CMPUT 428: 3D Modeling

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Contents

1 Lecture - Mar 12

Lec09DynTextimpColl12

Structure from Silhouette

  Get cone ray from silhouette

1.1 Incremental Free Space Carving

Triangulate sparse point cloud: remove tetrahedrons/triangles + remake w/ points

1.2 3D modeling system

online, incremental handling of new info events
works with sparse point clouds (good for vision/feature based methods)
models coarse

1.3 3 Tier Model

Macro, Meso, Micro model
refine geometry w/ coarse model as prior Multi Tiered Models:

- Commonly:
  - 2 Tiers: 3D geom and appearance (texture mapping)
  - Used in graphics applications, recovered from vision applications
- 3 Tier:
  - Macro - scene geometry (triangulation map)
  - Meso - fine scale geometric detail (displacement map)
    - Micro - fine scale geometry/reflectance (texture map)
- Captured via sequential refinement

1.4 Multiscale Model

Geometry alone doesnt solve modeling, need multiscale model
Need

1. Geometry
2. Depth
3. Dynamic Texture

$\rightarrow$ Rendering
Use image derivatives (know lighting changes, position of view, etc.) in forward way to render a diff. img (helps get photorealism)

1.5 Capgui

Step 1 - Calibration

Step 2 - Segmentation

Get rid of background

Step 3 - Shape From Silhouette

8-60 imgs
multiple views of same object $\rightarrow$ intersect **generalized cones** generated by each img to build a volume (guaranteed to contain object)
limiting smallest vol. obtainable in this way is known as the **visual hull** of the object

1.5.1 SFS methods

Voxel based (use voxel grid rep.)

    inaccurate

    triangulate w/ marching cubes algo

Image ray based (use image rays)

    accurate

Axis aligned (use rectlinear rays (instead of camera rays), mark 'cut' points of image rays)

    moderately accurate

    fast

    marching intersections algo

    (mix of img ray and voxel based)

Step 4 - Phototextures + Texture Mapping

For each triangle in model, establish corresponding region in the phototextures
Difficulties:

- Tedious to specify texture coords. for every triangle

1.5.2 Common Text. Coord. Mappings

Orthogonal
Cylindrical
Spherical
Perspective Projection
Texture Chart (ie. text. split + flatten; cut object into pieces and map textures to each piece (piecewise planner))

1.5.3 Advanced Texture Splitting and Mapping

Floating Planes Method

- split into dozen - several dozen perspective mappings
- union of persp. planes accurately represent obj

LCSM (Least Squares Conformal Mapping)

- least square (locally) preserve orthogonality

Step 6 - Texture Basis Computation

1.6 Performance

Can have many gb of texture memory
Key issue: efficient memory access and processing

1. Macro - conventional geom processing
2. Meso - pixel shader; fixed code and variable data access
3. Micro - Shader/Registration comb.; fixed code and fixed data access

1.7 Meso Struct

Depth with respect ot plane, doesnt work well with just one image (flat texture)

1.7.1 Computing Meso

Variational shape and reflectance Per point cost func:

$$\phi(\mathbf{X}, \mathbf{n}) = \sum_i h(\mathbf{X}, P_i) \| I_i(P_i(\mathbf{X})) - R(\mathbf{X}, \mathbf{n}, \mathbf{L}) \|$$

$h \rightarrow$ visibility + sampling
$R \rightarrow$ reflectance

1.7.2 Rendering Meso

$>$ 100 fps for consumer GPU

1.8 Micro Struct

Spatial texture basis
Render temporally varying dynamic texture by modulating a linear basis
Basis contains spatial derivs of img
Rendered by linear blending (?)

fixed execution and data access pattern

very fast implementation in graphics hardware

Can be done quickly in assembly (register extr.)

1.8.1 Dynamic Textures

3D geom and texture warp map b/w views and texture imgs

Diff texture img for each view;
A number of different misalignments

Planar error - incorrect texture coords
Out of plane error - object surface $\neq$ texture plane

1.9 Spatial Basis Intro

Moving sine wave can be modeled

$$\begin{aligned} I(t) &= \sin(u + at) \\ &= \sin(u)\cos(at) + \cos(u)\sin(at) \\ &= \sin(u)y_1(t) + \cos(u)y_2(t) \end{aligned}$$

u spatially fixed basis

Small image motion

$$I = I_0 + \frac{\partial I}{\partial u}\Delta u + \frac{\partial I}{\partial v}\Delta v$$

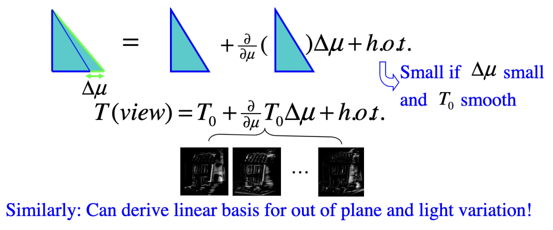
Spatial fixed basis

1.10 Linear basis for spatio-temporal variation

On the obj./texture plane:

variation resulting from small warp perturbation

Taylor expansion


$= \quad + \frac{\partial}{\partial\mu}(\quad)\Delta\mu + h.o.t.$
$\Delta\mu$
Small if $\Delta\mu$ small
and T_0 smooth
$T(view) = T_0 + \frac{\partial}{\partial\mu}T_0\Delta\mu + h.o.t.$
...
Similarly: Can derive linear basis for out of plane and light variation!

1.11 Geometric spatial temporal variability

Image 'warp'

$$T(\mathbf{x}) = I(W(\mathbf{x}, \mu))$$

Image variability caused by imperfect warp

$$\Delta T = I(W(\mathbf{x}, \mu + \Delta\mu)) - T_w$$

First order approx.

$$\Delta T = I(W(\mathbf{x}, \mu)) + \nabla T \frac{\partial W}{\partial \mu} - T_w = \nabla T \frac{\partial W}{\partial \mu}$$

Concrete examples: img plane; out of plane

1.12 Variability due to a planar projective warp (homography)

1.13 Out of Plane Variability

1.14 Photometric Variation

light changes how obj looks (?)
dont need to raytrace

1.15 Composite Variability

composite texture intesity variability

$$\mathbf{\Delta T} = \mathbf{\Delta T}_s + \mathbf{\Delta T}_d + \mathbf{\Delta T}_l + \mathbf{\Delta T}_e$$

planar + depth + light + res. err.

Can be modeled as sum of basis

$$\begin{aligned}\mathbf{\Delta T} &= \mathbf{B_s y_s} + \mathbf{B_d y_d} + \mathbf{B_l y_l} + \Delta(T_e)\\ &= \mathbf{By} + \boldsymbol{\Delta}\mathbf{T_e}\end{aligned}$$

1.16 How to Compute

Slide 31 - 32

1.17 Dyntex