Interactive Media Systems Group
Software Technology & Interactive Systems
Vienna University of Technology

Microsoft Research Cambridge

Surface Stereo with Soft Segmentation

Michael Bleyer[1], Carsten Rother[2], Pushmeet Kohli[2]

[1]Vienna University of Technology, Austria
[2]Microsoft Research Cambridge, UK

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Dense Stereo Matching

(Left Image)

(Right Image)

Dense Stereo Matching

(Left Image)

(Right Image)

(Disparity Map)

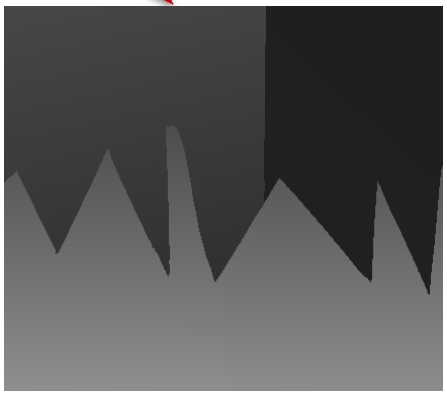
Common Approaches

Reference image

Common Approaches

Assign pixels to disparity values

Reference image



Disparity map

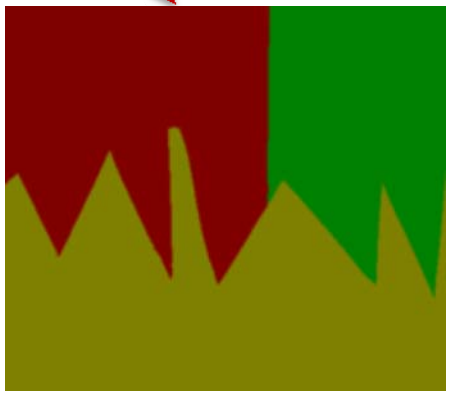
Our Approach

Reference image

Our Approach

Assign pixels
to 3D surfaces

Reference image



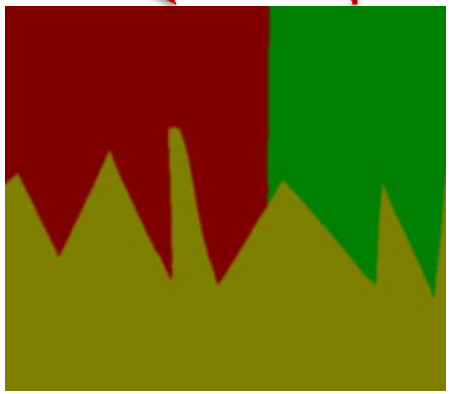
Surface map

Our Approach

Assign pixels to 3D surfaces

Surfaces implicitly define disparities

Reference image



Surface map

Disparity map

Our Approach

Assign pixels

Surfaces implicitly

- Our approach simultaneously infers:
  1. Which surfaces are present in the scene
  2. Which pixels belong to which surface

Reference image

Surface map

Disparity map

Energy

- Search an assignment of pixels to surfaces that minimizes an energy:

Data Term:
Computes pixel dissimilarities; Penalty for occluded pixels

Smoothness Term:
Penalty on spatially neighboring pixels assigned to different surfaces

Soft Segmentation Term:
Penalty on inconsistencies with a given color segmentation

MDL Term:
Penalty on the number of surfaces

Curvature Term:
Penalty on disparity curvature

- Surfaces: planes or B-splines.

Energy

- Search an [illegible]els to surfaces that minimizes an energy:

Contributions

Data Term:
Computes pixel dissimilarities; Penalty for occluded pixels

Smoothness Term:
Penalty on spatially neighboring pixels assigned to different surfaces

Soft Segmentation Term:
Penalty on inconsistencies with a given color segmentation

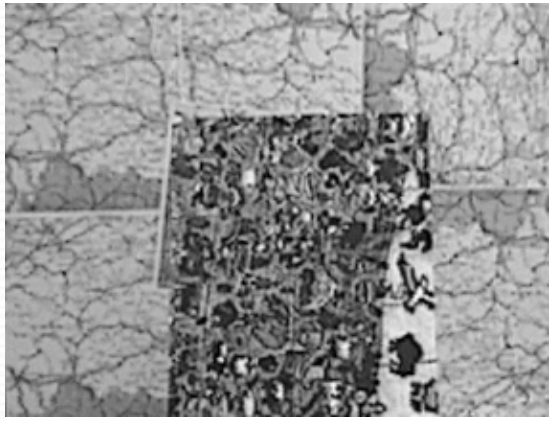
MDL Term:
Penalty on the number of surfaces

Curvature Term:
Penalty on disparity curvature

- Surfaces: planes or B-splines.

