Difficulty w/ CSG is its slow to render raytrace to a boundary or B-rep. Each primitive with a mesh of its.

Typically represented with looped edge solid of
- faces (faces) w/ ptrs to relevant edges, verts
- faces (edges)
- faces (vertices)

Options
- list edges in cw order going around a face's outward normal

Edge rep as
first vert last vert left face right face

next, prev moving along left ri.p along right
rt. one incident edge.

not all incident edges

face one edge

face list of edges
The operations are straightforward rendering - throw faces into polygon renderer

some joins
- eg. paste two objects together on shared face
  cases: • faces are "the same"
  • not...

extrusion
• Important operation to produce solids

plane figure

• many objects are made like this.
section is relatively easy
faces of \( \Lambda \) are pieces of faces
of components.
convex components are particularly
easy
- only one connected component
- only one no more than 1
  face of \( \Lambda \) from any face
  of component.
- verts are
\[
\text{(some of component verts)} U
\text{ face}(A) \cap \text{edge}(B)) U
\text{some (face}(B) \cap \text{edge}(A)))
\]
- each of these sets is easy
to find.
- rest is pointer chasing (example)
secting WES is relatively straightforward

find edge face as, chase

pass from WES to general

cup of polygons sometimes w/ combinatorial structure

not tough to have much if it isn't a solid.

not usually a solid

many computations can be tricky

hard to spot core geometric properties

interpolation over meshes is easy

... normals are NOT piecewise constant (or at least, not required to be)
WE MAKE ONE?

WES

telling system
in a set of sample points.

Meshes usually come from an assembly!
surface patches

These are usually built w/:

- splines
- subdivision surfs
- height maps (less often)

MAPS

plest)

- have \((x_i, y_i, z_i)\),
scatter) data.
(eg. image data)
interpolate or smooth, grid, resample

triangulate \((x_i, y_i)\) use this to get mesh.

- Hard to avoid "bad" 3D triangles
- Hard to sew together pieces
- Resampling may bias.

Interpolates, smoother have \(N\) pts \((x_i, y_i, z_i)\)
or on grid

Should like to build approximation interpolate
strategy:

choose $\phi(x,y; x_i, y_i) = f \left( (x-x_i)^2 + (y-y_i)^2 \right)$
(discuss choices later)

interpolate is

$$\sum_j a_j \phi(x, y; x_j, y_j)$$

$$z_i = \sum_i a_i \phi(x_i, y_i; x_j, y_j)$$

$$\bar{z} = \frac{\mathbf{M} \mathbf{a}}{\mathbf{c}}$$

(light conditions on $\phi$, $\mathbf{M}$ has full (McClellan))
Consider some choices of $\varphi$.

\[ f(x_i, y_i) = f((x-x_i)^2 + (y-y_i)^2) \]

\[ = f(c^2) \]

\[ c^2 = \frac{1}{d^2 + \varepsilon} \]

$\varepsilon$ has important control properties.

\[ \varepsilon = \max\left(1 - \frac{d^2}{\sigma^2}, 0\right) \]

$\sigma$ has control properties.

\[ \frac{d}{d^2 + \varepsilon} \]

\[ = -\log(d^2 + \varepsilon) \]

... not finite support.

\[ \nabla^4 f = 0 \]

... rather odd far away from data.

minimizes a form of bending cost.
Note each of these basis f's has a
meter, which is essentially a scale

\[ z_i - \sum_{j \in \text{base points}} a_j \phi(x_i, y_i; x_j, y_j) \leq \| \| x_i - M a \|_b \| \leq T M a = M_b T z \]  

solve for \( a \)

using scale param: plot err vs scale

for pt set, choose best

\[ \text{number of base points:} \]

- application logic
- MQL/All style reasoning
that choices of basis, scale affect linear algebra.

\[ 1^2 \cdot 0 \]

many zeros in \( M \)

can often solve w/ iterative method

precondition

is often a good preconditioner.

finishes Laplacian on some triangulation of visits
point, pass to shape from Shading


Given shaded image of a surface, with domain \( D \), viewed orthographically, with known radiometric libration, known albedo, known case, recover surface geometry.

Traditional Strategy:

Model

\[
I(x, y) = \left( N(x, y) \cdot S \right) \cdot c(x, y)
\]

image intensity, in radiometric units (hence calibration)

\( c(x, y) \)

known albedo

\( S \)

unit normal

\( N(x, y) \)

source vector

\( I(x, y) \)

assume WLOG, \( p = 1 \)
\[ N(x,y) = \left( -h_x, -h_y, 1 \right) \]
\[ \frac{1}{(1 + h_x^2 + h_y^2)^{1/2}} \]

for \( (x, y, h(x,y)) \)

PDE

\[ + \frac{h_x^2 + h_y^2}{1 + h_x^2 + h_y^2} + S_0 h_x + S_1 h_y - S_2 = 0 \]

an instance of an eikonal eyn

No soln when \( I^2 > S_0^2 + S_1^2 + S_2^2 \)

can be shown that existence of solutions is a serious problem

In general, solving this PDE does not yield approaches that

- make sense mathematically
- make sense practically
- yield good looking solns
The model is **WRONG**

- correct for
  - diffuse surfaces
  - isolated patches
  - distant sources

But these conditions don't apply.

The radiometric model is, at least:

\[
R(x) = B_0(x) + \int K(x,y) B(y) \, dy
\]

- radiosity at \( y \)
- **geometric, radiometric gain terms**
- radiosity at \( x \) due to source alone (e.g., when patch at \( x \) is isolated)
del is wildly unpromising

all pairs of patches interact

her patches change interaction

\[ y, y, z \]

\[ z \]

\[ / \]

\[ / \]

\[ y, x \]

doesn't, z is in the way

light transfer occurs

a complicated fn & geometry

x are claims in literature that can loaf the interferers into shape

reus - i discount them.
Modify shading model to

\[ I(x, y) = G(N; s) \]

some \( f \) of the unit normal

natural \( G \)

\[ G(N; s) = \sum_i a_i S_i(N) \]

tspherical harmonics

encode source properties

yields another PDE

... still have existence problems

give \textit{variational} methods that haven't been tested
\[ \lim_{\text{finite}} \left[ \text{Cost}(\text{Surface, albedo, Illum}) \right] \]

subject to

\[ I - \rho G(N; a) = 0 \]

does not have existence problems,

I is badly mishandled.

that is \( \text{Cost}(\text{Surface, albedo, Illum}) \)?

it should be)

ines:

- Illum field is "smooth"
  except at shadows

- albedo field is \( > 0, < 1 \)
  has few slow changes,
  has few distinct values.
Surface is "smooth"
- turns away from eye at outline
- is biased toward front
- it tends to be locally "flat"

\[ \frac{h_x^2 + h_y^2}{2} > \text{thresh (at boundary)} \]