Exact Voxel Occupancy with Graph Cuts

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CVPR 2000
Volume (silhouette) intersection

Color voxel black if on silhouette in every image
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Issues

Early hard decisions are a problem
  • Errors in silhouette identification
  • Can lead to “holes”

Can we add spatial smoothness with energy minimization?
Can we solve it fast?
Problem statement

Given voxels $p \in P$, assigned binary labels $f_p$
  • filled (1) or empty (0)

Each pixel corresponds to a line of voxels
  • If pixel is different from background, these voxels prefer 1, else 0
Energy function

\[ D_p(f_p) = \text{cost for voxel } p \text{ to have label } f_p \]

- \( D_p(\text{empty}) \) is large if voxel is different from background
- \( D_p(\text{full}) = \text{constant} \)

We seek the labeling \( f \) that minimizes

\[
E(f) = \sum p \, D_p(f_p) + E_{smooth}(f)
\]
What smoothness term?

Here is a natural one where we can efficiently find the global minimum!

\[
E_{smooth}(f) = \sum_{p, q \in N} V(f_p, f_q)
\]

\[
V(f_p, f_q) = T[f_p = f_q]
\]
Result
Result

Conventional Energy minimization
Running time

For 100x100x100 grid, 16 cameras

- 9 seconds total, on 500Mhz Intel PIII
  - > 7 sec: graph prep + project
  - > 1 sec: max flow computation
  - > 1 sec: min-cut labeling of voxels from max-flow
Multiway Cut for Stereo and Motion with Slanted Surfaces

Stan Birchfield and Carlo Tomasi

ICCV 1999
Motivation

Why does it look so bad?

an image from a stereo pair
disparity map from graph cuts
Solution

Think of this as a segmentation

- Fit plane to each region to give more accurate results
- Once you have these planes, reassign pixels to get better fit
Algorithm

1. Initialize a set of pixel labels
2. For each label, fit a plane to all pixels with that label
   - they do this by solving for an affine transformation (Lukas-Kanade) that best aligns region in left image to corresponding region in right image
     > this is appropriate under orthographic projection
3. Assign labels (planes) to pixels
   - use graph cuts of course!
4. Repeat Steps 2 & 3 until convergence
5. Cleanup phase
   - merge neighboring planes

This style of algorithm should look familiar...
Figure 3: LEFT: Segmentation of the Cheerios image after the convergence of the multiway cut and affine-parameter fitting steps. RIGHT: Two regions on the ground plane have been merged, with more to follow.
Stereo results
Motion segmentation
Discussion questions

1. Graph cuts vs. belief propagation
   • a winner?

2. Applications of GC, BP, EM
   • so far, apps are pretty narrow—too much hype?

3. What improvements to GC, BP, EM do you think are possible?