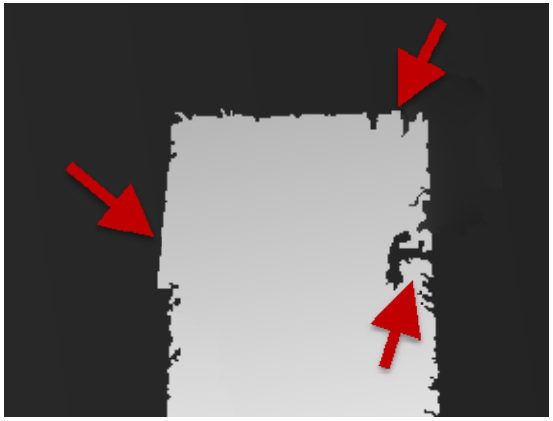
Soft Segmentation Term

- Common segmentation-based methods:
  - Color segmentation of reference image
  - Assign each segment to a single surface
  - Fail if segment overlaps a disparity discontinuity.



Map reference image

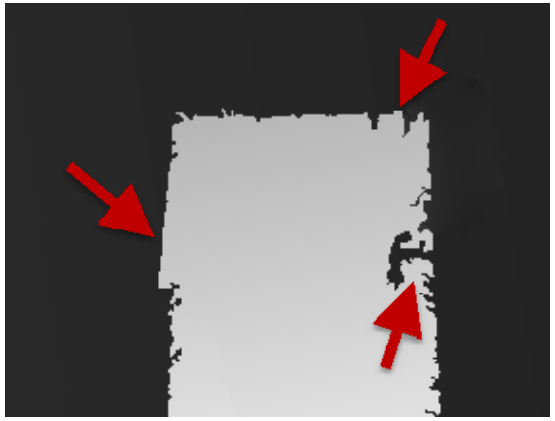
Ground truth disparities



Result of hard segmentation method

Soft Segmentation Term

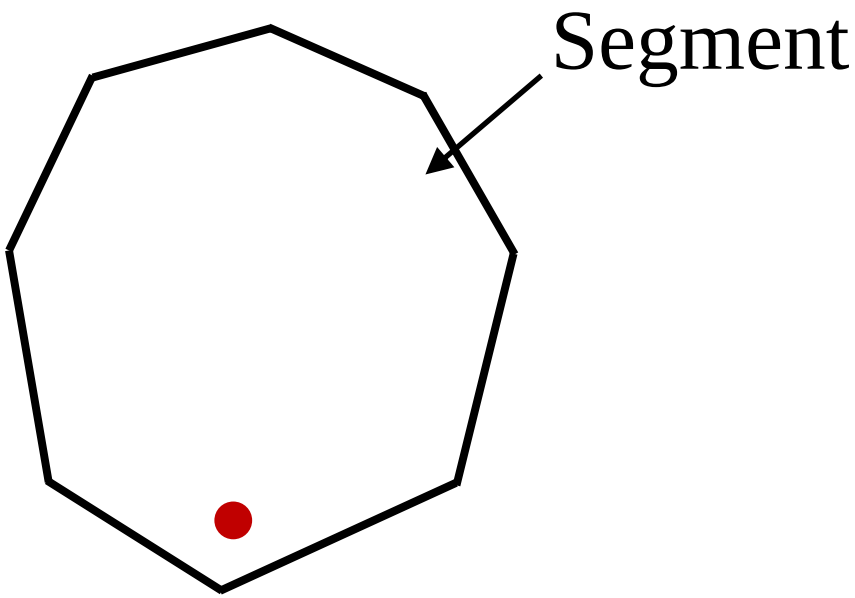
- Our approach:
  - Prefer solutions consistent with a segmentation (lower energy).
  - Segmentation = soft constraint.



