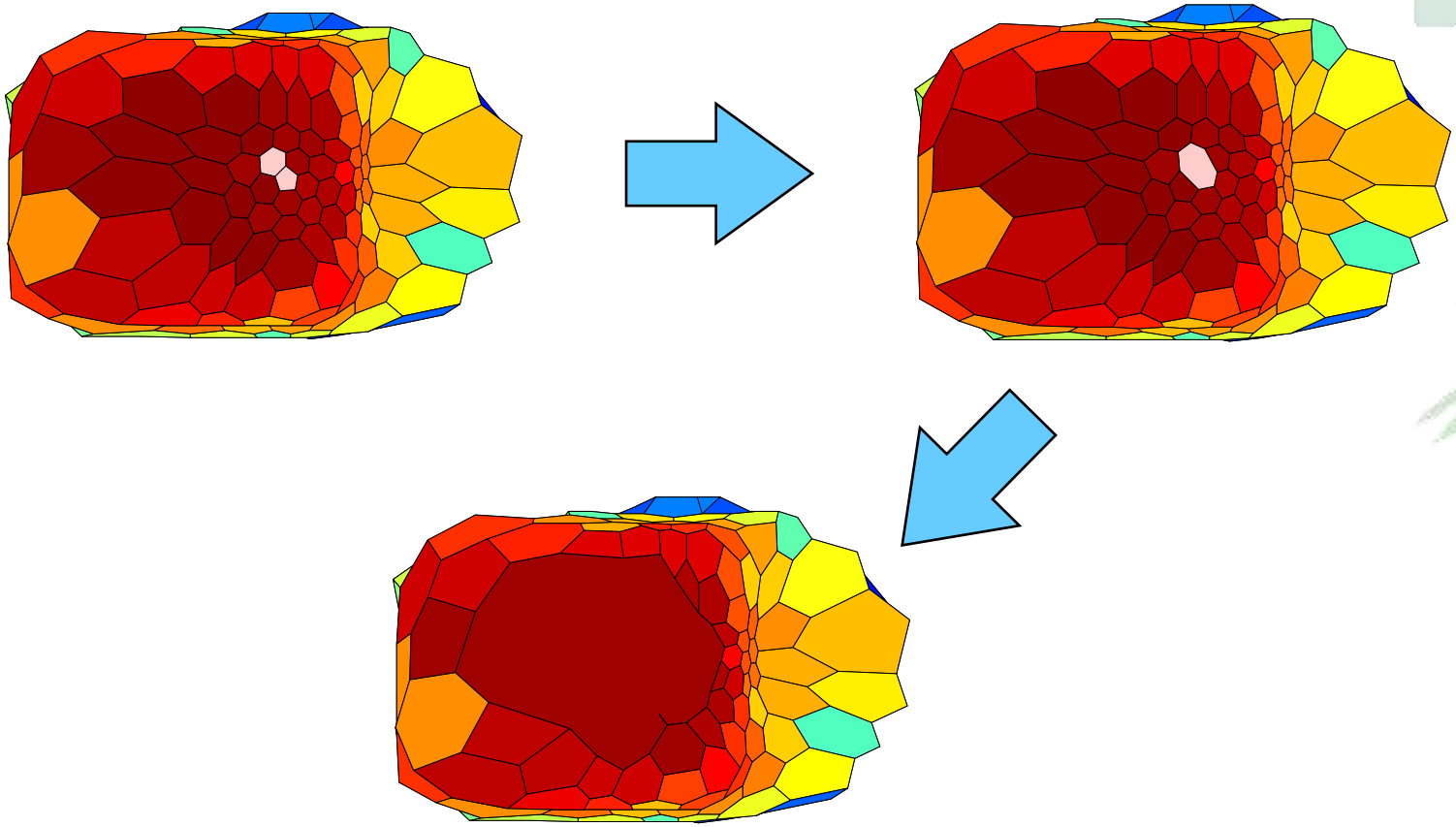
2-Simplex Meshes:

Topological & Geometric Modifications

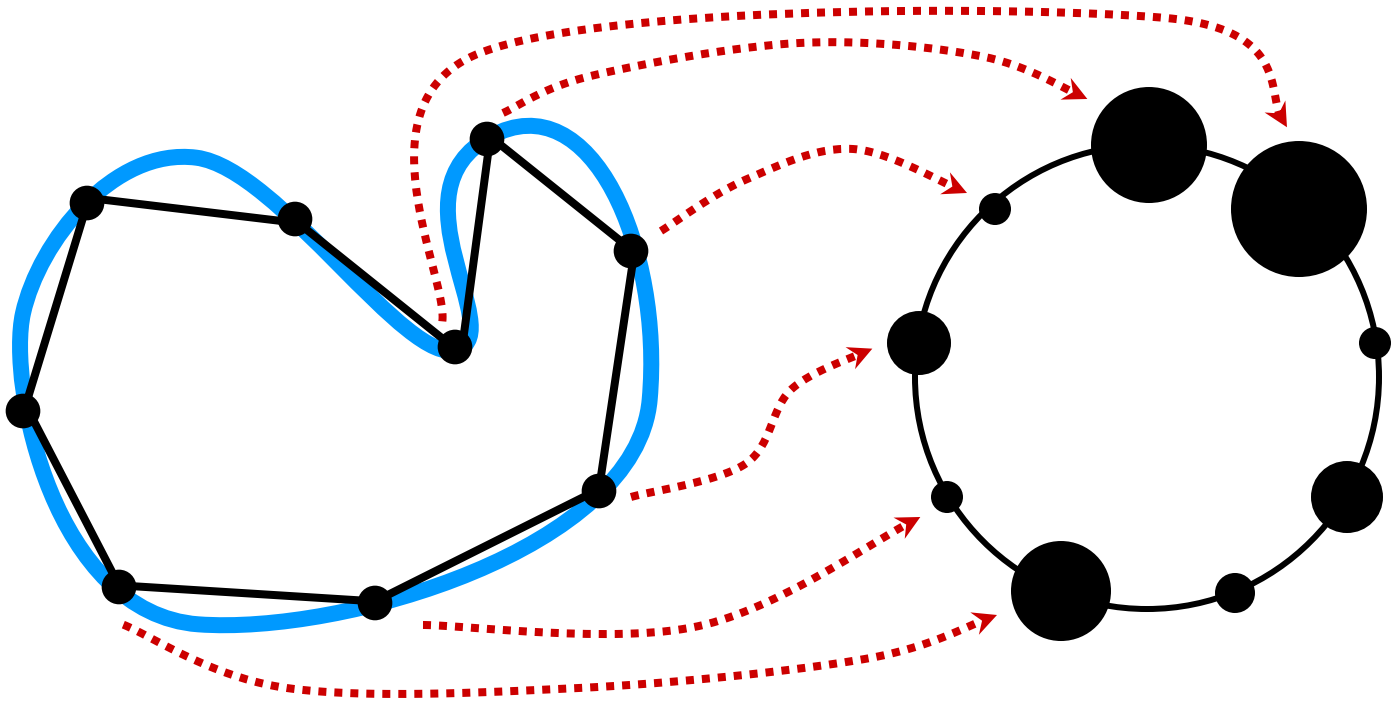


2-Simplex Meshes:

Edge Removal Example



Spherical Attribute Images



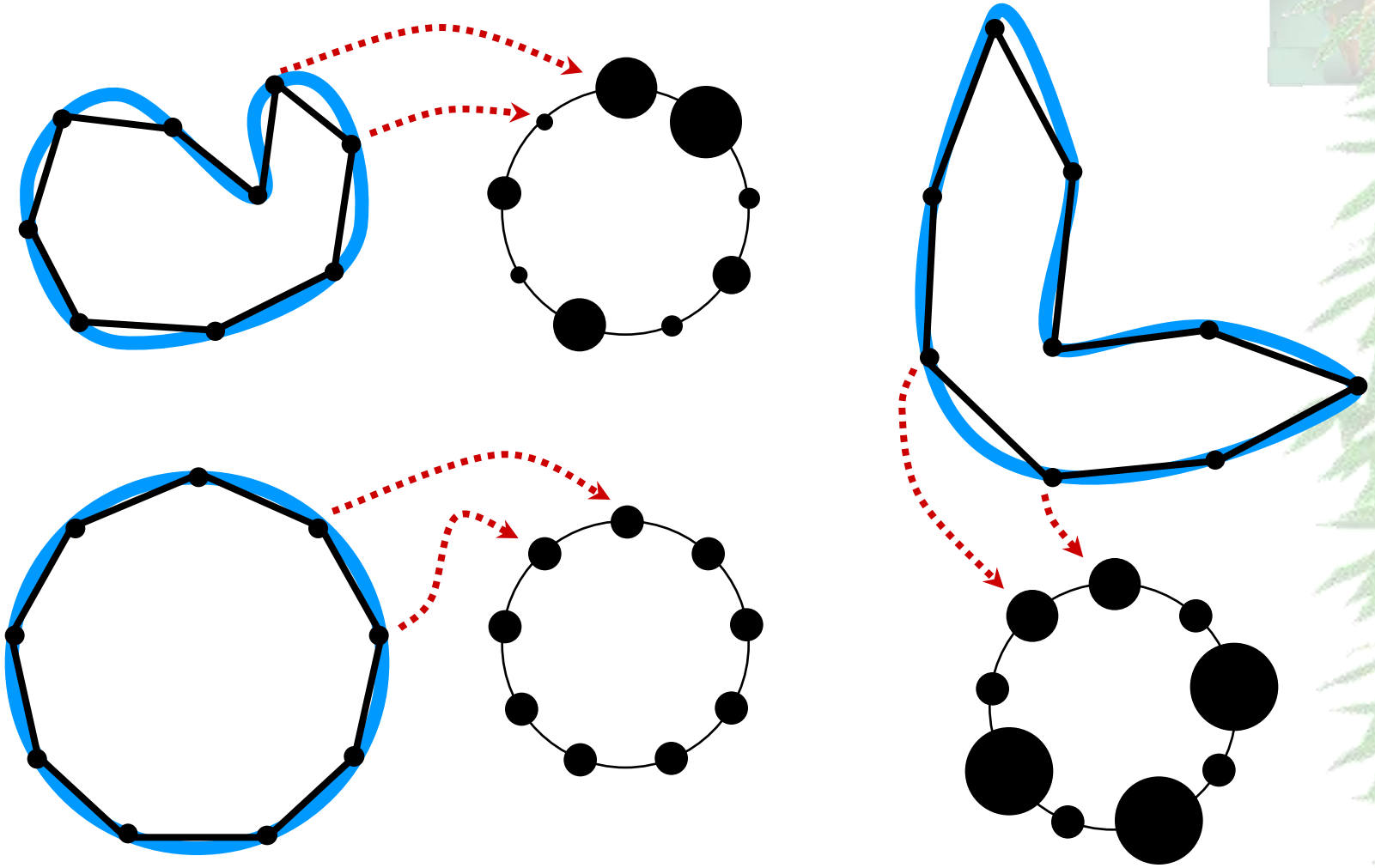
2D Contour

1-Simplex Mesh

SAI: Point size $\propto$ vertex curvature

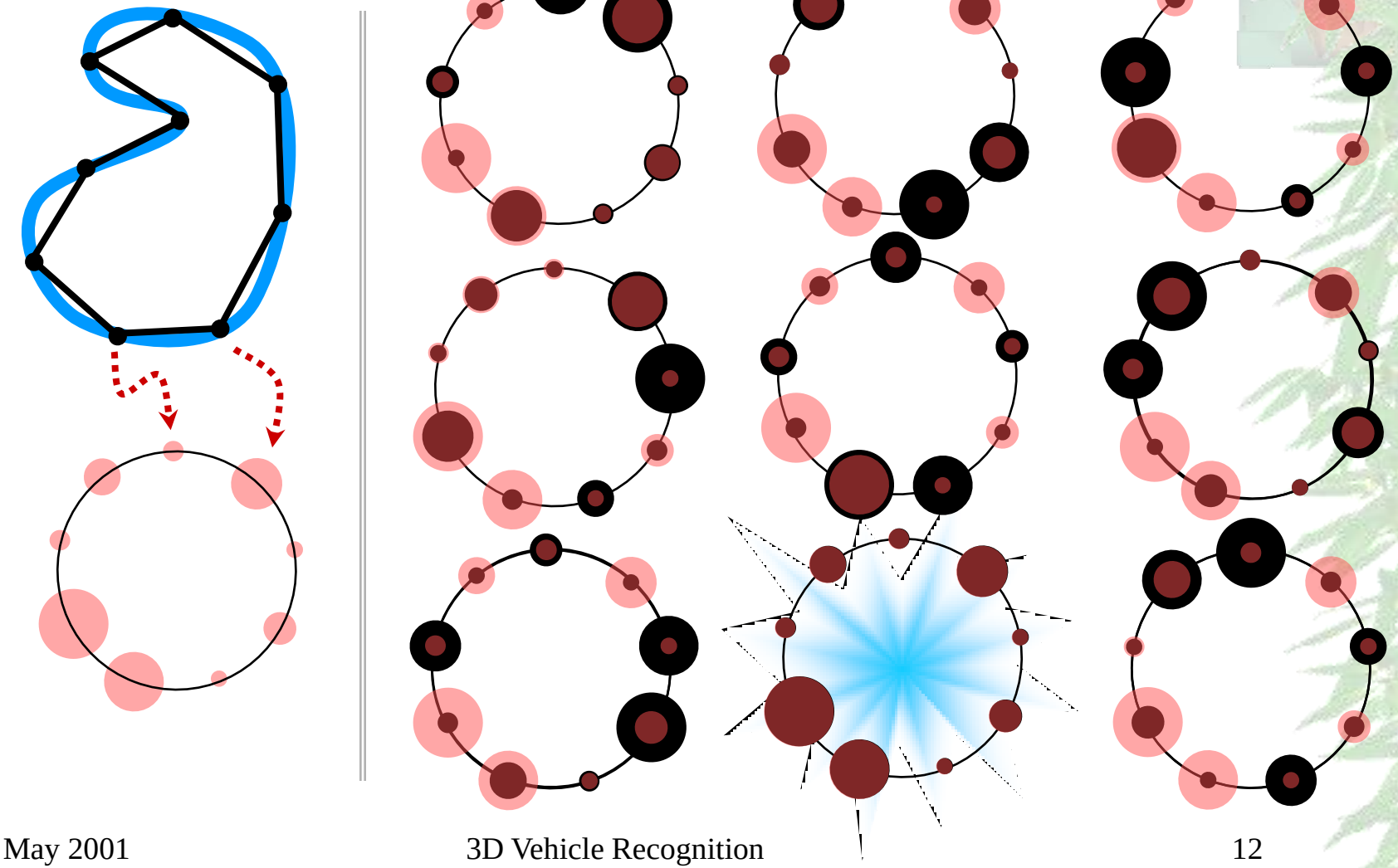
Spherical Attribute Images:

2D SAI Examples



Spherical Attribute Images:

Recognition



Further Reading

[1] Richard J. Campbell and Patrick J. Flynn. "A Survey of Free-Form Object Representation and Recognition Techniques". *Computer VIsion and Image Understanding*, 81(2):166–210, February 2001.2.

[2] Herv Delingette. "Simplex Meshes: a General Representation for 3D Shape Recognition". Technical Report 2214, INRIA Sophia Antipolis, March 1994.

[3] Katsushi Ikeuchi and Martial Hebert. "Spherical Representations: from EGI to SAI". Technical Report CMU-CS-95-197, Carnegie Mellon University, School of Computer Science, Carnegie Mellon University, Pittsburgh, PA 15213-3890, October 1995.

- Extended Gaussian Image (EGI) and its variants
- Spherical Attribute Image (SAI)

[4] Johan Montagnat, Herv Delingette, Nicolas Scapel, and Nicholas Ayache. "Rerpesentation, Shape, Topology, and Evolution of Deformable Surfaces. Application to 3D Medical Image Segmentation". Technical Report 3954, INRIA Sophia Antipolis, May 2000.

- Mathematics of simplex meshes
- Regularization and optimization of 2-simplex meshes