

## Surface Reconstruction

COSC 470: Special Topic  
Computer Vision | 3D Reconstruction  
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### Finding More Points

- We've looked at techniques which find the 3D scene structure and camera poses at once
- If you know one, then the other is easier
- Given the estimated camera poses we can make a much better estimate of the 3D scene
  - Dense pairwise stereo
  - Multi-view stereo

### Multi-View Stereo

- We don't just have two views of the scene
- Can combine information from multiple views to give more accurate depth estimates
- E.g.: Patch-Based Multi-view Stereo
  - Hypothesises small planar patches, and reprojects them into each view
  - Gives depth and orientation (surface normal)

## Surface Reconstruction

- The methods so far give us a point cloud
  - This point cloud is fairly sparse
  - It is made up of points that we are confident of
- What we really want is a continuous surface
  - May need more points to fill in gaps
  - Need to find a surface or mesh that fits the points

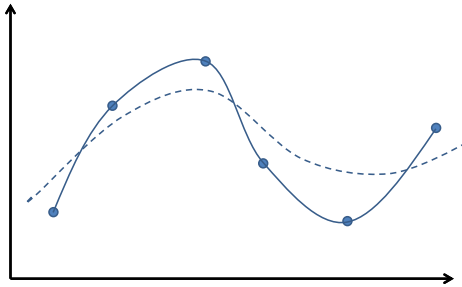
### Dense Pairwise Stereo

- This has long been an area of active research
- Use known epipolar constraint to restrict the search for matching points
  - Turns a 2D problem into a 1D problem
  - Need to introduce constraints between adjacent epipolar lines to maintain consistency
- Recent advances have been supported by the Middlebury Stereo data sets

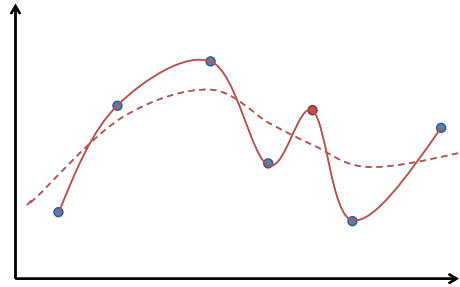
### Fitting Surfaces to Points

- We want to fit a continuous surface through a set of points
- Two basic approaches
  - Interpolating surfaces pass through the points
  - Approximating surfaces pass near the points
- Relatively easy in 1D or 2D, very hard in 3D

## Interpolation vs Approximation



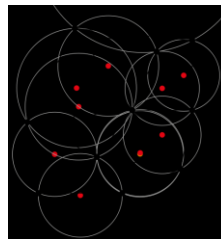
## Interpolation vs Approximation



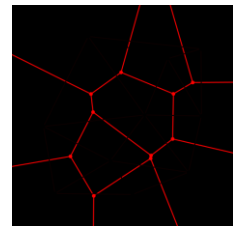
## Making a Mesh in 2D

- In 2D we can use Delaunay triangulation
  - Maximises the minimum angle of any triangle
  - Equivalently, no point is inside the *circumcircle* of any triangle in the mesh
- This is the *dual graph* of a Voronoi Diagram
  - Voronoi diagram – divide the plane into regions which are closest to each point
  - Dual graph – replace faces with vertices

## Delaunay and Voronoi



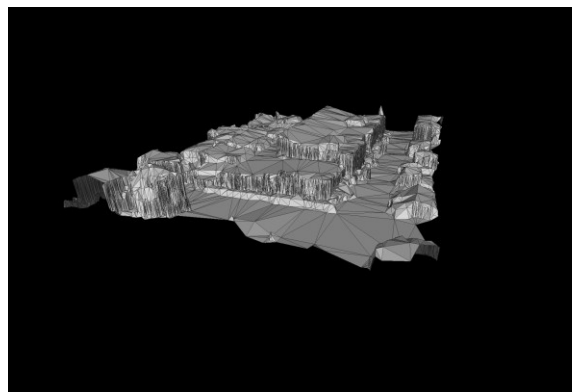
Delaunay triangulation of the black points. Circumcircles are in grey, centres in red



Connecting the circumcircle centres (red) gives a Voronoi diagram

## Delaunay in 3D

- Delaunay triangulation generalises to 3D
  - Circles become spheres, triangles tetrahedra
  - This is not what we want
- In some cases we can project the 3D model onto a plane and work in 2D
  - In aerial imaging we can use a ground plane
  - Simple, but not great for near-vertical walls



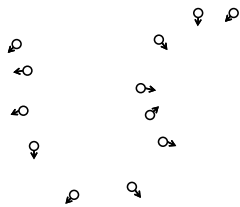
## Interpolating Surfaces

- Interpolating surfaces are sensitive to noise
  - Small errors will produce small ripples in the reconstructed surface
  - A single bad point will make a big spike
- Approximating surfaces can smooth this out
  - Fit a smooth surface across the points
  - May lose detail, and rounds off sharp edges

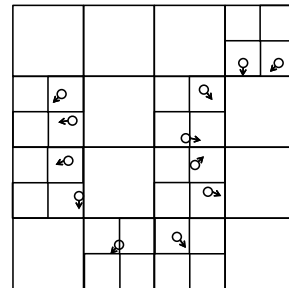
## Poisson Surface Reconstruction

- Subdivide the space to find out what regions have a surface passing through them
  - More subdivision gives more detail
- Use the points and their normals to estimate a smooth surface through these regions
  - More subdivision gives less smoothing
- Gives a closed surface as a result

## Poisson Surface Reconstruction



## Poisson Surface Reconstruction



## Poisson Surface Reconstruction