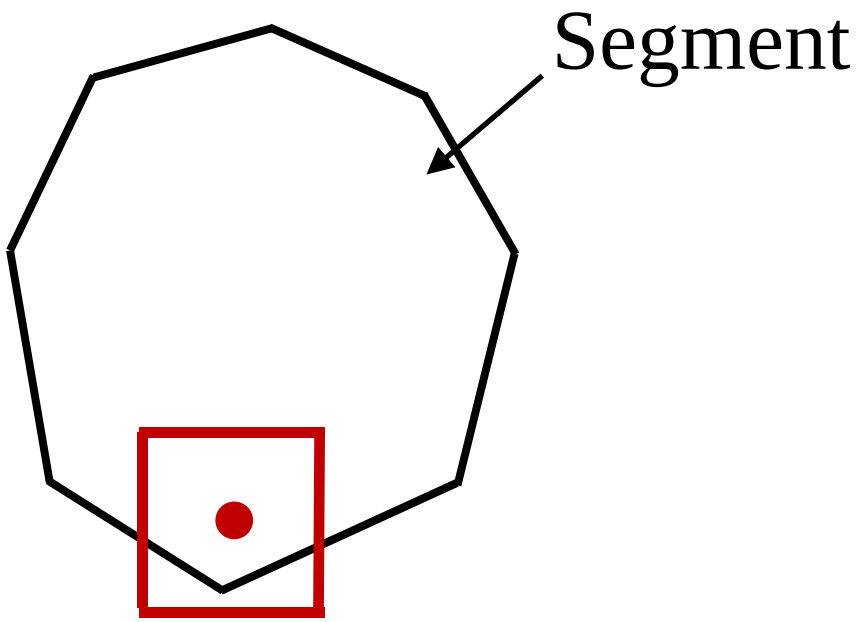
Result of hard segmentation method

Our result

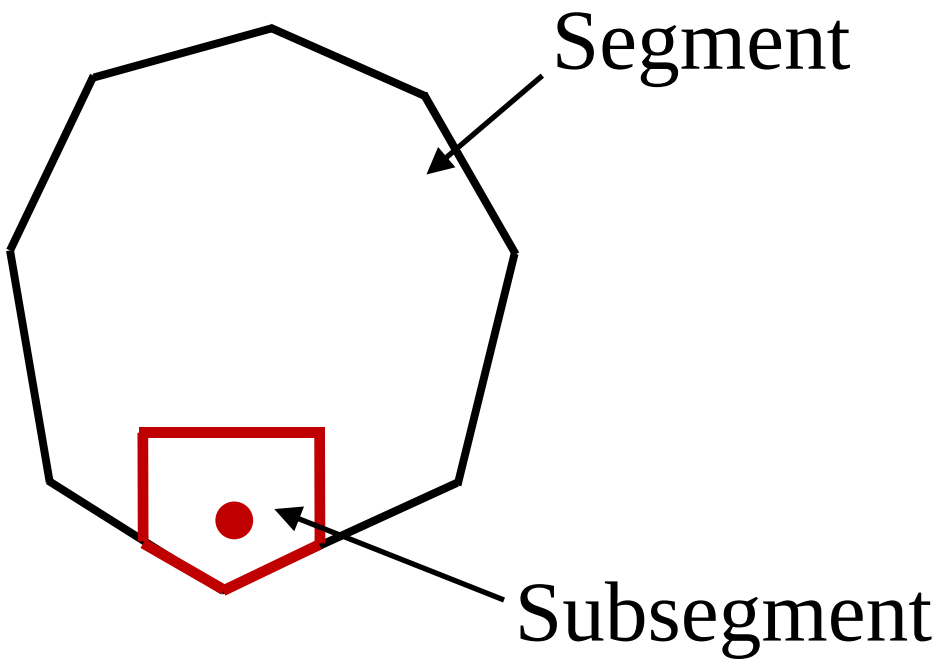
Soft Segmentation Term



Soft Segmentation Term

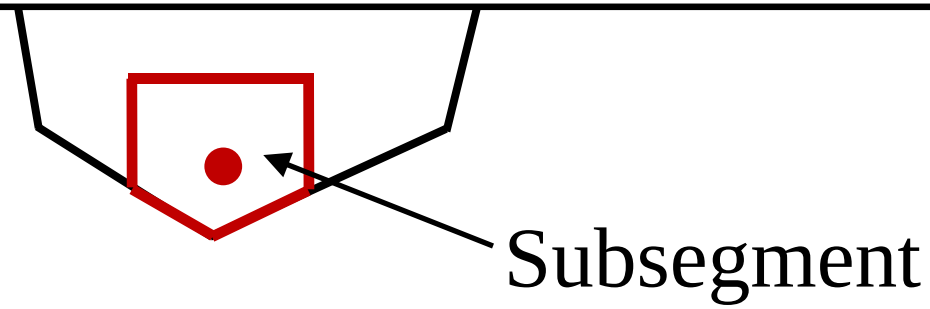


Soft Segmentation Term

