# Surface Reconstruction From Unorganized Points

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## Overview

- Introduction
- Approach
- Results
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## Introduction

- Start with unorganized points $\{x_1,...,x_i\}$
- Convert into implicit surface using a signed distance function
- Triangulate the implicit surface

## Introduction

- Calculate normals for each point $x_i$
- Calculate signed distance for a voxel grid
- Extract surface from the voxel grid using triangulation

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## Tangent plane estimation

- Tangent plane estimation
  - Start with point $x_i$ from the original set
  - Find $k$ closest neighbors, $Nbhd(x_i)$
  - Calculate centroid of $Nbhd(x_i)$, $o_i$
  - Compute $n_i$ using principal component analysis
- For each point $x_i$ we obtain $Tp(x_i)$ centered at $o_i$ with a normal of $n_i$

## Consistent orientation

- Ensure consistent orientation of $Tp(x_i)$
  - For two neighbor planes $Tp(x_i)$ and $Tp(x_j)$ $n_i.n_j \approx \pm 1$, but it should be $Tp(x_i)$ and $Tp(x_j)$ $n_i.n_j \approx +1$
  - For each plane $Tp(x_i)$ and $Tp(x_j)$ where $x_j$ is in the k neighborhood of $x_i$ assign a cost of $1-|n_i.n_j|$ to their edge
  - Perform a minimization in which planes with smallest costs are assigned the same orientation

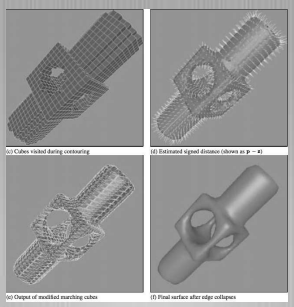
## Signed Distance Function

- Given a point $p \in R^3$ and its closest point on a surface $M$, $z \in M$, calculate signed distance
  - distance from p to z multiplied by ±1 depending on normal
  - z not available, use $Tp(x_i)$ whose center is closest to p
  - $f(p) = dist_i(p) = (p-o_i).n_i$
  - Assuming the sampling is ρ dense and δ noisy, if the nearest $o_i$ is further than ρ+δ from p, the surface is undefined at p.

## Triangulation

- Given the volume in $R^3$ that contains the implicit surface, extract it at iso 0
  - Perform contouring - visit only cells near the samples
  - Calculate signed distance from corners of grid cells
  - Use a modified marching cubes algorithm to triangulate
  - Refine triangles if they are of poor aspect ratio

## Triangulation



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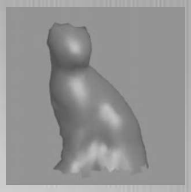
## Results

- Experimented with data from:
  - Randomly sampled meshes
  - Ray traced points
  - Range images
  - Contours

## Results

| Object | *n* | *k* | $\rho+\delta$ | cell size | time (s) |
|---|---|---|---|---|---|
| cat | 1000 | 15 | .06 | 1/30 | 19 |
| knot | 10000 | 20 | $\infty$ | 1/50 | 137 |
| mechpart | 4102 | 12 | $\infty$ | 1/40 | 54 |
| spock | 21760 | 8 | .08 | 1/80 | 514 |
| femur | 18224 | 40 | .06 | 1/50 | 2135 |

## Results

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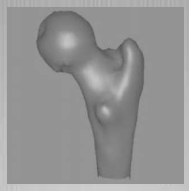

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## Conclusion

- Reconstructs surfaces from unorganized points
  - Most previous methods were for specific tasks
- Very fast
- Topologically correct results
- Can have problems with areas of rapid curvature change