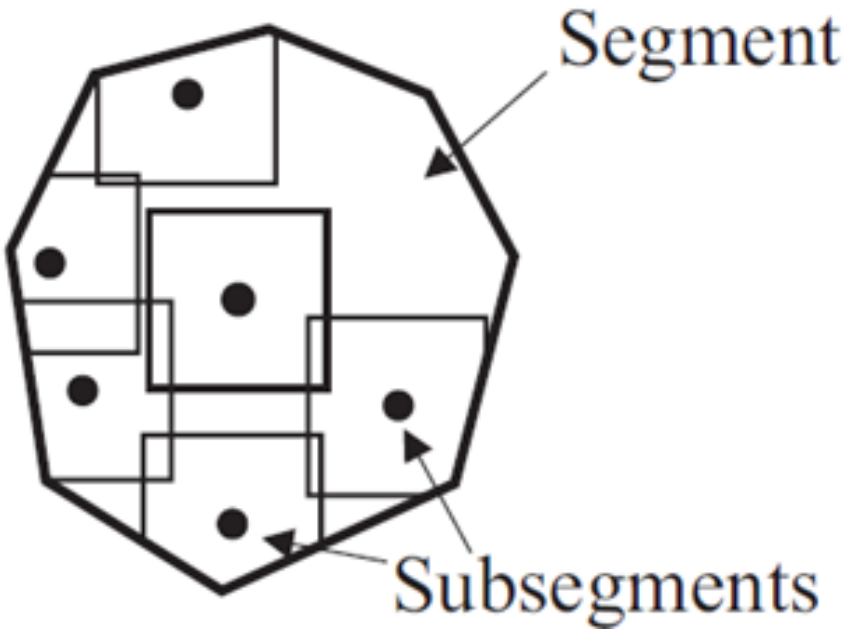


Soft Segmentation Term

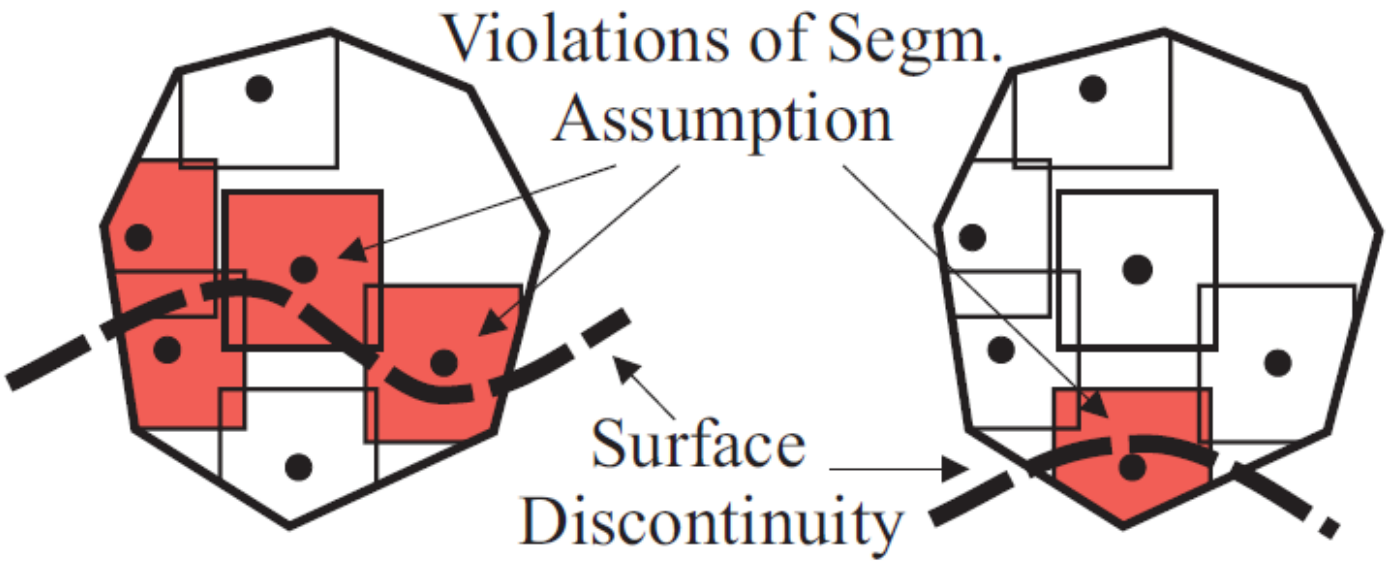
- Our term:
  - 0 penalty if all pixels within subsegment assigned to the same **surface**
  - Constant penalty, otherwise



Soft Segmentation Term



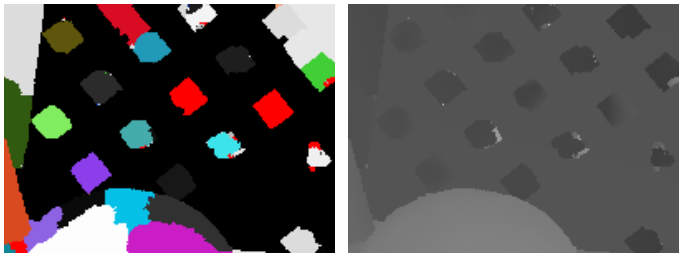
Soft Segmentation Term



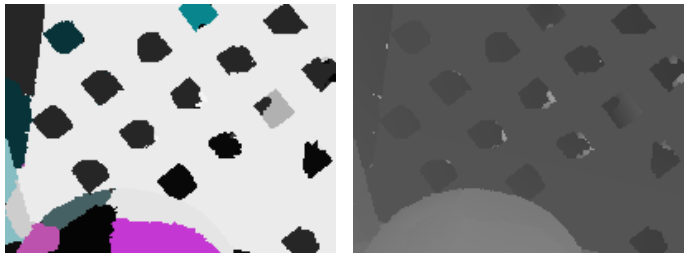
MDL Term

- Simple scene explanation better than unnecessarily complex one.
- Penalty on the number of surfaces.
- Solution containing 5 surfaces cheaper than one with 100 surfaces.

Crop of the Cones image



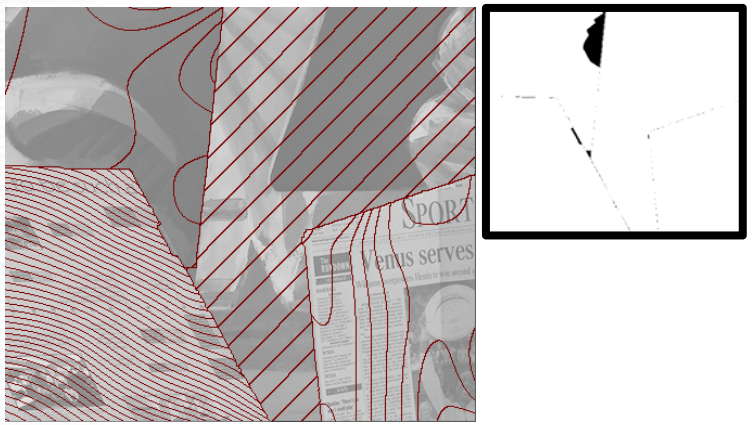
Solution without our MDL term.



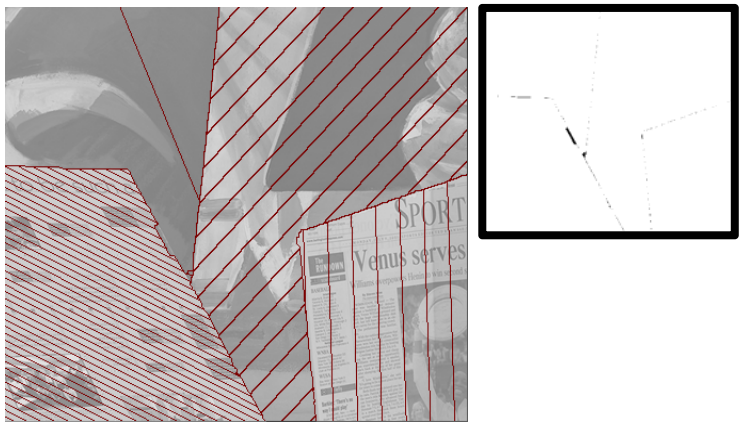
Our MDL term.

Curvature Term

- Second order priors:
  - Difficult to optimize in disparity-based representation due to triple cliques [Woodford et al., CVPR08].
- Our approach:
  - Curvature analytically computed from surface model.
  - Easy to optimize in surface-based representation (unary term).



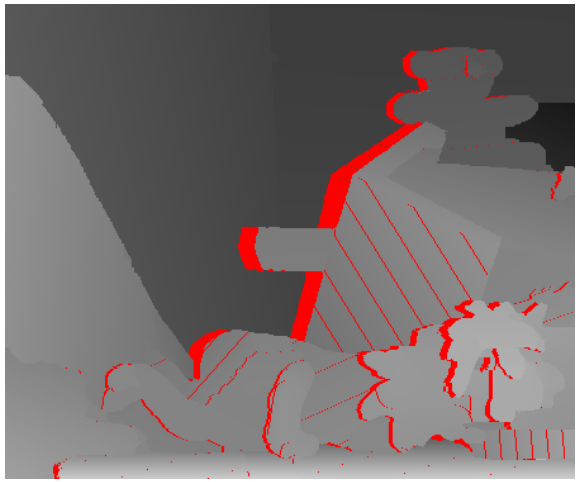
Result without curvature term.



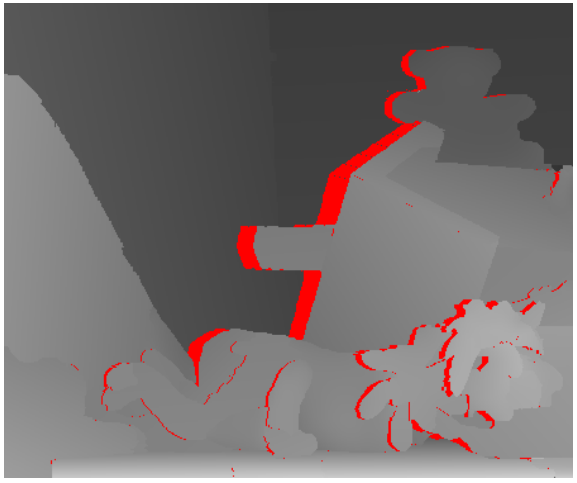
Result with curvature term.

Improved Asymmetric Occlusion Handling

- Uniqueness assumption violated for slanted surfaces:
  - Several pixels of the same surface correspond to a single pixel of the second view.
- Our approach:
  - Pixels must not occlude each other if they lie on same surface.
  - Avoids wrongly detected occlusions at slanted surfaces.



Standard Occlusion Handling

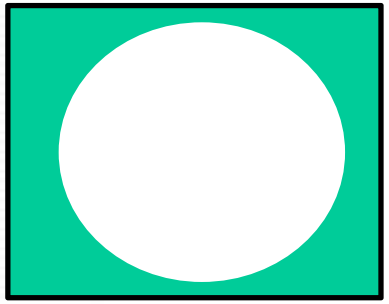


Ours

Energy Optimization

- Not easy – label set of infinite size!
- Fusion move approach [Lempitsky et al., ICCV07]:

Current Solution



Energy Optimization

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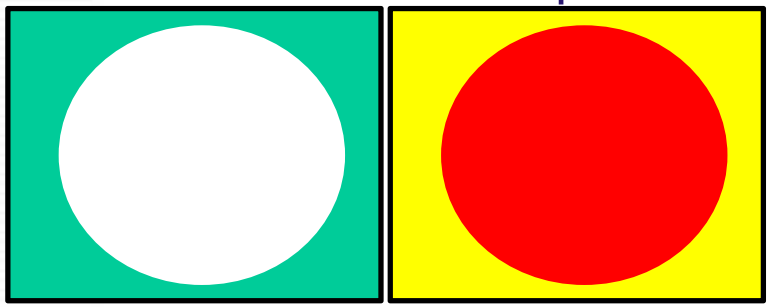
Current Solution Proposal



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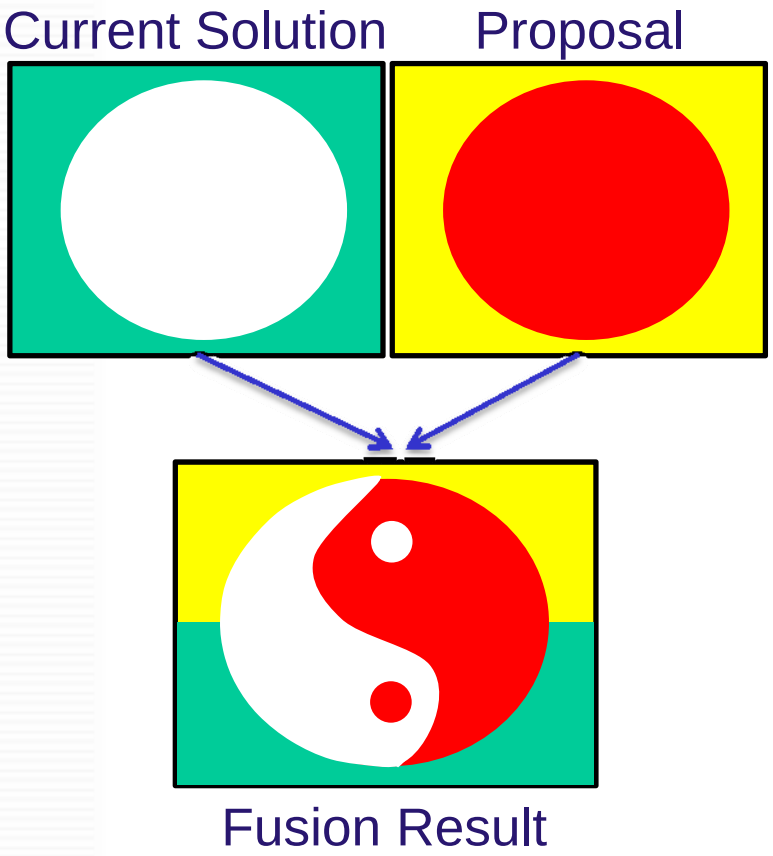

Energy Optimization

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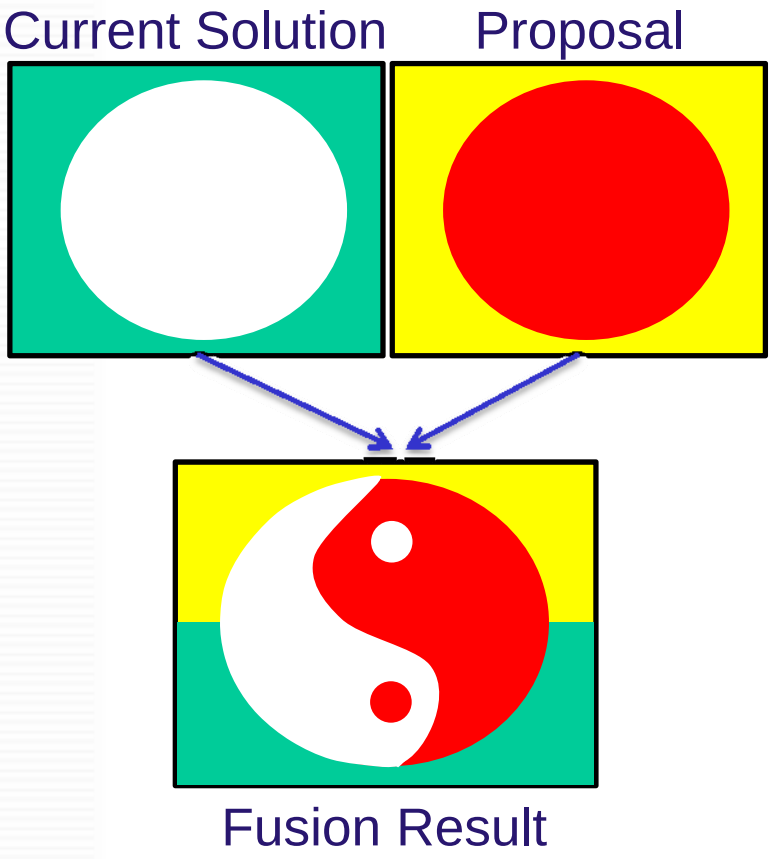
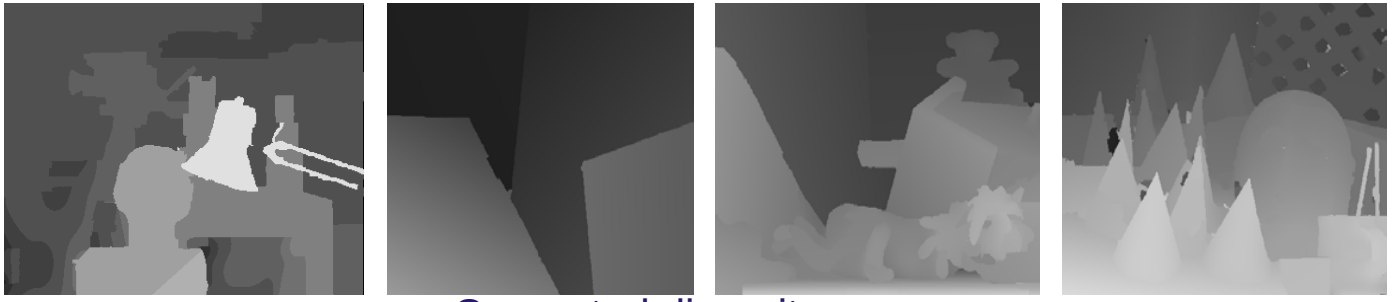
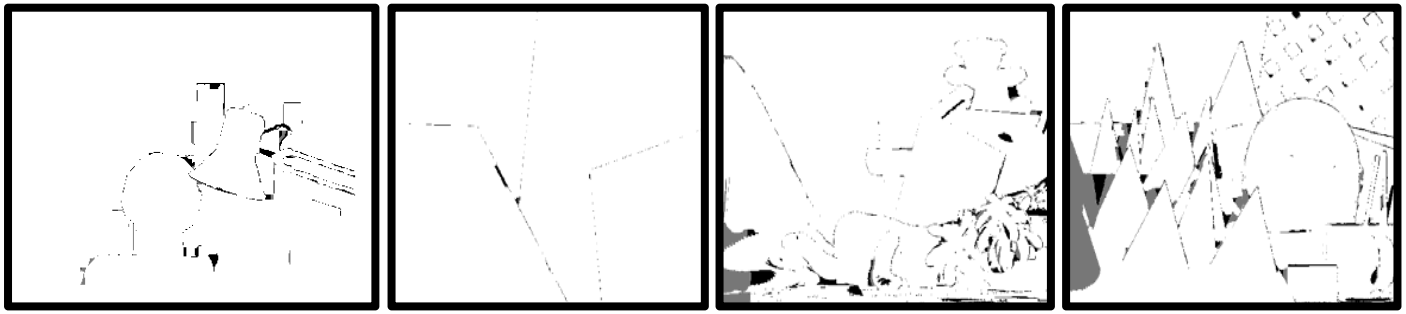


- Computing the “optimal” fusion move:
  - Recent work on sparse higher-order cliques ([Kohli et al., CVPR07] and [Rother et al., CVPR09]) for implementing soft segmentation term.
  - Non-submodular energy optimized via QPBOI.

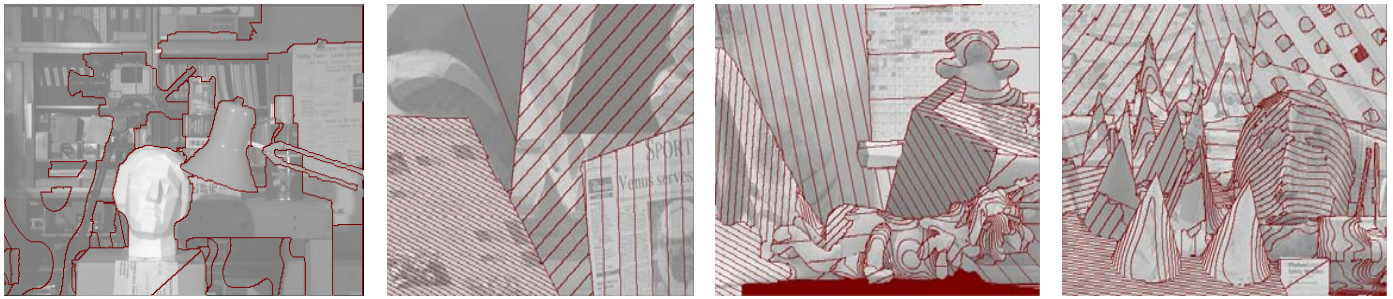


Computed disparity maps



Disparity errors > 1 pixel

Assignment of pixels to surfaces

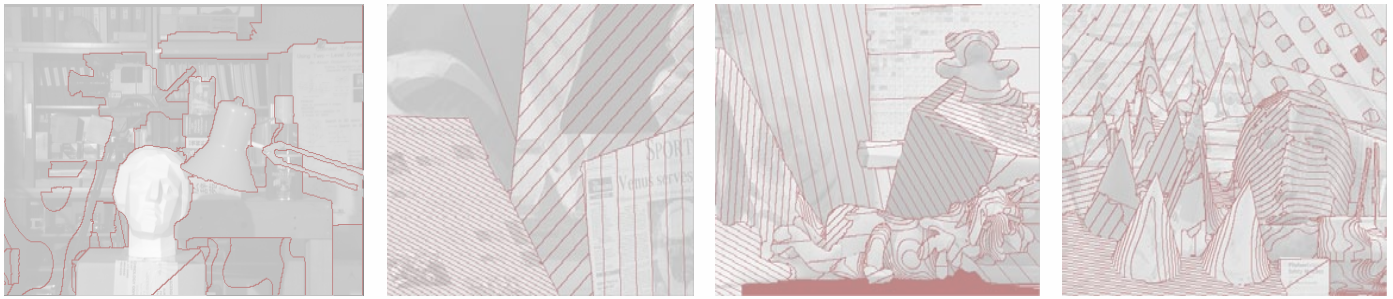


Left images with contour lines overlaid

Computed disparity maps

- 6th rank out of ~90 submissions in the Middlebury online table.
- 1th rank for the complex Teddy set on all error measures.

Assignment of pixels to surfaces



Left images with contour lines overlaid

Conclusions

- Surface-based representation is important.
- Enables several important contributions:
  - Soft segmentation
  - MDL prior